DEVELOPMENT OF A CLINICAL HAND REHABILITATION GUIDELINE FOR SECOND TO FIFTH METACARPAL FRACTURES IN SOUTH AFRICA

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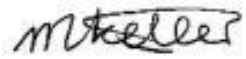
Declaration

I, Monique Keller, hereby certify that the thesis submitted for the degree, Doctor of Physiotherapy at the University of the Free State, is my independent effort and has not previously been submitted for a degree at another faculty/university. I furthermore waive copyright of the thesis in favour of the University of the Free State.



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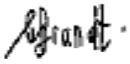
Dr Roline Barnes



Dr Corlia Brandt

July 2022

Dedication

This thesis is dedicated to my parents, Linda and Pieter Arangie, my husband Paul Keller, and our children, Erin and Ross. Thank you for your support, patience, and love. In loving memory of my brother, Riaan Arangie.

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Summary

In countries, such as South Africa, with limited resources and inequities in their healthcare delivery services optimal hand rehabilitation is essential in their quest to enable individuals sustaining second-to-fifth metacarpal fractures to return without delay to pre-injury functioning and to work safely. Sub-optimal hand rehabilitation service delivery impacts the already strained South African healthcare system, where individuals may return to hospitals or clinics with associated complications leading to time off from work and thus negative socioeconomic consequences (Poolman et al, 2005). Second to fifth metacarpal fractures are generally sustained as a result of motor vehicle accidents, trauma and violence, and in most cases, where the hand makes contact with an object. A fracture of the neck of the fifth metacarpal is one of the most frequent of the hand injuries to be sustained. The problem is that there are no guidelines and best-evidence information available to guide clinical practice which leaves a gap in the knowledge base in this respect. The result is that owing to the individual's hand not being optimally managed, there would then be a possible delay in returning to work, and more seriously, disability and dysfunction.

Three research phases were undertaken to achieve the aim of developing a clinical hand rehabilitation guideline for adults, male and female, between the ages of 20 and 59 years, after conservative and surgical management following a single or multiple second to fifth metacarpal fractures. The first phase included a systematic review according to Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) principles. The second phase involved a two-staged feasibility study and a cross-sectional study, and included healthy adult participants who met the inclusion criteria. The participants donned two gloves with force sensing resistors (FSR) attached with glue to the finger pads which allowed the finger and grasp forces to be measured. The basic and instrumental activities of daily living (ADL) were performed in a laboratory. The FSR testing phase allowed for the inclusion of grasp types in the guideline, as well as the

categorisation of ADL tasks into light, moderate and heavy task categories. The categorisation of ADL tasks allowed the clinicians to give advice, according to the timelines for bone healing, about returning to pre-injury tasks. The third phase involved an eDelphi method, with consideration being given to the Conducting and Reporting of DElphi Studies (CREDES), with recommendations included. In this case, the experts participated in a three-round eDelphi method to reach consensus and to further develop and finalise the clinical hand rehabilitation guideline. The guideline methodology was developed using the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument.

After three phases of the study, with the final phase being the eDelphi method, expert consensus was reached on 32 recommendations. A hand rehabilitation guideline consisting of the 32 recommendations was developed by the researcher to inform this research's clinical guideline which is presented in the format of the European Society of Cardiology (ESC).

Keywords

Second to fifth metacarpal fractures; activities of daily living; force sensor resistor; clinical guidelines; hand rehabilitation; grasps; South Africa

Clarification of key concepts

Activities of daily living

Activities of daily living are routine and essential tasks that healthy individuals perform without assistance from others (Edemekong et al, 2022).

Boxer's fracture

A Boxer's fracture is a fracture of the distal metaphysis/neck of the fifth metacarpal (van Aaken et al, 2016).

Disability

Restrictions or limitations in hearing, visual or physical denote the term, “disability”, or to refer to a person as one with a disability. The term, “disability”, includes the negative aspects relating to the interactions between the individual and the health condition experienced, that person’s environment and his/her personal context, these all preventing the person from participating freely and without hindrance in a broad range of activities and occupations and in society (World Health Organisation, 2011).

Revised Faces Pain Scale

This instrument is an outcome measure, with high validity, that subjectively assesses the intensity of pain experienced by an individual (Ferreira-Valente et al, 2011). Six faces represent the severity of pain, each with a different expression, ranging from a smiling face with a zero score, to a distorted face on the other end of the scale representing excruciating pain, and with a score of 10. According to the faces, pain increases in increments of two points, with the emotions depicted on the face increasing in association with the level of discomfort. This measure of pain intensity

was developed with the intent to assist numerically illiterate individuals in rating their pain experience.

Functioning

This is a term used to group the body functions, body structures and participation in tasks unique to an individual (World Health Organisation, 2008).

Grasp

The human hand grasp includes every static posture of the hand with which an object is securely held by one dominant or non-dominant hand, irrespective of the orientation of the hand (Feix et al, 2016).

Clinical Practice Guideline

These are “formalised” statements that include recommendations intended to create best practices and optimise patient care.” (American Academy of Audiology, 2021)

Health-related quality of life

This is a multidimensional concept that relates to the quality of life relative to the health status and diseases experienced by an individual (Bakas et al, 2012).

Second to fifth metacarpal fractures

For this research, second to fifth metacarpal fractures are defined as single or multiple fractures of the second, third, fourth and fifth metacarpals of the hand. Fracture levels include the distal

metaphysis, the proximal metaphysis, or the epiphysis of the metacarpal bone, with a transverse, oblique, comminuted, or spiral fracture pattern.

Operational definitions

Clinical hand rehabilitation guideline

In South Africa, hand rehabilitation, as described below, is performed by physiotherapists (PT) or occupational therapists (OT) in the public or private sectors, either on in-patients or outpatients. Not all hospitals, primary healthcare clinics, private practices, hospitals or community centres have PTs or OTs to provide hand rehabilitation, leaving individuals who sustained hand injuries without health education and hand therapy. The clinical hand rehabilitation guideline offers a possible treatment map for a carefully-selected individual who sustained second to fifth metacarpal fractures, but who sustained no associated injuries to the blood vessels (vascular), nerves (neurological), tendons, or extensive injury to the soft tissue, and who sustained no other fracture types, including crush-type metacarpal fractures and their associated injuries, and no infection. The guideline should be used as a possible treatment map, and not as a directive for patients or a "one-size fits-all" recipe. In fact, a careful and thorough assessment of the hand by the clinician should guide the appropriate management of each individual patient. Subsequent to the assessment, clinical reasoning should be the process that guides the clinician towards the best management of each patient sustaining second to fifth metacarpal fractures. Clinical reasoning should always be the decisive guide to the most appropriate management. In addition, the fracture type and the associated injuries, as stated above, as well as the International Classification of Functioning, Disability and Health (ICF) factors such as the health condition, other comorbid conditions (diabetes mellitus type I and type II, and osteoporosis), impairments, and environmental, as well as other personal factors unique to each injured individual (e.g. adherence to prescriptions and medical instructions, smoking status, and patient expectations). However, as mentioned above, the clinician using this hand rehabilitation guideline should be aware that it was not developed for second to fifth metacarpal fractures with associated injuries, as mentioned above. The premorbid conditions include, but are not limited to hormonal changes, age and renal failure (Wollstein et al, 2020). The clinician's understanding of and the adherence

of the patient to the prescribed medical and pharmaceutical interventions should further guide the management of the patient. How the clinician chooses to apply the clinical hand rehabilitation guideline would depend on the availability of resources and also on his/her critical decision-making. Operational definitions, as in the case of this clinical hand rehabilitation guideline, are the essence of this thesis and of the research phases. As such, no references are provided.

Fully functional hand

For this research study, a fully functional hand is defined as a pain-free hand, including the forearm region, and as measured on the visual analogue scale (VAS) (Delgado et al, 2018) or the revised FACES pain scale (Ferreira-Valente et al, 2011). For this study, the VAS was used in the "Grasps free Active no resistance allowed after injury" (Refer to Table 5.4 in Chapter 5). For completeness and because of literacy challenges in South Africa, the FACES scale is often used in patients in public sectors/settings and therefore was added as an additional option.

As measured with a Jamar dynamometer, and in cases where the dominant hand has sustained an injury, a fully functional hand has an average grip strength that is three kilograms (kg) greater than that of the uninjured hand. In cases where the non-dominant hand has sustained an injury, a fully functional hand has an average grip strength of less than three kg compared to that of an uninjured hand. Normative grip strength measurements per gender and age group have also been determined (Innes, 1999). As measured with a finger goniometer and compared to the fingers of the uninjured hand with a 270° range of motion (ROM) per finger as described by Kiral et al (2014), all fingers of the injured hand have the same digital ROM. As measured with the 2.83 size (0.07grams) Semmes and Weinstein monofilament (Bell Krotoski, 2011), and as compared to the uninjured hand, the sensation of the injured hand is intact on the dorsal and volar/palmar aspects.

A fully functional hand will not only be declared when the individual complies with the above-mentioned outcomes, but the individual must also be able to perform his/her daily tasks without

pain and to obtain a score of 0 or below 5 on the Disability of the Arm, Shoulder and Hand (DASH) (Hudak et al, 1996) or Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) (Beaton et al, 2005) standardised measurement tools which equates to little or no disability. The researcher acknowledges that the DASH is biased towards the dominant hand and may not highlight the functional implications when the injury is on the non-dominant hand. Having said this, the DASH still remains a comprehensive measurement tool to assess physical function of the upper limb and symptoms over time.

Hand rehabilitation

In the context of this study, hand rehabilitation refers to the restoration of an individual's hand to its normal, near-normal pre-injury ability following therapeutic interventions such as splinting, oedema management, improving joint ROM by means of therapeutic interventions, muscle-strengthening exercises, muscle stretches, scar/wound management, home education/advice, participating in a home exercise (HE) programme, and addressing functional and occupational demands.

Hand rehabilitation team

A hand rehabilitation team consists of a multidisciplinary team, including orthopaedic surgeons, orthopaedic surgeons specialising in hand injuries, general practitioners, orthotists, PTs, and OTs, all of whom are required to perform the interventions mentioned above for which they are best trained.

TABLE OF CONTENTS **Page**

Declaration…… **i**

Dedication.…… **ii**

Acknowledgements …… **iii**

Summary…… **iv**

Clarification of key concepts…… **vi**

Operational definitions…… **ix**

List of Abbreviations…… **xix**

List of Figures…… **xxi**

List of Tables…… **xxii**

List of Images…… **xxiv**

List of Addenda…… **xxv**

Table of Contents…… **xii**

Chapter 1 Introduction and background……1

1.1 Introduction…… 1

1.2 Background…… 1

1.3 Extent and nature of the problem…… 2

1.4 Management of second to fifth metacarpal fractures…… 4

1.5 International Classification of Functioning, Disability and Health…… 5

1.6 Problem statement…… 6

1.7 Research question…… 6

1.8 Aim of the thesis..... 7

1.9 Objectives of the thesis..... 8

1.9.1 Objectives: Phase I.....8

1.9.2 Objectives: Phase II.....8

1.9.3 Objectives: Phase III.....9

1.10 Ontology and theoretical framework.....9

1.11 Significance of the study.....10

1.12 Justification for the choice of a research setting and study sample.....12

1.13 Outline of the thesis..... 14

1.14 Summary..... 15

Chapter 2 Literature review.....16

2.1 Introduction..... 16

2.2 Hand function..... 17

2.3 Metacarpal anatomy and osteokinematics..... 17

2.4 Bone healing and forces.....19

2.5 Surgical management types..... 23

2.6 Surgical management outcomes.....24

2.7 Hand rehabilitation..... 27

2.8 International Classification of Functioning, Disability and Health Framework..... 29

2.9 Grasps and pinches included in the functional hand repertoire model.....32

2.10 Hand grasps.....33

2.11 Scientific testing of grasp tasks with force sensing resistors.....35

2.12 Calibration of testing equipment.....36

2.13 Sound rehabilitation principles..... 38

2.14 Motor learning principles…… 39
2.14.1 Adam's closed loop theory……41
2.14.2 Schmidt's schema theory……41
2.14.3 Newell's ecological theory……42
2.15 Adult learning theories and principles…….. 44
2.15.1 Instrumental learning theory…… 45
2.15.2 Transformative learning theory……45
2.15.3 Constructivism theory……46
2.16 Summary…… 46

Chapter 3 Methodology……47
3.1 Introduction…… 47
3.2 Overall study design……47
3.3 Phases and methods…… 47
3.3.1 Phase I: Systematic review…… 47
3.3.1.1 Methods and design…… 48
3.3.1.2 Participants/Population……48
3.3.1.3 Methodological quality appraisal of included studies……48
3.3.1.4 Dealing with missing data……49
3.3.1.5 Measuring the strength of the body of evidence…… 49
3.3.2 Phase II: Development of clinical hand rehabilitation guidelines for second to fifth metacarpal fractures with force sensing resistor testing……50
3.3.2.1 Methods…… 50
3.3.2.1.1 Design…… 50

3.3.2.1.2 Setting…… 50

3.3.2.1.3 Population……51

3.3.2.1.4 Sampling…… 51

3.3.2.1.5 Data collection tools……52

i) Self-administered questionnaire……52

ii) Jamar hydraulic dynamometer…… 52

3.3.2.1.6 Pilot testing…….. 53

3.3.2.1.7 Validity and reliability……54

3.3.2.1.8 Data analysis……55

3.3.3 Phase III: eDelphi method to develop and finalise the clinical hand rehabilitation guidelines……56

3.3.3.1 eDelphi method……57

3.3.3.2 Participants on the eDelphi panel…….. 57

3.4 Dissemination……..58

3.5 Summary……58

Chapter 4: Phase I

Hand rehabilitation programmes for second to fifth metacarpal fractures: a systematic review……59

4.1 Introduction……59

4.2 Journal details……60

4.3 Permissions and rights……61

4.4 Article Phase I: Primary Objective……61

Splints and immobilisation approaches used for second to fifth metacarpal fractures: a systematic review……71

4.5 Introduction……71

4.6 Journal details……71

4.7 Permissions and rights……71

4.8 Article Phase I: Secondary Objective……72

4.9 Discussion……94

4.10 Summary……95

Chapter 5: Phase II

Evaluation of finger forces and grasp types for 105 functional activities of daily living tasks measured with force sensing resistors: feasibility study……96

5.1 Introduction……96

5.2 Publication details……98

5.3 Journal details……98

5.4 Permissions and rights……98

5.5 Article……99

5.6 Second article Phase II……131

Hand grasp forces during activities of daily living tasks

5.7 Introduction……131

5.8 Journal details……131

5.9 Permissions and rights……132

5.10 Article Phase II: Secondary Objective……132

5.11 Discussion……158

5.12 Summary……159

Chapter 6: Phase III

Development of a clinical hand rehabilitation guideline for second to fifth metacarpal fracture rehabilitation: an eDelphi method……160

6.1 Introduction ……160

6.2 Journal details……160

6.3 Permissions and rights……161

6.4 Article: Phase III……161

6.5 Summary……186

Chapter 7 Clinical hand rehabilitation guideline for individuals who sustained second to fifth metacarpal fractures……187

7.1 Introduction ……187

7.2 Journal details……187

7.3 Permissions and rights……188

7.4 Article……188

7.5 Summary……220

Chapter 8 Limitations, recommendations and conclusion……221

8.1 Introduction……221

8.2 Limitations and challenges……221

8.3 Clinical recommendations……223

8.4 Research recommendations ……235

8.5 Policy recommendations……237

8.6 Conclusion……238

9. References……230

Addenda……250

List of Abbreviations

ADL	Activities of daily living
AGREE II	Appraisal of Guidelines for Research and Evaluation II
CREDES	Conducting and Reporting of DElphi Studies
DASH	Disability of the Arm, Shoulder and Hand
ESC	European Society of Cardiology
EQ-5D-5L	EuroQol - five dimensions - five levels
FITT	Frequency, intensity, type and time
FSR	Force sensing resistor/s
HE	Home exercises
HRQoL	Health-related Quality of Life
HSREC	Health Sciences Research Ethics Committee
ICF	International Classification of Functioning, Disability and Health
ICIDH	International Classification of Impairments, Disabilities and Handicaps
IPJ	Interphalangeal joint/s
IR	Incidence rate
IQR	Interquartile range
JBI	Joanna Briggs Institute
Kg	Kilograms
Kohms	Kelvin-ohms
K-wire/s	Kirshner wire/s

MCPJ	Metacarpophalangeal joint/s
NHI	National Health Insurance
N	Newton
OT	Occupational therapy/Occupational therapist
OTs	Occupational therapists
PT	Physiotherapy/Physiotherapist
PTs	Physiotherapists
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analysis
QuickDASH	Quick Disabilities of the Arm, Shoulder and Hand questionnaire
RCT	Randomised control trial
REDCap	Research Electronic Data Capture
ROM	Range of motion
TAM	Total active motion
VAS	Visual analogue scale
V/s	Voltage/s
WHO	World Health Organisation

List of Figures

Figure 1.1: Outline of the thesis

Figure 3.1: PRISMA flow diagram

Figure 4.1: PRISMA flow diagram for the first systematic review

Figure 4.2: PRISMA flow diagram for the second systematic review

Figure 5.1: Calibration voltage results with mass grams

Figure 5.2: Calibration voltage results with Newton forces

Figure 5.3: The GRASP taxonomy of human grasp types

Figure 5.4: Voltage-*versus*-force calibration graph

Figure 5.5: Text file: squeezing water out of a sponge

Figure 6.1 eDelphi process flow chart

Figure 7.1: Clinical hand rehabilitation guideline: development components

Figure 8.1: Three research phases informing the clinical hand rehabilitation guideline

List of Tables

Table 3.1: Statistical tests per outcome measure and data types

Table 4.1 Publication specifics

Table 4.2: Database search keywords

Table 4.3: Databases searched and results

Table 4.4: Appendix 1: Table 1-A1: Summary of findings

Table 4.5: Appendix 2: Table1-A2: Reasons for exclusion

Table 4.6 Publication specifics

Table 4.7: Search strategy keywords

Table 4.8: Database search results

Table 4.9 Summary of findings: Supplementary Table

Table 5.1 Publication specifics

Table 5.2: Demographic data of the participants (n=6)

Table 5.3: Grip strength measurements in kilograms of the participant's right (R) and left (L) hands (n=6)

Table 5.4: Average maximum finger forces in Newton per task category for all participants (n=6)

Table 5.5: Average maximum finger forces in Newton per task category for males (n=3)

Table 5.6: Average maximum finger forces in Newton per task category for females (n=3)

Table 5.7: Predominant grasp types and number of occurrences

Table 5.8 Supplementary Table: Tasks, grasp types, categorisation, maximum Newton forces per finger and gender t-test results

Table 5.9: Publication specifics

Table 5.10: Demographics for occupation and level of education

Table 5.11: Statistically significant differences between genders according to the GRASP taxonomy and activities.

Table 5.12 Supplementary Table 1: Grasp types, maximums, means, standard deviations in Newton and t-test results

Table 6.1: Publication specifics

Table 6.2: Inclusion criteria for expert selection

Table 6.3: Demographic details of the participating experts (n=14)

Table 7.1: Publication specifics

Table 7.2: Levels of evidence

Table 7.3: Classes of recommendation

Table 8.1: Clinical hand rehabilitation guideline statements during the research phase informing the clinical hand rehabilitation guideline development

List of Images

Image 2.1: Force sensing resistor

Image 5.1: Arduino and equipment setup

Image 5.2: Testing equipment and gloves

List of Addenda

Addendum A	The GRASP taxonomy	264
Addendum B	Test sheet with predominant grasp types and results	265
Addendum C	Permission obtained for use by Thomas Feix	274
Addendum D	PRISMA-P checklist	275
Addendum E	Data extraction instrument	282
Addendum F	Joanna Briggs Institute critical appraisal checklist for cohort studies	287
Addendum G	Joanna Briggs Institute critical appraisal checklist for cohort studies	288
Addendum H	Joanna Briggs Institute critical appraisal checklist for randomised controlled trials	289
Addendum I	Ethical clearance certificate Phase 1	290
Addendum J	Permission obtained from the owner of the laboratory for data collection	291
Addendum K	English self-administered questionnaire	298
Addendum L	IsiZulu self-administered questionnaire	301
Addendum M	English informed-consent document	304
Addendum N	IsiZulu informed-consent document	309
Addendum O	English Covid-19 screening tool	314
Addendum P	IsiZulu Covid-19 screening tool	315
Addendum Q	Grasp types tested per type and per category	316
Addendum R	Ethical clearance certificate Phase II	319

Addendum S	REDCap questionnaire: Round 1	320
Addendum T	REDCap questionnaire: Round 2	346
Addendum U	REDCap questionnaire: Round 3	372
Addendum V	Ethical clearance certificate for Phase III eDelphi Method	392
Addendum W	Author guidelines: South African Journal of Physiotherapy	394
Addendum X	South African Journal of Physiotherapy editor permission	415
Addendum Y	South African Journal of Orthopaedics editor permission	416
Addendum Z	Author guidelines: South African Journal of Orthopaedics	417
Addendum AII	Author guidelines: Occupational Health South Africa	441
Addendum BII	Author guidelines: South African Journal of Occupational Therapy	457
Addendum CII	Grasps free active no resistance allowed after injury	478
Addendum DII	Author guidelines: Hand Therapy	479
Addendum EII	REDCap questionnaire round one expert feedback	500
Addendum FII	REDCap questionnaire round two expert feedback	505
Addendum GII	REDCap questionnaire round three expert feedback	513
Addendum HII	Recommendations for the Conducting and Reporting of Delphi Studies	534
Addendum III	Author guidelines: Hand	537
Addendum JII	AGREE II reporting checklist	563
Addendum KII	American Society of Hand Therapists magazine article	572
Addendum LII	Language editor declaration	576

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

In this chapter, the reader is presented with the background to the research study, a short description of the management of second to fifth metacarpal fractures, and the extent and nature of the problem. The International Classification of Functioning, Disability and Health (ICF) framework and the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument used as the baselines from which to develop the proposed clinical hand rehabilitation guideline are briefly introduced. Thereafter, particular aspects of the study, such as the research question, the aim and objectives of the research, its ontology, theoretical framework, problem statement, and significance are presented. The justification for the choice of the research setting and the study sample follows, with the outline of the thesis and a summary presented in the conclusion.

1.2 Background

The human hand is the body part most frequently used during activities of daily living (ADL) (Reissner et al, 2019). Human beings interact with the environment by manipulating the world around them (Riddle et al, 2020). When the hand is injured, as in the case of a hand fracture, it impacts the individual and society negatively. The impact of hand fractures on the individual and society could involve a lack of hand function (Anakwe et al, 2011), lost days of work, economic loss, and additional costs in respect of productivity (De Putter et al, 2016). Robinson et al (2016) further agreed from conducting a systematic review that acute injuries to the hand and wrist cause a substantial burden to the individual and society. Twenty-one articles, 12 of which were related to cost-of-illness evaluations and seven to health economy evaluations were included in their systematic review. According to Robinson et al (2016), a total median cost per patient for all types of injuries amounted to US$6951 (interquartile range (IQR) $3357-$22.274) and US$8297 (IQR $3858-$33.939) for cost-of-illness and health economy evaluations, respectively.

Hand fractures are among the most common fractures suffered by adults (Taha et al, 2020; Bucholz, 2009), and 10% of all bone injuries are metacarpal fractures (Karl et al, 2015).

1.3 Extent and nature of the problem

Nakashian et al (2012) found that metacarpal fractures account for 33% of all hand fractures. In the United States of America, the incidence rate (IR) for sustaining metacarpal fractures was 13.6 per 100 000 persons per year (Nakashian et al, 2012), while in a Norwegian population, fifth metacarpal fractures accounted for 18.4% of all hand fractures (Gudmundsen & Borgen, 2009) Furthermore, metacarpal and phalangeal fractures accounted for 10% to 20% of all skeletal fractures. In some instances, individuals fully heal after sustaining metacarpal fractures without long-term functional impairments. In other individuals significant disability may be seen when hand fractures are viewed as a minor injury and not managed correctly (Kamath et al, 2011). When considering the interquartile range (IR) per gender and age, Nakashian et al (2012) stated that in the United States of America, the highest IR for metacarpal fractures occurred among males (IR 28.4) as compared to females (IR 4.4), with the age group 10-to-19 years displaying the highest IR, followed by the 20-to-29-year age group, with seemingly very few individuals sustaining metacarpal fractures after 59 years of age (Nakashian et al, 2012). Even though the 10 to 19 year olds presented with the highest IR in the afore-mentioned study (Nakashian et al (2012), this age group was not included in the current study, the reason being skeletal immaturity among a paediatric population. Mahery (2009) defines a paediatric population under the age of 18, where the clinical hand rehabilitation guideline developed in this research is specifically for the adult population, individuals aged from 20 years to 59 years, who uses their hands for a wider set of basic and instrumental everyday tasks. The researcher specifically wanted to develop a clinical rehabilitation guideline for the adult population with skeletal maturity. Skeletal maturity may be prolonged after the age of 18 years, especially in males and less in females (Eveleth and Tanner, 1990). Eveleth and Tanner (1990) state, “In all populations, girls are more skeletally

mature than boys from birth onwards and reach adult bone maturity, on average, two years earlier than boys (1.9 years here)."

There is a scarcity of data regarding the incidence of metacarpal fractures in Africa, and more specifically in South Africa. In the South African peri-urban (township) community of Soweto, hand fractures are the second-highest hand condition rehabilitated at the Chris Hani Baragwanath Academic Hospital Hand Unit, according to data compiled by the physiotherapy (PT) Department between 2016 and 2017 and to the author's personal experience.

The factor resulting in a metacarpal fracture would generally relate to an acute situation where the hand makes contact with a wall or door, which would generally occur during a punch (Nakashian et al, 2012), and often as a result of violence and trauma. Violence and trauma are among the leading causes of injury in South Africa and feature among the quadruple burden of diseases that the South African government wishes to address with its proposed National Health Insurance (NHI) legislation (Coovadia et al, 2009). The proposed NHI necessitates evidence-based research to be conducted in the Health Sciences to provide the most effective healthcare for improving patient outcomes. The reason why evidence-based research is important in guiding clinical practice is to optimally use the finite health resources (Hoffmann et al, 2010) pertinent to the South African public health sector, where resources are limited. Furthermore, conducting research to develop an evidence-based clinical hand rehabilitation guideline makes this research relevant and informative towards guiding the rehabilitation of individuals who sustain second to fifth metacarpal fractures. The problem in South Africa, and also globally, is that rehabilitation for individuals sustaining second to fifth metacarpal fractures lacks scientific evidence to guide the clinical practice of physiotherapists (PTs) and occupational therapists (OTs), to safely enable individuals to return to their pre-injury functional activities and renew their community participation.

Anakwe et al (2011) investigated the relationship between hand fractures and epidemiology in a socially deprived population and found that a fracture of the neck of the fifth metacarpal, also known as a Boxer's fracture, accounted for 27% of total hand fractures, and was significantly associated (p=0.017) with socially deprived men. The situation of being a member of a socially deprived community further influences the pattern and the management of the fractures, as affluent individuals generally receive surgical treatment more frequently than socially deprived individuals (Anakwe et al, 2011). Boxer's fractures have left individuals with functional deficits, and the concern following these residual deficits is that they most frequently affect the young and working adult population (Ali et al, 1999). These deficits include weakened grip strength and decreased metacarpophalangeal joint (MCPJ) range of motion (ROM). With a decline in the functioning of the hand, the ability to earn a living and increased days off from work lead to both employees and employers facing economic consequences, which is a matter of concern (Cooper & Wietlisbach, 2014).

1.4 Management of second to fifth metacarpal fractures

The management of individuals following second to fifth metacarpal fractures is determined by considering the type of fracture, the finger, the region where the injury took place, the level of displacement, angulation, and rotation of the metacarpal, as well as the available surgical instrumentation, and the expertise of the surgeon. Furthermore, the unique fracture configuration determines its management. Dependent on the location and stability of the fracture, a decision is made by the orthopaedic surgeon or plastic surgeons as whether to adopt surgical or non-surgical management (Toemen & Midgley, 2010). Such an intervention is chosen to ensure the stability of the fracture, the comfort of the patient, the earliest possible commencement of joint movement, and the appropriate time for the patient to return to normal functioning and work. Ultimately, all of the injured structures would need to be assessed. Thus, the treatment of second to fifth metacarpal fractures needs to balance the potential risks of non-

union or malunion fracture, necrosis of the skin, and rotation and angulation displacement of the fracture (Toemen & Midgley, 2010). Most metacarpal fractures are simple, closed, isolated, and stable injuries, not requiring surgical intervention, and with very good outcomes. As such, there is a paucity of literature and controversy as to the best management for metacarpal fractures (Kollitz et al, 2014). No clinical guidelines, neither locally nor globally, exist for guiding the rehabilitation of individuals following second to fifth metacarpal fractures.

1.5 International Classification of Functioning, Disability and Health

The ICF is a classification of health and health-related domains describing an individual's disability or functioning within a context and also includes environmental factors (World Health Organisation, 2001). The ICF was officially endorsed by all World Health Organisation Member States on 22 May 2002 as the gold standard to describe and measure disability and health, both on the individual and population levels (World Health Organisation, 2001). Injuries to the hand can leave South Africans without a dominant or non-dominant hand to earn a living (Mennen & Van Velze, 2008). The consequences of not being able to earn a living are placing an extra burden on society in that they are contributing to intensifying the burden of poverty in South Africa. A fully functional hand should be the primary outcome after rehabilitation to ensure the earliest return to functioning and work. Therefore, a successful clinical hand rehabilitation guideline should comprehensively attain all three ICF areas, set out by the World Health Organisation (WHO), namely, body function and structure, activity limitations, and participation restrictions. Contextual factors include environmental and personal factors, which may influence how the individual functions (World Health Organisation, 2001) should also be considered. To this end, the ICF framework is fundamental to this research and key considerations about the ICF are elaborated upon in Chapter 2.

1.6 Problem statement

No clinical hand rehabilitation guideline based on scientific best-evidence information exists to inform clinical practice in South Africa in respect of single or multiple second to fifth metacarpal fractures that might lead to potential disability. There is also a lack of scientific evidence on the progressive return to daily functional tasks after surgical and conservative management for individuals with second to fifth metacarpal fractures. Hand rehabilitation for second to fifth metacarpal fractures after surgical or conservative management without a best practice evidence-based clinical guideline may potentially lead to complications, such as ongoing pain, long-term disability, and decreased hand function. This may not only affect the individual, but also negatively impacts the family and community in terms of loss of income and participation by the individual. The absence of a clinical hand rehabilitation guideline may affects the individual in respect of the body functioning and impairment domains of the ICF framework, where symptoms of pain, decreased ROM, muscle weakness, decreased sensation, and oedema may persist after second to fifth metacarpal fractures. Differences in current rehabilitation utilised by clinicians may influence the ICF domains. Body functioning and impairments may limit the functioning of the hand in basic and instrumental daily activities which would in turn negatively impact the individual's ability to participate in meaningful activities and occupations and thus reduce his/her health-related quality of life (HRQoL).

1.7 Research question

The primary research question posed was: What should be included as recommendations for the development of a clinical hand rehabilitation guideline for the management of male and female adults in the South African population aged 20 to 59 years who have sustained single or multiple second to fifth metacarpal fractures?

Three phases were necessary to develop the clinical hand rehabilitation guideline, each phase presenting its own research question.

The first phase consisted of two systematic reviews, with the research question as follows: What is the evidence base for hand rehabilitation programmes, (including splinting and immobilisation approaches), on hand function, HRQoL, disability and other outcomes, after post-surgical and conservative management for individuals between the ages of 20 and 59 years who sustained a single or multiple second to fifth metacarpal fractures?

The second phase, the scientific testing phase, involved the application of force sensing resistors (FSRs) to all ten fingers of the research participant while he/she performed basic and instrumental daily tasks, sought an answer to the following: Can the functional task forces exerted by the human hand be determined by using FSRs in terms of grasps on the objects manipulated during basic and instrumental daily functional tasks among purposively sampled healthy human adults aged between 20 and 59 years be determined by using FSR's?

The third phase involved an eDelphi method to inform, adapt, and finalise the clinical hand rehabilitation guideline. The research question posed was as follows: What should the information, content, and format of the clinical hand rehabilitation guideline be that would need to be included in a clinical hand rehabilitation guideline for managing second to fifth metacarpal fractures?

1.8 Aim of the thesis

The aim of the research study was to develop a clinical hand rehabilitation guideline for male and female individuals in the South African population aged between 20 and 59 years, who, after sustaining a single or multiple second to fifth metacarpal fractures, received surgical or conservative management.

1.9 Objectives of the thesis

The objectives of the study per phase included the following:

1.9.1 Objectives: Phase I

Determine the content of hand rehabilitation programmes used after post-surgical and conservative management after second to fifth metacarpal fractures by means of a systematic review.

The primary objective of the systematic review was:

- to determine the hand rehabilitation programmes used and outcomes attained after post-surgical and conservative management for persons aged 20 to 59 years who had sustained a single or multiple second to fifth metacarpal fractures.

The secondary objectives of the systematic review included the following:

- to determine the home education and the resultant outcomes for post-surgical and conservative management.

- to determine the immobilisation, the splints used, and the resultant outcomes for post-surgical and conservative management.

- To determine the timelines for the commencement and progression of hand rehabilitation.

1.9.2 Objectives: Phase II

In order to develop a clinical hand rehabilitation guideline, it was necessary:

- to determine, with the aid of FSRs, the functional task forces exerted by the human hand in terms of grasps on objects manipulated during basic and instrumental daily functional tasks among purposively sampled healthy human adults between the ages of 20 and 59 years.

- to determine an association between mean forces, gender and grip strength in purposively sampled healthy human adults between the ages of 20 and 59 years.

1.9.3 Objectives: Phase III

The final objectives of the study were:

- to determine, with the aid of a Research Electronic Data Capture (REDcap) questionnaire, consensus among purposively sampled expert surgeons, PTs, and OTs in the field of hand injuries, hand surgery, and hand rehabilitation and to investigate their consensus on the developed clinical hand rehabilitation guideline.

- to adapt and finalise the clinical hand rehabilitation guideline based on the information obtained from the expert panel members in terms of the eDelphi method.

1.10 Ontology and theoretical framework

Scientific research is guided by research paradigms, where assumptions and principles are stated by researchers in their research designs. From the research proposal phase to the data collection and the presentation of results phases, paradigms provide the recipients of the research with clarity on the researcher's view on reality and how the research question, methods, and methodologies were created and selected. The theoretical framework for this research is based

on motor learning, as elaborated under section 2.14 in Chapter 2, and backed by the previously stated problem in section 1.6 and the clearly reported objectives, problem statement, and research question, as presented in section 1.9, backed by a robust literature review in Chapter 2 and 4. A positivist paradigm aligns with this research where reality is known and can be measured and proven with empirical evidence. According to Park et al (2020) "positivism is aligned with the hypothetico-deductive model of science that builds on verifying an *a priori* hypothesis and experimentation by operationalising variables and measures; results from hypothesis testing are used to inform and advance science"(Park et al, 2020). An objectivist ontology underpinned this research with the assumption that reality can be measured and observed. The reality can further be quantified, as in the case of the forces measurements with FSRs, and statistical analysis utilised.

In developing a clinical hand rehabilitation guideline, the researcher followed the systematic review, Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines in Phase I, with predetermined research questions and selection criteria to determine the best-available evidence. During Phase II, the researcher measured the individual finger forces of participants in a feasibility study and a cross-sectional data collection study that holds true to the positivism paradigm of experimentation to answer the research question. In Phase III, the eDelphi method, which is presented in Chapter 5, incorporates the views and unique experiences of expert participants in the area of hand injury rehabilitation to thus inform the development of the clinical hand rehabilitation guideline for second to fifth metacarpal fractures. The discovered evidence obtained guided the researcher to identify the items included in the final clinical hand rehabilitation guideline.

1.11 Significance of the study

A transformation in the healthcare system, particularly in South Africa, is called for in order to change how healthcare is organised and financed (Michel et al, 2020). The developed clinical

hand rehabilitation guideline answers this call by providing a cost-effective, time-saving, transformative and rehabilitative approach by promoting early optimal hand function - as discussed in the paragraphs below. The clinical hand rehabilitation guideline includes a graded scientific and objective approach to progression, according to the grasps of a fully functional hand, and may not only improve hand function and the HRQoL of the individual, but also prevent disability. In countries such as South Africa, and other countries in Africa with limited resources, a lack of interest amongst physiotherapists in the area of hand therapy/rehabilitation is seen due to the lack of research. Hand rehabilitation is performed in various clinical settings in South Africa by PTs or OTs but unfortunately not all hospitals have community service or qualified PTs or OTs to provide hand rehabilitation in primary healthcare clinics, private practices, hospitals or community centers, leaving individuals who sustained hand injuries without health education and therapy. Developing a clinical hand rehabilitation guideline for a selected group of individuals who sustained second to fifth metacarpal fractures without associated injuries, as mentioned above, provides therapists with a treatment map for the rehabilitation of these individuals. For those individuals, the opportunity to receive rehabilitation services, where light, medium and heavy tasks and grasps can be used as exercises can be specifically beneficial as these exercises can be performed at home. Incorporating various grasp types at specific fracture healing periods may promote function after the splinting and immobilisation period has ended.

The significance of the developed best-evidence scientific clinical hand rehabilitation guideline will potentially serve to save resources, including direct and indirect costs, and medical costs in the public health setting. Direct costs are attributed to directly caring for the patient, whereas indirect costs are the loss in finances for the individual, family, and community due to loss of productivity or cessation of occupation leading to a loss of income. This is especially pertinent in the South African public health setting, where rehabilitation professionals face a heavy workload or where there are shortages in terms of rehabilitation staff. The saving of resources can only be confirmed in the future with an economic evaluation, as was done by Robinson et al (2016) and reported in Chapter 1 of this thesis.

Since the programme could potentially be converted into a home-based health-education programme, resources may thus be saved by the Department of Health and by the individuals who sustained a second to fifth metacarpal fracture. For the individual, lower travel costs to reach the hospital would be incurred, and the Department of Health could potentially save on costs where patients could be attending fewer hand therapy sessions and consultations with orthopaedic surgeons, thus also reducing the workload of the overburdened healthcare workers. The reason for less frequent consultations could be attributed to the fact that the developed clinical hand rehabilitation guideline could potentially promote the development of hand functioning, starting with safe tasks as early as two weeks post-injury.

No evidence of such a scientifically supported and graded clinical hand rehabilitation guideline indicating at which point in time to commence with light, medium and heavy activities could be found in the literature and owing to the force testing performed in this study on a South African population, the results will indeed contribute to new knowledge in the field of hand rehabilitation in South Africa. Globally, the developed clinical guideline adds to the existing body of knowledge on hand rehabilitation for individuals who sustained second to fifth metacarpal fractures in that it provides for evidence-based practice, thus informing rehabilitation internationally. A best-evidence clinical hand rehabilitation guideline may improve individual outcomes, including hand function, ROM, grip strength, and thus reduce the number of days offwork. It may limit disability, including hand function, and improve HRQoL, and even preventing disability for individuals who sustained second to fifth metacarpal fractures.

1.12 Justification for the choice of the research setting and study sample

Kempton Park, together with an informal settlement situated in the eastern portion of Gauteng, South Africa, was the setting for the study. Owing to the study area being in close proximity to the OR Tambo International Airport, the residents and workers in the area represent a wide

variety of cultures, backgrounds and living environments. Living environments include informal settlements to townhouses, flats and stand-alone houses. Amenities such as water and electricity are more conveniently available in townhouses, flats and stand-alone houses than in the informal settlement where water often needs to be collected a distance away from the individual's living area. Carrying water in buckets or containers require different hand function. The impact of carrying buckets or containers with water, on hand function is more than for example opening a tap in the home and pouring only as much water as needed. Furthermore, there is the added attraction of employment in this area where many large transport, import and export companies are based in close proximity to the research setting. The airport and surrounding areas are also renowned for drug trading. The drug trade involves and draws many African country individuals (Grobler, 2020). The drug trade attracts individuals as access to an easy income. As such, both South Africans and other individuals from African countries generally flock as job seekers to the study setting (City of Ekurhuleni Annual Report, 2021).

The diversity of the research setting, the variety of cultures, nationalities and backgrounds of the participants ensured that the results of this study be generalised. The racial proportions in South Africa, which also reflect the variation in the proportions of the respective cultures, are as follows: 81% Black African, 9% Coloured, 8% White, and 2% Indian/Asian (Stats SA, 2019). Gauteng, the province into which the study area falls, hosts the largest percentage, namely 28% (15.2 million) of the South African population (Stats SA, 2019). According to the 2018 Stats Community survey, the language distribution in South Africa indicates that isiZulu is the most frequently spoken language, namely, 25.3% of the total population. IsiZulu has become the African language spoken in Gauteng due to the lure for job-seeking across South Africa. However, English is the most frequently spoken language in the sampled population.

Thus, healthy human adult participants, older than 20 years of age and younger than 59 years of age who could understand and follow English or isiZulu instructions, were included in the sample

group. Owing to skeletal immaturity, participants younger than 20 years were not included in the study (De Sanctis et al, 2014). Furthermore, on account of the statement in the literature that very few individuals sustain metacarpal fractures after the age of 59 years, participants older than 59 years of age were not included in the research sample (Nakashian et al, 2012).

1.13 Outline of the thesis

The thesis consists of eight chapters, with a brief description of each provided below.

Chapter 1 presents a brief outline of the background, the problem statement, the significance of the study, as well as the aim and objectives of the three different phases of the study. Chapter 2, a narrative section, reports on the relevant literature informing the reader of second to fifth metacarpal fractures, the healing process, and surgical management, to name but only a few.

Chapter 3 includes the methods used in the three phases to achieve the aim of developing a set of clinical hand rehabilitation guidelines.

Chapters 4, 5, and 6 include the results of the three phases undertaken to achieve the objectives and are presented in the format of journal articles. Chapter 4 presents systematic reviews in two articles discussing the results emanating from the literature study. Chapter 5 contains two articles with respect to FSR testing, while Chapter 6 contains an article presenting the results of the research that were obtained through the eDelphi method. Chapter 7 includes the presentation of the finalised guideline in the form of an article. Chapter 8 covers the limitations of the research, provides recommendations for the implementation of the clinical guideline, as well as for future research and policies, and ends with a conclusion. It is followed by the thesis references stemming from the chapters where no references are listed, which may include references also available in the result chapters and the Addenda.

Figure 1.1 below provides a visual illustration of the outline of the thesis.

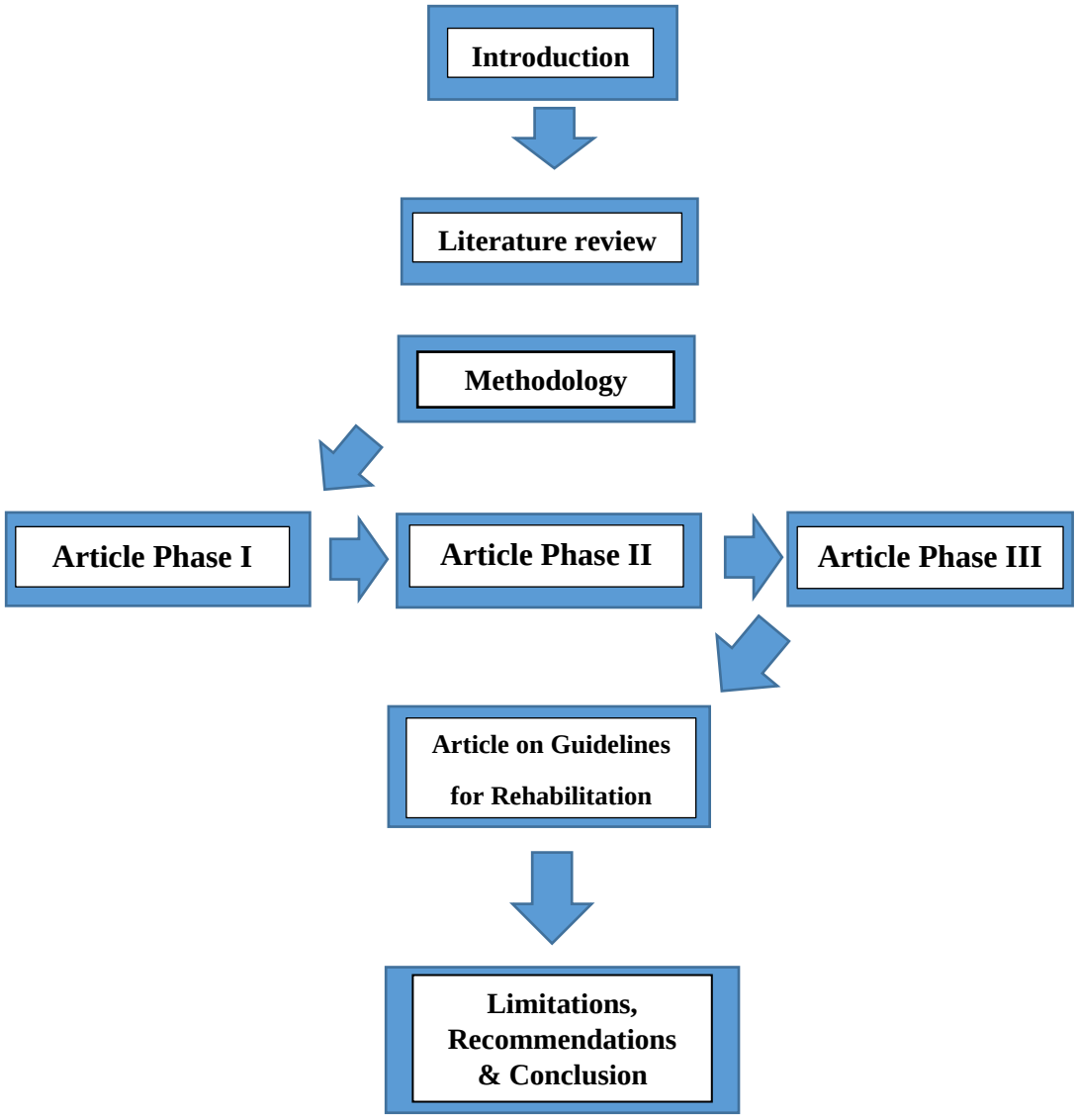

Figure 1.1: Outline of the thesis

1.14 Summary

The introductory chapter outlined the justification for the study, its aim, framework, and significance. The next chapter, Chapter 2, provides a broad literature review on the study topic, namely, the rehabilitation of second to fifth metacarpal fractures.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review chapter presents the relevant background to set the scene for rehabilitation in respect of second to fifth metacarpal fractures, including orthopaedics, bone healing, the International Classification of Functioning, Disability and Health (ICF), hand grasps, sound rehabilitation principles, motor and adult learning principles, and a brief introduction to hand rehabilitation which provides different information from Chapter 4 which includes two systematic reviews presented as peer-reviewed publications. Hand rehabilitation is covered extensively by the researcher in Chapter 4. Chapter 4 thus covers literature pertaining to hand rehabilitation, splinting and immobilisation approaches for second to fifth metacarpal fracture management to achieve the primary and secondary objectives of the study and to inform the clinical hand rehabilitation guideline.

The researcher independently searched Google, Google Scholar and the EBSCO Host databases, namely, Academic Search Ultimate, African-Wide Information, CINAHL, Health Source: Nursing/Academic Edition, Scopus 21, MasterFILE Premier, Medline, SportDiscus, Web of Science Core Collection 21, that are available on LibGuides at the University of the Witwatersrand. Textbooks were also included in the search. With the assistance of an information scientist from the University of the Free State, a more in-depth literature search was conducted, using the keywords: "metacarpal fractures", “second to fifth metacarpal fractures”, “non-thumb metacarpal fractures”, “rehabilitation”, “hand therapy”, “force sensing resistor”, “FSR”, “grasps”, “pinches”, “light function”, “mild/moderate function”, “high/heavy demand/heavy functional”, “functioning”, “tasks”, “activities of daily living”, “ADL”, “hand strength”, and “hand function”.

The main topics dealt with in Chapter 2 are hand function, metacarpal anatomy and osteokinematics, bone healing and forces, types of surgical management, outcomes following surgical management, and hand rehabilitation, the last-mentioned section only briefly discussed. The systematic review chapter (Chapter 4) further discusses and elaborates upon the relevant literature. In this chapter, the ICF, grasps, and pinches are included in the functional hand repertoire model, while hand grasps, the scientific testing of grasping in tasks with FSR, sound rehabilitation principles, motor learning principles, and adult learning theories and principles are discussed. A final summary concludes the chapter.

2.2 Hand function

Hands allow human beings to interact with the environment and world around them and are considered akin to tools that are used to interact mechanically with objects (Riddle et al, 2020). Hand-skill patterns include reach and carry functions, manipulations of the hand, voluntary release, and the bilateral use of hands and grasps. Hand sensation, a highly perceptual tool, gives rise to the perceptual skills that humans are able to exploit in terms of the environment around them (Bassini & Patel, 2007; Cooper & Wietlisbach, 2014). Humans analyse and interpret the various shapes, textures, and sizes of objects around them during their manipulation of them to effectively perform the basic and instrumental activities of daily living (ADLs). For this reason, hands are moulded into very specific grasps to perform basic and instrumental ADLs. The thumb, index, and middle fingers, together known as the radial side of the hand, are considered the skilled or manipulative side of the hand (Cooper & Wietlisbach, 2014). The ring and little fingers, together known as the ulnar side of the hand, are known as the stability side (Cooper & Wietlisbach, 2014; Mennen & Van Velze, 2008).

2.3 Metacarpal anatomy and osteokinematics

Metacarpal bones are deemed essential in ensuring the stability and mobility of the human hand. The anatomy of the metacarpals, its articulations and the surrounding soft tissue are briefly

mentioned (Okafor et al., 2022). The hand's metacarpal bones, together with the surrounding soft tissue, contribute to its intrinsic muscular stability and function (Cooper & Wietlisbach, 2014). Considering osteokinematics, the metacarpal bones are volarly concave, giving the palm its characteristic concave nature. The metacarpal bones connect the carpal wrist bones to the phalangeal bones of the fingers and contribute to two joints in the hand. Firstly, at the carpometacarpal joints, the cuboidal base of the metacarpal articulates with the condyloid-shaped carpal bones. Secondly, at the MCPJ, the head of the metacarpal articulates with the proximal phalanx base. Minimal movement occurs at the second and third carpometacarpal joints, whereas the movement increases at the fourth and fifth carpometacarpal joints. At its base, the MCPJs articulate with one another, with added stability provided by the transverse ligaments and dorsal and volar longitudinal metacarpal ligaments. Distally, from the base, the metacarpal bone narrows where the shaft has three longitudinal surfaces, namely, the volar-ulnar, volar-radial, and dorsal flat surfaces. More distally and into the neck, the shaft becomes wider. The head of the metacarpal articulates with the proximal phalanx by means of a condyloid joint named the MCPJ. Stability at the MCPJ is increased by the deep transversal metacarpal and volar plate ligaments. The muscles close to the metacarpals are the intrinsic muscles, namely, the interossei and the lumbricals. They cross both volarly and dorsally to the metacarpal ligaments, from where they move distally to merge into the dorsal expansion at the dorsal surface of the proximal phalanx. The extrinsic muscles inserting volarly on the second and third metacarpal bases are the *Flexor carpi radialis* muscle and on the fifth metacarpal base, the *Flexor carpi ulnaris* muscle. On the dorsal surfaces of the second metacarpal base is the *Extensor carpi radialis longus* muscle; on the third metacarpal base, the *Extensor carpi radialis brevis* muscle, and on the fifth metacarpal base, the *Extensor carpi ulnaris* muscle (Wong & Higgins, 2017).

After considering the anatomy of the metacarpal bones with their surrounding soft tissue, the literature relating to the forces that act on the bone and bone healing needs to be explored.

2.4 Bone healing and forces

Bone healing is an important clinical decision-making consideration undertaken by the treating orthopaedic and/or plastic surgeon to guide the period of immobilisation before starting with unprotected active movement (Wollstein et al, 2020). Bone healing after a fracture occurs in three phases: the reactive phase, the preparative phase, and the remodeling phase (Nyary & Scamell, 2015). An explanation of the processes which occur during each phase of bone healing is provided below.

The reactive phase, which occurs first, is immediately initiated following the injury and fracture. The reactive phase includes the mechanism of injury causing the fracture, the initial inflammatory phase, and finally, the phase involving the formulation of granulation tissue (Kalfas, 2001). The first visible change observed under an electron microscope in the tissues surrounding the injury site is the presence of blood cells, with constriction of the blood vessels controlling further bleeding in the area (Brighton & Hunt, 1997). Within hours after the injury, a blood clot (haematoma) forms with the assistance of the extravascular blood cells. The extravascular blood cells release cytokines, which in turn increase the permeability of the capillaries. The cells present within the blood clot start to degenerate and cell death occurs in the case of specific cells close to the injury site but outside the haematoma (Brighton & Hunt, 1997).

Fibroblasts survive and undergo replication and therefore increase in number. The fibroblasts are responsible for the formation of granulation tissue, starting with the cells loosely distributed between the cells (Ham & Harris, 1972). By reducing the strain on it, the granulation tissue promotes the healing of the fracture site. The osteoclast cells move into the area and are responsible for removing necrotic tissue and reabsorbing the dead bone ends (Nyary & Scamell, 2015). It is in this phase where the orthopaedic or plastic surgeon makes a decision as to the management of the fracture (Wollstein et al, 2020), based on when clinical healing of the fracture has occurred, clinical stability has been achieved and the joints close to the fracture site could be moved unprotected (Wollstein et al, 2020). Depending on the pattern of the fracture and its severity, the decision made by the expert may result in his/her prescription of conservative or surgical management. Conservative management includes manipulation/reduction and

immobilisation with plaster of paris or splinting. Surgical management is required when the fracture is more seriously displaced, angulated or rotated; or when, along with the fracture, other soft tissue structures have been injured. Surgical management is performed using open reduction and internal fixation (ORIF), with plates and screws, (Gülke et al, 2018) or closed reduction, with the insertion of percutaneous Kirshner wires (K-wires) (Neagu et al, 2018).

The reparative phase follows a few days after the initial inflammatory phase. It includes the formation of cartilage callus and the deposition of lamellar bone (Kalfas, 2001). The periosteal cells then replicate and transform. The periosteal cells directly adjacent to the proximal fracture gap transform into chondroblasts, which then become hyaline cartilage, while the periosteal cells further away from the fracture gap transform into osteoblasts. Both of these lead to the formation of woven bone. The same conversion occurs where the fibroblasts change and the granulation tissue matures into chondroblasts, which in turn change into hyaline cartilage (Brighton & Hunt, 1997). The new tissue on both the proximal and distal regions on both ends of the fracture site grows until union occurs where they touch. This process results in new tissue, called callus (Brighton & Hunt, 1986). As the healing progresses, the gap resulting from the fracture is restored through the occurrence of hyaline cartilage and woven bone, and at this stage, the strength of the bone starts to be restored. According to Brighton & Hunt (1997), because callus is visible on X-rays, gentle active mobilisation can be commenced. Depending on the clinical setting and referral system, the availability of therapists, and whether surgical or conservative management was used, the surgeon then refers the patient to an OT or PT. Historically, the rehabilitation that takes place during this phase to support the healing of the fracture includes light self-care activities, with no heavy lifting activities allowed (Midgley and Toemen, 2011). In the bones of the hand, healing occurs between three to four weeks, and the referral depends on the healing of the fracture site, as observed on the follow-up X-rays. During the healing process, hyaline cartilage and woven bone are replaced by lamellar bone, a stronger bone formation. This process is called endochondral ossification, where, before the appearance of the hyaline cartilage, the woven bone is substituted with lamellar bone (Brighton & Hunt, 1997). As soon as the collagen

matrix of both the woven bone and the hyaline cartilage becomes mineralised, the formation of lamellar bone is initiated. The mineralised matrix incorporates channels containing osteoblasts, as well as micro vessels. The osteoblasts are responsible for the formation of lamellar bone, and this new lamellar bone is called trabecular bone (Brighton & Hunt, 1986). The woven bone and the hyaline cartilage are ultimately entirely replaced by trabecular bone, and at this stage, the strength of the bone is almost completely restored. Increasingly heavier tasks are allowed with increased bone strength. Grip strength testing is allowed between six to seven weeks after the normal anatomical alignment and restoration of the fracture site (Gülke et al., 2018).

To ensure adequate healing of hand fractures, the timelines prescribed by the management principles need to be adhered to (LaStayo et al, 2003). According to LaStayo et al (2003), following closed reduction by means of either conservative management or K-wire fixation, splinting and immobilisation should start immediately with oedema management (not specified). Oedema management following a hand injury is critical and explained below.

Oedema management, and its importance in closed metacarpal shaft fractures is highlighted in the study by McMahon et al (1994), where they used a compression glove and early movement to reduce oedema. The management of oedema after conservative treatment includes early mobilisation to prevent complications arising from the soft tissue structures (Meals & Meals, 2013). The use of ice, periods of rest, and appropriate splinting are indicated for oedema and pain. Poor splinting can lead to complications of stiffness, compartment syndrome and pressure sores (Meals & Meals, 2013). In their systematic review, Miller et al (2017) reviewed the best available literature to determine the effectiveness of management techniques for subacute hand oedema. To highlight the respective successes achieved in managing hand oedema, 16 intervention studies, with sample sizes ranging between eight and 54 individuals, were included. The included studies used a variety of techniques, namely, massage (intermittent and retrograde), kinesiology taping, and strengthening, normal functional use of the hand, elevation,

manual lymph drainage, manual oedema mobilisation, cryotherapy, and high-voltage pulse ultrasound.

Additional techniques that were applied and named in the included articles featured splinting/orthoses and positioning exercises - either active or passive, neuromuscular stimulation, compressive bandaging with Coban, and string wrapping, or the use of compressive devices such as intermittent pneumatic pumps or isotoner gloves. The quality of the evidence stemming from the Level 2b systematic review was low to moderate. In conclusion, Miller et al (2017) found that the conventional treatment techniques of elevation, massage, compression, and exercise are sufficient for treating mild to moderate oedema. Manual oedema mobilisation should be used when excessive oedema is present and as long as the former is not contraindicated.

From five to seven days after reduction, controlled active physiological movement, as well as flexion and extension of unaffected joints, should be commenced, and splints should remain on for four to six weeks.

An X-ray is required between four to six weeks after reduction to determine the level of bone healing before progression is made to control the movement of the affected joint/MCPJ. In a study by LaStayo et al (2003), splints were intermittently continued for protection, including during the night, but were not allowed for 24 hours per day/night. Passive mobilisation was allowed from six to eight weeks and strengthening from eight weeks after reduction, both depending on the level of healing observed from the X-ray in respect of the fracture (LaStayo et al, 2003). For open reduction and immobilisation with plates or screws, initial protection for a five-day period would be advised, with a splint or plaster of paris applied in the case of oedema management. These authors recommended that controlled movement of all joints should start from five to seven days.

However, strengthening exercises should be delayed until eight weeks post-surgery (LaStayo et al, 2003).

Callus formation may only be visible from six weeks. The biomechanical features of callus were investigated by Han et al (2016) through a compression test and measurement of the resultant load-displacement forces of bone callus (Han et al, 2016). In the early stage of callus formation, the calculated load was found to be 30.6 Newton (N) (±11.6N), 43.8N (±14.0N) in the medium stage, and 62.8N (±11.6N) in the late stage (Han et al, 2016). The timeframe where early-stage callus is formed is from Week 5 to Week 6 where the forces that the hand encounters have to be graded to ensure that no displacement occurs. In the early stages, a displacement of between 0.6 to 1.3 millimetres occurs with forces of 5N. Five N (5N) is equal to a 0.51 kilograms (kg) force, for example, when a 500 millilitre water bottle is held upright on the palm of the hand.

The management of second to fifth metacarpal fractures varies in the literature and is dependent on, but not limited to surgical or conservative medical management, the area of the fracture, the level of angulation, rotation, and the shortening of the metacarpal bone. The literature related to surgical and conventional management is discussed in the next sections.

2.5 Surgical management types

The primary goal in respect of interventions for individuals who sustained second to fifth metacarpal fractures is to achieve a stable reduction, acceptable alignment, good joint motion, and a strong bone union (Fatima et al, 2021). Surgical intervention is dependent on the assessment by the orthopaedic or plastic surgeon, decision-making, and to a large extent on the expert's level of experience. Often surgical management is conducted when the metacarpal fracture demonstrates rotation, angulation in different planes, and shortening of the two bone ends (Fatima et al, 2021). The types of surgical intervention used to address second to fifth metacarpal fractures include a minimally invasive approach, with ORIF (Jun et al, 2021), a mini

open reduction and fixation approach (Jeong et al, 2019), intramedullary fixation with screws (Beck et al, 2019), a plate and screws (Neagu et al, 2018) or K-wires (Neagu et al, 2018). Fifth metacarpal transverse and oblique diaphysis fractures can also be surgically managed through intramedullary antegrade or retrograde pinning by a surgeon (Lazarus et al, 2020).

2.6 Surgical management outcomes

Research investigating surgical management subsequent to metacarpal shaft fractures has focused mainly on the metacarpal fracture of a displaced shaft and the various fixation methods used. The surgical methods used did not, however, reveal a statistical significance in patient satisfaction or functional outcome measures (Henry, 2008; Ozer et al, 2008; Wong et al, 2006). In a systematic review, Greeven et al (2016) compared the use of ORIF to K-wires for the surgical management of fifth metacarpal shaft fractures (Greeven et al, 2016). Five studies were included in their review, which investigated ORIF-managed participants (n=36) and participants' fractures managed with K-wires (n=65). Good functional outcomes were reported for both groups; however, the ORIF-managed group reported six participants, who needed surgery once more for functional impairments, as opposed to the K-wire participants, who needed no additional surgery.

Taha et al (2020) conducted a systematic literature review in 2020 on the treatment interventions for shaft metacarpal fractures (Taha et al, 2020). Of the 1 600 sources identified, seven complied with the eligibility criteria and compared surgical with conservative management. No randomised control trial (RCT) could be sourced. Hence, the call was made for multicentred, well-designed trials to provide evidence on the most effective and cost-efficient management of metacarpal shaft fractures.

Researchers investigated the surgical management with a K-wire fixation of fractures of the neck of the fifth (Boxer) metacarpal (Boussakri et al, 2014). All 28 participants sustained a closed Boxer’s fracture. Irrespective of the volar angulation of the metacarpal head or the malrotation of the fifth finger, the fractures in each case were managed with a K-wire, which was removed

after four weeks (Boussakri et al, 2014). At the 20.75-month follow-up, only one participant needed to receive an internal fixation revision and a further three individuals presented with superficial wound infection complications. Owing to the low morbidity, no residual pain was experienced and good functional outcomes achieved (Boussakri et al, 2014). Boussakri et al (2014) recommended that percutaneous intramedullary nailing with a K-wire be performed in the case of all Boxer's fractures.

Wormald et al (2019) conducted a systematic review and meta-analysis on managing fractures of the extra-articular neck of the fifth metacarpal (Wormald et al, 2019). Two trials, with 125 participants, showed no statistically significant differences at 12 months in radiographic, clinical, or patient-reported outcomes in both the surgical and non-surgical groups. Non-surgically managed participants were off work for fewer days and were less likely to experience any adverse events. In a meta-analysis of current evidence from 1987 to 2018 on fractures of the neck of the fifth metacarpal, the five studies included reported on the comparative aspects of conservative and surgical management (Chong et al, 2020). Conservative management resulted in a higher degree of palmar angulation that was assessed radiologically, but no statistical difference in functional outcomes measured the Quick Disability of the Arm, Shoulder and Hand questionnaire (QuickDASH), and grip strength was evident. Similar to the finding of Boussakri et al (2014), conservatively managed participants had fewer days off work compared to those participants who were managed surgically. Studies included in the systematic review had insufficient data for outcomes of total active motion (TAM) and the visual analogue scale (VAS) score of pain to be pooled. Conservatively managed participants, however, achieved similar TAM and VAS scores when compared to the surgically managed participants. The authors concluded that the evidence for managing fractures of the neck of the fifth metacarpal indicates that, depending on a thorough assessment, it could be either surgical or conservative. A systematic review concluded that 90% of fifth metacarpal neck fractures with angulation up to 70° could be treated conservatively as no significant difference was found in hand function measured with the Disability of the Arm, Shoulder and Hand (DASH) questionnaire (Boeckstyns, 2021).

In a systematic literature review and meta-analysis, Beck, Horesh & Taub (2019) sought to describe the functional outcomes after metacarpal fracture fixation with intramedullary screws (Beck et al, 2019). Nine articles with 169 participants who had sustained a variety of metacarpal fracture types, 66 neck fractures, 31 shaft fractures and 10 head fractures, and who had been surgically managed with a headless compression screw, were included. Outcomes at an average of an 11-month follow-up period were 100% radiographic bone union, 86°of MCPJ flexion range of motion (ROM) (n=83), 251° digital TAM (n=72), and a 96% grip strength, compared to the contralateral hand in four studies. Minor complications in nine participants and in the removal of hardware in four participants were recorded. A lack of functional outcomes was reported, with twelve complications noted. Although the authors stated that intramedullary fixation using headless compression screws is a successful and safe surgical treatment option, further research on the use of headless compression screws is indicated where functional outcomes are included and reported on. Additional evidence on the topic of associated injuries that may occur after sustaining a second to fifth metacarpal fracture now follows.

Direct trauma is often the reason why an individual sustains a second to fifth metacarpal fracture (Chung & Spilson, 2001) with or without associated injuries. The associated bony injuries of excessive angulation, rotation and displacement are often surgically fixated (Carreño el al, 2020), thus preventing further soft tissue injuries. Complications after metacarpal fractures include hand stiffness, mal-union or non-union, and infection (Kozin et al, 2000). Infections require irrigation and debridement of the infected soft tissue, removal of the hardware used during ORIF, and antibiotics. To prevent joint stiffness, exercises for patients managed with k-wires or splinting need to be commenced as soon as clinical bone healing has been achieved (Kozin et al, 2000).

A discussion on the injuries associated with second to fifth metacarpal fractures now follows. In their study, Carreño et al (2020) observed that the associated injuries include soft tissue

structures, such as the displacement of the attachments of the *flexor carpi ulnaris* tendon with base of fifth metacarpal fractures, and disruptions to the attachments of the *extensor carpi radialis brevis* and *longus* tendons on the bases of the second and third metacarpals. Lacerations to the skin may also be present. It is imperative that a thorough assessment and observation of the hand be conducted by the clinician to identify dorsal wounds over the MCPJs and "fight bites", where a person's metacarpal head makes contact with the teeth of the person that is being punched. This mechanism of injury is considered a traumatic arthrotomy and part of an open fracture pattern (Okafor et al, 2022). Extensor tendon injuries can also be associated with dorsal injuries sustained during metacarpal fractures (Ramage & Veracallo, 2022).

Information concerning surgical management, outcomes and decision-making when considering injuries associated with metacarpal fractures is covered in this section. No mention was made in the above studies of the specific rehabilitation programme to be followed after conservative or surgical management of second to fifth metacarpal fractures; hence, the necessity for the current research study to investigate such evidence in respect of rehabilitation. The void in respect of therapeutic rehabilitation for post metacarpal fractures needs to be filled. As such, the literature related to hand rehabilitation is discussed in this next section.

2.7 Hand rehabilitation

Hand rehabilitation is imperative for the post-surgical and conservative management of metacarpal fractures (Mennen & Van Velze, 2008; Cooper & Wietlisbach, 2014). Hand rehabilitation programmes in clinical practice incorporate muscle stretches, wound and/or surgery scar management, oedema management, joint mobilisation, blocking exercises with the other hand, various exercises using functional tasks (e.g., dressing, eating, washing, and others) and/or the manipulation of external tools (e.g., doing leatherwork, using therapeutic putty, bottles, balls, pegs, and elastics) (Mennen & Van Velze, 2008; Cooper & Wietlisbach, 2014).

The researcher conducted a literature search to determine the evidence base of the management of oedema after second to fifth metacarpal fractures. Carreño el al (2020) reviewed the conservative and surgical management for individuals presenting with metacarpal fractures and stated that tenderness and swelling over the hand's dorsum are symptoms that are often seen. The management of oedema after metacarpal shaft fractures is further emphasised by McMahon et al (1994), where a compression glove, used with good outcomes, was seen to cause a reduction in pain, increased joint ROM and good hand function. (Please also refer to section 2.4 where oedema management was previously discussed.)

When considering other hand rehabilitation interventions laterality should be considered for individuals who sustained second to fifth metacarpal fractures. Laterality of the hand is the ability to cognitively orientate the limb (Geete et al, 2022). Geete et al (2022) found that the laterality of the hands was affected after a short period of immobilisation. As the clinical hand rehabilitation guideline includes splinting and immobilisation types and the period for the initial management, the concept of laterality is imperative in that it enhances and provides holistic hand therapy. Furthermore, the inclusion of laterality in hand rehabilitation allows for the full benefits of holistic rehabilitation.

Technology in hand injury management and rehabilitation is also evident in the literature. In a research study conducted by Then et al (2020), mention is made of gamification as a further treatment method for injured individuals. In the gamification group, where cost-effective devices, namely, mobile devices, are used, no statistically significant difference was seen in composite finger ROM and grip-strength outcomes when compared to the conventional PT rehabilitation for individuals who had sustained second to fifth metacarpal fractures. However, a small statistically significant difference ($p=0.038$) was seen in hand function measured with the standard outcome tool, Patient-rated Wrist and Hand Evaluation , which complied with the

gamification rehabilitation level ($p<0.05$) and cost-effectiveness standards of the method (Then et al, 2020). No adverse events were observed in either the gamification or the PT group.

The development of the clinical hand rehabilitation guideline during the current research study for second to fifth metacarpal fractures is underpinned by the ICF. The following section describes the development of the ICF over time as well as the importance of the ICF to this research.

2.8 International Classification of Functioning, Disability and Health Framework

In 1980, the World Health Organisation (WHO) developed a widely accepted and recognised system to define function, namely, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) (World Health Organisation, 1980). Function in the ICIDH was described in terms of a three-level hierarchy, namely, handicap, impairments, and disability. Nagi, In: Pope, Tarlov & Nalional (1991), suggested modifications to the original ICIDH which were followed by a further modification to a fourth and fifth-level model (Laver Fawcett, 2007). In 1993, the WHO started revising the original ICIDH and produced the ICIDH-2 in 2001, which included activity restrictions in daily activities and limitations in terms of social integration (Leistner, 2001). Whereas the revised system was initially referred to as the ICIDH-2, the finalised version of this revision process was named the ICF framework (Laver Fawcett, 2007). Before the ICF was revised, there was a need to establish a common language to improve on and clarify the research findings in respect of health and state of health. The ICF is a widely accepted conceptual model providing a universal language for functioning and disability (Stucki, 2005; Rauch et al, 2008). The ICF offers a clinical tool for research, for use in the clinical setting, education, and statistics, and in so doing, has raised awareness, with the result that an inclusive social paradigm has ensued. Owing to its integration of medical and social models, the ICF is a particularly valuable tool for therapists to use in their rehabilitation services (Laver Fawcett, 2007). The integrative ICF model of Functioning, Disability, and Health consists of various components. They are firstly, body functions, these being the body's psychological and physiological functions; secondly, body structures, these involving the body's anatomical parts; thirdly, activities related to the execution

of actions and tasks by the individual; fourthly, participation, where the life situation of the individual is taken into consideration; fifthly, environmental factors, including the social, physical and attitudinal situations in which the individual finds him/herself; and lastly, personal factors, which refer to the specific background, involving the living and life situation of the individual which does not often constitute part of the health condition (Rauch et al, 2008). In this ICF model, as explained above, it is clear that the individual's experience of functioning is not a consequence of the injury or disease, but rather a result of the interaction between the individual's personal attributes, health condition and the environmental or contextual factors.

The strength of the ICF as a tool for therapists in providing rehabilitation services lies in the holistic approach, with the focus on the functioning of the individual and on restoring function rather than merely on the disease-based model of disability, as was previously the case and which, in some instances, is still being used. The ICF places the individual in a unique context, either positive or negative, as an integral part of the healthcare process, including the management, assessment and decision-making processes that he/she initiates and sustains (Laver Fawcett, 2007).

The ICF framework acts as an overriding framework used to develop the clinical hand rehabilitation guidelines. According to Stucki (2005), with the exception of the personal factors unique to each individual, the ICF model components are classified in a standardised manner to provide a universal description and understanding of the health-related condition and general health of an individual. In this thesis, a category and chapter are assigned to each component, which is further organised into different levels of specifications (Rauch et al, 2008). The organisation of the health state offers a hierarchical structure allowing for either a very detailed or a general description, where second, third and fourth-level categories can be appreciated (Üstün et al, 2004). To facilitate the use of the ICF in research and clinical practice, ICF Core Sets have been developed by the cooperative effort of the German Social Accident Insurance, the

Prevention in the Health and Welfare Services, The Institution for Statutory Accident Insurance and the ICF Research Branch. The ICF Core Sets are lists that generally agree on the ICF categories specific to diseases and contexts relating to healthcare. The ICF Core Sets can be used in multidisciplinary team assessments, health statistics and clinical studies (Cieza et al, 2004).

A fully functional hand should be the primary outcome after rehabilitation and, therefore, a successful rehabilitation programme should comprehensively attain all three ICF areas set out by the WHO, namely, body function and structure, activity limitations, and participation restrictions (Saleeby, 2016). According to the ICF areas, the outcomes related to a hand injury are as follows: body function and structure which include digital ROM, sensation, pinch strength, and grip strength; activity limitations, which include hand function (grasps and fine motor dexterity) and disability; and participation restrictions, which include disability and health-related quality of life (HRQoL).

The value of the ICF in providing a framework that guides rehabilitation in the clinical setting is of importance in the current research. A second to fifth metacarpal fracture may negatively impact the three ICF levels, as stated above, and impact contextual factors such as the individual's personal factors, community, and the environment. Personal factors include race, age, coping styles, smoking status, gender, health condition, such as diabetes mellitus types I and II, osteoporosis, adherence to a health practitioner's advice and prescriptions, and renal failure (Wollstein et al, 2020), and play an integral role in the management of injuries such as metacarpal fractures. As such, they should be considered by the clinicians. The bio-psycho-social impact can further be seen when one considers the physical challenges and psychological challenges to functioning and performing daily tasks without a dominant or non-dominant hand. Owing to the trauma-ridden society in South Africa, psychological challenges that often precede injury linger unseen and could be another source of disability (Coovadia, 2009; Roberts, Kitchiner, Kenardy & Bisson, 2010). Activity limitations, as classified in the ICF, are caused by poor hand function, which

is in turn directly affected by the inability of the individual, after a hand fracture, to grasp and pinch normally.

2.9 Grasps and pinches included in a functional hand repertoire model

The concern of Kimmerle, Mainwaring & Borenstein (2003) for rehabilitation programmes that do not incorporate function is apparent. In a plea to inform future hand rehabilitation success, the authors developed a functional hand repertoire model, which further emphasises the importance of clinical hand rehabilitation guidelines that consider not only body impairments, but also activity limitations and participation restrictions (Kimmerle et al, 2003). The key components of the model devised by Kimmerle et al (2003) include personal constraints (physical and psychological status), hand roles (unimanual and bimanual), hand actions (objects related to reaching, grasping, and manipulation), and task parameters (objects, movement patterns, and performance demands).

Kingston, Tanner & Gray (2010) investigated the functional impact of traumatic hand injuries on people in Australia's rural and remote regions. The results revealed residual challenges resulting from traumatic hand injuries. Occupational performance and leisure activities were mainly affected, with less difficulty noted in self-care and rest. Kingston, Judd & Gray (2014) also conducted qualitative research on remote and rural participants in North Queensland, Australia, with the specific aim of understanding how the participants engaged in social activities, work, and ADL after sustaining traumatic hand injuries. The results showed that more emphasis should be placed on occupation and activity (basic and instrumental functional tasks) in rehabilitation programmes rather than on following a strict protocol. The relevance of the research performed by Kingston, Tanner & Gray (2010) and Kingston, Judd & Gray (2014) lies in the fact that the participants in their studies sustained traumatic injuries and received hand rehabilitation services but that this research resulted in deficits being noticed in the ICF's participation level classification.

Kimmerle, Mainwaring & Borenstein (2003) voiced their concern about the assessment and treatment of hand injuries. The various available grips, grasps, and movement repertoires incorporated in the research under the activity limitation domain of the ICF were not fully embraced and incorporated into hand rehabilitation practices (Kimmerle, Mainwaring & Borenstein, 2003). Owing to the value of the rehabilitation principles guiding the return to the full participation of individuals who had sustained second to fifth metacarpal fractures, the research performed by Kimmerle, Mainwaring & Borenstein (2003) was deemed imperative in informing the development of the rehabilitation programme for the current study.

It was evident from the systematic literature review performed by Keller et al (2021) and the above-mentioned literature sources that a best-evidence clinical hand rehabilitation guideline for second to fifth metacarpal fractures requires that special consideration be given to hand grasps.

2.10 Hand grasps

Since the era of designing and manufacturing robotic hands, a change has been observed. Whereas research previously focused on biomechanics, rehabilitation, and surgery, it has recently shifted to investigating the basic and instrumental functioning of the human hand and the grasps used during functioning. The earliest studies on human grasp behaviour allowed for the description of grasp categories into cylindrical, lateral, tip, palmar, hook, and spherical grasp (Schlesinger, 1919). These categories were defined by the object the hand had to manipulate and not the manipulation required of the hand to complete a task. Further research was conducted where a taxonomy of human grasp was developed (Cutkosky, 1989). The taxonomy divided the grasps into power and precision grasps; subsequent to that, the shape of the object and function were included. Earlier studies on grasps also focused predominantly on the hand posture for objects that had previously been selected but did not include investigation into hand

manipulation during unstructured tasks and behaviours. Hand manipulation in unstructured tasks and behaviours was addressed where the grasp type and the frequency of its use in manipulation tasks were investigated (Bullock et al, 2013).

The most extensive and complete grasp study was conducted by Feix et al (2016) and resulted in the GRASP taxonomy (Feix et al, 2016). The GRASP taxonomy includes the following categories: power grasps with palm or pad, intermediate grasps with the sides of the fingers, precision grasps with either the pad or the sides of the fingers, and opposition (Addendum A). For each of the three grasp categories, a distinction was made between thumb abduction and adduction during use (Feix et al, 2016; Bullock et al, 2013). After the literature had been reviewed, 33 different hand grasp types were identified and included in the GRASP taxonomy (Feix et al, 2016). The GRASP taxonomy (Addendum A) of the human hand served to determine the predominant grasp type for the respective functional tasks, as listed in the ADL Task sheet (Addendum B), to inform the development of the clinical hand rehabilitation guideline in the current study. Thomas Feix granted permission for this researcher to use the GRASP taxonomy in her research and the permission email is presented in Addendum C. In order to better understand and gain insight into the functional tasks performed by individuals in their occupations and workday activities, the next section discusses the research focusing specifically on hand functioning in the case of machinists and housekeepers. The researcher could find no other research studies focussing on other occupations.

Bullock et al (2013) investigated two housekeepers and two machinists. The participants were video-recorded for 7.45 hours, and the recordings analysed for the most frequently used grasp types that they employed (Bullock et al, 2013). The ten most frequently used grasps for all four participants presented under each grasp category were medium wrap, power sphere, index finger extension, light tool, lateral pinch, lateral tripod, thumb-two finger, tripod, thumb-three finger, and precision disc (Bullock et al, 2013).

Although grasps during daily tasks were identified as imperative towards developing a clinical hand rehabilitation guideline in the current study, a scientific approach was required to grade the return to basic and instrumental daily functional tasks. The finger and grasp forces required to perform basic and instrumental daily functional tasks could not be found in literature and was a missing element identified by the researcher to develop robust recommendations to be included in a guideline. Information pertaining to the scientific testing of the basic and instrumental tasks now follows.

2.11 Scientific testing of grasp in tasks with force sensing resistors

FSRs in hands have increased in popularity in engineering and robotics. They allow for the measurement of static and dynamic forces that the hand applies to a contact surface (Sadun et al, 2016). FSRs are affordable, lightweight and allow for the objective measurement of the static and dynamic forces produced by the human hand (Sadun et al, 2016). An example of a FSR is provided in Image 2.1.

Image 2.1: Force sensing resistor (https://www.elecbee.com/)

2.12 Calibration of testing equipment

Calibration before testing of the FSRs is essential and provides the range in the variation of the anticipated forces in order to group the basic and instrumental functional tasks into various known quantities and thus into categories of force (Testing, 2012). Static forces ranging between zero and 15 N (zero to 1.5 kg) are placed on the sensors during a static test (Flórez & Velásquez, 2010).

A literature search was conducted to find information related to force testing in basic and instrumental functional tasks, and 26 sources were found where FSRs had been used in previous research. No studies have investigated the use of FSRs in an attempt to grade and categorise frequently used grasps during basic and instrumental functional tasks.

Studies using tactile pressure sensors to measure the forces exerted by the fingers of healthy participants have in fact been performed in the areas of cardiopulmonary resuscitation (Solevåg et al, 2016), handwriting, in operating a drill (Kulothungan et al, 2013), and during surgical operations using laparoscopic instruments (Skiadopoulos & Lango, 2016). Castro and Cliquet (1997) investigated 15 healthy male adults and 15 healthy female adults using a force sensing glove. They measured the static forces produced while each of their participants grasped a cylindrical object, weighing between two and 10 N. Grasps were plotted for the different forces produced with the manipulation of 2 N (0.2 kg), 4 N (0.41 kg), 6 N (0.61 kg), 8 N (0.82 kg) and 10 N (1.02 kg) weights. According to the literature sourced in testing grasp forces during object manipulation, the following ranges of force were measured for the index and middle fingers: a 0.2-kg weight resulted in a zero to one-and-a-half N force; a 0.41-kg weight resulted in a zero to three N force; a 0.61-kg weight resulted in a zero to four-and-a-half N force; a 0.82-kg weight resulted in a zero to six N force; and a 1.02-kg weight resulted in a zero to seven N force (Castro & Cliquet A, 1997). The influence of age, gender, the weight of the object, and hand size were determined using an ANOVA analysis with $p < 0.01$. No significant difference was found between

the male and female participants in these respects. The differences between the various ages and weights are still unknown.

In another study, the human hand was tested to determine the strength of the force when a spherically shaped ball was held in a tripod grasp. FSRs were mounted on the contact area of the ball and the forces exerted on the shape by the thumb, index finger, and middle finger were measured. The participant was instructed to grasp, then steadily hold the ball, and then to let the ball slip out of his/her hand. Forces ranged between 0.3N and a maximum of 2.7N. A recommendation for future research would be to test more objects in order to analyse a wider range of grasp types (Romeo et al, 2015).

A study was also conducted by Rice et al (1998) to investigate the relationship between finger and handgrip performance with the opening of household containers. FSRs were placed on six common containers, and the grip and pinch strengths of 46 college students, each instructed to open six containers, were measured (Rice et al, 1998). The forces measured during the opening of the containers ranged between 9.74N and 43N. A weak correlation between grip and pinch strength and the FSR forces measured during the opening of the containers ($r = -0.179$ to $r = 0.333$) was found. As was to be expected, there was a significant difference between the grip and pinch strength measurements for the two genders, with the males displaying stronger grip and pinch-strength measurements than the females. However, no significant difference was found between the genders in the force needed to open the containers (Rice et al, 1998). The authors concluded that grip and pinch-strength measurements in isolation are not sufficient and not conclusive predictors of successful hand functioning during basic and instrumental daily tasks such as the opening of household containers. The research study further emphasised the importance of incorporating hand grasps used during basic and instrumental hand tasks to develop the current hand rehabilitation programme.

By incorporating hand grasps in the current study, and by testing the daily basic and instrumental functional task forces using FSRs, the categories, body function and structure, activity limitations, and participation restrictions were deemed to be fully appropriate, as relevant ICF areas, to being incorporated into the clinical hand rehabilitation guideline (Saleeby, 2016).

2.13 Sound rehabilitation principles

After careful consideration, the incorporation of sound rehabilitation principles (Brukner et al, 2016) is imperative in rehabilitation services/therapies. Relevant rehabilitation principles that should be considered include progression in the choice of exercises, muscle flexibility, functional exercises, and muscle conditioning. Physical activity is a complex and multidimensional behaviour prescribed and developed progressively according to four components (Barisic et al, 2011). The four components of exercise prescription are frequency, intensity, time, and the type of activity that is prescribed. Frequency refers to how many times in a day the individual should perform the exercise; intensity is the 'how much?' factor; and the rate of energy expenditure is the 'how hard?' factor. Time refers to the duration of a session, and lastly, the type of activity to be performed should also be considered. The four components are named the frequency, intensity, type and time (FITT) principles and are an effective foundation and gold standard to exercise prescription (Shambhu et al, 2021). The original FITT principles were modified in 2014 to FITT-VP, where volume, indicating the amount of exercise and its progression, was added. After critically reviewing the literature and the prevailing evidence, the FITT-CORRECT principle of exercise prescription was introduced (Shambhu et al, 2021) to improve and optimise intervention outcomes for the person or patient performing the exercises. The inclusion of a combination of interventions (C), the order of the intervention (O), the number of repetitions required (R), the rest periods between the sets and also between the exercise sessions (R), the exercises to be performed at home (E), the cognitive domain (C), and the re-evaluation plans and total dosage of exercises (T) together constitute the CORRECT principle (Shambhu et al, 2021). As stated above, one of the considerations of a rehabilitation programme aimed at restoring hand function after a second to fifth metacarpal fracture has been sustained is biomechanical by nature. Therapists

should, however, recognise that in isolation, the biomechanical overview does not allow for a holistic and occupationally-focused approach to rehabilitation. Hand rehabilitation prescription also needs to consider the FITT-CORRECT principles in exercise prescription to optimise outcomes of function, improved strength, joint ROM and reduction in pain levels. The researcher acknowledges that although the rehabilitation principles are important to ensure successful rehabilitation after sustaining an injury, the clinical reasoning of the clinician ultimately remains key to individually tailored and optimal rehabilitation delivery.

2.14 Motor learning principles

Because of the importance of fully functioning hands, and in the light of the necessity to return to basic and instrumental daily activities, the consideration and incorporation of motor learning principles - imperative to the rehabilitative process (Muratori et al, 2013) - into such a programme , especially in the rehabilitation of the human hand. Relearning motor tasks/activities in the context of an environment known and familiar to the individual is essential and fosters learning. The learning environment is also culturally embedded in the cultural setting in which the individual who has sustained a second to fifth metacarpal fracture finds him/herself in that the tools/utensils and basic and instrumental functional tasks are unique to that environment.

The next section makes an in-depth understanding of motor learning principles possible. It presents a definition, and expounds upon theories, stages, and factors that may affect the clinical significance of motor learning. In his definition of motor learning as “the process of acquiring a skill by which the learner, through practice and assimilation, refines and makes automatic the desired movement”, Umphred (2013) succinctly introduces the concept.

Motor learning is a process that involves the compilation of a motor programme which strengthens both the error-detection process and movement schemas. Furthermore, motor learning occurs in the brain. Through practice and the repetitive experience of performing a

particular skill, a change occurs in the central nervous system and the brain. In this manner, a new motor skill develops. Thus, motor learning requires practice, a circle of feedback, where the knowledge of results is also applied in the ensuing practice to bring about change (Lennon, 2011; Umphred, 2013).

According to the e-resource at the University of Victoria, the principles applicable to motor learning include interest, practice, distributed practice, skill specificity, whole-part learning, transfer, skills improvement, feedback, and variable practice. Each of the principles is presented as follows: The principle of interest conveys that the learner's attitude towards the skill determines the type of learning that occurs, and the amount of information assimilated. The practice principle states that learning can take place only when the motor skill is practised correctly. Intense and short practice periods result in greater learning than would be the case with prolonged practice sessions. The former is an example of distributed practice. The principle of skill specificity states that the learner's ability to perform one motor skill effectively is not dependent on the learner's ability to perform other motor skills. The principle of whole-part learning states that learning depends on the learner's ability and how complex the skill is, which both impact on the issue as to whether the skill should be taught as a whole or broken up into smaller components. The principle of transfer presents two aspects to learning. Positive transfer occurs when two tasks are closely related or similar and the conditions under which the motor skill is taught should match the conditions under which it would normally be used. The skills improvement principle states that on the path to learning and developing a new motor skill, progression occurs from the least mature to the most mature, while the amount of learning that takes place and the rate of progression depend on the individual. The principle of feedback states that for motor learning to take place, external and internal information sources about motor performance provide feedback to the learner to refine and improve their learning of the new skill. The variable practice principle implies that block practice is ideal for enhancing performance, but to assist learning, variable practice is ideal as it increases the level of attention (University of Victoria, e-resource).

The three motor learning theories that are mentioned in this section include the following: Adam's closed loop theory (1971), Schmidt's schema theory (1975), and Newell's ecological theory (1991). The diverse research setting that was selected for the data collection requires the acknowledgment that individuals learn differently. No intervention involving the transfer of information (teaching) in respect of the clinical hand rehabilitation guideline and its use in the management of individuals who sustain a second to fifth metacarpal fracture was carried out. For this reason, sections 2.14.1 to 2.14.3 present possible motor learning theories that may be used in its future implementation. For this reason, three motor learning theories are now presented in the next section.

2.14.1 Adam's closed loop theory

Adam's closed loop theory presents the concept that motor learning occurs through sensory feedback and the ongoing production of skilled movement during slow movement practice. Where errors are made, it is essential that they be corrected in the following practice session. This is because undesired responses are made when practising with errors in the learning of a specific skill which would in turn increase the strength of the incorrect perceptual trace. The more the person practises the skill, the greater the amount of motor learning that occurs. The improvement gained in acquiring a skill increases the person's capabilities and is represented in the form of a closed loop.

2.14.2 Schmidt's schema theory

Prior to Schmidt's schema theory (1975), it was believed that there must be a motor programme for every single movement. Schmidt believed and proposed in the schema theory that as a general motor programme, there is only one motor programme per movement. Different stages make up the schema theory. Stage 1 is the perception of where the body is and the conditions surrounding it. The second stage is named the response specification and involves the

expectations around the person. The first two stages are called the recall schema. After the person has identified what is expected of him/her in the current environment, the movement or skill is performed in a motor programme. The next is the third stage, which is a discussion on the sensory consequences. The person performing the skill experiences sensory inputs from the limbs and body that are then transmitted to the central nervous system. Using the sensory consequences, adaptation to the current motor programme is now possible. How was the skill perceived and what did it feel like when it was being performed? The fourth stage, the response and outcomes stage, asks whether the adaptation of the motor programme works and gives the desired outcomes and results. The third and fourth stages are called the recognition schema. The recognition schema follows movement. Thus, at its core, the schema theory requires continuous adaptation until the desired motor programme and its results are achieved.

2.14.3 Newell's ecological theory

The Ecological Theory by Newell (1991) is based on the systems and ecological motor control theories. Motor learning occurs with increased coordination between the actions performed and the perceptions made through the task that must be performed, with consideration being given to the environmental constraints. The perceptual motor workspace included in the theory requires that the most relevant perceptual cues and movements essential to performing a specific task are identified. There are no rules; merely an optimal task-relevant mapping of the actions and perceptions pertaining to the task and the relevant skill (Fitts , Posner, & Michael, 1967).

There are three stages of motor learning, namely, cognitive, associative, and autonomous. In all three stages of motor learning, feedback is required to guide the person who is learning the motor task or skill to enable him/her to refine, practise and identify the specific changes required to attain the desired outcomes and results. Using visual feedback, the learner develops a cognitive map and thus also the strategies to perform the task. The difference is that the earlier stage, the cognitive stage, is the beginning of the task and learning how to perform a new skill. Because the

learning of a new task requires considerable cognitive effort and activity, the movements are still inconsistent, slow, and ineffective. The largest part of the movement task occurs under conscious control. For this reason, a high level of attention is required of the learner to understand what should move to produce a specific task. An early and a late cognitive stage can be differentiated in terms of the fact that the essential elements of the motor programme or movements are not present in the early stage but start to appear in the late cognitive stage. The practice sessions thus include fewer variables, require a clear mental image using either visual or technical images or videos, and with the practice being specifically focused on performing the task. Intervention strategies during the cognitive stage include ensuring the purpose of the task in a functionally relevant context and demonstrating the fact that the task should be accurate. At a pace that allows the learner to perform the task together with the individual who demonstrates the task, the learner can actually verbalise the strategy. Complex tasks are broken up into more manageable components and progress is made at executing them at the learner's pace. A final intervention is to provide manual assistance or guidance to foster learning.

The second stage is called the associative stage. In the associative stage of motor learning, the movements are more reliable, efficient and fluid. The prerequisite for the associative stage is mastery of the late cognitive stage. The organisation of the motor programme is now refined through practice. Some movements are still controlled consciously but others automatically show signs of less cognitive activity than in the cognitive stage. As cognitive monitoring steadily declines, so the spatial and temporal aspects of movement tend to become better organised. Intervention strategies include assisting the learner in developing his/her own decision-making abilities. At this stage, guidance or facilitation may be counterproductive, and introducing performance in a real-world scenario, where distractions and interference are included, is appropriate to learning and refining the motor programme. Feedback is needed to identify errors in movement. When the errors become consistent, focus is placed on the specificity and detail of the task by allowing the learner brief periods of introspection as to how he/she performed during the practice sessions.

In the final stage, the autonomous stage, the task is practised in different environments as the aim at this stage is to get the learner to focus during the task. The spatial and temporal components become highly organised as the movements become increasingly more autonomous, with little cognitive control required to perform the movements and complete the task. There is consistent goal attainment as the skill or task is developed. Intervention strategies include practising in an environment at the actual prescribed pace and with the required level of accuracy, and allowing for all the distractions in the real-life environment and context. Feedback is now aimed at confirming the success of the performance or, after careful analysis, at augmenting it with increased specificity and detail. However, there is less feedback at this stage.

In the next section, adult learning theories and principles are discussed. Adult learning is important to discuss as the developed hand rehabilitation guideline needs to be taught to a wide variety of adults who learn in different ways.

2.15 Adult learning theories and principles

Adult learning involves the acquisition of skills, knowledge, and attitudes to achieve changes in performance, behaviour and to reach the full potential of the individual (Aliakbari et al, 2015). In this study, the age category for which the clinical hand rehabilitation guideline was developed is 20 to 59 years, which falls into the adult learner category. The correct use of terminology is essential when discussing learning theories. “Andragogy”, meaning "man," used for adult learners, and is distinctly different from “pedagogy”, the term used to refer to "child" (Mukhalalati & Taylor, 2019). The definition of adult learners remains controversial. In an attempt to define adult learners, Massyn (2009) proposed an internal category, where factors, such as motivation to learn and the individual learner’s ability to change, are presented.

Massyn (2009) suggested that when teaching or instructing adult learners to perform or adhere to rehabilitation guidelines and exercises, a holistic approach should be used to address this diverse group. Mukhalalati and Taylor (2019) state that adult learning theories play an instrumental role in the design and implementation of educational programmes in healthcare (Mukhalalati & Taylor, 2019). Adult learning theories in the literature are divided into the following main categories: instrumental, transformative, constructivist, motivational, social, and reflective learning theories (Mukhalalati & Taylor, 2019). The instrumental, transformative and constructivist adult learning theories are expanded upon in the presentation below.

2.15.1 Instrumental learning theory

The instrumental learning theories are further subdivided into behavioural, where a learner's behaviour is changed by focusing on a stimulus in that individual's environment; cognitive, where the focus is on the cognitive structure; and internal environment and experiential learning, where the authentic environment facilitates learning (Mukhalalati & Taylor, 2019). The humanistic theory focuses on the dignity and freedom of all humans to achieve their full potential. It is subdivided into andragogy and self-directed learning (Taylor & Hamdy, 2013). When considering andragogy, the following assumptions underlie the humanistic adult learning theory for the learner: self-concept, prior experiences, readiness to learn, orientation to learning, the need of the learner to know, and his/her motivation to learn (Massyn, 2009). The learner needs to take responsibility for learning and acquiring knowledge. Adult learning involves acquiring skills, knowledge, and the correct attitudes to achieve changes in their performance and behaviour, and to reach their full potential (Aliakbari et al, 2015).

2.15.2 Transformative learning theory

Transformative learning theories focus on empowering the learner to transform his/her propositions, which are often long-standing, meaningful and in context. Motivational models include the self-determination theory, the expectancy valence theory and the chain-of-response

theory. The motivational models imply that the learner's motivation and reflection are associated with adult learning. Social learning theories are an integration between the behaviour modelling concepts and cognitive learning. The integration strengthens the understanding of the task to be practised and performed. Social learning theories include the zone of proximal development, communities of practice, and situated cognition.

2.15.3 Constructivism theory

Constructivism is a psychological and epistemological learning theory that explains how the learner makes meaning of acquiring knowledge (Mukhalalati & Taylor, 2019). Adult learners differ among one another with regard to their unique personalities. Taking this into account, those individuals who sustained second to fifth metacarpal fractures will learn differently. As such, the healthcare practitioners need to recognise this fact and to adapt to allow for successful learning in respect of hand rehabilitation and the implementation of the relevant guidelines, with optimal outcomes as a result.

2.16 Summary

This chapter provided key discussion topics, such as hand function, metacarpal anatomy, osteokinematics, bone healing and the associated forces, the respective types of surgical management, outcomes following surgical management, and a hand rehabilitation section. In addition, the ICF framework, grasps and pinches, hand grasps, FSR scientific testing, sound FITT rehabilitation principles, motor learning principles, and adult learning principles and theories were discussed. In Chapter 3, the two published systematic review articles are presented as the first phase utilised to develop the clinical hand rehabilitation guideline.

Chapter 3

Methodology

3.1 Introduction

In the previous chapter, the literature relating to metacarpal bone fractures and rehabilitation, was discussed. In Chapter 3, the methodology chapter, the reader can expect a brief overview of the methodology applied in the research. The research itself is presented in three research phases in order to respond to the research objectives and to achieve the aim of developing a clinical hand rehabilitation guideline for second to fifth metacarpal fractures.

3.2 Overall study design

The researcher selected three phases namely, systematic literature review, a quantitative cross-sectional study, and an eDelphi method, to address the problem statement, gather data to reach the stipulated objectives, and to ultimately attain the research aim. Ethical clearance was obtained from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State before the commencement of each phase, namely, Phase I: UFS-HSD2019/0046/2602, Phase II: UFS-HSD2019/0046/2602-0002 and Phase III: UFS-HSD2019/0046/2602-0003.

3.3 Phases and methods

3.3.1 Phase I: Systematic review

Two independent reviewers participated in the identification, screening, eligibility, inclusion, and extraction of the data for the systematic reviews, with a pilot test precluding the main review to ensure the consistency, reliability and validity of the review procedures. In the first phase, the available evidence on hand rehabilitation programmes, home education, advice, immobilisation

types, splint types, the timelines and the outcomes used in clinical practice for second to fifth metacarpal fractures were reviewed. Prior to its initiation, the systematic review was registered with PROSPERO under the number CRD42019132620.

3.3.1.1 Methods and design

To answer the set research question and achieve the objectives of Phase I, the author conducted a systematic review with the reporting methods for the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) applied in order to guide the development of the protocol. In this way, accuracy, completeness, and transparency were achieved in the planning of the review (Shamseer et al., 2015). A PRISMA-P checklist (Addendum D) was completed and included in the proposal phase (Moher et al., 2015). On account of the limited number of articles sourced and the lack of diversity amongst the studies, no meta-analysis was conducted. Hence, a narrative representation of the results followed. A summary of findings table as well as the descriptive details for each included study is included in Chapter 4.

3.3.1.2 Participants/Population

Studies reporting on adult human participants older than 20 years and younger than 59 years of age were included. The inclusion and exclusion criteria, as well as the methodology, are outlined in the two systematic review articles in the next chapters.

3.3.1.3 Methodological quality appraisal of included studies

Two independent reviewers undertook the quality assessments of all the included studies. A third reviewer was not required to offer a deciding vote in resolving any disagreement. The two reviewers performed the quality assessments using the Joanna Briggs Institute's (JBI) critical appraisal checklists (Addenda F to H) for randomised control trials (RCT), quasi-experimental

studies, and controlled observational studies, including cohort studies and case control studies (Tufanaru, Munn, Aromataris, Campbell & Hopp, 2017). The appraisal tools assessed the respective biases in terms of selection, allocation, reporting, performance, and attrition, as well as the detection risk. The quality assessment results affected the quality of evidence and were, therefore, reported in the respective articles.

3.3.1.4 Dealing with missing data

In the case of missing data in articles, the primary authors were contacted to fill in the information gaps, as was the case in the Midgley and Toemen (2011) study. Missing data included information regarding the advice given to the participants. If the primary author could not be reached, the secondary author was contacted, and the missing information was sent to the researcher via an email.

3.3.1.5 Measuring the strength of the body of evidence

A thorough assessment of the overall quality of the evidence for each outcome was performed using the Cochrane grading of recommendations, assessment, development and evaluation (GRADE) method. The recommendation made by the GRADE working group was followed where a high and moderate certainty level of evidence was accepted, and a low and very low certainty level was documented (GRADE working group, 2004).

The systematic review informed the development of the initial clinical hand rehabilitation guidelines. For more detail on the methodology of Phase I, refer to Chapter 4. A short description of Phase II is provided next.

3.3.2 Phase Two: Development of a clinical hand rehabilitation guideline for second to fifth metacarpal fractures with Force Sensing Resistor testing

The aim of Phase II was to assist the development of the clinical hand rehabilitation guideline for single or multiple second to fifth metacarpal fractures using literature obtained in the systematic review, the GRASP taxonomy and the force sensing resistor (FSR) testing data.

3.3.2.1 Methods

The inclusion and exclusion criteria are described in the article in Chapter 5.

3.3.2.1.1 Design

A quantitative, feasibility cross-sectional study design was the research design for Phase II as it allowed the researcher to collect numerical hand forces data for all ten fingers and to compare the maximum forces between participants and genders. Two studies, the first a feasibility study with six participants, were undertaken and the categorisation of 105 tasks into light, moderate and heavy tasks was achieved. Thereafter a larger study with 32 participants testing 31 activities of daily living (ADL) where similar forces were measured per grasp type were extracted and tested.

3.3.2.1.2 Setting

The study setting was Kempton Park and the neighbouring townships of Tembisa, Alexandra, and Glen Marikana in east Gauteng, South Africa. The research was conducted in a laboratory in Kempton Park where the FSR and data collection phases took place. The laboratory remained unchanged for all testing procedures and provided a standardised environment with adequate space to adhere to Covid-19 precautions.

3.3.2.1.3 Population

Healthy adults living and/or working in close proximity to the laboratory constituted the study population. The socioeconomic status of the participants living and/or working in Kempton Park and the neighbouring townships proved to be culturally diverse. This is due to the OR Tambo International Airport, situated in Kempton Park being the focal point for attracting job seekers from across South Africa and Africa. The large, diverse population in Kempton Park and the neighbouring townships were selected as the study population due to its high levels of violence and trauma.

3.3.2.1.4 Sampling

Convenience snowball sampling of six healthy human adults, three males and three females, who lived and/or worked in close proximity to the laboratory, was conducted for inclusion into the testing phase for the 105 tasks. The Health Sciences Research Ethics Committee (HSREC) approved a smaller sample size for Phase IIs. The reasons for approving a smaller sample size were the technical demands of the FSRs, the Covid-19 pandemic, the four-to-five-hour testing time per participant for the 105 tasks, and the fact that there would be a second data collection process conducted during Phase II. A total of six participants wasdeemed sufficient for the first feasibility study. The participants who had completed the force testing nominated additional potential participants for the next round who were subsequently approached and asked to participate. Previous studies using FSR to test manipulation forces did not find a statistical difference in the forces measured amongst genders, which added to the confidence level for the data collected from the smaller sample.

Subsequent to the force testing of the 105 tasks the data text files showing each individual finger were imported into Excel, where a sheet for each activity was created. An initial sample size of six participants for a feasibility study and thereafter, of 32 participants, at a 95% confidence level

and a five percent (5%) margin of error, was deemed sufficient for the study population. A final sample size of 32 participants allowed for descriptive statistical tests, determining the maximum forces and associations among the proposed population.

3.3.2.1.5 Data collection tools

i) Self-administered questionnaire

A self-administered questionnaire and informed consent in English (Addenda K & M) and in Zulu (Addenda L & N) were provided to participants with the instruction to complete the questionnaire as long as consent had been given to participate. Gauteng hosts the largest percentage, namely, 28% (15.2 million) of the South African population (Stats SA, 2019). According to the 2018 Stats Community survey, the language distribution in South Africa indicates that Zulu is the language most frequently spoken (25.3% of the total population), but in terms of the study population, English was the most frequently spoken language. The questionnaire consisted of closed-ended questions and fixed-response questions covering the following themes: demographic data, occupation and previous injuries. The purpose of the questionnaire was to describe the population and to determine whether any of the exclusion criteria were present.

ii) Jamar hydraulic dynamometer

Grip strength measurement is a frequently used standardised assessment measure used on patients after a metacarpal fracture has been sustained (Mathiowetz, 2002). The Jamar dynamometer is a sealed hydraulic system which allows grip strength to be read off a gauge dial in kilograms (kg) or pounds (Innes, 1999). The instrument has also been tested for validity and reliability and found to be good (Mathiowetz, 2002). Advantages of use include an economical, portable device with normative data available for gender and age (Innes, 1999).

Information about the grip strength testing and FSRs as data collection tools can be found in Chapter 5.

3.3.2.1.6 Pilot testing

A pilot test was undertaken in the laboratory where the 105 activities were completed. The data collection process included one conveniently sampled healthy adult between the ages of 20 to 59 years who had given his/her written informed consent. Before completing the questionnaire, the pilot participant underwent Covid-19 screening and his/her temperature was taken. Grip strength measurements were taken, after which the functional tasks on the test sheet (Addendum B) were performed and measured. The pilot test assessed the consistency of the procedures, the technical aspects concerning the hardware and software equipment, determining the reading of forces during the functional tasks and the data analysis process. During the pilot testing, the testing time was determined, documented and used to inform the participants during the data collection phase. The pilot testing participant data was omitted from the overall research data because of two FSRs bending and providing inaccurate results.

The procedures provided to the participants will now follow: Put on the FSRs/two gloves, one on the dominant and the other on the non-dominant hand. A sensor is pasted with glue on each finger of your glove. No glue will come into contact with your skin or fingers. The sensors will be connected to a board which will be connected to a laptop. You will be requested to do tasks that you are familiar with and that you perform on a daily basis. The tasks include, but are not limited to opening bottles, opening cans, dressing, and cutting vegetables. While you perform the dressing/undressing ADL, a screen will be placed between you and the research team to ensure privacy. The tasks may be challenging but will not cause pain or any discomfort. The sensors will detect the forces which your fingers exert while doing the tasks. The voltages will be visible on

the software programme on the laptop. After a task/activity, you will be asked to do another task/activity until finally, all the functional tasks recorded on the testing sheet have been completed.

Owing to the technical demands of the FSR technology, a specialist technologist in electrical engineering provided the necessary technical support. The maximum testing period for the initial six participants was two days over a period of 15 working days. The testing procedures are elaborated upon in Chapter 5.

3.3.2.1.7 Validity and reliability

The Jamar hydraulic dynamometer is a valid and reliable tool for measuring grip strength. Consistent instructions and the fact that the grip strength testing was performed by one person only ensured that the results of the test were reliable. Furthermore, for the sake of reliable results, the researcher, familiar with the use of the Jamar hydraulic dynamometer, tested the grip strengths of the dominant and non-dominant hands of the respective participants with the use of a Jamar hydraulic dynamometer and adopted the recommended testing method proposed by the American Society of Hand Therapy (Fess & Moran, 1981; Cooper & Wietlisbach, 2014). Participants were seated, elbow by their side and elbows at 90° flexion, the wrist in a neutral position, with the dynamometer on the second handle position (changed to the third handle position for larger hands). The researcher provided support where needed by putting one finger under the dynamometer. The average value for the three maximum gripping efforts was used as indicative of the grip strength during the force sensor testing (Fess & Moran, 1981; Cooper & Wietlisbach, 2014). A biomedical engineer calibrated the dynamometer before the pilot test and data collection process. The dynamometer was carefully stored in a custom-made case for protection, and care was taken not to drop it or let it fall. (The mean grip strength value against age for the dominant or non-dominant hand per sample population is available (Dodds et al., 2016).)

An FSR used in pressure sensing is regarded as a qualitative device (Hollinger & Wanderley, 2006); however, the improvements in technology and in Arduino software make the microcontroller's programming easier and more reliable. FSRs are still widely used because of the miniature sensing area on the fingers that makes hand/finger force testing with calibrated FSRs a valid, easily accessible and affordable force measuring instrument, as tested in a hardness sensing and controlled force-position system (Sadun, Jalani & Sukor, 2016).

The reliability of this testing method was improved by conducting the data collection process in a standardised environment, namely, a laboratory set up with the ADL. The testing sheet included a variety of functional tasks to test, and the setup of the hardware, software, and instructions remained consistent and unchanged. The reliability of this test was further ensured through the services of an electrical technologist, a specialist in high-stream electrical engineering, who was present during the pilot testing and testing phases. This person also had 24 years of experience in electronics and software analysis, including Excel and Matlab.

3.3.2.1.8 Data analysis

Descriptive statistics, namely frequencies and percentages for categorical data, and means and standard deviations or medians and percentiles for numerical data were calculated. Associations were calculated using the t-test for numerical data and the chi-square for categorical data. The analysis was performed by the Department of Biostatistics at the University of the Witwatersrand. The researcher, although registered as a student at the University of the Free State, is employed at the University of the Witwatersrand. Consulting a statistician in closer proximity, thus allowing for face-to-face consultations, was the reason for using the services of this specific statistician.

The table below indicates the outcome measures, data types, and statistical tests used per objective.

Table 3.1: Statistical tests per outcome measure and data types

Objectives	**Outcome measure**	**Types of data**	**Statistical test used**
To determine the demographics of the sample population	Demographic questionnaire	Descriptive statistics	Frequencies and percentages
FSR forces exerted by the human hand with its grasps on object manipulated to determine the functional task	Newton (forces)	Parametric continuous Nominal	Contingency tables
To determine an association between mean forces, gender, and grip strength	Newton (forces), male/female, mean kilogramme	Parametric continuous Nominal	Pearson/Spearman rank Contingency tables for nominal data

For more in-depth methodology of Phase 2 refer to Chapter 5. The methodology for Phase III is presented in the next section.

3.3.3 Phase III: eDelphi method to develop and finalise the clinical hand rehabilitation guideline

The data collected from the first two phases of the research study were incorporated into the initial clinical hand rehabilitation guidelines, with Phase III remaining as the final development phase. An eDelphi method was used to inform and finalise the clinical hand rehabilitation

guideline. The aim was to reach consensus among sampled expert surgeons, PTs, and OTs in the field of hand injuries, hand surgery and rehabilitation.

3.3.3.1 eDelphi method

The researcher used REDCap (Research Electronic Data Capture), a secure, web-based software platform designed to support data capture for research studies (Addenda S, T and U) to develop all three eDelphi round questionnaires. A questionnaire template, created on REDCap, allowed the experts to indicate their agreement on a five-point Likert scale. At least 75% of the panel of experts was required to indicate a preference in respect of each question before consensus could be reached. The researcher selected the 75% consensus percentage based on the same percentage used in a previous hand therapy study using an eDelphi method (van de Ven-Stevens et al., 2015).

Consensus was not reached after two rounds, and therefore the researcher performed a third and final eDelphi round, to inform the recommendations but also to avoid sample fatigue. Anonymity was ensured in all invitations and communication with the participating experts by sending anonymous emails. Following the final round of the eDelphi, the clinical hand rehabilitation guideline was updated and finalised by the researcher.

3.3.3.2 Participants on the eDelphi panel

The researcher identified experts by using the article sources from Phase I and the registered member lists of the South African Society of Hand Surgeons and Therapists. Informed consent was incorporated into the eDelphi questionnaire on REDCap; the participant was requested to press "true" to the first question if they gave consent to participate and "false" if they did not consent to participation. Although the researcher included the results of the eDelphi method in the thesis and in the associated articles, the details of the participants remained confidential.

3.4 Dissemination

The systematic review proposal (pre-print), systematic review, development of the clinical hand rehabilitation guideline, scientific testing, and the eDelphi method results are either published or submitted for publication with peer-reviewed journals in the form of articles. National and international conferences presentations are also planned as part of the process to disseminate the findings of this research study. The clinical hand rehabilitation guideline will be published and made accessible to clinicians.

3.5 Summary

Chapter 3 reported on the methodology of the three phases that the researcher conducted to achieve the research aim of developing a clinical hand rehabilitation guideline for second to fifth metacarpal fractures. In each of the following chapters, a more detailed methodology section can be accessed. Chapter 4, the next chapter, covers the first phase, namely the systematic literature reviews, in two articles.

Chapter 4: Phase I

Hand rehabilitation programmes for second to fifth metacarpal fractures: a systematic review

4.1 Introduction

In this chapter, Phase I, namely the two systematic reviews are presented in article format, with two peer-reviewed and published articles. The first article is based on the primary objective of the systematic review, namely, to determine the hand rehabilitation programmes used and outcomes attained after post-surgical and conservative management of persons aged 20 to 59 years of age who had sustained a single or multiple second to fifth metacarpal fractures. The second article is based on the secondary objective of the systematic review, namely, to determine the types of immobilisation, the splints used, and the resultant outcomes for post-surgical and conservative management and to determine the timelines for the splinting and immobilisation. However, articles (surgical/medical) about splinting and immobilisation strategies were excluded, as no mention was made of hand therapy or hand rehabilitation programmes in these articles. Due to the importance of splinting and immobilisation, the articles from the initial database search were screened again to achieve the secondary objective. The variability of management protocols and clinicians' clinical reasoning skills in the selection of splinting/immobilisation types, especially with regard to hand, orthopaedic, and plastic surgery, could, therefore, be included in a second review. The two systematic review articles share the same methodology and PROSPERO number. During the peer review process after submission to the selected journal, the peer reviewers suggested that the author include additional articles to strengthen the discussion in the two systematic review articles presented below. These included articles with content that differed from the inclusion criteria of the initial systematic review (e.g., the age of the participants being older than 18 years). However, no studies using paediatric participants were included. The rationale for not including studies with participants younger than 20 years of age is that they have not at that age reached skeletal maturity, which may affect bone healing and hand rehabilitation time periods of exercise and splinting/immobilisation. Two

exceptions to the age criteria potentially could occur during the search. The peer reviewers suggesting the inclusion of articles in the discussion and Toemen and Midgley's (2010) article. The author deemed the inclusion on Toemen and Midgley (2010) necessary and valuable due to the study design being a systematic review which searched for similar studies as our review. Toemen and Midgley (2010) included studies about second to fifth metacarpal fracture management since inception to just prior to 2008. Data management describes the organisation, storage, preservation, sharing and destruction of the data that was collected during a research study. It is an organisational process that the data that stemmed from the systematic reviews is to be destroyed after seven years.

Although the two objectives for the initial systematic review were necessary for providing information regarding the management of individuals who had sustained second to fifth metacarpal fractures, presenting the relevant information in one article proved to be a complex process. Thus, a decision was made to publish two separate articles. To be noted is that where pilot study is mentioned in the published articles, the wording should be pilot testing. Unfortunately, the wording could not be changed due to the articles already been peer reviewed and published. The first article is now presented.

First article: Phase I

The article has been published in a double peer-reviewed journal entitled, South African Journal of Physiotherapy, and was written according to the format and author guidelines as an Addendum W.

4.2 Journal details

The journal details are presented in Table 4.1 below.

Table 4.1 Publication specifics

Title of publication	Hand rehabilitation programmes for second to fifth metacarpal fractures: a systematic literature review
Authors	Monique M. Keller, Roline Barnes, Corlia Brandt, Lauren M. Hepworth
Journal name	South African Journal of Physiotherapy
ISSN	Online: 2410-8219. Print: 0379-6175
Year	2021
Volume	77 (1)
Pages	1536
DOI number	Doi: 10.4102/sajp.v77i1.1536

4.3 Permissions and rights

The first author emailed the editor of the journal requesting permission to include the article in this thesis. Permission was granted by the editor and the email is included as an Addendum X.

4.4 Article Phase I: Primary Objective

Hand rehabilitation programmes for second to fifth metacarpal fractures: a systematic literature review

South African Journal of Physiotherapy
ISSN: (Online) 2410-8219, (Print) 0379-6175

Hand rehabilitation programmes for second to fifth metacarpal fractures: A systematic literature review

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Background: Metacarpal fractures, one of the most prevalent upper limb fractures, account for 10% of all bony injuries.

Objective: Our systematic review aimed to review, appraise and collate available evidence on hand rehabilitation programmes for the management of second to fifth metacarpal fractures in an adult human population after conservative and surgical management. Since 2008, no review on a similar topic has been performed, thus informing clinical practice for physiotherapists and occupational therapists.

Methods: Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) principles guided the reporting. Experimental, quasi-experimental, cohort and case–control studies between January 2008 and September 2018 were included. Searches were conducted on Medline, Academic Search Ultimate, CINAHL, CAB Abstracts, Health Source – Consumer Edition, Health Source: Nursing/Academic Edition, SPORTDiscus, Africa-Wide Information and MasterFILE Premier, Web-of-Science and Scopus. Screening, selection, appraisal and data extraction were independently performed by two reviewers. No meta-analysis was performed.

Results: A total of 1015 sources were identified, 525 duplicates removed and 514 excluded. Three articles were included in the final data extraction: one randomised controlled trial (RCT) and two observational studies.

Conclusion: Limited evidence is available that a well-designed, well-implemented home-based exercise programme results in statistically significant improved hand function ($p < 0.0001$) and digital total active motion (TAM) ($p = 0.013$) compared with traditional physiotherapy (PT) post-surgically.

Clinical implications: Our study contributes to the knowledge base of hand rehabilitation after an individual sustained a second to fifth metacarpal fracture. The authors identified a gap where future studies should further investigate the effect of hand rehabilitation after conservative and surgical management.

Keywords: boxer's fractures; exercises; metacarpal fractures; rehabilitation; therapy.

Introduction

Metacarpal fractures are amongst the most prevalent upper limb injuries in adults (Bucholz 2009). An incidence rate (IR) for metacarpal fractures is 13.6 per 100 000 with a prevalence of 33% in the United States of America (Nakashian et al. 2012), and boxer's fractures, break of the fifth metacarpal bones, account for 20% of all hand fractures (Ali, Hamman & Mass 1999). The IR of metacarpal fractures is higher amongst males (IR 28.4) than in females (IR 4.4). Metacarpal fractures frequently occur when the hand makes contact with a solid surface, during falls and in motor vehicle accidents (Nakashian et al. 2012).

As indicated by Cooper and Wietlisbach (2014), hand rehabilitation is important to ensure optimal hand function post-surgery and during conservative management of second to fifth metacarpal fractures (Cooper & Wietlisbach 2014). Only one review on the same topic was performed in 2008. Thus, the purpose of our systematic review was to determine the available evidence on the outcomes of rehabilitation after single or multiple second to fifth metacarpal fractures sustained by adult human participants between the ages of 20 and 59 in terms of physical outcomes, disability and health-related quality of life.

Methods

Our systematic review was registered with PROSPERO (CRD42019132620). The review protocol can be accessed at https://www.researchgate.net/profile/Monique-Keller-2.

Eligibility criteria

Experimental study designs (randomised controlled trials [RCTs]), quasi-experimental, cohort studies and case–control studies from January 2008 to September 2018, with a language restriction of English, were included. Studies undertaken before 2008 were not included because a literature review had been performed up to 2008 (Toemen & Midgley 2010). Eligible studies met the following inclusion criteria: adult human participants older than 20 years and younger than 59 years of age. Those younger than 20 years were not included because of skeletal immaturity (De Sanctis et al. 2014), and very few individuals sustain metacarpal fractures after the age of 59; thus, no participants older than 59 years were included (Nakashian et al. 2012). Studies that report on post-surgical and conservative hand rehabilitation interventions include functional and/or non-functional exercises, other hand rehabilitation modalities/treatments/exercises and home education (could include advice, home education and home exercises [HEs]). Studies measuring outcomes which included, but were not limited to, hand function, health-related quality of life, disability, digital range of motion (ROM), grip strength and fine motor dexterity were included. Studies investigating thumb metacarpal fractures, associated tendon injury, infections, nerve injury or pre-existing osteoarthritis or rheumatoid arthritis were excluded, as were studies investigating second to fifth metacarpal fractures with a concurrent fracture of the phalangeal bones, carpal bones, distal radius and ulna.

A comparison was made according to the fracture site and amongst the varieties of hand rehabilitation programmes used: hand therapy modalities, exercises, immobilisation and home education, after surgical and conservative management. All control-intervention forms were included, and no limitations were applied.

Information sources and search strategy

Databases and electronic platforms were searched with the assistance of an information scientist. The keywords used during the search on CINAHL are presented in Table 1.

TABLE 1: Database search keywords.

Search	Search string
#1	Database: CINAHL ([Boxer* or metacarpal*] n2 fracture*) and (Exercise* or program* or protocol* or 'functional rehab*' or rehab* or advise* or advice* or educate* or splint* or immobilise* or physiotherapy* or 'physical therapy*' or 'occupational therapy*' or outcome*)

Note: The search was limited to January 2008 to September 2018, and also limited to English.
*, indicates boolean modifiers.

Reference lists of included full-text articles were screened for potential inclusion of further eligible studies by two independent reviewers. The Internet, with the help of Google and Google Scholar, was searched for additional grey literature. The results from the searched databases are presented in Table 2.

Study selection

All sources found during the search of the databases were subsequently imported into Endnote® (Clarivate Analytics, United States of America). Duplicates were removed. The remaining records were independently screened by two reviewers against the inclusion criteria by using the titles and abstracts. Assessment for eligibility of all remaining sources was independently performed after full-text articles were obtained for the articles included for data extraction. The inter-rater reliability of the two reviewers was high at 0.80, and a third reviewer was not needed.

Data extraction process

The reviewers independently extracted the data with the use of an adapted Cochrane data extraction document. The adapted Cochrane document was piloted on three other studies to ensure accuracy and consistency between reviewers. No changes were made after the pilot study, and one study from the pilot study was included in the final data extraction. The information that was obtained during data extraction included: study design, demographics of participants, participant numbers, participant's characteristics, fracture type, level and finger, randomisation settings and procedures, interventions, hand rehabilitation programmes, comparisons, controls, outcome measures, sampling details, statistical tests used and results as can be seen in Appendix Table 1-A1.

Methodological quality appraisal of included studies

The methodological quality of all included sources was assessed with the Joanna Briggs Institute (JBI) critical appraisal checklist to assess the risk of bias (Tufanaru et al. 2017).

TABLE 2: Databases searched and results.

Database	Number of records identified
Academic Search Ultimate	93
African-Wide Information	2
CAB Abstracts	34
CINAHL	42
Google Scholar	10
Health Source: Consumer Edition	18
Health Source: Nursing/Academic Edition	5
Scopus 21 (which indexes EMBASE)	409
MasterFILE Premier	1
MEDLINE (with full text)	220
SPORTDiscus	8
Web of Science Core Collection 21	171
Total	**1015**

Measuring the strength of the body of evidence

The grading of recommendations, assessment, development and evaluations (GRADE) method was used to test the strength of the body of evidence. The level of evidence that was accepted was of high and moderate certainty, where low and very low certainty level was documented (Oxman 2004).

Data synthesis

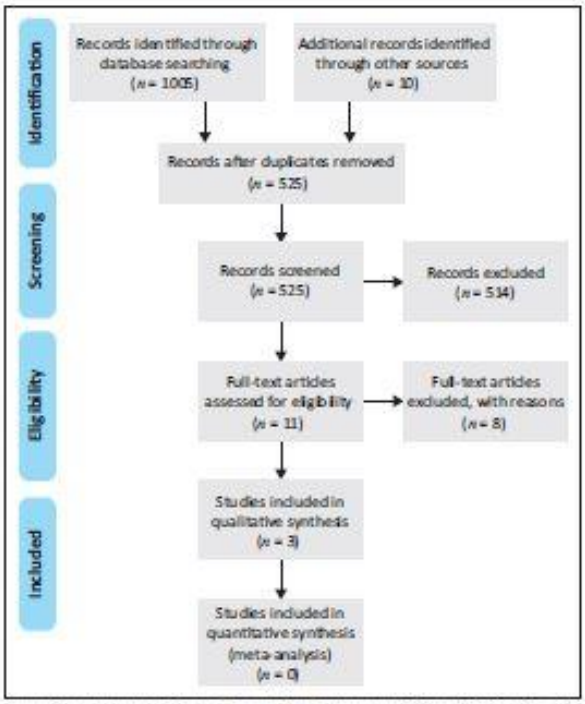
The final total of three studies was included. A meta-analysis was not deemed possible because of the limited number of studies included for data extraction. A summary of the findings is, therefore, presented in Appendix Table 1-A2 and presented descriptively in the results section.

Ethical considerations

Our study was approved by the Health Sciences Research Ethics Committee of the University of the Free State (UFS-HSD2019/0046/2602).

Results

The database searches generated a total of 1005 initial hits, with 10 additional sources from a Google Scholar search, and 490 duplicates were removed from the initial total of 1015 records. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram (Figure 1) presents how the sources were handled through the identification, screening, eligibility and inclusion phases.



Source: Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C. & Mulrow, C.D. et al., 2021, 'The PRISMA 2020 statement: an updated guideline for reporting systematic reviews', BMJ 372, n71. https://doi.org/10.1136/bmj.n71

PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis.

FIGURE 1: Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram.

Reasons for the exclusion of 514 articles by the reviewers were: languages other than English (68), paediatric sources with participants younger than 18 (37), thumb metacarpal fractures (11), tendon injuries with an associated metacarpal fracture (15), studies on animals with metacarpal fractures (88) and only surgical intervention, with no rehabilitation, for metacarpal fractures (295). Full-text versions of the remaining 11 articles were obtained and assessed for eligibility. A further eight full-text articles were excluded with detailed reasons for exclusion in Appendix Table 1-A2. The three studies included in the review were a RCT by Gülke et al. (2018) and two observational studies by Gamble et al. (2015) and Al-Qattan (2008). The RCT had a high GRADE rating because of the study design, clear reporting and no serious inconsistencies and study limitations. The remaining two included articles scored a low grading because they both were observational studies with no evidence of strong associations in the results.

Methodological quality of the included studies

Results revealed that the RCT study had a medium risk of bias where more than one criteria were not met (Gülke et al. 2018), one observational study had a moderate risk of bias because of unclear reporting of more than one criteria (Gamble et al. 2015) and one a high risk of bias because of more than one criteria not being met (Al-Qattan 2008). A detailed description of the included three articles will now be given.

Description of included studies

The first observational study by Gamble et al. (2015) included 162 individuals who sustained fifth metacarpal (neck, shaft, base) fractures. The management included buddy strapping of the fourth and fifth fingers, together with issuing a handout detailing information about the fracture, guidance on early mobilisation and the natural history of the injury. No hand therapy was administered, but a handout information sheet on early mobilisation guided the rehabilitation at home. The handout information sheet advised that the buddy strapping will allow early movement, the hand should be moved and the buddy strapping should be taken off after 1 week. Participants were cautioned that the lifting of heavy objects might be painful for 6 to 8 weeks (Gamble et al. 2015).

The outcomes included client satisfaction on a four-point Likert scale, function of the upper limb assessed with the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire and health outcomes assessed with the EQ-5D. A postal questionnaire was utilised and a follow-up telephone call at a mean follow-up period of 21.6 months (SD = 1.9) with no other follow-up appointments. Out of the 167 individuals included in the cohort, 98 individuals (59%) responded, indicating a 31% attrition rate. A total of 79 individuals (80.6%) was very satisfied with the outcome of their fracture management, EQ-5D had a median health index score of 0.87 (interquartile range [IQR] 0.74–1.00)

and hand function measured with the QuickDASH had a median score of 2.3 (IQR 0–6.8). There was a significant correlation between age and EQ-5D ($r = -0.38$, $p < 0.001$) and for the QuickDASH ($r = 0.313$, $p = 0.002$). No association between gender or fracture location with the EQ-5D or QuickDASH was found. No difference could be found in EQ-5D or QuickDASH with individuals with or without a fracture. Gamble et al. (2015) advocated a 'self-care' management for isolated fifth metacarpal fractures. Although the information leaflet provides advice for early mobilisation, the implementation and progression of early mobilisation and 'self-care' remain unclear. A retrospective study design, high attrition rate, lack of robust statistical analysis and subjective assessment of outcome measures over the telephone affect the generalisability and transferability of the results.

In the second observational study, a prospective study, by Al-Qattan (2008), adult participants between the ages of 20 and 50 years were included. All 42 individuals with 54 single and multiple spiral or long oblique metacarpal shaft fractures of the long fingers were followed up after conservative treatment. Conservative treatment included a palmar wrist orthotic with the fingers left free to move, followed by immediate active and passive mobilisation of all the affected fingers with no formal physiotherapy (PT). Outcomes included: fracture healing, extensor lag at the metacarpophalangeal joint (MCPJ), total active motion (TAM) of the MCPJ and interphalangeal joints measured with 260° possible range per digit, grip strength with a dynamometer and time before returning to work. All the outcomes except grip strength (from week 6 onwards) were measured at 2 and 6 weeks, 3 months, 6 months, 9 months and 1 year. Callus formation was radiologically visible at 6 weeks (Al-Qattan 2008).

The second week follow-up included, 54 individuals' outcomes measurement results, which were: mean extensor MCPJ lag of 26° in all fingers, TAM range mean of 234° (220° – 250°) and grip strength not assessed because of pain. Six weeks' follow-up outcome results were measured for 54 individuals: a mean MCPJ extensor lag of 19° in all fingers, TAM range mean of 241° (230° – 255°), grip strength measurements were 60% of the contralateral hand. Only five individuals were measured during the 1 year follow-up session: no MCPJ extensor lag was present, TAM range of 260° in all fingers and grip strength was 94% (89% – 96% range) compared with the uninjured hand. Of the 54 individuals, 35 were office workers or students and they all went back to their vocations between 2 and 6 weeks. There were seven manual workers and their return to work was between 6 and 8 weeks, post-injury. A high attrition rate was observed where 25 individuals' outcomes were measured at 6 weeks and only 5 at the final follow-up. A concern exists that outcome measures for pain, hand function and disability were not assessed, as these are measurements required to determine the success of a conservative and immediate mobilisation hand rehabilitation programme (Al-Qattan 2008).

In the third included study, Gülke et al. (2018) conducted a prospective cohort RCT on 60 participants who sustained a single diaphyseal or metaphyseal second to fifth metacarpal fracture. The RCT aimed to determine the effectiveness of a traditional PT programme compared with a developed HE programme after an open reduction internal fixation (ORIF) surgical management. The participants were divided into two groups, a PT and HE group with the use of standardised, controlled block randomisation. After a 2-week splinting period for both groups, the intervention and control group programme commenced. The PT group received 12 units of 30-min PT over 6 weeks (between 3 and 8 weeks after injury). The therapists administering treatment for the PT group were instructed to provide exercises that could be performed at home. No controlled PT programme existed. The HE programme group was instructed to perform the exercises three times a day, four to six exercises per session and for a period of 20 min – 30 min. For the HE programme, the first week after immobilisation included: scar treatment for five 5 min – 10 min, a chamomile bath for 5 min, decongestive massage for 5 min, three times 10 repetitions of active fist making and three times 10 repetitions of crocodile metacarpal exercises. The second week after the immobilisation included: repeat exercises from week 1 and add three times 10 repetitions of an upper limb stretching exercise ('steal and hide cherries'); for week 3 and 4: stop the decongestive massage, active fist making and crocodile metacarpal exercises. Add three sets of 10 repetitions of rolling a pen up in fingers, flexing from the distal interphalangeal joints to the MCPJ, and 10 repetitions of opening pegs with unaffected and affected fingers. For weeks 5 and 6, the pen roll-ups and peg exercises were stopped, the previous exercises were continued and three sets of 10 repetitions of ball squeezes were added. The follow-up assessments at 2 weeks post-surgery demonstrated a severe loss of digital ROM in both groups. The ROM measured at 3 months improved to 245° and 256° TAM for the PT and HE group, respectively, from a normal digit ROM of 270°. The TAM ROM for the HE group (256°) was significantly higher than the (245°) TAM for the PT group ($p = 0.013$). The grip strength measurements improved from 6 to 12 weeks for the PT group from 68% to 91% and for the HE group, from 71% to 93% compared with the uninjured hand. Mean DASH score at 6 weeks for the PT group was 30 and for the HE group 25. The mean DASH score at 12 weeks was 16 for the PT group and 14 for the HE group ($p < 0.0001$). The findings suggested that a well-developed HE programme after post-surgical management for second to fifth (non-thumb) metacarpal fractures can be as effective as traditional PT rehabilitation (Gülke et al. 2018).

From these three studies, the following could be included in a post-surgical intervention programme:

- A handout information sheet on early mobilisation and rehabilitation at home (Gamble et al. 2015).
- A palmar wrist orthotic with the fingers left free to move, followed by immediate active and passive self-mobilisation of all the affected fingers with no formal PT (Al-Qattan 2008).

- Two-week splinting followed by a developed HB exercise programme of free active MCPJ exercises, strengthening, neurodynamic exercises, stretching exercises and scar treatment (Gülke et al. 2018).

Discussion

High-level evidence (Level 1b) from the RCT included in our systematic review indicates that a well-developed and instructed HE programme after a surgical management for second to fifth metacarpal fractures is as effective or even more effective than traditional PT (Gülke et al. 2018). The variability and quality of the other included studies make it difficult to draw definite conclusions on the best hand rehabilitation programme after a surgical and conservative management for second to fifth metacarpal fractures.

Only studies from 2008 were included. A systematic review that included a wider age range and covered all literature up to 2008 is now presented and compared with the results of our review. The evidence-based treatment pathway for second to fifth metacarpal fractures was compiled by Midgley and Toemen (2010). A systematic literature review was conducted and included published sources up to 2008. The intervention entailed a period of splinting and early active mobilisation of all the unaffected joints that were not splinted. This was applied for all types of fractures. The treatment for metacarpal fractures was as follows: conservative or surgical management with K-wires was used for extra- and intra-articular fractures. At 4 weeks after the injury, light function and wrist exercises were commenced. In the instance where fracture management was performed surgically with an ORIF, light function was commenced at 2 weeks. After the conservative or K-wire management of MCPJ shaft fracture treatment, exercises were started at 3 weeks and included wrist and MCPJ active movement to regain full ROM. At 4 weeks, light function was commenced. Where the metacarpal shaft fracture was managed surgically with an ORIF, light function was introduced at 2 weeks. For neck and head metacarpal fractures that were managed either conservatively or with K-wire fixation, light function was introduced at 4 weeks. For neck and head metacarpal fractures that were managed with ORIF, light function was introduced earlier at 2 weeks. Strengthening was only commenced at 6 weeks.

Midgley and Toemen (2010) tested the developed evidence-based pathway, in an observational study, on a sample of 50 participants. The included participants' second to fifth metacarpal fractures were either managed surgically or conservatively (Midgley & Toemen 2010). Phalangeal fractures and thumb metacarpal fractures were excluded. Treatment sessions delivered by a therapist specialising in hand therapy included: fabrication of a splint, treatment and an information leaflet. Outcomes were measured based on telephonic interviews with 23 participants carried out at a period of 10–24 weeks after sustaining the injury. Splint compliance was 47%, with no complications, 72% patients had no pain, all participants who were employed had returned to work, full hand function was restored in 92% of participants and the service satisfaction was 8/10, with an average of three therapy sessions administered. A small sample size, low splinting compliance, omission of outcomes such as ROM, disability and grip strength, lack of standardised outcome measures used and assessments by using a telephonic interview, however, compromise the generalisability of the results.

The findings from Midgley and Toemen's (2010) and Toemen and Midgley (2010) studies suggest the following:

- A period of splinting and early active mobilisation of all the unaffected joints; encouragement of graded light function, self-mobilising exercises and lastly strengthening exercises could be of benefit to be included post-surgery in the rehabilitation of second to fifth metacarpal fractures.

No definite conclusion can be drawn about the best hand rehabilitation programme after surgical or conservative management for second to fifth metacarpal fractures based on the previous review by Midgley and Toemen (2010) and our review. The possible reasons are different management approaches used amongst participating healthcare practitioners, the limited number of high-quality studies, the presence of heterogeneity and the strict inclusion criteria, ages and years, in our review. There are, however, studies describing early active mobilisation in various age groups that may improve a post-surgical and conservative programme (Debnath et al. 2004; Feehan & Bassett 2004; Khan & Giddins 2015; Muller et al. 2003; Retrouvey, Morzycki & Wang 2018; Wong & Higgins 2017; Yalizis et al. 2017).

This is however contradicting the question asked by Retrouvey et al. (2018) on whether we are overtreating hand fractures. Based on this controversy and research question they conducted a national survey in Canada. The cross-sectional survey was completed by 113 plastic surgeons, where 50% of the participants had more than 15 years of experience. Seventy-three per cent of surgeons prefer splinting and early active ROM, where 21% would instead immobilise the fracture after splinting and no early mobilisation. An interesting finding was that years of experience and practice did not influence the decision between surgical or non-surgical approaches, but the surgeons with more years of practice did not refer their patients to hand therapists (Retrouvey et al. 2018). Perhaps the reason for the paucity in hand rehabilitation programmes found in this review could be because of a lack of referral to a hand therapist.

Feehan and Bassett (2004) conducted a systematic literature review to assess the effectiveness of early mobilisation on function and fracture healing for individuals who sustained extra-articular hand fractures. Studies included those investigating the comparisons between a complete immobilisation of joints proximal and distal to the fracture and an early mobilisation commenced before 21 days of one or both joints proximal and distal to the fracture. The authors

concluded that no level I or II evidence could be found to support or refute early motion ≤ 21 days of the joints surrounding the fracture. Interestingly, as in our review, the authors could only give a narrative description of the results because of the limited number and heterogeneity amongst sources.

Further evidence for early mobilisation was found in a study by Debnath et al. (2004) who conducted a prospective study on 17 participants after fifth metacarpal shaft fractures. Management included reduction and hand-based casting to immobilise the fracture for 1 month where the wrist and MCPJs were left free for immediate mobilisation. The fractures of three participants lost the reduction (15° – 20° of angulation), but after a 6-month follow-up, all fractures healed fully with no functional deficits. Khan and Giddins (2015) also used early mobilisation after conservative management for 25 participants who sustained spiral metacarpal fractures. The outcome measures of grip strength and ROM ranged from good to excellent and all fractures healed after 6 months. Another prospective RCT included 35 participants who had sustained a boxer's fracture with an angulation of 15° – 70° (Muller et al. 2003). A 3-week immobilisation period was compared with a pressure dressing applied for 1 week with immediate immobilisation. No statistically significant difference was found for pain, ROM and satisfaction outcomes at a 3-month follow-up. Van Aaken et al. (2016) in a high-grade evidence-based, randomized, multicentre trial on 68 participants who sustained boxer's fracture with ≤ 70° angulation and no rotational deformities compared immediate active wrist and finger mobilisation to forearm wrist POP immobilisation. Both groups had good outcomes. The only statistically significant difference was days off work. On an average, the participants of the early mobilisation groups returned to their occupation 11 days earlier ($p = 0.03$).

After a surgical management, early mobilisation also seems to be successful. An observational study on 16 Australian Rules football players who sustained second to fifth metacarpal fractures and managed surgically with reduction and fixation (Yalizis et al. 2017) showed a return to professional play in 2 weeks with a soft glove and a protective dressing to protect the sutures with good hand function in 12 participants. Fracture union was seen in all participants at 6 weeks. These studies give a reasonable assurance that early mobilisation after surgical and conservative management is safe in shaft and boxer's fractures, which are minimally displaced (Wong & Higgins 2017).

Recommendations

Based on our review the standardised outcome measurements used in assessing outcomes improve the transferability of the HE programme and have the added benefit of potentially saving resources for stakeholders, medical staff and injured individuals across the world (Gülke et al. 2018). This is especially beneficial in countries where the incidence of metacarpal fractures is high because of violence and the resources and hand rehabilitation expertise are limited. However, generalisation is difficult as countries with limited resources do not always have the instrumentation at their disposal to perform ORIF. Future high-quality research is recommended where an HE programme is implemented not only for individuals with second to fifth metacarpal fractures that were managed surgically with an ORIF but also for conservative and K-wire management, to inform clinical practice when surgical management is not indicated and in countries where surgical interventions are not always possible because of limited resources.

Limitations

The lack of controlled studies and heterogeneity of the included studies prevented the conduction of a systematic review of efficacy, which would be the design of choice to determine the highest level of evidence in this field.

Conclusion

Level 1b evidence is available from an RCT indicating that a well-designed HE programme is the best and most effective rehabilitation programme after surgical management for second to fifth metacarpal fractures, where the hand function and digital TAM are statistically and significantly higher than the traditional PT programme group (Gülke et al. 2018). Some evidence is available on early active mobilisation for minimally displaced, conservatively managed, spiral and long oblique metacarpal shaft fractures (Al-Qattan 2008) and fifth metacarpal fractures (Gamble et al. 2015).

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

M.K. proposed the topic of research, which was refined with the help of R.B., C.B. and M.K. wrote the protocol for ethical approval and the first version of the article. The article was read, elaborated and refined with the help of R.B., C.B. and L.H.

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Data availability

The authors confirm that the data supporting the findings of this study are available within the article [and/or], in its supplementary materials. Any future results will be made accessible on the authors' ORCID accounts.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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Appendices starts on the next page →

Appendix 1

TABLE 1-A1: Summary of findings.

Authors	Sampling strategy	Description of rehab/exercise/ splint modality	Follow-up periods	Profession delivering intervention	How is treatment delivered	Outcome measures used (for each outcome)	Results on outcomes 1st assessment (Copy for each outcome)	Results on outcomes 2nd and more assessments (Copy for each outcome)	Grade
Al-Qattan (2008) (No control group)	Purposive sampling (all patients with spiral or long oblique metacarpal shaft fractures of the fingers who were treated conservatively with a palmar wrist splint between 2003 and 2006 were studied prospectively).	No formal PT Active and passive exercises of all finger joints.	2 weeks, 6 weeks, 3 months, 6 months, 9 months, 1 year (patients included with a minimum of 6 weeks follow up)	Doctor (surgical)	Conservative management (face to face)	TAM Grip strength	*N* = 54 2 weeks TAM = lag of 26° (mean range - 234°) Grip strength = difficult to assess 6 weeks TAM = mean lag of 19° (mean range - 241°) Grip strength = 60% *N* = 36 3 months TAM = mean lag is 15° (mean range = 253°) Grip strength = 74%	*N* = 25 6 month TAM = 5° lag in 2 (mean range - 260°) Grip strength = 81% *N* = 11 9 months TAM = 260° Grip strength = 90% *N* = 5 TAM = 260° Grip strength = 94%	Low
Gamble et al. (2015) (No control group)	Purposive sampling (The patient cohort was collated from a search of the Emergency Department's information system, Omnis, that identified patients directly discharged from the Emergency Department with a fracture of the fifth metacarpal.	Functional bracing - neighbour strapping (buddy) Information leaflet - outlining diagnosis, advice for early mobilisation and a helpline contact number	No follow up (but questionnaire sent out a minimum 1-year post-intervention)	Emergency medicine doctor or emergency nurse practitioner	Bracing Information leaflet	Satisfaction Likert scale EQ-5D Quick Dash	Post 1 year: 80.6% were very satisfied Median EQ-5D = 0.87 Median Quick Dash = 2.3	No other outcomes measured	Low
Gülke et al. (2018)	Standardised controlled block randomization.	Custom made Functional dorsal orthotic device (Light Cast) fixated with an elastic wrap. MPIs = 70 flexion; PIP, DIPIs free movement. Removed post 2 weeks. Physio teaching exercises that can be done at home After week 8, exercises carried out independently	Group 1: 2 weeks post-surgery: 12 units of PT over 6 weeks (week 3–8) Week 8–12: Independent (Group 1 & 2) Reassessment at week 12	Hand surgeon Physio	Individual physio session (30 mins twice per week)	ROM (neutral zero methods) Week 2: MPI: 42.5° PIPJ: 88.3° DIPJ: 89.1° Jamar Dynamometer DASH	ROM Week 6 MPI: 61.7° PIPJ and DIPJ - increased a little Grip strength Week 6 68% DASH Week 6 Score 30	ROM Week 12: MPI: 73.3° Grip strength Week 12 91% DASH Week 12 Score 16	High
Gülke et al. (2018) Control group	Standardised controlled block randomization.	Custom made Functional dorsal orthotic device (Light Cast) fixated with an elastic wrap. MPIs = 70 flexion; PIP, DIPIs free movement. Removed post 2 weeks. Exercise booklet with pictures, individual exercises. Questions answered by hand surgeon after reading.	Group 2: 2 weeks post-surgery: independent exercises (week 3 - 8) Week 8–12: Independent (Group 1 & 2) Reassessment at week 12	Hand surgeon Self-management	Exercise booklet	ROM (neutral zero method) Week 2 MPI: 46.5° PIPJ: 86.8° DIPJ: 89.8° Jamar Dynamometer DASH Documenting exercise	ROM Week 6 MPI: 68.5° PIPJ and DIPJ - increased a little Grip strength Week 6 71% DASH Week 6 Score 25	ROM Week 12: MPI: 73.3° Grip strength Week 12 93% DASH Week 12 Score 14	

Appendix 2

TABLE 1-A2: Reasons for exclusion.

Authors	Inclusion Criteria				Exclusion Criteria				Comments
	Study design: Experi, quasi, RCT, cohort, case-control (2008 –2018)	Participants 20 – 59 years	Intervention: post-surgical, hand rehab, home ed, immob	Outcomes: Function and pre-functional	Presence of tendon or nerve injury; pre-existing arthritis	Other # (phalanges, carpals, radius and ulna)	Thumb metacarpal #	Presence of infections	
Al-Qattan	✓ (prospective/cohort)	✓	✓	✓	x	x	x	x	
Cepni et al.	✓ (prospective)	x	✓	✓	x	x	x	x	Excluded due to not meeting full inclusion criteria (18 year patients)
Gamble et al.	✓ (retrospective)	✓	✓	✓	x	x	x	x	
Gulabi et al.	✓ (retrospective)	X (age range 10 – 66 years)	-	-	-	-	-	-	Excluded due to not meeting full inclusion criteria
Gulke et al.	✓	✓	✓	✓	x	x	x	x	
Khan & Giddins	✓ (prospective)	X (age range 17 – 60 years)	-	-	-	-	-	-	Excluded due to not meeting full inclusion criteria
Klibanoff & Potter	?	-	-	-	-	-	-	-	Excluded - only abstract given
MacDonald et al.	✓ (prospective)	X (age range 11 – 54 years)	-	-	-	-	-	-	Excluded due to not meeting full inclusion criteria
Midgley & Toeman	✓ (prospective)	X (age greater than 16 years)	-	-	-	-	-	-	Excluded due to not meeting full inclusion criteria
Moon et al.	✓ (retrospective)	X (age range, 16 –73 years)	-	-	-	-	-	-	Excluded due to not meeting full inclusion criteria
Strub et al.	✓ (experimental)	X (group B range from 21 – 70 years)	-	-	-	-	-	-	Excluded due to not meeting full inclusion criteria

Second article: Phase I

4.5 Introduction

The article has been published in a double peer-reviewed journal, entitled South African Journal of Orthopaedics, and was written according to the format and author guidelines, as in Addendum Z.

4.6 Journal details

The journal details are presented in Table 4.6 below.

Table 4.6: Publication specifics

Title of publication	**Splints and immobilisation approaches used for second to fifth metacarpal fractures: a systematic review**
Authors	Monique M. Keller, Roline Barnes, Corlia Brandt, Lauren M. Hepworth
Journal name	South African Orthopaedic Journal
ISSN	Published Online
Year	2022
Volume	21
Pages	82-88
DOI number	Doi: 10.17159/2309-8309/2022/v21n2a3

4.7 Permissions and rights

The first author emailed the editor of the journal requesting permission to include the article in this thesis and is presented in Addendum Y.

4.8 Article Phase I: Secondary Objective

Splints and immobilisation approaches used for second to fifth metacarpal fractures: a systematic review

South African Orthopaedic Journal

HAND

Splints and immobilisation approaches used for second to fifth metacarpal fractures: a systematic review

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Abstract

Background

The second to fifth metacarpal fractures are immobilised with splints, plaster of Paris (POP) or buddy strapping for a period of time. However, no recent evidence-based splinting and immobilisation programme exists for the management thereof, leaving a gap in the literature to inform clinical practice. This review aimed to review, appraise and collate the literature on splints and immobilisation approaches used for second to fifth metacarpal fractures after surgical and conservative management in adults aged 20 to 59 years.

Methods

The review included experimental study designs, quasi-experimental studies, cohort studies and case-control studies from January 2008 to September 2018. Two reviewers independently screened, selected, appraised and extracted data from the included studies. Preferred reporting items for systematic reviews and meta-analysis (PRISMA) guided the reporting. Joanna Briggs Institute (JBI) critical appraisal tools were used to assess the risk of bias for each included study.

Results

Database searches generated 1 005 articles with ten additional articles found on Google Scholar. Ten articles were included: two randomised controlled trials (RCTs), one quasi-RCT, four prospective studies, one retrospective record review, one retrospective study and one comparative study with descriptive reporting of the results.

Conclusion

High level 1b evidence suggests that no reduction, a soft wrap and buddy strapping for three weeks with early active finger and wrist mobilisation are effective for individuals who sustained boxer's fractures with ≤ 70° angulation. To guide clinical practice, high-level research is needed to determine the immobilisation of second to fifth metacarpal fracture types.

Level of evidence: Level 2

Keywords: boxer's fracture/s, immobilisation, metacarpal fractures, splints, orthosis

Introduction

Metacarpal fractures account for 10% of bony injuries and are one of the most prevalent upper limb injuries among adults.[1] Among all hand fractures identified in the United States (US), metacarpal fractures have an incidence rate of 13.6 per 100 000 persons per year and a prevalence of 33%.[2] Fifth metacarpal neck fractures or boxer's fractures account for 10% of all hand fractures that have left individuals with functional deficits, including weakened grip strength and decreased metacarpal joint range of motion (ROM).[3] The concern is the residual deficits that impact the young and working adult population as they seem to sustain metacarpal fractures more often.[4] The potential functional implications of sustaining a second to fifth metacarpal fracture can impact the individual in all components of the International Classification of Functioning, Disability and Health (ICF) framework, namely body functions and structures, activity and participation.[5]

The problem is that no best-evidence splinting and immobilisation programme exists to inform clinical practice. This can lead to disability, decreased hand function and poor health-related quality of life (HRQoL). A period of immobilisation is widely deemed part of the management after sustaining second to fifth metacarpal fractures.[6] Surgical intervention includes open reduction internal fixation with compression and plates, screws, or

Kirshner wires (K-wires) to improve stability, followed by a period of immobilisation.[7-9] Conservative management includes closed reduction if required, with external protection utilising a splint, U-shaped, non-circumferential plaster of Paris (POP), strapping the injured metacarpal finger to the adjacent uninjured metacarpal finger (buddy strapping) or mobilisation.

Splints and immobilisation approaches for second to fifth metacarpal fracture management vary in the literature. Fabrication of customised splints requires technical skill, in-depth knowledge of pathology and anatomy, bone-healing time frames, and surgery. Occupational therapists and physiotherapists trained in the management of hand injuries are qualified to choose, design, apply, individualise and adjust splints according to their specific needs, and administer rehabilitation programmes. Reviewing existing literature on splints and immobilisation approaches used for second to fifth metacarpal fractures would provide an appraisal of evidence on the various splints and immobilisation approaches currently used to provide guidance to clinicians in clinical practice.

Therefore, the research question guiding the scoping type systematic review was: What evidence is available for conservative and post-surgical splints and immobilisation approaches utilised (including, but not limited to, POP and/or splints) as part of initial management for adults older than 20 years and younger than 59 years of age, reporting on outcomes which included, but were not limited to, hand function, HRQoL, disability, digital ROM, grip strength and fine motor dexterity after sustaining single or multiple second to fifth metacarpal fractures?

The review's objective was to determine the immobilisation and splint approaches utilised for post-surgical and conservative management for 20- to 59-year-old adults who sustained a single or multiple second to fifth metacarpal fracture.

Methods

This research was registered with PROSPERO (number CRD 42019132620), and the review protocol adhered to PRISMA recommendations.[10] Databases accessible to the University of the Free State and the electronic platforms searched were: Academic Search Ultimate, MEDLINE with Full Text, CINAHL with Full Text, CAB Abstracts, Health Source: Consumer Edition, Africa-Wide Information, Health Source: Nursing/Academic Edition, SPORTDiscus with Full Text and MasterFILE Premier with additional searches on Scopus and Web of Science. An information scientist, an expert librarian at the University of the Free State was consulted and assisted with searching databases and searching for databases. The reference lists of included full-text articles were screened for additional research/articles. An additional search for grey literature was performed on the internet with Google and Google Scholar with the keywords: boxer's fracture/s, immobilisation, metacarpal fractures, splints, orthotic devices, splinting with Boolean operators. An example of the search strategy keywords for one database is presented in *Table I*.

An adapted Cochrane document for randomised controlled trials (RCT) and non-RCTs (Cochrane website) was piloted on three studies to ensure accuracy and consistency. Two independent reviewers independently screened, selected, appraised and extracted data from three eligible studies. The pilot study was undertaken to assess the consistency of the review procedures. Joanna Briggs Institute (JBI) critical appraisal tools were used to assess risk of bias for the pilot studies.[12] No changes were made after the pilot study, a high inter-rater agreement was found, and one of the pilot studies was included in the final data extraction.

Eligibility

Intervention studies in English for the period January 2008 to September 2018 were included. Eligible studies complied with the following inclusion criteria: adult participants between 20 and 59 years of age, reporting on conservative and post-surgical immobilisation and splints utilised (including, but not limited to, POP and/or splints, buddy strapping) for single or multiple second to fifth metacarpal fractures. Studies with participants younger than 20 years were not included due to skeletal immaturity.[11] Nakashian et al. reported that very few individuals sustain metacarpal fractures after 59 years of age.[2] Thus, studies with participants older than 59 years were omitted. Studies reporting on outcomes included, but were not limited to, hand function, HRQoL, disability relating to the loss of hand function, digital ROM, grip strength, return to work, and fine motor dexterity.

Exclusion criteria were studies investigating thumb metacarpal fractures, studies investigating second to fifth metacarpal fractures with an associated tendon injury, nerve injury or pre-existing osteoarthritis or rheumatoid arthritis. Studies reporting on concurrent fractures of the phalangeal, carpal, distal radius and ulna bones were also excluded. Studies reporting on fractures with infections were also excluded.

Table I: Search strategy keywords

Search	Search string
#1	Database: CINAHL ((boxer* or metacarpal*) n2 fractur*) and (exercis* or program* or protocol* or "functional rehab"* or rehab* or advis* or advic* or educat* or splint* or immobil* or physiotherap* or "physical therap"* or "occupational therap"* or outcome*)

Screening

After the database searches, all identified articles were imported into Endnote® (Clarivate Analytics, PA, USA), and duplicates removed. Two reviewers independently screened the identified articles against their titles and abstracts. The remaining articles were independently assessed for eligibility according to the inclusion criteria in a standardised and unbiased manner. Disagreement in selecting included articles was resolved between the reviewers. Inter-rater reliability of 0.80 Cronbach's alpha among the two reviewers during the second phase indicated a substantial agreement and consensus during the eligibility phase. Full-text articles were retrieved for all eligible articles. Data was extracted from the included articles using the piloted data extraction template.

Data extraction

The database searches generated 1 005 research articles, with ten additional articles identified through a Google Scholar search,

Table II: Database search results

Database	Number of records identified
Academic Search Ultimate	95
African-Wide Information	2
CAB Abstracts	34
CINAHL	42
Google Scholar	10
Health Source: Consumer Edition	18
Health Source: Nursing/Academic Edition	5
Scopus 21 (which indexes EMBASE)	409
MasterFILE Premier	1
MEDLINE (with Full Text)	220
SPORTDiscus	8
Web of Science Core Collection 21	171
Total	**1 015**

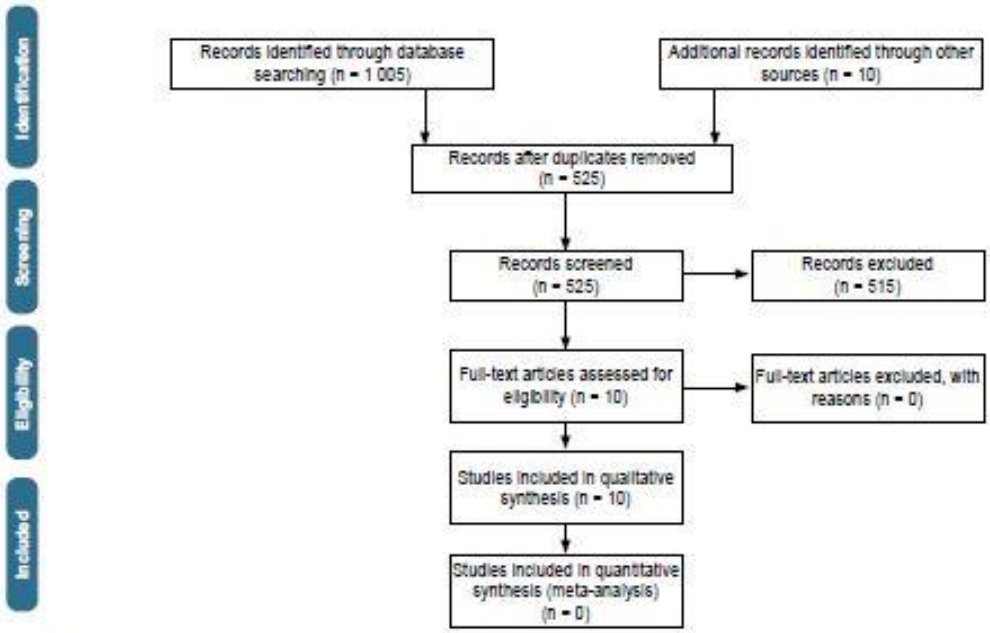

Figure 1. PRISMA 2009 flow diagram[10]

resulting in 1 015 articles (*Table II*). From the total 1 015 research articles, 490 duplicates were removed, with 525 articles remaining for screening by the two reviewers. The reviewers excluded 515 articles due to languages other than English (69), paediatric articles (37), metacarpal fractures with associated tendon injuries (15), studies performed on animals (88), articles reporting on only surgical intervention for metacarpal fractures (295) and other sources with participants older than 59 years and first (thumb) metacarpal fractures (11) (*Figure I*).

Assessment of the methodological quality

The reviewers independently assigned a grade and assessed the risk of bias for each included study, with the JBI critical appraisal tools assessing the studies' relevance, results and trustworthiness.[12] Depending on the study design, the aspects assessed were: use of true randomisation, concealment of allocation to treatment groups, clear description of the study setting, and included participant numbers, whether the exposure to the measurement was valid and reliable, identification of confounding variables, strategies to deal with confounding variables reported on, outcomes measured reliably and validly, appropriate statistical analysis, to name a few.

To ensure methodological rigour, the reviewers assessed all the included eligible articles according to the grading of recommendations assessment, development and evaluation (GRADE) method.[13] A high and moderate certainty level of evidence was accepted, and a low and very low certainty level was documented.[11]

Ten articles were included in totality, showing a dearth of literature in the field. Two articles had high-quality ratings, one moderate quality, and seven low-quality ratings, as shown in the summary of the findings table available online (*Supplemental table*). High-quality rating indicated confidence in estimating effects, and future research is unlikely to affect or change the confidence. A moderate quality rating indicated that further research is likely to impact confidence and may even change the estimate. A low quality indicated that future research has a very high likelihood of impacting the confidence in effect estimation.[13] A narrative analysis of all ten included articles is provided with a summary of the findings in the supplemental table (https://saoj.org.za/index.php/saoj/article/view/524/628).

Results

According to the objective, the presentation of the narrative results below is to appraise and collate the literature on splint and immobilisation approaches for conservative and post-surgical immobilisation and splint approaches used in 20- to 59-year-old patients who sustained a single and/or multiple second to fifth metacarpal fracture(s) according to the specified fracture levels.

Evidence on shaft metacarpal fractures

A prospective study conducted in Saudi Arabia investigated the conservative management of spiral and long oblique shaft fractures of second to fifth metacarpal bones.[14] Participants presenting with minimally displaced, no significant angulation fractures with no rotation malalignment, were included in the study.[14] A low GRADE quality of evidence rating was given. Management included immobilisation using a wrist POP (20° to 30° wrist extension with fingers free) for two weeks, which was followed by mobilisation guided by a home programme. Follow-up occurred at two weeks, six weeks, three months and six months postoperatively (n = 42). Extension lag was noted in all participants (50%) at two and six weeks, but no extension lag was reported at six months. Total active motion (TAM) and grip strength were significantly increased by six months with a resulting mean TAM of 260° and 90% grip strength compared to the contralateral hand.[14]

A prospective study conducted in the United Kingdom included 30 individuals who sustained single or multiple, middle or border, closed spiral metacarpal fractures.[15] All participants had fractures with malrotation.[15] A low GRADE quality of evidence rating was given. Management included both no splint and thus no

immobilisation. Gradual early mobilisation was encouraged. The participants had to make a fist, up to 2 cm measured from finger to the palm, before they were discharged. Twenty-five participants attended the follow-up session. At seven days after injury, malrotation was measured through visual observation, and no formal X-ray measurements were taken. Malrotation was present in a third of the participants during the clinic follow-up session. The outcomes measured between six and 14 months after injury included: ROM, grip strength, palpation of the fracture site to assess bone union, obtaining verbal feedback from participants on a scale of poor, fair and good, verbally assessing functional limitations, verbally assessing cosmetic satisfaction of the hand on a scale of good, fair and poor, and shortening of the fingers. Fingers shortening ranged between 2 and 5 mm with a mean of 4 mm. The authors concluded that good hand function and no clinically significant sign of malrotation was present.[15] The lack of formal X-ray measurements to ensure optimal bone healing and guide management is a concern. Not using standardised outcome measures for hand function compromised the generalisability and quality of the findings.

In Nova Scotia, a prospective research study was conducted on 61 patients with second to fifth non-scissoring spiral metacarpal fractures where they were managed conservatively.[16] A low GRADE quality of evidence rating was given. Exclusion criteria included metacarpal fractures requiring surgical intervention and thumb fractures. Conservative management included immobilisation in a splint moulded to 20° of wrist extension, affected metacarpophalangeal joint (MCPJ) with one adjacent unaffected MCPJ in 30° flexion and the interphalangeal joints extended for one week. After one week, the splint was removed for showering, exercises, and at night for the patients deemed to be compliant and who no longer took pain medication or experienced pain. The splint was kept on during sleep periods and for more demanding activities during the day. During less busy daytime periods, the splint was removed, hands were moved when movements did not cause pain, but no other use of the hand was allowed. The splint was removed after three weeks. Grip strength and ROM as outcomes were measured at three, six and ≥ 22 weeks after the injury. At five months, the final follow-up, the mean grip strength for the uninjured hand was 36.18 kg and the injured hand 36.58 kg.[16]

From these three studies, the following splint can be used with confidence for individuals who sustained second to fifth metacarpal shaft fractures:

- Thermoplastic splint with the wrist in 20–30° with the fingers free.

Evidence on neck and shaft of fifth metacarpal fractures

A Turkish retrospective record review comparative study was conducted on 140 participants with a mean age of 30.56 years. A low GRADE quality of evidence rating was given. The inclusion criteria included sustaining an isolated, extra-articular, neck or shaft fifth metacarpal fracture with more than 30° of angulation. The participants were allocated to two groups.[17] The management of group A included reduction and immobilisation of the fourth and fifth fingers in a short arm POP with the following joint positions: wrist 30° extension, MCPJ 45° flexed, proximal interphalangeal joints (PIPJs) and distal interphalangeal joints (DIPJs) in 15° flexion for a mean of 29.15 days. Group B's management included reducing and immobilising the fourth and fifth fingers in a U-shaped gutter splint with the following joint positions: wrist 30° extension, MCPJ 45° flexed, PIPJs and DIPJs in 15° flexion for a mean of 29.15 days.[17] After removing the POP and splints, an X-ray was taken, and bone healing clinically assessed with pain present or absent on the fracture line. A month later, assessments were performed including: ROM with a goniometer, clinical assessment of rotational deformity in the fifth finger and grip strength of the dominant and non-dominant hands with a Jamar hand dynamometer. Group A scored 90.38% grip strength compared to the unaffected side, and group B 90.58%. Two participants from group A and group B had a 10° extension lag. In group A, two participants had hypoesthesia along the ulnar nerve's dorsal cutaneous branch, which resolved in three weeks. One participant presented with a superficial wound between the third and fourth webspace due to POP pressure. No complications were experienced in group B. No significant statistical difference was found between groups for grip strength, range of motion (ROM) and dorsal angulation.

A clinical concern is that group A and group B, the wrist, PIPJ and DIPJ joints were included with possible reporting bias where complete ROM reporting was omitted. In the POP group, the long period of immobilisation caused pressure points and neuropraxia. The participants preferred the U-shaped ulnar gutter splints for their comfort, which clinicians should consider.

From these studies:

- No best-evidence splinting and immobilisation approach can be deducted as unaffected joints are included in the immobilisation.

Evidence on neck, shaft and base of fifth metacarpal fractures

A retrospective study was conducted in Glasgow, on 162 individuals who sustained fifth metacarpal (neck, shaft, base) fractures.[18] A low GRADE quality of evidence rating was given. Exclusion criteria included dislocations, open injuries, intra-articular fractures, significant rotational deformities and polytrauma. The management had buddy strapping of the affected fifth finger to the neighbouring fourth finger for one week that allowed early active mobilisation, with information and no follow-up sessions. The information provided to the participants included an explanation of the fracture, guidance on how to commence early mobilisation and the natural history of the injury.[18] Assessments were performed at a mean follow-up period of 21.6 months via a postal questionnaire and a follow-up telephone call. Outcomes assessed were: satisfaction with the injury outcome and the process on a four-point Likert scale, hand function with the QuickDASH, and disability with the EQ-5D. Response from 59% of the contacted individuals indicated satisfactory outcomes. The results revealed a median EQ-5D score of 0.87 (interquartile range [IQR] 0.74–1) out of a possible best score of 1 and a median QuickDASH score of 2.3 (IQR 0–6.8). Normative QuickDASH data used to make comparisons were a mean of 10.9, median 4.5, a standard deviation of 15.3, IQR 0–14.3 and a range of 0–88.6. Eighty-three participants (84.9%) were satisfied with the management process, and 79 participants (80.6%) were satisfied with the outcome of their injury. No significant difference was found when comparing EQ-5D ($p = 0.307$) and QuickDASH ($p = 0.820$) scores of uninjured individuals.[18]

A lack of reporting on outcomes, such as pain information measured with the EQ-VAS, which is part of the EQ-5D, TAM of the fifth finger and grip strength, affects the generalisability of this study's results to other populations. However, in a well-selected group of individuals who sustained fifth metacarpal neck, shaft and base fractures, the management pathway adds a valuable option for clinicians, especially in settings with limited resources. The benefits include decreased orthopaedic and hand therapy follow-up sessions, with positive financial and time implications for both government and patients.

From the studies, the immobilisation that can be used with moderate confidence, for individuals who sustained single or multiple neck, shaft or base of fifth metacarpal fractures, is:

- Buddy strapping the fifth to the fourth finger.

Evidence on neck of fifth (boxer's) metacarpal fractures

In Switzerland, a randomised multicentre trial on 68 participants who sustained fifth metacarpal neck fracture with ≤ 70° of angulation and no rotational deformities was conducted.[19] A high GRADE quality of evidence rating was given. The 68 participants were allocated to two intervention groups. Management for one group included no reduction, a soft wrap around the palm, and a buddy strap around the fourth and fifth fingers for three weeks. Immediate active wrist and finger mobilisation was encouraged with the soft wrap/buddy strap as conservative management. The other intervention included a reduction followed by a forearm wrist POP immobilisation extending to the PIPJ with MCPJ in extension for four weeks.[19] The QuickDASH questionnaire results at four months displayed a mean difference of −10.9 between the groups indicating no significant difference. For other outcomes: pain, MCPJ ROM, grip strength, and aesthetic appearance, no significant differences were found. However, a significant difference was measured with days off work. The soft wrap and buddy strapping group participants returned to their occupation on average 11 days sooner than the reduction and POP immobilisation group ($p = 0.03$).[19] The evidence provides clinical guidance that using a soft wrap and buddy strapping is as effective as reduction and POP immobilisation with no complications for neck of fifth metacarpal (boxer's) fractures with ≤ 70° of angulation and no rotational deformities.

In Turkey, a comparative study included 24 male participants working in professional environments and who sustained uncomplicated closed fifth metacarpal neck fractures.[20] A low GRADE quality of evidence rating was given. The participants were allocated to either a conservative or a surgical group based on preference.[20] The conservative management group's intervention consisted of the Jahss closed reduction manoeuvre and immobilisation in a U-shaped ulnar gutter splint. The U-shaped splints positioned the fourth and fifth MCPJs and the PIPJs and DIPJs in a slightly flexed position. Follow-up appointments were conducted on the second and seventh days post-reduction, with the splint removed after four weeks. The surgical group underwent closed reduction with the Jahss manoeuvre and insertion of two K-wires. U-shaped ulnar gutter splints were applied directly after wound dressing for the surgical group and were removed after seven days.

The participants were allowed to perform self-care and other light everyday activities. Outcomes included: satisfaction and hand function on days 30 and 45 follow-up, with the QuickDASH questionnaire, TAM, angulation, shortening and rotation of the fractures at 30 days follow-up and return to work. All participants returned to work by 30 days postoperatively. No statistically significant difference between the conservative and surgical groups was seen in TAM, final shortening and final angulation. However, statistically significant differences were seen when the surgical group returned to work earlier ($p < 0.001$) and presented with improved hand function ($p < 0.05$). The recommendation from the authors was that antegrade intramedullary K-wire fixation for fifth metacarpal fractures should be performed.[20] Randomisation, according to preference, is a limitation and a methodological flaw that affects the trustworthiness of the results. The prolonged period of immobilisation in the U-shaped ulnar gutter splints, which crosses the wrist for four weeks as conservative management compared to only seven days post-surgical immobilisation, may be the reason for a statistically significant difference in hand function and return to work. For clinical practice, it is advisable to have a shorter immobilisation period to avoid stiffness and facilitate earlier return to work. Also imperative is not to include unaffected joints in the splints to improve the hand's functionality.

In a Swiss study, 40 individuals sustained a closed neck of fifth metacarpal fracture with palmar displacement of 30° to 70°.[21] A moderate GRADE quality of evidence rating was given. Pseudo-randomisation was used to allocate 20 participants to the surgical group and 20 participants to the conservative group. The surgical group was managed with a Jahss manoeuvre reduction, K-wire insertion followed by a five-day immobilisation in a palmar two-finger splint, followed by a metacarpal hand-based brace (thermoplastic splint covering the dorsal and palmar aspects of the metacarpals of the fourth and fifth fingers) for five weeks where functional mobilisation was encouraged. K-wires were removed at three months. The conservative group received no reduction, with immobilisation for five days in a palmar two-finger splint, followed by functional mobilisation in the metacarpal hand-based brace for five weeks. No hand therapy was prescribed for either group. Follow-up appointments were: two and six weeks, three, six, and 12 months. Outcomes measured included: fifth finger MCPJ ROM, palmar angulation, MCPJ shortening, grip strength, and patient satisfaction. The mean fifth MCPJ ROM for the operative group was 98° and 96° for the conservative group compared to the unaffected side. At one year, the surgical group's mean grip strength was 51 kg, and 46 kg for the conservative group. None of the ROM or grip strength was statistically significantly different between groups. The surgical group indicated higher satisfaction scores and satisfaction with hand appearance.[21] The metacarpal hand-based thermoplastic splint used as immobilisation covered the metacarpal and the metacarpal head without covering the wrist or PIPJs. Strub et al. found similar results to Van Aaken et al., where conservative management for boxer's fractures with ≤ 70° degrees of angulation had satisfactory patient satisfaction outcomes, MCPJ ROM and grip strength.[19,21] A palmar two-finger splint, followed by a metacarpal hand-based brace, supports the fracture site while allowing hand function and ROM while the fracture is healing.

From the three studies, the following splints can be used with confidence for individuals who sustained neck of fifth metacarpal fractures:

- Soft wrap and buddy strapping the fifth to the fourth fingers for three weeks.
- Palmar two-finger splint for five days followed by applying a thermoplastic metacarpal hand-based splint including the fourth and fifth MCPJs for five weeks.

In conclusion, in carefully selected individuals who sustained fifth neck of metacarpal fractures, buddy strapping and metacarpal hand-based splint immobilisation provide comfort, improved hand function, less stiffness and earlier return to work.

Evidence on second to fifth (not yet covered in other objectives) metacarpal fractures

A German prospective cohort RCT was conducted on 60 participants who sustained non-thumb metacarpal fractures.[9] A high GRADE quality of evidence rating was given. The aim was to measure the effectiveness of a traditional physiotherapy (PT) programme compared to a home exercise (HE) programme after surgical management with open reduction internal fixation procedures. The 60 individuals were divided into two groups. Standardised controlled block randomisation was used to randomise participants into either a PT or HE group. A dorsal splint, including wrist, placed the MCPJ at 70° flexion (the interphalangeal joints were not included in the splint to move without restriction), was issued to both group participants for two weeks, after which the intervention and control group programmes commenced. The follow-up assessments at two weeks postoperatively demonstrated a severe loss of digital ROM in both groups. The grip strength improved for the PT group from six weeks to 12 weeks

from 68% to 91% (100% is 270°) and from 71% to 93% for the HE group. At three months, the ROM improved to 245° TAM for the PT group and 256° TAM for the HE group out of a normal digit range of motion of 270°.[9] A limitation of the study is that the management was not specific to the type of fracture sustained, and uninvolved joints were included during immobilisation. A further limitation was that a non-surgical management option was not included. In resource-restricted countries, surgical intervention with open reduction and internal fixation is not always feasible; thus, the results cannot be generalised to these countries, although they will greatly benefit from an HE programme for individuals with second to fifth metacarpal fractures to save resources expended for follow-up sessions.

In another article, an evidence-based pathway was compiled using a systematic review of all research before 2008.[22] Following the development, the evidence-based pathway was tested on a sample of 50 patients in London who received surgical or non-surgical management for metacarpal fractures.[22] Thumb metacarpal and phalangeal fractures were excluded. The therapy treatment sessions included: splint fabrication, treatment administered and a leaflet describing fracture management. The pathway will now be presented according to the area where the fracture occurred, namely base, shaft, neck and head.

The base of the metacarpal fracture treatment pathway of the index finger (IF), middle finger (MF), ring finger (RF), and little finger (LF) was as follows: extra- and intra-articular fractures treated conservatively or with K-wires were given a forearm wrist splint positioned with the wrist at 20° extension, for four weeks. At four weeks from the day of the injury, light function and wrist exercises were encouraged. The splint was discarded after six weeks. When the fracture was managed surgically with an ORIF, light function was commenced at two weeks, with the splint discarded at four weeks.[22]

The shaft of metacarpal fracture treatment pathway for the IF, MF, RF and LF: forearm-based splints incorporating and positioning the wrist at 20° extension with the affected and one adjacent finger MCPJs positioned in 70° of flexion with a dorsal hood piece of the splint which was to be worn for three weeks. All other joints were left free and were able to move in the splint. After three weeks, the dorsal hood was removed, but the forearm-based splint was continued and only taken off for exercise periods. Exercises at three weeks included wrist and MCPJ active movement. The splint was worn only at night for two more weeks and discarded at six weeks. At four weeks, light function commenced. This time frame was applied to conservative or K-wire management of MJPJ shaft fractures. The fracture was managed with an ORIF, light function was initiated at two weeks, and the splint was discarded at four weeks.[22]

Neck and head metacarpal fracture treatment pathway for the IF, MF, RF and LF: a splint (hand-based) that positioned the affected MCPJ and an adjacent finger's MCPJ in flexion of 70° was worn for a period of two to four weeks. After this period, the splint was removed, and the finger's buddy strapped for another two weeks. In conservative or K-wire management, light function was commenced at four weeks, splint intervention continued at night and for protection during activities, and discarded at six weeks. In the ORIF managed fractures, light function was commenced at two weeks, splint intervention continued at night and for protection during activities and discarded at four weeks. Strengthening was started at six weeks.[22]

The evidence-based pathway was tested on 23 individuals.[23] A low GRADE quality of evidence rating was given. Telephonic interviews performed follow-up assessments at 10–24 weeks post injury with the following results: compliance with the splint intervention was 47%, no complications were present, no pain in 72% of patients, employed patients had all returned to work, 92% of patients had full hand function, satisfaction with service among patients was 8/10, and three therapy sessions on average were provided.[23] The results' generalisability was compromised by the small sample size and low compliance with the splint intervention. The lack of standardised outcomes used for hand ROM, disability and grip strength, and telephonic interview assessments affect the trustworthiness of the results. However, the splints proposed in the evidence pathway remain highly valuable for clinical practice because of the careful consideration given to not immobilise unaffected joints. The authors made a recommendation to conduct further research to evaluate the evidence pathway.[23]

From these studies for individuals who sustained a variety of different types of single or multiple second to fifth metacarpal fractures:

- Thermoplastic customised splinting and immobilisation period with all the unaffected joints not included, with early active mobilisation of unaffected joints encouraged.

Discussion

The purpose of this scoping-type systematic review was to determine the immobilisation and splint approaches utilised for post-surgical and conservative management for 20- to 59-year-old adults who sustained a single or multiple second to fifth metacarpal fracture. A detailed description of the literature has been provided, indicating no single preferred splint and method of immobilisation for each type of second to fifth metacarpal fracture.

Shaft fractures of second to fourth metacarpals were managed with certain similarities, such as spiral fractures, receiving forearm-based wrist splints.[15,16] Active mobilisation was suggested for spiral fractures, but intra- and extra-articular fractures were conservatively or surgically managed with forearm-based thermoplastic splints with a dorsal hood piece left for three weeks with the splint being removed from four weeks.[14,23] Wrist POP for two weeks was also suggested for spiral and long oblique fractures.[14] A clinical recommendation is to use thermoplastic forearm wrist splints, which place the wrist at 20° extension, MCPJ in 70° of flexion, not including the PIPJs and DIPJs. Various articles suggest that care should be taken not to immobilise the unaffected joints, such as the wrist, for long periods, which will delay return to work and affect hand function.[15,16,20] The authors in the sourced articles recorded various immobilisation methods for the neck (boxer's) of the fifth metacarpal fractures. These included a short POP wrist splint, a U-shaped gutter splint including the wrist, a soft palmar wrap and buddy strapping for three weeks or a wrist POP up to PIPs for four weeks.[18,19] Also included was a U-shaped ulnar gutter splint for four weeks for conservative management and a U-shaped ulnar gutter splint seven days from K-wire insertion.[20] Another method was a K-wire palmar two-finger splint for five days followed by a metacarpal hand-based splint for five weeks and conservative no reduction and similar splints.[21] The hand surgery group had higher satisfaction and hand appearance satisfaction (including head). Finally, a hand-based thermoplastic splint for two to four weeks followed by buddy strapping for a further two weeks was used.[23] In their multicentre RCT, Van Aaken et al. preferred buddy strapping as management for boxer's fractures with less than 70° palmar displacement.[19] Recent literature supports buddy strapping instead of POP immobilisation for uncomplicated neck of fifth metacarpal fractures, and for neck of fifth metacarpal fractures without rotation deformities and for volar angulation less than 70°, due to less time off work and no complications due to POP immobilisation.[24,25] At eight weeks, participants who sustained neck of fifth metacarpal fractures managed with an elastic bandage around their metacarpals and wrist with early protected movement, displayed stronger grip strengths than the immobilisation in a U-shaped splint participants.[26] Patients with closed, isolated neck of fifth metacarpal fractures without rotational deformity were managed either by functional metacarpal splints supporting only the metacarpals or

an ulnar gutter splint immobilising the wrist. At the six-month follow-up, both groups displayed similar grip strengths, reduction and hand function outcomes. In conclusion, patient comfort and splint-wearing compliance seen in the functional metacarpal splint group should be considered in practice.[27]

For the metacarpal base, intra- and extra-articular fractures, a forearm wrist splint for four weeks after K-wires and six weeks after conservative management was utilised.[23] However, taking into account the post-surgical immobilisation for all types of second to fifth metacarpal fractures, a dorsal wrist splint for two weeks was sufficient as four weeks may be too long.[9] In terms of positioning and type of material used, it was found that thermoplastic splinting material was preferred over POP due to the lower prevalence of pressure sores and hypoesthesia.[17]

The heterogeneity of the studies prevented the authors from conducting an effectiveness systematic review, and hence a scoping-type systematic review resulted. OpenDOAR was not used in the grey literature search and is a limitation.

Conclusion

We report on the evidence on splinting and immobilisation approaches used for second to fifth metacarpal fractures. The information provided should be used to guide decision making in clinical practice to ensure optimal hand function, decreased stiffness and early return to work. As the review only yielded ten relevant articles, a gap in the literature regarding evidence-based splinting and immobilisation programmes is seen, except for the initial immobilisation of boxer's fractures, where adequate evidence was found. Level 1b evidence for no reduction, a soft wrap and buddy strapping for three weeks with early active wrist and finger for management of boxer's fractures was found to be effective. Further research is, however, required for the other types of second to fifth metacarpal fracture immobilisation.

It is recommended that future research focuses on the effects of splints and immobilisation approaches using adequately powered RCTs and controlling for confounding variables, e.g., fracture type. Standardised outcome measures for both conservative and post-surgical groups should be used.

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Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to commencement of the study, ethical approval was obtained from the following ethical review board: The Health Sciences Research Ethics Committee of the University of the Free State, ethical clearance number UFS-HSD2019/0046/2602.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

MMK: conceptualised, drafted the protocol, submitted for ethical clearance, wrote the first draft and refined the article

RYB: read, elaborated on and refined the article

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Table 4.9: Summary of findings: Supplementary Table

South African Orthopaedic Journal

Splints and immobilisation approaches used for second to fifth metacarpal fractures: a review

Supplementary table: Summary of findings

Authors	Study design, sampling and type of frame of wear	Splints/immobilisation device strategy description and metacarpal fracture time	Surgical or conservative intervention	Follow-up periods	Outcome measures used (for each outcome)	Results on outcomes first assessment (copy for each outcome)	Results on outcomes Second and more assessments (copy for each outcome)	Grade
Al-Qattan[14] (No control group)	Prospective study, n = 42, purposive sampling. All patients with spiral/long oblique metacarpal shaft fractures treated conservatively with a palmar wrist splint between 2003 and 2006	Palmar wrist splint (POP immobilisation) 20–30° wrist extension and fingers free for 2 weeks No formal PT Active and passive exercises of all finger joints. Splint removed at 2 weeks with more exercises	Conservative management	2 weeks, (patients included with a minimum of 6 weeks follow-up)	TAM Grip strength	n = 54 **2 weeks** TAM = lag of 26° (mean range 234°) Grip strength = difficult to assess		Low
				6 weeks			**6 weeks** TAM = mean lag of 19° (mean range 241°) Grip strength = 60%	

3 months		n = 36 **3 months** TAM = mean lag of 15° (mean range 253°) Grip strength = 74%
6 months		n = 25 **6 months** TAM = 5° lag in 2 (mean range 260°) Grip strength = 81%
9 months		n = 11 **9 months** TAM = 260° Grip strength = 90%
1 year		n = 5 TAM = 260° Grip strength = 94%

Khan and Giddins[15]	Prospective study, n = 30, single or multiple, middle or border, closed spiral metacarpal fractures Sample of convenience	No splint or immobilisation Gradual early mobilisation Participants had to make a fist, up to 2 cm measurement from fingertip to palm, before discharge was Allowed	Conservative management	7 days	Malrotation with visual observation ROM Grip strength Functional limitations verbal assessment Shortening of fingers Return to work Bone union through palpation Cosmetic satisfaction	n = 25 **7 days** = malrotation in 1/3 of participants		Low
				Between 6 and 14 months	ROM Grip strength Hand function Rotation Shortening Union		**6 and 14 months** = ROM = full and no extensor lag Grip strength = within 10% of uninjured hand Good hand function No clinical malrotation Mean shortening of fingers 4 mm (2–5 mm). Return to work range (2 to 4 weeks, mean 3 weeks) Bone union in 23 participants No cosmetic complaints	

MacDonald, et al.[16]	Prospective study, n = 61, non-scissoring spiral metacarpal fractures	Splint individually moulded: wrist 20° wrist extension, affected MCPJ and one adjacent unaffected MCPJ in 30° flexion and interphalangeal joints extended for 1 week One week splint removed for exercises, shower, at night for compliant participants without pain Splint on for sleep and demanding activities Splint removed after 3 weeks	Conservative management	3 weeks, 6 weeks and more than 22 weeks (5 months) after injury was sustained	Grip strength ROM	**5 months** = Grip strength uninjured hand mean = 36.18 kg Grip strength Injured hand = 36.58 kg No extensor lag	Low
Gulabi, et al.[17]	Retrospective record review on a total of 140 participants allocated into 2 groups Group A: Isolated, extra-articular neck of shaft 5th metacarpal fracture more than 30° of angulation	Reduction and immobilisation of 4th and 5th fingers in short arm POP: wrist 30° extension, MCPJs 45° flexion, DIPJ and PIPJ in 15° flexion for mean 29.15 days with	Conservative	POP removed after a period of 29.15 days (mean) One month after POP removed	X-ray assess bone healing Grip strength ROM Extensor lag	**1 month** after removal POP: Grip strength 90.38% compared to unaffected Two participants had 10° extensor lag	Low
Gulabi, et al.[17]	Retrospective record review on 140 participants allocated into 2 groups Isolated, extra-articular neck of 5th metacarpal fracture more than 30° of angulation	Group B: Reduction and immobilisation of 4th and 5th fingers in U-shaped gutter splint: wrist 30° extension, MCPJs 45° flexion, DIPJ and PIPJ in 15° shaft flexion for mean 29.15 days with	Conservative	U-shaped gutter splint removed period of 29.15 days (mean) One month after splint removed	X-ray Grip strength ROM Extensor lag Rotational deformity clinical assessment	**1 month** after removal splint: Grip strength 90.58% compared to unaffected Two participants had 10° extensor lag	Low

Gamble, et al.[18] (No control group)	Retrospective study Purposive sampling Cohort of 162 patients was collated from a search of the Emergency Department's Information System, Omnis, that identified patients directly discharged from the Emergency Department with a fracture of the fifth metacarpal (neck, shaft or base)	Functional bracing: neighbour strapping (buddy) for 1 week, early active mobilisation with information and no follow-up sessions	Conservative	No follow-up mean 21.6 months (but questionnaire sent out a minimum 1-year post-intervention)	Satisfaction Likert scale EQ-5D Quick Dash	**Post 1 year** (59% response rate): 80.6 % were very satisfied and 84.9% satisfied with the new process of management Median EQ-5D = 0.87 (IQR 0.74 to 1.00) Median Quick Dash = 2.3 (IQR 0.6.8)	No other outcomes measured	Low
Van Aaken, et al.[19]	Multicentre, randomised controlled trial, n = 68 divided into 2 intervention groups, 5th metacarpal neck/boxer's fracture with ≤ 70° degrees of angulation and no rotational deformities	No reduction with soft palmar wrap and buddy strapping 4th and 5th fingers for 3 weeks. With immediate active mobilisation	Conservative (soft wrap and buddy strap)	Baseline 4 months	QuickDASH mean (SD) Pain mm mean (± SD) MCPJ ROM Flexion° mean (± SD) Hyperextension° mean (± SD) Grip strength kg mean (± SD) Jamar position 1 grip strength Jamar position 2 grip strength Satisfaction Fully satisfied Satisfied Days off work mean (± SD)	n = 37 **Baseline** QuickDASH: 45.7(18) Pain VAS: 31.9 (19.9) Flexion° contralat 92 (12.1) Hyperextension° contralat −7 (9) Jamar position 1 grip strength contralat @1 month 32 (11) Jamar position 2 grip strength 42 (19)	n = 20 **4 months** QuickDASH: 0.96(2.7) Pain VAS: 1.7 (5.8) Flexion of the 5th MCPJ° 92 (9.90) Hyperextension of the 5th MCPJ° −5 (11) Jamar position 1 grip strength (mean) 31 (11.32)	High

Jamar position 2 grip strength (mean) 41 (20)

Fully satisfied = 13

Satisfied = 7

Days off work: 22 (18)

Van Aaken, et al.[19]	Multicentre Randomised controlled trial, n = 68 divided into 2 intervention groups, 5th metacarpal neck/boxer's fracture with ≤ 70° degrees of angulation and no rotational deformities	Reduction with forearm wrist POP immobilisation including MCPJ and PIP, MCPJ in extension for 4 weeks	Conservative (POP cast)	Baseline 4 months	QuickDASH mean (SD) Pain VAS mm mean (SD) MCPJ ROM Flexion° mean (± SD) Hyperextension ° mean (± SD) Grip strength contralat kg at **1 month** mean (± SD) Jamar position 1 Grip strength Jamar position 2 Grip strength Satisfaction Fully satisfied Satisfied Days off work mean (± SD)	n = 27 **Baseline** QuickDASH 49.7 (21.8) Pain: VAS 35.2 (22.7) Flexion° contralateral 92° (19) Hyperextension ° contralateral −9° (13) Jamar position 1 Grip strength 38 kg (12) Jamar position 2 Grip strength 41 kg (10)	n = 19 **4 months** QuickDASH 2.78 (5.1) Pain: VAS 4.6 (10.7) Flexion of the 5th MCPJ° 94° (8) Hyperextension of the 5th MCPJ° −3° (8) Jamar position 1 Grip strength 35 kg (12) Jamar position 2 Grip strength 39.7 kg (11) Fully satisfied = 12 Satisfied = 6 Days off work 33 days (17)	High

Cepni, et al.[20]	Comparative study, n = 24, fifth metacarpal neck/ boxer's fracture	Reduction and immobilisation in U-shaped ulnar gutter splint with 4th and 5th MCPJ, PIP and DIP in slight flexion for 4 weeks	Conservative	Prior to treatment 2 days after reduction 7 days after reduction	Palmar angulation (mean, range) MC shortening (mean range in mm) TAM measured against the uninjured side Flexion % (range) Extension % (range) Return to work (mean range) QuickDASH mean (range)	**Prior to treatment:** 42.6° (27–55°) MC shortening 5.6 mm (5.3–6.1)		Low
				30 days			QuickDASH: **At 30 days**: 69.6, (59.1–79.5)	
				45 days			45 days: 13.5° (10–28°) MC shortening 2 (0–4) TAM Flexion 91.25% (75–100%) Extension 92.5% (80–100%) Return to work 33.6 days (26–41) QuickDASH	

							39.3 (22.7–61.4)	

Cepni, et al.[20]	Comparative study, n = 24, fifth metacarpal neck/boxer's fracture	Reduction and K-wire insertion with U-shaped ulnar gutter splint for 7 days	Surgical	2 days after reduction 7 days after reduction	Palmar angulation (mean, range) MC shortening (mean range in mm) TAM % measured against the uninjured side Flexion % (range) Extension % (range) Return to work mean QuickDASH (range)	**Prior to treatment:** Palmar angulation 43.0° (40–55°) MC shortening 9.3 mm (6–15)		Low
				30 days			**At 30 day:** QuickDASH 2.96 (0–15.9)	

				45 days			**45 days:** 8.0° (0–17°) MC shortening 0.5 (0–3) Flexion 94% (75–100%) Extension 95.5% (90–100%) Return to work 3.9 days (3–5) QuickDASH 0.69 (0–2.3)	
Strub, et al.[21]	Pseudo randomisation, n = 40 (2 groups), fifth metacarpal neck/ boxer's fracture with 30° to 70° palmar displacement	No reduction with five days immobilisation in palmar splint including 4th and 5th fingers Thereafter metacarpal hand-based thermoplastic splint covering dorsal and palmar for five weeks and functional mobilisation encouraged No hand therapy	Conservative (Group B)	2 weeks, 6 weeks, 3 months, 6 months, 12 months	Flexion ROM 5th MCPJ (mean) Total ROM MCPJ (compared to uninjured hand) Pain Time off work Palmar angulation Satisfaction Grip strength (mean) Complications Union	Flexion ROM 5th MCPJ = 96°		Moderate
				3 months			Pain = 0.57 (0–3 range)	

				12 months			Flexion ROM 5th MCPJ = 93° (4) Extension ROM 5th MCPJ = 3° (5) Pain = 0.1 (0–2 range) Time off work = 4.8 weeks (1–8 range) Palmar angulation = from (mean) 39° before surgery to 34° at 1 year Satisfaction = 55% (11) patients very satisfied, 35% (7), 1 undecided Grip strength = 46 kg (8.5) Complications: 2 patients with highly displaced fractures (more than 50°) Union in all fractures	
Strub, et al.[21]	Pseudo randomisation, n = 40 (2 groups), fifth metacarpal neck/ boxer's fracture with 30° to 70° palmar displacement	Reduction, K-wire insertion with five days immobilisation in palmar 2-finger splint including 4th and 5th fingers Thereafter metacarpal hand-based thermoplastic splint covering dorsal and palmar for five weeks and functional mobilisation encouraged No hand therapy	Surgical (Group A)	2 weeks, 6 weeks, 3 months, 6 months, 12 months	ROM MCPJ Pain Time off work Palmar angulation Satisfaction Grip strength (mean) Complications Union	Total ROM 5th MCPJ = 2 weeks: 62% of (uninjured hand), 6 weeks 80%, 3 months 87%, 6 months, 1 year 95%		Moderate

3 months	Pain = 3 months 0.53 (0–4 range)
12 months	Flexion ROM 5th MCPJ = 92° (5) Extension ROM 5th MCPJ = 6° (5) Pain = 0.03 (0–1 range) Time off work = 6.0 weeks (2–10 range) Palmar angulation = from (mean) 44° before surgery to 9° at 1 year Satisfaction = 70% (14) patients very satisfied, 25% (5) satisfied, 1 undecided Grip strength = 51 kg Complications: 2 patients with highly displaced fractures (more than 50°) Union in all fractures

Gülke, et al.[9]	Prospective cohort randomised controlled trial Standardised controlled block randomisation	Custom made Functional dorsal splint (Light Cast) fixated with an elastic wrap. MPJs = 70° flexion; PIP, DIPJs free movement Removed post 2 weeks Physio teaching exercises that can be done at home After week 8, exercises carried out independently	Open reduction internal fixation	Group 1: 2 weeks post-surgery: 12 units of PT over 6 weeks (week 3–8) Week 8–12: Independent (group 1 & 2) Week 2 follow-up	ROM (neutral zero method) Jamar Dynamometer DASH	**Week 2**: ROM MPJ: 42.5° PIPJ: 88.3° DIPJ: 89.1°		High
				Week 6			**Week 6** MPJ: 61.7° PIPJ and DIPJ – increased a little Grip strength 68% DASH score 30	
				Week 12			**Week 12**: ROM MPJ: 73.3° Grip strength 91% DASH score 16	
Gülke, et al.[9] Control group	Prospective cohort randomised controlled trial Standardised controlled block randomisation	Custom made Functional dorsal splint (light cast) fixated with an elastic wrap MPJs = 70° flexion; PIP, DIPJs free movement Removed post 2 weeks Exercise booklet with pictures, individual exercises Questions answered by hand surgeon after reading	Open reduction internal fixation	Group 2: 2 weeks post-surgery: independent exercises (week 3–8) Week 8–12: Independent (group 1 & 2) Week 2 follow-up	ROM (neutral zero method) Jamar Dynamometer DASH Documenting exercise	**Week 2** ROM MPJ: 46.5° PIPJ: 86.8° DIPJ: 89.8°		

	Week 6	ROM MPJ: 68.5° PIPJ and DIPJ – increased a little Grip strength 71% DASH score 25
	Week 12	ROM MPJ: 73.3° Grip strength 93% DASH score 14

Toemen and Midgley[22,23]	n = 23	Evidence-pathway per type and area of fracture: Base of the metacarpal fracture: extra- and intraarticular fractures treated conservatively or with K-wires with a forearm wrist splint wrist at 20° extension, for four weeks. At four weeks from the day of the injury, light function and wrist exercises were encouraged. Splint discarded after 6 weeks. After ORIF, light function was commenced at 2 weeks with the splint discarded at four weeks. Shaft metacarpal fractures: forearm-based splint wrist 20° extension with affected and one adjacent finger MCPJs positioned in 70° of flexion with a dorsal hood piece of the splint worn for three weeks. After three weeks, the dorsal hood was removed, but the forearm-based splint continued and only taken off for exercise periods. The splint only worn at night for 2 more weeks, discarded at 6 weeks. This timeframe was applied to conservative or K-wire management of MJPJ shaft fractures. After ORIF, light function initiated at 2 weeks, and splint discarded at four weeks. Neck and head metacarpal fractures: hand-based splint position affected MCPJ and an adjacent finger's MCPJ in flexion of 70° worn for 2 to four weeks. After this period, the splint was removed, and the fingers buddy strapped for another 2 weeks. In conservative or K-wire management, light function was commenced at four weeks, splint intervention continued at night and for protection during activities and discarded at 6 weeks. In the ORIF managed fractures: splint intervention continued at night and for protection during activities and discarded at four weeks.	10–24 weeks	Pain Complications Return to work Satisfaction with service Hand function per telephonic interview	Pain = 72% no pain No complications All previously employed patients return to work Satisfaction score 8/10 92% of participants full function	Low

4.9 Discussion

Two systematic reviews were conducted according to the PRISMA guidelines to reach the primary and secondary objectives of Phase I. A limitation to this phase was the paucity of evidence and the high attrition rate of articles not included in the final data extraction stage, especially for the first systematic review. A limitation to some of the study's included in the systematic reviews was the reporting on the remaining participants data in the studies, where high attrition rates were seen. The entire sample was therefore not represented which may show favourable results for 'adherent' clients who 'turn up'. Heterogeneity among the included studies necessitated a descriptive presentation of results, as a meta-analysis could not be performed. An important limitation was the low quality of the studies included in the two systematic reviews. It is advised that consideration should be given regarding the quality of evidence to guide the management of individuals with second to fifth metacarpal fractures. The author used the word confidence when referring to the included articles in the published article, however clinical reasoning should inform the management as each individual and their injury is unique. There is no one-size-fits-all management of individuals who sustained second to fifth metacarpal fractures.

As indicated in the Introduction, section 4.1, it was during the peer review process that the peer reviewers suggested that the author should include other articles to strengthen the discussion in the two systematic review articles. These included articles may have different inclusion criteria (e.g., the age of the participants being 18 years). It may have occurred that studies were excluded because of one participant being 18 or 19 years old, without considering the remaining participants data. The decision of the researcher to only include articles published in English may have minimised the search results. The researcher in addition acknowledges the limitation of not including all possible search terms such as "buddy strapping, plaster of Paris, conservative, and surgical management", which might have impacted the systematic review results.

The two systematic reviews ultimately guided the development of the first eDelphi method round, where the experts indicated their agreement on the proposed management of second to fifth metacarpal fractures. The first systematic review informed the clinical hand rehabilitation guideline by finding the best evidence to support the time period before return to activities after injury, namely, two weeks for light activities, four weeks for medium activities, six weeks for heavy activities, and eight to 10 weeks before individuals who sustained second to fifth metacarpal fractures without associated injuries can return to all pre-injury tasks. The type of splint used after post-surgical fixation of base of second to fifth metacarpal fractures, the type of splint, and the time wearing the splint for such fractures after conservative management were identified in the second systematic review. Identified during the second systematic review were also the splint type and the period required for wearing the splint after sustaining head of second to fifth metacarpal fractures.

4.10 Summary

Chapter 4 presented two peer-reviewed publications undertaken to answer the primary and secondary objectives of the systematic review. Chapter 5 shares the FSR testing-phase studies in two articles that informed the development of the clinical hand rehabilitation guideline.

Chapter 5: Phase II

Evaluation of finger forces and grasp types of 105 functional activities of daily living tasks measured with force sensing resistors: a feasibility study

5.1 Introduction

In this chapter, a two-phased data collection process is presented in two articles to achieve the objectives and answer the following research question: force sensing resistors ()Can the functional task forces exerted by the human hand be determined by using FSRs in terms of grasps on the objects manipulated during basic and instrumental daily functional tasks among purposively sampled healthy human adults aged between 20 and 59 years be determined by using FSR's? The objectives of each study phase, the link between the phases and how the results from the two phases informed the development of a clinical hand rehabilitation guideline now follow.

In the context of informing the development of a clinical hand rehabilitation guideline, the researcher identified the lack of objective scientific evidence available in the literature concerning for finger forces during manipulation and grasp types used during activities of daily living (ADLs) to inform the development of a clinical hand rehabilitation guideline. The lack of evidence was specifically concerning when education is needed to guide individuals who sustained second to fifth metacarpal fractures regarding returning to ADLs. In addition, specific information regarding which specific types of activities classified as, light, medium and heavy activities, to commence after surgical and conservative management, was lacking in the literature. The objective of the first article in Chapter 4 (Refer to 4.5) was to determine the functional task forces exerted by the human hand with its grasps during object manipulation in purposively sampled healthy human adults between the ages of 20 and 59 years while

performing daily basic and instrumental functional tasks. Information gleaned during the second phase of the study assisted the researcher in the development of a clinical hand rehabilitation guideline. The researcher was able to identify the predominant grasp types to be used in hand rehabilitation by physiotherapists (PTs) and occupational therapists (OTs) and was able to classify 105 basic and instrumental everyday tasks into light, moderate and heavy categories that could potentially guide individuals to an earlier return to functioning.

The results of the second article, presented in Chapter 4 (Refer to 4.10), informed the clinical hand rehabilitation guideline by incorporating grasp types according to the progression in the range of motion (ROM) of the metacarpophalangeal joint (MCPJ) (Addendum CII). The objective of the second article was to determine whether there is an association between mean forces, gender, and grip strength in purposively sampled healthy human adults between the ages of 20 and 59 years. The researcher undertook force-sensor testing on the sample of 32 healthy participants. The unique value of this phase of the study added to the overall aim of developing a clinical rehabilitation guideline in that the researcher was able to identify the respective grasp types, as well as to test the respective grasp forces. Ultimately, the eDelphi method enabled the researcher to gain expert consensus on the relevant recommendations and thus to incorporate them into the final clinical hand rehabilitation guideline.

Phase II of the study was conducted during the Covid-19 pandemic, which made data collection with respect to recruitment and number of participants included in the study challenging.

The article is intended for publication in a double peer-reviewed journal entitled, Occupational Health South Africa, and was written according to the format and author guidelines, as in Addendum AII.

First article: Phase II

5.2 Publication details

In Chapter 5, the results of the force sensor testing phase are presented as published articles. In the first article, the testing of all ten finger forces during 105 activities assisted in categorising activities of basic and instrumental daily living into light, moderate and heavy tasks that were thus able to inform the clinical hand rehabilitation guideline.

5.3 Journal details

The publication specifics of the journal are presented in Table 5.1.

Table 5.1 Publication specifics

Title of publication	Evaluation of finger forces and grasp types of 105 activities of daily living tasks measured with force sensing resistors: a feasibility study
Authors	Monique M. Keller, Roline Barnes, Corlia Brandt
Journal name	**Occupational Health South Africa**
Is submitted and under review with the Occupational Health South African journal.	

5.4 Permissions and rights

The first author submitted the article to the journal, received comments from two reviewers, made the corrections and resubmitted the article to the journal. In the instance that the article

is accepted for publication, the researcher will request permission to include the article in this thesis.

5.5 Article

Evaluation of finger forces and grasp types of 105 activities of daily living tasks measured with force sensing resistors: a feasibility study

Abstract

Background Healthcare practitioners guide patients who have sustained metacarpal fractures, to return to basic and instrumental activities of daily living (ADL) without the necessary scientific evidence regarding force measurements. Measuring patients' finger forces and grasp types after they sustained second to fifth metacarpal fractures may fill this gap in the research and be valuable in informing and grading their rehabilitation to ensure a safe return to work without disrupting bone healing.

Objective The objective of the study was to determine the functional forces exerted by the human hand with its grasps, while manipulating objects with force sensor resistors (FSRs) during basic and instrumental daily functional tasks among purposively sampled healthy human adults between the ages of 20 and 59 years.

Methods A cross-sectional feasibility study investigated the finger forces and grasp types of six healthy adult participants aged 20 to 59 years during their performance of 105 predetermined activities. Being guided by the GRASP Taxonomy, it was possible to identify the predominant grasp associated with each task. Finger forces were measured with 13mm FSRs glued to a glove attached to the fingers of the dominant and non-dominant hands.

Results Maximum forces per category ranged from personal care (1-25 Newton (N)), transport and moving around (1-9 N), home environment and inside (1-41N), gardening and outside (1-

26.5N), and office (1-20N). The predominant grasp type identified was the adducted thumb. No statistically significant differences were seen between the genders in respect of the maximum forces for the tasks.

Conclusion The results add to the minimal existing knowledge on finger forces and types of grasps to guide clinical practice, return to work, and ADL.

Keywords:

Activities of daily living; grasps; hand forces; force sensing resistors; hand function

1. Introduction

Hand function is of utmost importance in performing ADL in healthy individuals and is a primary outcome for individuals who have sustained a hand injury.[1] The safe return to basic and instrumental ADL tasks after injury is not, however, backed by scientific evidence on force to ensure optimal healing and early return to occupation. Functioning entails a dynamic and complex interaction between the injury (health condition) sustained and the personal and environmental factors (contextual setting) unique to the individual.[2] The WHO upholds an invaluable hypothesis, expressed in the International Classification of Functioning, Disability and Health (ICF) framework,[3] as in the Functioning and Disability Reference Group (2010), that patient management after injury should not begin and end at body function and structure level, but should also incorporate the activity limitation and participation restriction domains, as set out in the ICF framework. Performing self-care activities, occupational activities, domestic life routines, and leisure activities[4] is imperative for patients after injury, and not only the body function and structure challenges, such as pain and stiffness, that are often addressed by healthcare professionals. The health of an individual who sustained a hand injury is essential, and optimal management is imperative.[5]

Owing to the inability to perform ADL independently and without assistance, any injury to the hand may affect the individual negatively.[6] ADL is divided into basic and instrumental ADLs[7]. Basic ADLs are tasks necessary for functional living, whereas instrumental ADL, although not essential for functional living, add to the quality of life[7]. Basic ADL are self-care tasks to manage basic physical needs, and include grooming and personal hygiene, ambulating, or transferring, eating and toileting. Instrumental ADLs are everyday activities allowing individuals to live independently in their community, requiring more complex thought processes and planning, for example, cleaning, laundering, cooking, financial management, transportation,[7] maintaining the home, and using technology.

Disability, lack of functioning related to hand injuries, and poor management have direct consequences for productivity and healthcare costs to the individual, [4] thus leading to financial challenges. In a Dutch study, injuries to the hand and wrists ranked first as the most expensive type of injury, amounting to an annual expenditure of $740 million. [4] When considering hand and wrist injuries, finger fracture injuries are the costliest, with a yearly expenditure of $278 million. The high cost of managing hand and finger fractures can be related to the loss of productivity in the age group 20 to 64 years, with the working class more seriously affected. [4,8] Unfortunately, no information is available regarding the cost of managing hand fractures in the South African context.

Measuring finger and hand forces using FSRs is often conducted in the fields of robotics and engineering, with only a few studies performed in the field of the Health Sciences. Although FSR force testing is a valid, easily accessible, and affordable force-measuring instrument[9], it has not been fully utilised to inform clinical practices for managing individuals who have sustained hand injuries. A recommendation of a study performed by Feix et al., (2016) which resulted in the GRASP taxonomy[10] was that more objects should be tested in future to analyse a wider variety of

grasp types.[10] Riddle et al., (2020) also recommended testing the forces of a wider range of tasks.[11]

The research performed in our study attempted to add to the existing knowledge of force-sensor testing research[12,13,14,15,11] and to provide scientific evidence to guide clinical practice and occupational return for individuals who have sustained hand fractures by considering finger forces and grasp types.

2. Procedure

The Health Sciences Research Ethics Committee (HSREC) of the University of the Free State approved this study (UFS-HSD2019/0046/2602-0002).

2.1 Study design and setting

A quantitative cross-sectional feasibility study was performed in the heterogeneous city of Kempton Park, Ekurhuleni, Gauteng province, South Africa.

2.2 Participants

Healthy adults between the ages of 20 and 59 were recruited for participation. The decision to exclude participants younger than 20 years was based on their skeletal immaturity[16], while those older than 59 were excluded on the grounds that research has found that the prevalence of metacarpal fractures sustained after the age of 59 decreases.[17] Participants who understood and spoke English or isiZulu, with no previous upper limb and/or hand injury, no current hand infection, no diagnosed developmental delay, and no diagnosed cognitive deficits were eligible for participation.

2.3 Recruitment

Convenience snowball sampling was used. The researcher invited participants living and working close to the laboratory, where the tests were conducted, to participate. After participating, the participant was then asked to nominate a friend, family member or co-worker for possible inclusion in the research sample. Six participants, three males and three females, were approached and recruited for participation. On considering the size of the sample in previous studies investigating the forces and pressures exerted by hands and fingers, a sample size of six participants was deemed sufficient. In the preparatory assessment of the type of participants to select for the research, the researcher was guided by two studies, one involving two surgeons and the pressure and forces exerted by their hands and fingers in performing surgery, and also in their instrumental ADLs.[15] The other was a study that focused on the frequent hand grasps identified during the daily occupational tasks of two machinists and two housekeepers.[18] The participants did not receive any incentives for participation.

2.3 Outcomes

2.3.1 Questionnaire

The self-administered questionnaire, translated from English to isiZulu, used a back-translation method. It consisted of nominal and ordinal measurements (such as closed-end questions and fixed-response questions) and included demographic data to describe the sample population, their occupations, and previous injuries, and to determine any exclusion criteria. The translation was performed by the research assistant and reviewed for clarity and correctness by a qualified OT, fluent in both English and isiZulu.

2.3.2 Grip strength dynamometer

Following the completion of the questionnaire, the grip strength of each participant was determined with the aid of a calibrated Jamar hydraulic dynamometer. This was done before

testing the first activity, at intervals after the completion of every 25 functional activities, as indicated on the test sheet, and again after the last activity. The grip strength testing ensured that hand fatigue did not affect the finger force measurements.

The Jamar hydraulic dynamometer shows good inter-instrument reliability compared to the Rolyan hydraulic dynamometer, indicated by intraclass correlation coefficient ranges between 0.90-0.97. The test-retest reliability is excellent r = 0.976 for the Jamar hydraulic dynamometer. Concurrent validity is acceptable with calibrated known weights with correlation coefficients of r ≥ 0.9994.[19] The reliability of the grip-strength testing was ensured as it was performed according to the recommended testing method of the American Society of Hand Therapy.[20,21] Grip strength was calculated after three attempts, with the mean value of the three attempts captured for each hand. [20,21] In cases where the average grip strength of any of the hands, either dominant or non-dominant hand differed by two kilograms (kg) from the previous grip strength testing, the participant was given a five-minute resting period before testing resumed.

2.3.3 Force sensing resistors

A Flexiforce 13 millimetres FSRs 5" circle, 10k 1/4w (50 pack) resistors, an Arduino pro-mini-5.0v–compatible Esp-01-kit, an Arduino UNO r3–compatible board, and USB ab cable were used during the testing. The FSRs were connected in series with 10 kilo-ohm resistors: the 10 kilo-ohm resistors were inserted into the ARDUINO Pro mini and the FSRs connected to the Arduino Pro Mini 5 voltage (V) with a USB port. The two Arduinos, one for each hand, were connected to the computer with a USB cable. RealTerm 2.0 and Arduino software programmes created a sketch in the software programme where measured V were fed into the software for hardware setup before testing. RealTerm 2.0 software is an engineering terminal software programme designed to capture, control, and debug complex data streams.

The FSRs were calibrated using known weights before data collection commenced,[22,23] providing ranges of the various anticipated forces to group the functional activities into known quantities and categories of forces. Static forces ranging between one (1) gram and 10 kg were placed on the sensors during a static test. A characteristic curve was drawn up electronically, using the data collected during the calibration process. The curve is known as the seventh-order curve. The forces (N) were seen on the Y-axis of the curve, while the V were seen on the X-axis of the curve. This curve was used to calculate the forces from the V outputs from the FSRs. Calibration took place before the study and testing. A known weight in kg was placed on the FSR. [22] The calibration graph can be viewed below in Figure 5.1, with V and mass (in grams (g)) and in Figure 5.2, with V and force (in N).

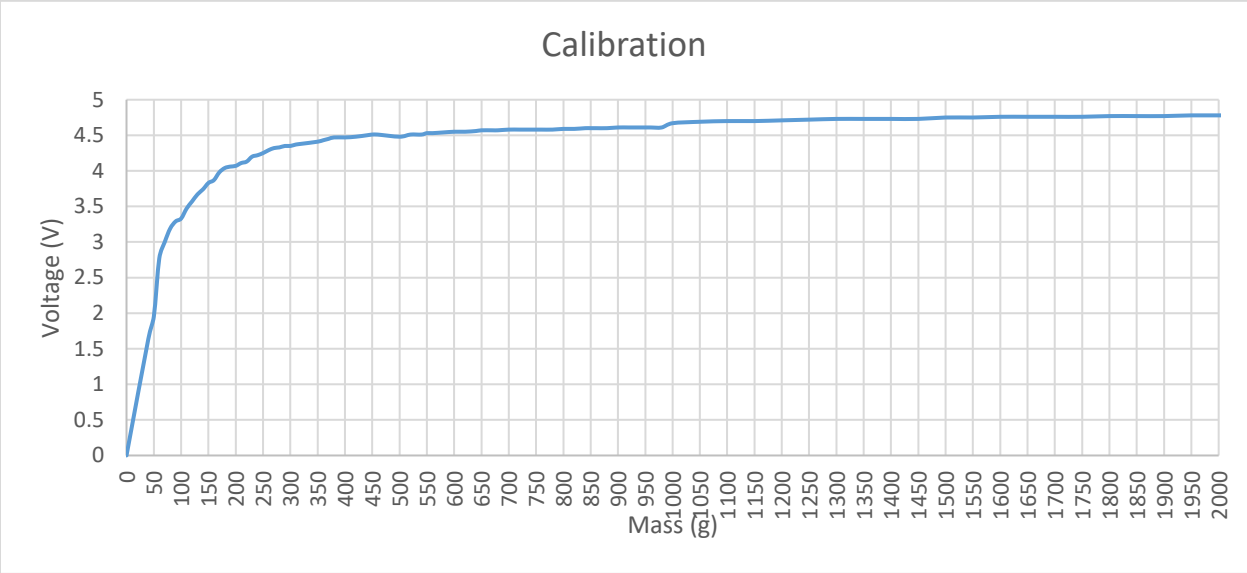

Figure: 5.1 Calibration voltage results with mass in grams

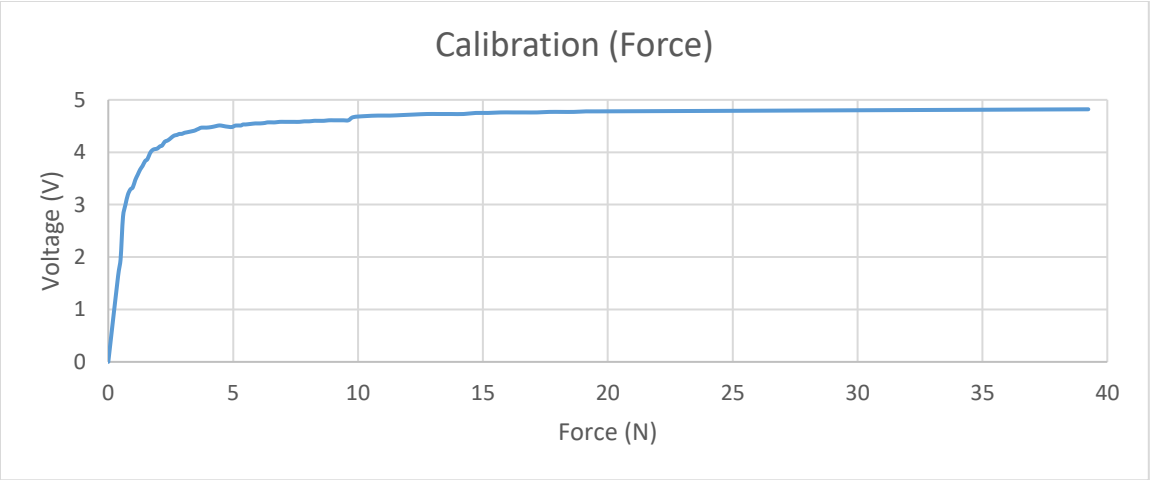

Figure 5.2: Calibration voltage results with Newton forces

The forces exerted on the FSR are distributed through the hand and the healing structures. The ADLs for the study were identified through observations of hand movements of one of the authors (MK) over a 24-hour period to inform the 105 ADL task selection. To confirm the inclusion of the most important basic and instrumental ADL in hand functioning, the Disability of the Arm, Shoulder and Hand (DASH) questionnaire was analysed, and any tasks not yet included by the researcher were then included in the 105 ADL tasks for the study. The predominant grasp types, according to the GRASP taxonomy of human grasp types, were identified and documented in Table 5.8 Supplementary table. The 105 activities were further categorised into five sections, namely, personal care and hygiene, transport and moving around, home environment (inside the home), gardening and outside the home activities, and lastly, other, a category for tasks not falling into the above-mentioned categories.

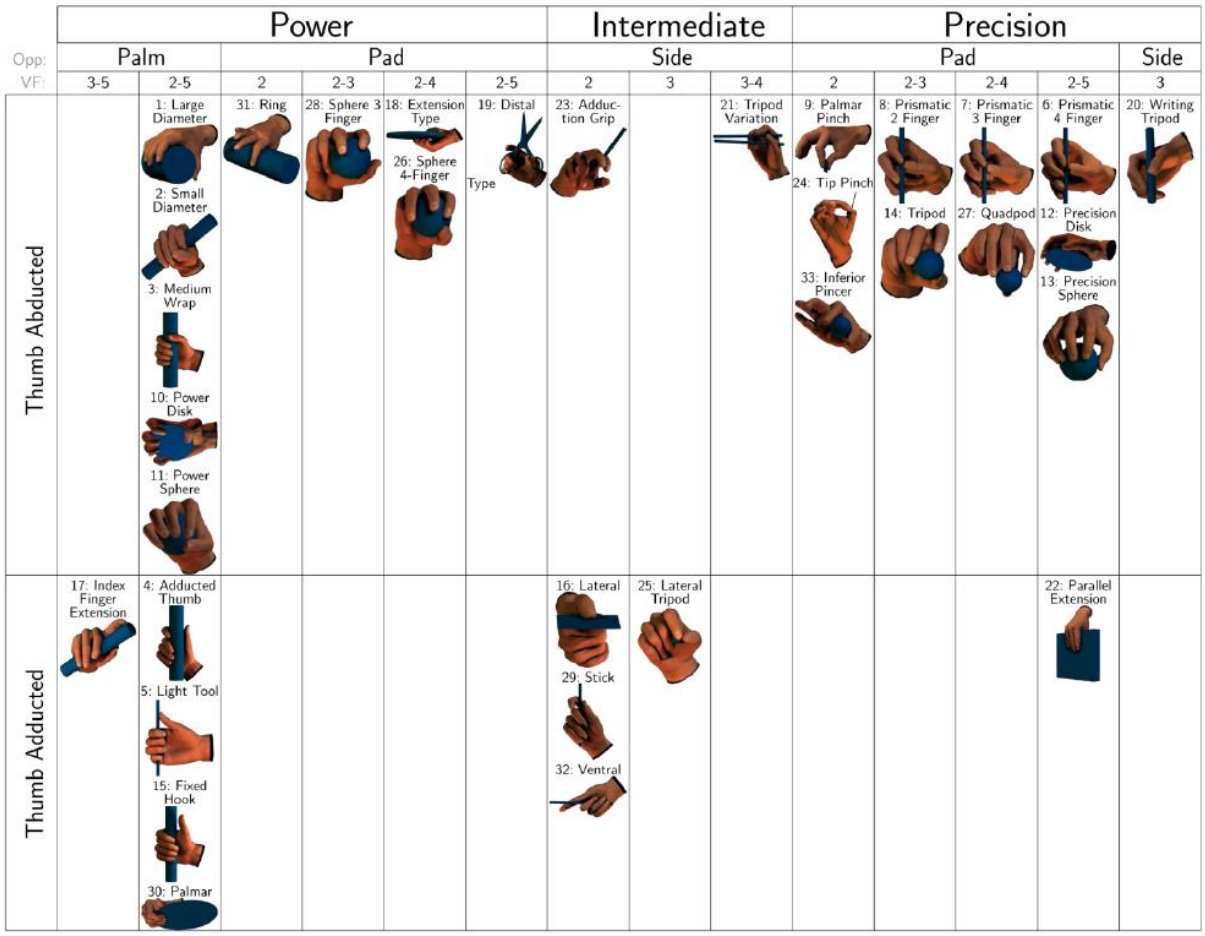

Figure 5.3: The GRASP taxonomy of human grasp types (Feix et al., 2016)

2.4 Data collection

A laboratory, specifically designed for data collection provided a consistent testing environment where the force sensor testing data could be collected. Prospective participants were approached by the researcher and research assistant in the laboratory in the Kempton Park area. The researcher, a qualified physiotherapist with a Master's degree in hand rehabilitation, trained the research assistant, fluent in isiZulu and English, to perform Covid-19 screening, to assist the researcher with the informed-consent process, to complete the questionnaire should the participants require assistance or clarification, and to set out, together with the researcher, the

105 activities to ensure an efficient data collection process. Participants provided written consent before participation.

Ten FSRs were glued to two gloves, one for the left and one for the right hand. A pilot testing on one participant precluded the main data collection process to test for consistency and repeatability of the testing procedures, as well as the technical aspects of the equipment and data collection procedures, and data analysis. Owing to the bending of two of the FSRs, the participant data collected during the pilot testing were excluded from the feasibility data collection results. The participants were instructed to don latex gloves before putting on the FSR testing glove to perform the 105 predetermined activities. Testing commenced with instructions to perform the activities, as they would normally do. Each activity was performed only once unless an error in the reading of the force in question occurred. Where an error occurred, the researcher would instruct the participant to repeat the activity. The collected data were saved on the author's laptop under the individual anonymously-labelled participant folders. Using a comma-delimited setting, data for each activity per participant were collectively imported as a data file into an Excel spreadsheet. Using a predetermined formula 0.5917*tan(0.3223*max value), maximum values were computed and converted to N in the Excel spreadsheet. Data analysis was conducted in Stata software and included descriptive statistics that were presented as means, standard deviations, maximum and paired t-test values to be used in determining the associations between the variables, gender and grip strengths.

3. Results

Six participants, three males and three females, all right-handed, participated in the study. The median age for males was 47 years, and for females, 45 years of age. Table 5.2 below provides the demographic data for the participants, followed by the grip strength (GS) for the right (R) and left (L) hands of the participants and according to the respective intervals, namely, before testing, after 25 activities, after 50 activities, after 75 activities, and finally after testing all activities. All the data in the tables are in N.

Table 5.2: Demographic data of the participants (n=6)

Participant number	Gender	Age	Education level	Occupation	Handedness
1	40	Female	Bachelor's degree	Teacher	Right
2	36	Male	Completed schooling up to 8th grade	Gardener	Right
3	47	Male	Bachelor's degree	Electrical technologist	Right
4	48	Female	Completed schooling up to 8th grade	Domestic worker	Right
5	58	Male	Completed schooling up to 8th grade	Gardener	Right
6	45	Female	High school completed	Domestic worker	Right

The grip strength measurements are presented in Table 5.3 below. The results from the paired t-test analysis revealed no statistically significant difference between the before-testing stage and the final after-testing stage between the genders and between the left ($t = 0.407$) and the right ($t = -0.053$) hands of the participants.

Table 5.3: Grip strength measurements in kilograms of the participants' right (R) and left (L) hands (n=6)

Participant Number	(R) Before testing	(R) At 25 activities	(R) At 50 activities	(R) At 75 activities	(R) After Testing	(L) Before Testing	(L) At 25 Activities	(L) At 50 activities	(L) At 75 activities	(L) After testing
1	26	27	23	21	24	27	25	23	20	22
2	45	43	40	38	37	42	39	39	31	31
3	32	31	31	38	47	26	34	38	40	46
4	20	15	17	21	20	19	16	19	17	18
5	29	28	27	27	28	31	27	28	25	29
6	20	15	18	12	17	21	14	18	12	17

Maximum force ranges per category were as follows: personal care and hygiene (1-15.536N (1.584 kg), right index finger), transport and moving around (1-11.667N (1.189 kg), left ring finger), home environment/inside (1-16.209N (1.652 kg), left middle finger), gardening and outside (1-33.676N (3.433 kg), left thumb), and office/other (1-20.666N (2.107 kg), left middle finger). Maximum forces per gender per category for males, can be viewed in Table 5.5, where personal care and hygiene (1-11.667N (1.189 kg), right thumb), transport and moving around (1-13.825N (1.409 kg), right ring finger), home environment/inside (1-16.209N (1.652 kg), left middle finger), gardening and outside (1-33.676N (3.433 kg), left thumb), and office/other (1-20.666N (2.107 kg), left middle finger). Maximum forces per gender per category for females, can be viewed in Table 5.6. They included: personal care and hygiene (1-15.536N (1.584 kg) right index finger), transport and moving around (1-9.111N (0.929 kg), right thumb), home environment/inside (1-15.536N (1.584 kg), right thumb), gardening and outside (1-7.049N (0.719 kg), right thumb), and office/other (1-7.624N (0.777 kg), right ring finger).

Table 5.4 below presents the average maximum forces for ten fingers per category for all six participants.

Table 5.4: Average maximum finger forces in Newton per task category for all participants (n=6)

Category	Left Fifth Digit	Left Ring	Left Middle Finger	Left Index Finger	Left Thumb	Right Fifth Digit	Right Ring Finger	Right Middle Finger	Right Index Finger	Right Thumb
Personal care and hygiene (39 activities)	0.87	2.01	2.79	2.73	3.61	0.41	2.59	2.24	3.13	5.61
Home environment : inside (39 activities)	1.63	4.44	4.71	2.44	3.16	0.55	5.05	1.82	2.57	3.58
Gardening and outside (8 activities)	1.94	4.96	7.11	4.07	9.25	2.68	6.91	5.62	2.28	5.12
Office or other (11 activities)	0.41	1.95	3.11	0.80	1.77	0.31	2.26	1.08	1.55	2.09

Table 5.5 below presents the average maximum forces in N for ten fingers per category for the male participants.

Table 5.5: Average maximum finger forces in Newton per task category for males (n=3)

Category	Left Fifth Digit	Left Ring	Left Middle Finger	Left Index Finger	Left Thumb	Right Fifth Digit	Right Ring Finger	Right Middle Finger	Right Index Finger	Right Thumb
Personal care and hygiene (39 activities)	0.67	1.76	2.60	2.16	2.90	0.29	2.33	1.61	2.03	5.01
Transport and moving around (8 activities)	0.77	4.24	6.53	2.44	4.47	0.74	6.53	4.23	1.54	4.56
Home environment : inside (39 activities)	1.39	4.27	4.63	1.94	3.11	0.39	4.87	1.20	2.28	2.72
Gardening and outside (8 activities)	1.74	4.73	7.11	3.99	9.25	2.68	6.91	5.62	1.75	4.05
Office or other (11 activities)	0.24	1.83	2.98	0.77	1.77	0.11	1.76	0.73	1.34	1.80

Table 5.6 below presents the average maximum forces in N for ten fingers per category for the female participants.

Table 5.6: Average maximum finger forces in Newton per task category for all females (n=3)

Category	Left Fifth Digit	Left Ring Finger	Left Middle finger	Left Index finger	Left Thumb	Right Fifth Digit	Right Ring finger	Right Middle finger	Right Index finger	Right Thumb
Personal care and hygiene (39 activities)	0.41	1.14	1.24	1.77	2.45	0.27	1.20	1.56	2.30	3.65
Transport and moving around (8 activities)	0.12	1.10	1.61	0.61	0.92	0.15	2.29	0.94	1.71	3.66
Home environment : inside (39 activities)	0.59	1.88	2.06	1.55	0.61	0.28	2.87	1.46	1.38	2.72
Gardening and outside (8 activities)	1.17	2.08	1.70	0.37	0.45	0.16	2.90	1.34	1.40	2.68
Office or other (11 activities)	0.23	0.75	0.73	0.29	0.53	0.21	1.31	0.84	1.19	1.42

Predominant grasps, in brackets observed during the 105 predetermined activities. The occurrence numbers, stated in brackets, are presented in Table 5.7 below. The adducted thumb was seen most during the 105 tasks (n=17).

Table 5.7: Predominant grasp types and number of occurrences

Predominant Grasp type	**Number of occurrences (n)**
Adducted thumb	17
Prismatic three fingers	12
Lateral tripod	10
Small diameter	9
Prismatic two fingers	9
Medium wrap	7
Fixed hook	5
Sphere four fingers	4
Palmar	4
Parallel extension	4
Index finger extension	3
Distal	3
Tripod	2
Quadpod	2
Prismatic four fingers	2
Lateral	2
Large diameter	2
Ventral	2
Power sphere	1
Precision sphere	1
Palmar pinch	1

Light tool	1
Inferior pincher	1
Writing tripod	1

4. Discussion

The human hand is a highly sophisticated and primary tool in the mechanical interaction of an individual with his/her world. The measurement of individual finger forces, as conducted in our study, offers a more precise model of human hand biomechanics in action and thus of hand function.[24] Force measurements during ADL exerted by the individual fingers would provide a valuable contribution to understanding hand function.[11] The FSRs successfully measured individual finger force in 105 activities, where the participants performed the tasks as they would normally do. The maximum values obtained subsequent to the descriptive statistics analysis of the finger forces may provide evidence to guide clinical and rehabilitation practices in the future.

In other studies, forces were measured during the opening of the containers provided, and the forces ranged between 9.74 N and 43 N. A weak correlation between grip and pinch strength and the FSR forces measured during the opening of the containers ($r = -0.179$ to $r = 0.333$) was found. No significant difference was found between the genders and the respective forces needed to open the containers. [13] The authors concluded that grip and pinch strength measurement in isolation is insufficient as a conclusive predictor of successful hand functioning during activities such as opening household containers. This further emphasises the importance of measuring the forces of a wider variety of hand grasps used during activities in order to guide clinical practice.

When comparing the results of our study to the force sensing results,[12] the forces were also found to range from zero to seven N. To determine the forces that are exerted during spherical-shaped ball-grasping with a tripod grasp, the researchers mounted FSRs on the contact areas of the ball to measure the forces exerted by the thumb, index finger, and middle finger. The participants

were instructed to grasp, to steadily hold the ball, and then to let the ball slip out of their hands. The forces ranged between 0.3N and a maximum of 2.7N. [14] Comparing the average maximum forces produced by all fingers during the power sphere grasp to the forces measured in our study revealed that the average forces per finger on the right hand were as follows: thumb 2.44N, index finger 1.48N, middle finger 1.38N, ring finger 1.66N, and little finger 0.21N, compared to a 0.3N to 2.7N range. [14]

Prior to the FSR testing of the participants, the researcher identified hand activities through observations of her own and others' hands while performing activities during the waking hours of one day. The researcher acknowledges that by observing her own hands and using this information during the study could have introduced bias into the study. Observed activities of the hands were compared to the Disability of the Arm, Shoulder and Hand (DASH) questionnaire for accuracy and completeness.

The feasibility of the FSR testing with gloves initially proved to be challenging and an improvement of the set-up was considered necessary. The sensors were attached to the fingers by means of 24 mm masking tape, and the direction of the wires ran volar into the palm. This caused the sensors to bend at the finger creases. To prevent the bending of the sensors, a new set of sensors was glued to the household gloves, and the wires ran from the fingertip dorsally over the nails and were secured on the dorsum of the wrist. A challenge, however, was that the glue did not hold the sensor to the glove, with the result that the sensor loosened with hand use. Golf gloves then replaced the household gloves, with the wires placed to run dorsally. The golf gloves worked well, but during data collection, the sensors continued to come off the tips of the fingers after repeated gripping and rotational tasks. As such, the sensors had to be glued to the gloves with a stronger glue. Furthermore, the fact that the number of tasks associated with the participants' data had to be entered and saved in a separate folder proved to be time-consuming. In one instance, a participant had to redo the tasks as a result of an incorrect data entry by the

researcher, but fortunately, no data was lost during any stage of the data collection process. A systematic approach during data capturing is advised for future research to ensure that participants do not have to repeat tasks that is already time consuming.

Although the use of gloves during the study was crucial to prevent the infection risks associated with the COVID-19 pandemic restrictions, using gloves proved to present limitations to the study that should be acknowledged. The gloves change the sensory input and possibly the hand dexterity while performing ADLs and may have impacted manipulation of the objects and the resultant forces. However, the testing gloves with sensors on, in the researcher's experience with the testing equipment and the FSRs set-up, may have improved the repeatability of the data collection process. Taking all the challenges into account, the data collection method was found to be feasible for testing hand and grasp forces.

The study results contributed to a possible solution to inform hand rehabilitation and advice regarding a return to pre-injury ADLs. Through the progressive incorporation of ADLs after second to fifth metacarpal fractures - by starting with tasks requiring lighter forces and by progressing to tasks requiring heavier forces - may allow for a more holistic and safe hand rehabilitation approach. A holistic clinical hand rehabilitation guideline is encouraged where the tasks are unique to each individual's needs, considering occupation, recreation and hobbies, to allow return to pre-injury function.

Although, on account of the small sample size, the findings of the current study were unable to propose normative values for the forces involved in ADL tasks, the results still offer a guideline for therapists to work backwards to the safe forces that can be applied after a second to fifth metacarpal fracture. The study is, however, is able to propose normative values that can be used to develop a baseline of ADL task forces. A normative guide, based on a larger sample of healthy participants, is to be recommended. Equal representation of the genders, age groups,

handedness, the variety of occupations, especially those requiring significant grip and pinch strength for manual tasks to be performed (as in the case of the work of a labourer), should be considered as it poses limitations to the study. Not having a representative sample was a limitation of this study where the age group between 20 and 35 years was not represented in the current study to offer a baseline of forces produced during ADLs. To elaborate more on the limitation of handedness, 10.6% of the participants in the five meta-analyses were left-handed (Papadatou-Pastou et al, 2020), but only 6.25% of participants in the current study were left-handed, which limited the comparison of results. It should be noted that the baseline normative forces obtained during the study phase can also be used for other hand injuries, as in the case of phalangeal fractures.

The study offers a possible solution to address the high monetary cost, on account of productivity loss and time off work, the lack of scientific data supporting hand rehabilitation for hand fractures, and the healthcare costs incurred by healthcare providers and society.

Conclusion and Limitations

The first of its kind, this research study on force sensor measurement of all ten fingers performing a range of basic and instrumental ADLs has contributed significantly to the knowledge base. The finger forces collected during this phase of the study assisted in the categorisation of activities into light, moderate and heavy categories (Addendum B). The rationale for including grasp types as free active exercises in the clinical hand rehabilitation guidelines was to improve hand function. Although a feasibility study, the strength of the study lies within the potential to guide clinical practice and may become a valuable instrument for evaluating function and an assessment tool for future evaluation of occupational return after injury. A limitation of the study was not including individuals who sustained second to fifth metacarpal fractures and testing their finger forces with FSRs. The rationale for the inclusion and data collection on healthy participants was to establish a baseline of finger and grasp forces to work backwards determining safe

activities which may be done by individuals after sustaining a second to fifth metacarpal fracture. If injured individuals were to be tested, a wide variety of unreliable forces might be produced due to pain, and it would be challenging during testing to ensure the safety of the healing site and to protect the healing of the bone injury/fracture - unless callus had formed. The opportunity to test all the categories, namely, light, medium, and heavy tasks, would have been lost and there would perhaps have been a chance that the healing process would have been disrupted. Owing to the potential harm that might have been inflicted on such injured participants, the HSREC might not have approved the testing.

Another limitation to the study was the small sample size and the need to validate the FSR testing hardware and procedures The possible impact that the surgical and testing gloves had in altering the sensation of touch while the tasks were being performed, as well as the potential impact on finger dexterity, was a limitation. However, these aspects did not influence the ability of the FSRs to measure the relevant forces. It is recommended that future research should include a validation of the FSR testing instrument and the recruitment of a larger sample size.

Key messages

- The forces produced during basic and instrumental ADL tasks can be evaluated.
- FSRs provide a low-cost, easily accessible, and effective means for measuring valid outcomes in assessing hand forces.
- Personal care and hygiene tasks require the least force.
- Scientific evidence is needed to guide a safe return to work after an individual has sustained a hand injury.

Declaration

Competing interests

The authors, MK, RB, and CB, declare no competing interests.

Author contributions

All authors have read and approved the manuscript. MK proposed the topic of the research study and wrote the protocol for ethical approval and the first version of the article. The protocol and article were read, elaborated upon, and refined with the assistance of RB and CB.

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Table 5.8: Supplementary Table: Tasks, grasp types, categorisation, maximum Newton forces per finger and gender t-test results

ADL Task	Predominant Grasp type	Light tasks	Moderate tasks	Heavy tasks	Fifth digit L	Ring L	Middle L	Index L	Thumb L	Fifth digit Right	Ring R	Middle R	Index R	Thumb R	Two-sample Test Gender
Personal care and Hygiene															
Washing body with a washcloth	25. Lateral tripod	**X**			2.85	3.41	3.92	5.74	5.83	1.22	3.04	3.34	4.23	6.55	p =0.002
Washing hair	13. Precision Sphere	**X**			1.67	2.30	2.99	2.41	1.57	0.57	2.30	1.05	2.25	3.54	p = 0.261
Squeezing water out of a sponge	11. Power Sphere	**X**			2.85	6.69	4.78	2.68	3.41	0.86	3.04	3.34	3.80	5.41	p = 0.015
Wringing water out of a washcloth/facecloth	2. Small Diameter		**X**		2.59	5.57	3.04	3.76	1.95	0.50	5.41	1.27	1.87	6.12	p = 0.163
Opening and closing a tap (small round shape)	14. Tripod	**X**			0.33	0.96	1.39	8.12	2.34	0.34	2.85	7.78	1.26	3.28	p = 0.407
Opening and closing a tap (small cylindrical shape)	7. Prismatic 3 Finger	**X**			1.00	1.65	6.23	1.96	3.09	0.46	2.56	0.73	0.72	8.49	p = 0.447
Opening and closing a tap (large round shape)	27. Quadpod	**X**			3.34	5.57	4.23	2.96	5.83	1.36	3.25	3.31	3.01	4.98	p = 0.175
Carrying a bucket containing three litres of water	2. Small Diameter		**X**		0.08	5.57	3.96	2.03	3.44	0.05	8.69	2.96	1.78	2.56	p = 0.102
Carrying a zinc basin containing three litres of water	15. Fixed Hook		**X**		1.51	6.02	7.78	1.80	0.87	0.52	3.84	2.28	1.11	2.70	p = 0.064
Drying the body with a towel	25. Lateral tripod	**X**			0.32	0.54	0.67	0.46	1.88	0.27	1.13	1.96	3.54	3.88	p = 0.530
Drying hair with a hairdryer	3. Medium Wrap	**X**			0.95	2.49	3.92	1.17	2.17	1.86	5.26	2.56	0.55	5.74	p = 0.069
Drying hair with a towel	25. Lateral tripod	**X**			0.41	1.11	1.05	1.80	2.66	0.68	1.78	2.46	1.50	5.74	p = 0.165
Brushing hair	2. Small Diameter	**X**			0.22	3.25	1.85	2.54	3.20	0.04	2.96	1.91	0.76	5.41	p = 0.349
Tying up hair with an elastic band	27. Quadpod	**X**			0.59	3.72	4.29	1.92	4.38	0.003	0.90	2.89	1.05	2.44	p = 0.823

Putting on base make-up_	8. Prismatic 2 Fingers	**X**			0.001	2.64	0.63	0.92	2.15	0.56	5.26	3.76	3.92	11.67	p = 0.917
Applying mascara on the eyelashes	8. Prismatic 2 Fingers	**X**			0.18	1.44	1.88	3.31	2.08	0.02	2.99	2.51	0.74	9.34	p = 0.849
Washing clothes using hands and soap (SIZE Medium)	25. Lateral tripod	**X**			0.71	1.79	1.85	1.90	5.04	0.45	1.95	2.66	1.26	4.55	p = 0.663
Hanging washing up on the washing line	8. Prismatic 2 Fingers	**X**			0.10	0.53	0.59	0.73	2.36	0.22	0.63	1.86	0.42	2.62	p = 0.813
Using pegs to secure clothes on the washing line	9. Palmar Pinch		**X**		0.002	0.93	1.59	3.57	5.57	0.001	0.21	2.58	4.23	6.55	p = 0.695
Drying water out of clothes by hand	3. Medium Wrap	**X**			2.47	3.04	8.12	2.42	5.74	1.08	2.60	2.44	2.56	4.33	p = 0.088
Brushing teeth with a toothbrush	6. Prismatic 4 Fingers	**X**			0	0.39	1.57	0.63	1.60	0.003	5.26	2.05	0.94	7.62	p = 0.702
Squeezing toothpaste out of a tube Standard Large	8. Prismatic 2 Fingers	**X**			0.001	2.15	1.56	1.15	2.68	0.38	6.79	2.28	2.01	7.78	p = 0.547
Dressing	7. Prismatic 3 Fingers	**X**			0.20	0.60	3.14	5.74	4.84	0.49	0.95	2.49	2.07	6.55	p = 0.622
Putting t-shirt on	7. Prismatic 3 Fingers	**X**			0	0.36	2.31	3.06	5.26	0.17	0.33	0.16	2.20	3.84	p = 0.043
Taking t-shirt off	7. Prismatic 3 Fingers	**X**			0.001	0.37	3.84	4.78	2.49	0	0.40	2.49	2.62	3.23	p = 0.217
Undoing buttons on a long-sleeved shirt	7. Prismatic 3 Fingers	**X**			0.29	0.02	2.34	2.82	2.21	0.002	0.52	2.05	4.33	4.19	p = 0.057
Doing up buttons on a long-sleeved shirt:	7. Prismatic 3 Fingers	**X**			0.18	0.64	2.68	1.23	7.95	0.10	2.96	1.32	2.02	4.14	p = 0.993
Putting tie on	7. Prismatic 3 Fingers	**X**			0	0.24	1.89	2.08	2.25	0.004	0.35	3.01	1.37	5.11	p = 0.870
Putting trousers on	8. Prismatic 2 Fingers	**X**			4.84	3.65	2.51	3.06	1.33	0.41	7.33	1.93	1.80	4.78	p = 0.675
Taking trousers off	6. Prismatic 4 Fingers	**X**			0.70	0.94	2.44	0.88	2.60	0.25	1.89	1.42	1.76	9.34	p = 0.192
Zipping up trousers	8. Prismatic 2 Fingers	**X**			0.93	1.39	2.72	1.80	6.12	0.21	0.31	1.00	6.67	8.49	p = 0.130
Unzipping trousers	8. Prismatic 2 Fingers	**X**			1.43	1.65	0.49	0.14	1.82	0	0.15	0.140	3.06	6.44	p = 0.020
Putting socks on	7. Prismatic 3 Fingers		**X**		0.02	0.77	3.44	6.92	5.26	0.50	0.44	1.80	15.54	7.62	p = 0.008
Taking socks off	7. Prismatic 3 Fingers	**X**			0.48	0.97	0.36	2.78	4.18	0	0.32	0.73	6.44	4.38	p = 0.050

Putting shoes on	7. Prismatic 3 Fingers	**X**			0.25	1.42	2.89	2.96	10.38	1.33	3.31	1.83	8.69	6.67	p = 0.053
Taking shoes off	7. Prismatic 3 Fingers	**X**			1.10	0.94	4.23	1.30	2.96	0.36	1.18	3.34	6.12	5.57	p = 0.754
Tying laces	8. Prismatic 2 Fingers	**X**			0.28	1.46	2.78	2.70	3.12	0.13	1.04	2.01	4.78	5.66	p = 0.779
Putting belt on	8. Prismatic 2 Fingers	**X**			0.64	0.26	2.07	2.90	5.49	0.50	2.51	1.37	3.34	6.02	p = 0.943
Buckling a belt	7. Prismatic 3 Fingers		**X**		0.29	0.87	1.70	7.19	2.85	0.20	4.28	2.31	5.57	5.26	p = 0.777
Transport and Moving Around															
ADL Task	**Predominant Grasp type**	**Light tasks**	**Moderate tasks**	**Heavy tasks**	**Fifth digit L**	**Ring L**	**Middle L**	**Index L**	**Thumb L**	**Fifth digit Right**	**Ring R**	**Middle R**	**Index R**	**Thumb R**	**Test Gender**
Closing car door	15. Fixed hook	**X**			2.54	4.33	3.31	1.61	3.34	1.78	6.44	1.89	2.94	3.54	p = 0.908
Turning the key to start the car	16. Lateral	**X**			0	1.85	2.47	2.36	2.74	0.43	4.00	8.69	2.91	9.11	p = 0.441
Turning the steering wheel	15. Fixed hook		**X**		0.76	2.15	7.05	3.23	4.44	2.72	8.30	7.95	4.84	7.95	p = 0.273
Shifting the gears (Manual)	26. Sphere 4 Fingers	**X**			0.28	2.94	10.38	0.28	1.76	0	1.53	0	0.30	6.33	p = 0.315
Opening a door knob (circular)	26. Sphere 4 Fingers		**X**		0.23	3.80	4.18	0.90	3.68	0.01	7.47	2.15	2.78	5.26	p = 0.506
Opening a door (long horisontal handle)	4. Adducted Thumb		**X**		1.01	5.04	8.69	3.80	10.89	1.32	5.66	3.80	1.40	4.09	p = 0.029
Holding onto a rail in a taxi	4. Adducted Thumb			**X**	0.61	11.67	12.04	6.67	7.19	0.001	13.83	8.69	3.96	5.49	p = 0.337
Closing a taxi door	4. Adducted Thumb	**X**			2.10	4.09	1.70	1.64	0.009	4.97	0.94	0.74	2.51	0.76	p = 0.040
Home environment (Inside home)															

ADL Task	Predominant Grasp type	Light tasks	Moderate tasks	Heavy tasks	Fifth digit L	Ring L	Middle L	Index L	Thumb L	Fifth digit Right	Ring R	Middle R	Index R	Thumb R	Test Gender
Making a bed	25. Lateral Tripod	**X**			0.47	2.99	3.57	0.98	3.04	0.32	1.27	1.67	3.24	3.88	p = 0.294
Carrying a shopping bag	15. Fixed Hook	**X**			0.71	4.91	5.49	0.15	1.03	0.58	6.23	1.61	0.41	4.55	p = 0.185
Mopping	2. Small Diameter	**X**			2.64	3.12	4.33	1.89	4.09	1.97	3.76	2.54	2.02	7.95	p = 0.756
Dusting	5.Light Tool	**X**			0.97	3.92	0.86	0	1.59	1.15	2.99	1.84	1.99	3.96	p = 0.374
Sweeping floors with a broom	2. Small Diameter	**X**			3.88	3.23	2.36	1.30	2.45	1.88	4.38	2.05	1.15	2.25	p = 0.133
Vacuum cleaning	3. Medium Wrap	**X**			0.17	3.34	4.84	0.93	3.31	1.28	6.92	1.80	1.10	2.96	p = 0.563
Washing dishes	30. Palmar	**X**			0.82	4.33	4.38	0.93	4.97	0.49	6.12	1.78	1.49	15.54	p = 0.847
Drying dishes	30. Palmar	**X**			4.38	4.66	1.37	1.10	5.26	1.56	5.04	1.42	1.16	3.88	p = 0.691
Packing dishes away	22. Parallel Extension	**X**			2.85	2.14	2.33	0.60	6.33	1.06	3.54	0.98	2.27	3.54	p = 0.969
Ironing	3. Medium Wrap	**X**			0.74	1.29	3.84	1.93	1.24	1.24	2.74	1.27	4.14	1.47	p = 0.136
Eating with hands	14. Tripod	**X**			0.11	3.50	4.05	1.27	4.97	0.26	5.41	3.23	1.32	3.06	p = 0.051
Holding a pint glass	15. Fixed Hook	**X**			0.93	3.61	4.44	0.24	1.52	0.08	3.09	1.08	0.65	0.54	p = 0.039
Opening a tight or new jar	26. Sphere 4 Fingers/12. Precision Disk		**X**		1.65	8.12	8.69	4.66	5.66	0.52	4.33	1.92	4.00	4.28	p = 0.493
Eating using utensils	17. Index Finger Extension	**X**			1.06	3.72	2.96	1.33	2.34	0.26	3.09	1.21	4.23	3.54	p = 0.823
Opening a heavy door	2. Small Diameter	**X**			1.54	4.66	6.67	4.60	6.92	0.16	6.12	3.06	1.98	2.87	p = 0.655
Lifting a box (1kg) onto counter	4. Adducted Thumb	**X**			0.56	5.66	2.51	1.92	0.001	0.09	0.76	1.76	1.52	0	p = 0.735
Lifting a box (2kg) onto counter	4. Adducted Thumb	**X**			3.23	6.67	3.04	3.14	1.01	0.17	3.50	1.20	2.28	0	p = 0.127

Lifting a box (3kg) onto counter	4. Adducted Thumb	**X**			3.47	5.11	3.61	2.58	0.001	0	4.78	0.10	4.18	0	p = 0.159
Lifting a box (4kg) onto counter	4. Adducted Thumb	**X**			1.85	3.76	1.60	1.99	0.001	0.001	2.94	0.99	2.64	0	p = 0.104
Lifting a box (5kg) onto counter	4. Adducted Thumb	**X**			1.25	4.60	5.83	4.60	0.14	0.23	4.00	1.66	4.14	0.001	p = 0.130
Lifting a box (10kg) onto counter	4. Adducted Thumb		**X**		1.98	6.33	4.66	1.99	0.01	0.001	5.11	2.30	3.17	1.78	p = 0.748
Lifting a box (15kg) onto counter	4. Adducted Thumb		**X**		2.02	11.67	9.58	2.68	1.96	0.46	7.95	2.17	2.94	0.003	p = 0.792
Lifting a box (20kg) onto counter	4. Adducted Thumb		**X**		2.56	5.57	9.34	5.18	0.05	0.003	10.38	2.19	3.12	0.003	p = 0.969
Lifting a box (25kg) onto counter	4. Adducted Thumb			**X**	1.34	4.78	7.62	9.34	0.001	0.003	10.38	3.04	3.06	0.003	p = 0.751
Lifting a box (30kg) onto counter	4. Adducted Thumb			**X**	1.22	5.33	8.12	7.47	1.50	0.003	10.98	2.32	5.93	0.003	p = 0.340
Stirring pap in a pot	2. Small Diameter		**X**		1.86	1.96	4.66	1.78	3.76	0.76	8.49	1.55	3.04	12.44	p = 0.130
Lifting a pan and putting it down	4. Adducted Thumb	**X**			0.97	1.64	3.96	1.00	2.19	0.64	5.18	1.70	1.01	6.23	p = 0.752
Lifting a pot and putting it down	30. Palmar	**X**			2.76	4.97	4.78	3.01	5.74	0.25	6.92	1.60	2.99	4.44	p = 0.932
Filling a kettle with water and lifting it	3. Medium Wrap	**X**			3.96	3.01	5.18	2.45	2.85	0.31	4.72	1.33	2.12	5.33	p = 0.956
Pouring water into a cup to make tea	3. Medium Wrap		**X**		0.69	3.28	3.31	0.37	4.38	0.23	6.44	1.39	1.64	3.31	p = 0.440
Changing a lightbulb overhead	26. Sphere 4 Fingers	**X**			0.41	2.58	0.91	1.07	1.26	0.35	1.57	1.32	1.74	4.72	p = 0.529
Opening a can by pulling on the ring	33. Inferior Pincher	**X**			0.06	1.36	2.58	1.07	1.41	0.001	1.33	2.42	3.34	2.64	p = 0.608
Cutting potatoes with a knife	25. Lateral Tripod	**X**			1.26	6.23	7.47	4.44	6.55	0.30	6.33	0.70	2.54	6.23	p = 0.798
Peeling carrots with a peeler	25. Lateral Tripod	**X**			0.24	2.60	3.25	2.80	4.97	0.35	0.84	1.31	2.40	4.33	p = 0.323
Grating cheese with a grater	25. Lateral Tripod	**X**			1.34	3.14	2.99	1.45	2.44	0.48	3.57	1.41	1.54	4.84	p = 0.307
Cutting with scissors	19. Distal	**X**			0.10	0.69	1.73	1.87	1.94	3.61	0.20	1.01	2.62	1.73	p = 0.934
Turning a salt grinder	3. Medium Wrap		**X**		0.98	2.85	3.96	2.68	2.30	0.29	3.72	1.19	3.96	5.18	p = 0.926

Picking up a child	1. Large Diameter		**X**		2.96	10.67	6.55	1.36	13.33	0.81	8.12	3.72	1.95	6.02	p = 0.467
Moving couch in living room	1. Large Diameter		**X**		3.41	11.31	16.21	7.19	10.67	0.12	13.83	4.33	5.11	6.12	p = 0.224
Gardening and Outside home															
ADL Task	**Predominant Grasp type**	**Light tasks**	**Moderate tasks**	**Heavy tasks**	**Fifth digit L**	**Ring L**	**Middle L**	**Index L**	**Thumb L**	**Fifth digit Right**	**Ring R**	**Middle R**	**Index R**	**Thumb R**	**Test Gender**
Sweeping pavement	2. Small Diameter			**X**	1.84	11.67	14.34	13.82	33.68	0.64	13.83	4.33	5.11	7.95	p = 0.084
Raking leaves	2. Small Diameter		**X**		2.51	3.61	3.12	2.25	9.58	3.38	3.76	5.93	3.68	2.49	p = 0.478
Pruning trees	19. Distal		**X**		2.96	2.40	2.31	3.84	4.66	8.69	9.83	8.89	2.94	6.12	p = 0.776
Cutting branches	19. Distal	**X**			2.51	3.12	2.72	0.77	1.25	2.08	6.23	2.74	0.54	3.47	p = 0.586
Washing car	17. Index Finger Extension	**X**			0.62	2.36	4.49	1.32	7.19	0.43	6.12	6.55	2.09	2.96	p = 0.728
Using wheelbarrow	4. Adducted Thumb	**X**			1.27	8.30	4.55	1.79	3.57	2.27	4.28	5.11	1.13	7.05	p = 0.066
Shovelling ground	4. Adducted Thumb		**X**		1.79	4.38	14.34	3.68	5.41	2.70	5.33	5.26	1.11	5.33	p = 0.616
Using fork in flower beds	4. Adducted Thumb		**X**		2.02	3.84	10.98	5.11	8.69	1.29	5.93	6.12	1.61	5.57	p = 0.304
Other (tasks not included in above sections)															
ADL Task	**Predominant Grasp type**	**Light tasks**	**Moderate tasks**	**Heavy tasks**	**Fifth digit L**	**Ring L**	**Middle L**	**Index L**	**Thumb L**	**Fifth digit Right**	**Ring R**	**Middle R**	**Index R**	**Thumb R**	**Test Gender**
Shaking hands	22. Parallel Extension	**X**			0.23	0.12	0.50	0.32	1.35	0.47	2.09	0.37	1.39	2.36	p = 0.098
Using a manual cellular phone	16. Lateral	**X**			1.17	5.04	4.05	0.67	6.12	0.14	1.48	0.15	1.76	3.20	p = 0.473

Using a touch-screen cellular phone	32. Ventral	**X**			0.21	0.37	0.47	1.01	1.08	0.63	0.31	0.73	1.18	1.00	p = 0.036
Using the remote of the television	32. Ventral	**X**			0	0.78	1.14	0.36	3.31	0.72	2.12	1.50	0.26	4.78	p = 0.660
Typing on laptop	22. Parallel Extension	**X**			0.89	0.75	1.63	1.57	0	0.38	3.09	1.05	2.40	0.53	p = 0.794
Using the mouse on computer	25. Lateral Tripod	**X**			0	0	0	0	0	0.49	0.56	0.70	1.31	0.17	p = 0.152
Typing on desktop	22. Parallel Extension	**X**			0.34	1.45	0.92	1.22	0	0	1.04	0.70	1.69	0	p = 0.345
Writing a handwritten letter	20. Writing Tripod	**X**			0	1.31	1.06	0.76	0.51	0.29	1.48	0.48	2.42	4.72	p = 0.354
Lifting a 400-page book and reading it	30. Palmar		**X**		0.70	7.95	20.67	1.52	3.23	0.04	7.62	3.28	2.28	0.003	p = 0.095
Picking a magazine up and reading it	17. Index Finger Extension	**X**			1.01	2.89	1.81	0.87	2.37	0.07	3.84	1.85	0.93	3.25	p = 0.676
Handling money	25. Lateral Tripod	**X**			0.001	0.81	1.99	0.52	1.45	0.16	1.29	1.06	1.47	2.99	p = 0.088

5.6 Second article: Phase II

5.7 Introduction

The article, written according to the format and author guidelines as in Addendum BII, is to be submitted to the South African Journal of Occupational Therapy, a double peer-reviewed journal. The article is the second of two articles presenting the results of the second phase of the research to develop a clinical hand rehabilitation guideline.

The design of the testing procedure and equipment was refined by the researcher. Golf gloves replaced household gloves and the wires were placed to run dorsally. Stronger glue was used to glue the sensors to the gloves, the glue was placed on all ten sensors, allowing five minutes before they were attached to the glove, as instructed by the glue manufacturer for a more secure glue connection. To further secure the sensors to the glove and avoid them from falling off during testing, washing-line pegs were used to secure them to the glove for five to ten minutes.

5.8 Journal details

The publication specifics of the journal are presented in Table 5.9 below.

Table 5.9: Publication specifics

Title of publication	**Hand-grasp forces during activities of daily living tasks**
Authors	Monique M. Keller, Roline Barnes, Corlia Brandt
Journal name	South African Journal of Occupational Therapy
To be submitted for publication in the South African Journal of Occupational Therapy	

5.9 Permissions and rights

The first author intends to submit the article to the South African Journal of Occupational Therapy. With this submission, the researcher will inform the journal editor of the inclusion of the manuscript in this thesis.

5.10 Article Phase II: Secondary Objective

Hand-grasp forces during activities of daily living tasks

Abstract

Background

There is a gap in scientific evidence with respect to the grasp forces that subsequent to a second to fifth metacarpal fracture would guide the clinical hand rehabilitation services/therapy for ensuring optimal basic and instrumental hand functioning and an early and safe return to work. The research objective of the study was to determine the grasp types, forces, and their association with gender during activities of basic and instrumental daily living (ADL). From these

results, a clinical hand rehabilitation guideline was developed for the management of individuals who had sustained second to fifth metacarpal fractures.

Methods

A cross-sectional, quantitative study was conducted on 32 conveniently sampled healthy adults between the ages of 20 and 59 years who were living or working in east Gauteng, South Africa and had sustained no previous hand injuries. Thirty-two (32) basic and instrumental ADLs, each associated with a predominant grasp type, were tested. The participants donned two pairs of testing gloves, with force sensing resistors (FSRs) glued to the ten glove fingers. A demographic questionnaire, with both inclusion and exclusion criteria, and data on grip strength that were measured with a hand-held dynamometer, preceded the force testing. The data were imported by the researcher into an Excel spreadsheet for data analysis.

Results

Descriptive and inferential statistics were computed on STATA software. Thirty-two (32) participants, 14 males and 18 females with a mean age of 37 years, completed all the tasks. The maximum and mean force measurements of the grasp types were determined and presented per grasp type. According to the GRASP taxonomy, statistically significant differences were seen between the genders in respect of the seven grasp types. Three thumb-adducted power palm grasps, three thumb-abduction precision pad grasps, and one thumb-abduction power palm grasp constituted the testing.

Conclusion

To ensure optimal metacarpal bone healing and optimal hand function, a clinical hand rehabilitation guideline should be inclusive of various tasks in terms of grasp force and gender.

Keywords

Human grasp, manipulation, metacarpal fractures, rehabilitation, activities of daily living

Introduction

Human hands are complex in that they accommodate thousands of sensory organs, 38 muscles, and 21 degrees of controlled movement. How humans use their hands has been a topic of interest in the areas of hand surgery, biomechanics, and rehabilitation, but has intensified with prosthetic and robotic applications[1]. Sancho-Bru (2003) also emphasised the complexity of the hand and its anatomy during research into biomechanical models of the human hand[2]. Biomechanical models are used in elemental analyses, in a stress/strain analysis or simulation of multibody segments, thus allowing for the measurement of force-dependent kinematics. Biomechanical models thus provide some insight into the pathological and healthy normal biomechanics of a healthy human hand. The complexity of the hand therefore necessitates an in-depth consideration of the grasp types that are used during basic and instrumental daily activities to inform clinical hand rehabilitation practice. The problem is the lack of scientifically-based evidence on grasp forces to inform hand rehabilitation in both the research setting and in clinical practice in order to guide an earlier safe return to work and improved hand function.

Kimmerle et al. (2003) advocated for more functional assessments and rehabilitation therapies for individuals who had sustained hand injuries[3]. The functional hand repertoire model encourages therapists to incorporate reaching, the manipulation of objects, and grasping into the key components of hand actions, and encourages special consideration being given to the object, movement patterns, and performance demands under task parameter[3]. In his study, Bullock (2013) investigated grasp types and the frequency of their use in common manipulation task classes. The unstructured hand-use behaviour of two housekeepers and two machinists was investigated by taking video footage over a period of 7.45 hours of their working day. In previous studies, hand grasps were measured in terms of preselected objects, with the hand posture used in manipulation[1]. In another study, Sperling and Jacobson-Sollerman (1977) encoded the human grasp types and general surfaces of the hand in 30 participants while they were eating a meal and documented 1 277 grips[4]. The most comprehensive collection of grasp types is collated in the GRASP taxonomy of the grasp types of the human hand.[5]

Riddle et al. (2020) measured individual finger forces to provide a biomechanical hand model to determine the effect of osteoarthritis on hand function[6]. Although the studies are useful, Riddle et al. (2020) suggested that force analysis be conducted during the execution of a wider variety of everyday ADL tasks[6].

Studies measuring forces with limited fingers and grasps and using sensors on a glove or on the objects have been performed[6-9]. Castro and Cliquet (1997), for instance, investigated the grasping of cylindrical objects and measured the associated static forces with FSRs, while Romeo et al. (2015) determined the finger forces exerted with a tripod grasp during spherically shaped ball grasping, with the FSRs mounted on the contact areas of the ball[9].

In hand rehabilitation, after having sustained second to fifth metacarpal fractures, individuals may interpret light functions differently, thus leading to inappropriate bending, torsion, and shear loading between the two fracture ends, and thus disrupting the bone healing process[10]. The healing of the bone could also be disrupted as a result of physical damage to the new capillaries and repairing tissue, with possible non-union as a result[10]. There has been a need for a scientific approach to inform hand rehabilitation, to grade the rehabilitation forces and joint range of motion with grasp-type exercises, and to thus ensure a timely but safe return to hand tasks in the basic and instrumental functional activities of daily living.

The aim and objectives of this cross-sectional study were to develop clinical hand rehabilitation guidelines by determining the basic and instrumental task forces exerted by the human hand through its grasps on the objects that it manipulates, as well as the associations between mean maximum forces, gender and grip strength, among a purposively sampled group of healthy human adults between the ages of 20 and 59 years, and with the aid of FSRs.

Methods

This research has been approved by the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State (UFS-HSD2019/0046/2602-0002). Any underlying research material related to the results will be made accessible on the primary author's ORCID account.

Population and setting

Adult human participants living and working in the east of Gauteng, specifically in the city of Kempton Park and its neighbouring areas in the Ekurhuleni municipality, speaking English or isiZulu, older than 20 years and younger than 59 years of age were included in this research study. Participants younger than 20 years were excluded owing to their skeletal immaturity[12]. Participants older than 59 years of age were also excluded owing to the statement in the literature that very few individuals sustain metacarpal fractures after the age of 59[13]. Yet another exclusion criterion was having suffered any previous hand injury. No incentives for participation were given to the participants.

Testing procedure

After the participants had been screened for Covid-19 by the research assistant, who is proficient in English and isiZulu, and who had received training in the screening process, they completed a demographic questionnaire. Grip-strength measurements, taken with a calibrated Jamar hand-held dynamometer according to the standardised measurements prescribed by the American Society of Hand Therapy, preceded the FSR force testing. To ensure that the participants would not be fatigued, and that the validity of the force measurements would not be compromised, the grip-strength measurements with the hand-held dynamometer were taken by the primary author, after sixteen tasks and at the completion of the 31 tasks. In the instance where the average grip strength of both dominant and non-dominant hands differed by two kilograms (kg),

with an average taken from three maximal attempts, the participant was given an extra five minutes to rest before the testing was resumed. Five minutes was deemed sufficient resting time during the pilot testing before participants felt that they could continue with the testing. Over the course of a 24-hour period, during awake hours, the researcher informally observed the hand use of healthy individuals as well as her own hands during ADL tasks and documented 105 ADL tasks performed by individuals during this time. To ensure the validity of a standardised hand function outcome measure, the researcher used the DASH questionnaire to ensure that all tasks on the DASH questionnaire were included in the observed tasks. If they were not presented, the researcher would add them to the DASH tasks. The researcher proceeded to categorise the 105 basic and instrumental ADLs into light, moderate and heavy tasks and extracted the predominant grasp type for each of the 105 ADLs.

The 105 ADL task forces were measured on a sample of six participants during a feasibility study. Following the feasibility study, the researcher grouped the tasks per section with similar forces. The five sections of the ADLs were personal care and hygiene, transport and moving around, home environment (inside the home), gardening and outside the home, and lastly, "other", a category for tasks not falling into the above-mentioned categories. The groupings per category and section, where forces were similar, resulted in the identification of 31 tasks. Following on the data collection process of the 31 ADLs, data analysis was performed by the primary author with the assistance of a biostatistician. Thereafter, an assessment of the grasp types followed. The purpose of categorising the grasp types was to inform the clinical hand rehabilitation guideline. It is hypothesised that incorporating grasp types as exercises directly addresses the activity limitation domain of the ICF to improve hand function. After the grasp testing, the researcher, with the aid of the GRASP Taxonomy, visually assessed the various grasps, with consideration given to Gülke et al. (2018)'s randomised control trail (RCT) exercise programme considering the degrees of metacarpophalangeal joint (MCPJ) range of motion (ROM) for each grasp type[14]. The data collection methods are now presented.

After donning the testing gloves and being told to perform the tasks as they would normally do at home, the participants received standardised instructions pertaining to the data collection and testing processes. The researcher read out the task from the grasp types tested per type and per category sheet (Addendum Q) and either the researcher or the research assistant ensured that the equipment needed for the next task was in the participant's reach and that no other objects needed to be moved by the participant, thus ensuring that the FSR measured only the forces associated with the respective tasks.

FSRs are made from material that undergoes a change in its resistance when a pressure, force, or mechanical stressor is applied to it. They are commonly used in the industry to measure pressure or force. By connecting the FSR to a voltage (V) divider circuit, the change in resistance can be detected as a change in the number of volts. Each FSR exerts pressure on an object (Sadun et al, 2016) and produces a force sensing range of a few dozen grams to over 10 kg. The pressure of the tested object provides a resultant V output, which is displayed on a software programme, and is visible to the researcher on a laptop or desk top computer. The V-values are converted to forces, measured in Newton (N). The maximum force needed to perform a functional task/activity is collected as data and saved on an Excel spreadsheet. Force sensors decrease in resistance when additional force is applied; thus the less ohms, the greater the force. Both the right and left hands are placed in gloves with Flexiforce 13-millimetre FSRs glued onto them. They encounter an object (e.g. a bottle for the participant to open) or an item of clothing (e.g., a pair of trousers for the participant to don while dressing). A change in force applied to the device or item causes a change in resistance across the two open terminals used to measure pressure during the course of performing that specific functional task. When the applied pressure is placed on the FSR, the resistance drops until the device becomes saturated. The force applied versus resistance is not linear; as the resistance in ohms decreases, so the force increases, until saturation occurs on the response curve. The FSRs are connected in series with 10-Kohms (Kelvin –ohms) resistors; the 10-Kohms resistors are inserted into the ARDUINO Pro mini, and the FSRs are connected by means of a USB port to the Arduino Pro Mini 5 V.

Arduino Uno hardware refers to the circuit boards and a microcontroller placed on the Arduino Uno. Arduino Uno is a programmable microprocessor, used to record a change in V. A picture of an Arduino Uno board is shared in Image 5.1 below. Each Arduino Uno board can monitor five FSRs; hence, two Arduino Uno boards were used to monitor ten FSRs, one per finger. Microcontrollers are integrated circuits that are tiny computers, which run small, simple software programmes, powered by a battery, and which are fast enough to process the incoming data obtained from the FSRs. The microcontroller chip mounted on the crystal resonator of the circuit board controls how fast the microcontroller runs. This chip on the Arduino Uno allows for the uploading of the created software via the USB cable to the main microcontroller, allowing messages to be sent between the computer and the Arduino. This feature is also important for debugging. The Universal Serial Bus (USB) cable's power and built-in V-regulator reduces the number of volts to five volts. A reset button, found on the Arduino Uno board, allows for the rebooting of the programme. The programming language is created in the Arduino software and allows for the configuration of the data.

The Arduino Uno has pin connectors for wire connections to send and receive information through Wi-Fi. There are six analogue input pins to measure continuous V from zero to five volts. To set up the hardware before testing, Arduino software was downloaded from the Arduino.cc website and installed on the researcher's laptop. This software programme made it possible to create a sketch, where measured V could be fed into the software.

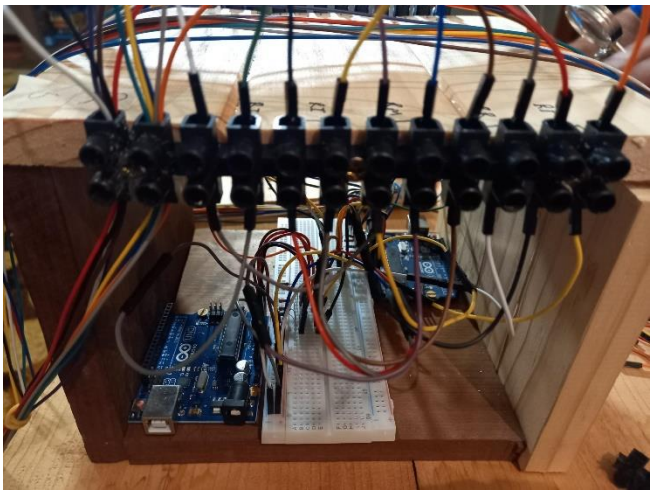

Image 5.1: Arduino and equipment setup

The FSRs needed to be calibrated and for this a range of calibrated weights was used. The weights ranged from one gram to 10 kg. For every calibrated weight, a V was recorded. This allowed the researcher and technical expert to create a V *versus* weight graph. Mass can be converted to force with the equation F=m x g, where F is equal to force in Newtons (N), g is equal to gravitational acceleration (m/s^2), and m is equal to mass (kg). This allowed the researchers to draw a graph of V *versus* force, as can be seen in Figure 5.4 below. This graph allows any V recorded by the Arduinos for any FSR to be converted to a force. A curve-fitting programme was used to determine the general equation for the V force graph. The general equation for this graph is 0.5917*tan (0.3223*max. value). The Arduinos were programmed to record 10 measurements per second.

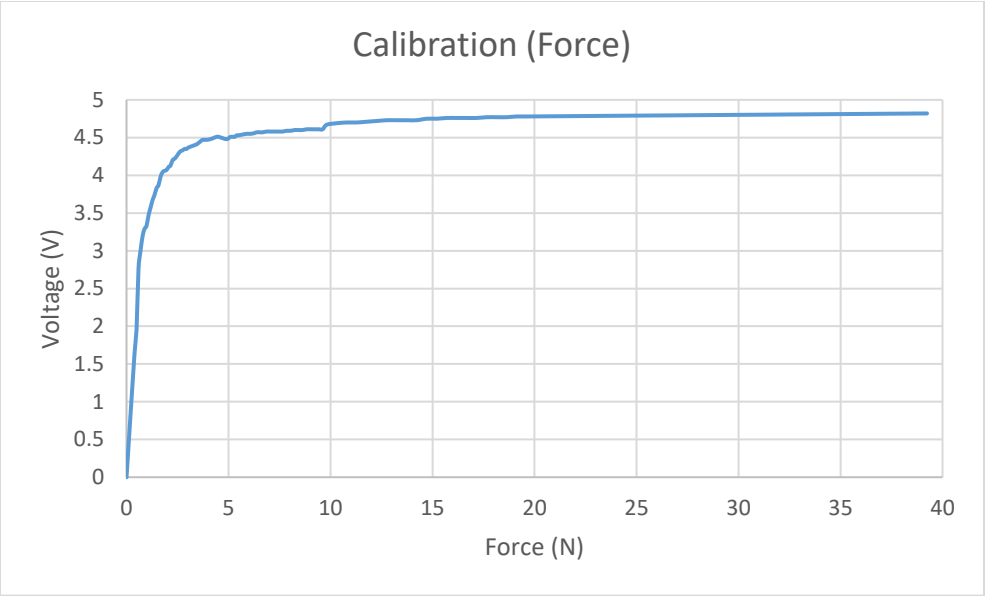

Figure 5.4: Voltage versus force calibration graph

To measure the force for each finger, two gloves were equipped with FSRs, one per finger. Image 5.2 depicts the gloves with the attached FSRs.

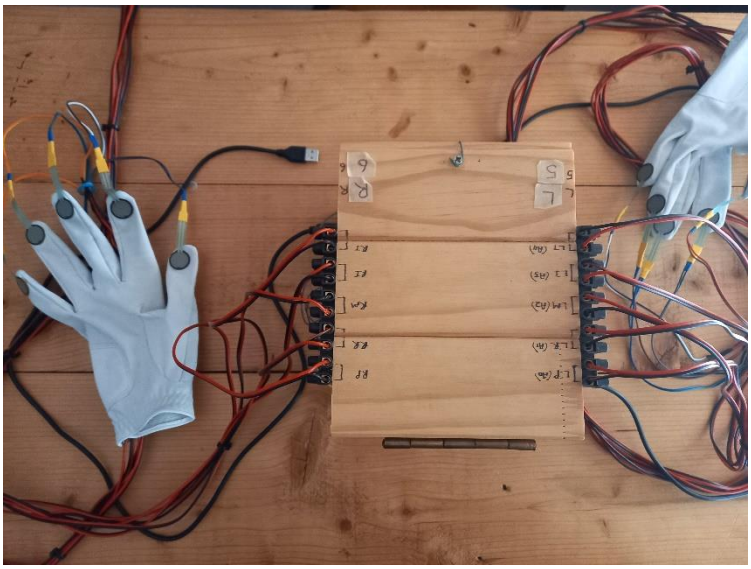

Image 5.2: Testing equipment and gloves

All measurements taken during the tasks were recorded and written to a comma-delimited text file. The software package, Realterm, was used for this purpose. The comma-delimited text files were imported into Excel, where the V measurements were converted by means of the above-mentioned equation to forces. An example of the text file of the five fingers of the left hand is shown in Figure 5.5 below. For each grasp type, both a left and a right hand, with all 10 fingers, were captured in the text file. Using Statacorp, the researcher then imported an Excel spreadsheet with data into STRATA statistics software, at which point the data were analysed by a statistician.

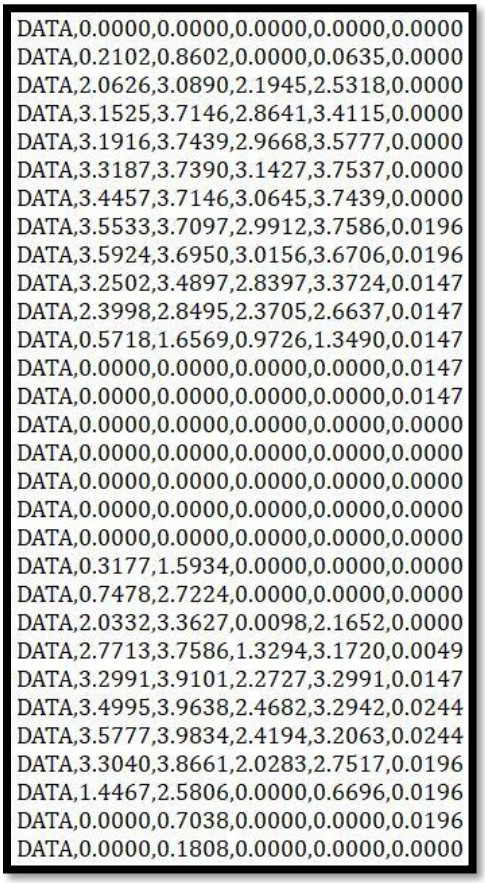
DATA,0.0000,0.0000,0.0000,0.0000,0.0000
DATA,0.2102,0.8602,0.0000,0.0635,0.0000
DATA,2.0626,3.0890,2.1945,2.5318,0.0000
DATA,3.1525,3.7146,2.8641,3.4115,0.0000
DATA,3.1916,3.7439,2.9668,3.5777,0.0000
DATA,3.3187,3.7390,3.1427,3.7537,0.0000
DATA,3.4457,3.7146,3.0645,3.7439,0.0000
DATA,3.5533,3.7097,2.9912,3.7586,0.0196
DATA,3.5924,3.6950,3.0156,3.6706,0.0196
DATA,3.2502,3.4897,2.8397,3.3724,0.0147
DATA,2.3998,2.8495,2.3705,2.6637,0.0147
DATA,0.5718,1.6569,0.9726,1.3490,0.0147
DATA,0.0000,0.0000,0.0000,0.0000,0.0147
DATA,0.0000,0.0000,0.0000,0.0000,0.0147
DATA,0.0000,0.0000,0.0000,0.0000,0.0000
DATA,0.0000,0.0000,0.0000,0.0000,0.0000
DATA,0.0000,0.0000,0.0000,0.0000,0.0000
DATA,0.0000,0.0000,0.0000,0.0000,0.0000
DATA,0.0000,0.0000,0.0000,0.0000,0.0000
DATA,0.3177,1.5934,0.0000,0.0000,0.0000
DATA,0.7478,2.7224,0.0000,0.0000,0.0000
DATA,2.0332,3.3627,0.0098,2.1652,0.0000
DATA,2.7713,3.7586,1.3294,3.1720,0.0049
DATA,3.2991,3.9101,2.2727,3.2991,0.0147
DATA,3.4995,3.9638,2.4682,3.2942,0.0244
DATA,3.5777,3.9834,2.4194,3.2063,0.0244
DATA,3.3040,3.8661,2.0283,2.7517,0.0196
DATA,1.4467,2.5806,0.0000,0.6696,0.0196
DATA,0.0000,0.7038,0.0000,0.0000,0.0196
DATA,0.0000,0.1808,0.0000,0.0000,0.0000

Figure 5.5: Text file: squeezing water out of a sponge

Results

Thirty-two (32) participants, 18 females and 14 males, with a mean age of 37 years, the oldest participant aged 58 years and the youngest 18, consented and committed to participate. Two participants (6.25%) were left-handed, and thirty participants (93.75%) were right-handed. In Table 5.10 below, the occupations and level of education of the participants can be seen in Table 5.10 below.

Table 5.10: Demographics for occupation and level of education

Occupation			**Level of Education**		
Name	**Frequency**	**Percentage (%)**	**Name**	**Frequency**	**Percentage (%)**
Cleaner	7	22.58	High school completed	15	46.88
Student	5	16.13	Some college credits, no degree	7	21.88
Gardener	3	9.68	Bachelor's degree	4	12.50
Administrator	2	6.45	Completed schooling up to Grade 8	3	9.38
Teacher	2	6.45	Master's degree	1	3.13
Aircon Technician	1	3.23	Trade, technical, vocational training	1	3.13
Nurse auxiliary	1	3.23	No schooling completed	1	3.13
Designer	1	3.23			
Electrical technologist	1	3.23			
Executive personal assistant	1	3.23			
Financial manager	1	3.23			
Fitter and turner	1	3.23			
Quality and compliance manager	1	3.23			
Security guard	1	3.23			
Self-employed	1	3.23			
Store manager	1	3.23			
Trader	1	3.23			
Unemployed	1	3.23			

The means, standard deviations, and the minimum and maximum N force measurements for the grasp force are presented in Table 5.12 (Supplementary Table). According to the GRASP Taxonomy developed by Feix et al. (2016), as presented together with a t-test of equal variance test results in Table 5.11 below, statistically significant differences were noted between the grasp measurements for males and females for the grasp types per ADL task. No statistically significant differences between grasp forces were seen for the other 25 tasks that were tested.

Table 5.11: Statistically significant differences between genders according to the GRASP taxonomy and activities

GRASP Taxonomy Headings	**Grasp type**	**ADL task**	**t-test p-value**
Thumb-adducted Power Palm	Adducted thumb	Lifting box of 25 kg onto counter	p = 0.009
	Index finger extension	Washing car	p = 0.002
	Power sphere	Squeezing water out of a sponge	p = 0.000
Thumb-abducted Precision Pad	Quadpod	Opening and closing a tap (large round shape)	p = 0.003
	Prismatic four fingers	Brushing teeth	p = 0.047
	Precision disc	Opening a tight or new jar	p = 0.006
Thumb-abducted Power Palm	Large diameter	Moving a couch in living room	p = 0.002

The two-sample t-test with equal variance on gender differences for grip strength measurements, taken before force testing commenced, revealed no statistically significant difference with $p = 0.0958$.

After the grasp testing, the researcher, aided by the GRASP Taxonomy, assessed the various grasps, taking into consideration the position of the MCPJs for each grasp type according to the prescribed RCT exercise programme devised by Gülke et al. (2018)[14]. To ensure the degrees of MCPJ ROM per grasp, the researcher proposed the use of free grasping rather than forced grasping. (Addendum CII). The former might be a valuable additional recommendation for the management of individuals who have sustained second to fifth metacarpal fractures. Grasps where the MCPJ is flexed minimally may be started first when it is possible for the affected fractured joint to be moved. The grasps permitted are as follows: Light Tool, Prismatic Two Fingers, Power Disc, Precision Disc, Fixed Hook, Lateral, Index Finger Extension (for index finger fractures), Extension Type, Adduction Grip, Sphere Four Fingers, Sphere Three Fingers, Ventral (for index finger fractures), and Inferior Pincher. The previously mentioned grasps are allowed when pain is < 3/10. A progression to grasp types where the injured MCPJ is flexed up to 45° would include the following: Large Diameter, Medium Wrap, Adducted Thumb, Prismatic Four Fingers, Prismatic Three Fingers, Palmar Pinch, Tripod, Tripod Variation, Tip Pinch, and Ring Index Finger. A further progression to grasps where the injured MCPJ is flexed to more than 45° would include the following: Small Diameter, Power Sphere, Precision Sphere, Index Finger Extension (for middle, ring and little finger fractures), Distal, Writing Tripod, Parallel Extension, Lateral Tripod, Quadpod, Stick, Palmar, Ventral (for middle, ring and little finger fractures).

Discussion

It is possible, when examining the data for healthy participants, to relate the results of this research to those of the Riddle et al. (2020) study [6]. The respective age ranges of the Riddle et al (2020) study are 20 to 65 years for healthy participants and 52 to 79 years for osteoarthritic

participants. Although not precisely similar, the ages of the healthy participants included in this study[6] are close to the inclusion age, namely, 20 to 59 years, for the force data collected in our research study. However, the individual finger force measurements collected by Riddle et al (2020) for the osteoarthritic group cannot be compared to those of our research.

The range of forces measured by Castro and Cliquet (1997) presented the following values: the index and middle fingers: a 0.2 kg weight resulted in zero to one-and-a-half N; a 0.41 kg weight, between zero and three N; a 0.61 kg weight resulted in zero to four-and-a-half N; a 0.82 kg weight, between zero and six N; and a 1.02 kg weight, between zero and seven N[8]. In comparing similar grasp forces from the previous unpublished study by our authors, according to the taxonomy of grasps[5], the forces were also zero to seven N during tasks requiring cylindrical object manipulation, namely the fixed hook. Although Romeo et al. (2015) did not measure forces exerted by all ten fingers, as in this research, these authors did in fact measure forces produced by the thumb, index finger, and middle finger, thus allowing for a comparison of these three fingers[9]. Forces ranged between 0.3N and a maximum of 2.7N[7]. A comparison of the average maximum forces produced by all fingers during the power-sphere grasp in this research revealed that the average forces per finger on the right hand were as follows: thumb 2.44N, index finger 1.48N, middle finger 1.38N, ring finger 1.66N, and little finger 0.21N, as opposed to a 0.3N to 2.7N range[9], where similar forces were produced, even though the FSRs in our study were mounted on the fingers of a glove and not on the object being manipulated.

Studies measuring finger and grasp forces also investigated the associations between forces and the respective genders. Rice, Leonard, and Carter (1998), and Castro and Cliquet (1997) found a significant difference between grip and pinch-strength measurements, as was to be expected, but no significant difference was found between the genders and the respective forces[7,8]. Similarly, in our study, the majority (78%) of grasp types showed no statistically significant difference for male and female participants. No research could be found where FSRs were used to measure

forces which would inform the hand rehabilitation of individuals who had sustained second to fifth metacarpal fractures. The identification of grasp types in basic and instrumental ADLs, and the maximum grasp forces measured in this study served to provide valuable exercise grasps for PTs and OTs to use during hand rehabilitation and home exercise prescriptions for individuals who had sustained second to fifth metacarpal fractures. Linking the grasp types used during the manipulation of objects during ADLs to the ICF activity restriction domain, allows for function to be at the forefront of hand rehabilitation for metacarpal fractures.

The development of the clinical hand rehabilitation guideline was underpinned by the ICF framework and the comprehensive ICF core set for hand conditions which encapsulate the basic and instrumental ADL tasks that the researcher selected for the data collection process in Phase II. An open or closed, single or multiple second to fifth metacarpal fracture, denoting the health condition and the associated pain, joint stiffness, oedema in the finger, hand and wrist, falls within the body functions and structures or impairments of the ICF. The data collected during the force testing of basic and instrumental ADL tasks using FSR sensors to determine finger and grasp forces during the manipulation of objects used during ADLs was used to develop the clinical hand rehabilitation guideline. The ADL tasks tested in a healthy adult population fall under the activity limitation domain in the ICF framework and are incorporated in the ICF core set for hand conditions. The predominant grasp type was identified by the researcher during each ADL task. The predominant grasp types, together with the MCPJ ROM of the grasp types introduce an element into hand rehabilitation where the activities (ICF) domain can be directly addressed by PTs or OTs so that the injured individual is able to return to pre-injury function. They also aid in guiding the return to full participation of the individual in the ICF domain. Promotion of early hand function, possibly allowing for an earlier return to pre-injury functioning and occupation, are some of the possible outcomes.

The results obtained from this study were incorporated into the eDelphi method, whereby expert consensus regarding second to fifth metacarpal fracture management was sought, and subsequently informed the development of the clinical hand rehabilitation guideline. The main outcomes of the research were the forces associated with the predominant grasp types that were determined and the recommendations made as to how they could be utilised in free, active exercises.

Conclusion and Limitations

Backed by the MCPJ ROM exercise positions, as propounded by Gülke et al (2018), the researcher determined the degrees of MCPJ ROM per grasp through visual observation. The researcher proposes the use of these grasps with specific MCPJ ROM to be included in the clinical hand rehabilitation guideline as free and not forced grasping exercises.

The amount of force sensing data on the predominant grasp types collected when the 31 ADL tasks were being performed was considerable and presented a valuable addition to the existing knowledge base for informing clinical practice. Furthermore, a wide variety of manipulations of the human hand was uncovered during the analysis of the ADL tasks. As such, the drawing of absolute truths from the data proved to be a difficult task, and even in the larger sample sizes, the different occupations and unique individual distinctions among the participants made this task even more challenging. Future implementation research is needed in respect of the implementation of such grasp type exercises and progressive return to ADLs and also to validate FSR testing for a wide variety of occupations.

It is important to note that in terms of the limitation of the study, a female participant, aged 18 years, was included and participated in the 31 ADL data collection. The researcher acknowledges the inclusion as being outside the methodology of the study. However, this participant did not fall under the paediatric population, where parental informed written consent was required.

Instead, she provided her own written consent. The researcher argues that at her age and according to her gender, she has, according to Eveleth and Tanner (1990), reached skeletal maturity. Her age would not, therefore, have impacted on the study results and therefore her results were not excluded. The reliance of the researcher on visual observations in the data collection process, and the fact that the ROM values for the MCPJs per grasp were not measured with a standard or digital goniometer are limitations that should be amended in future research in order to substantiate the findings of this study.

Although there were limitations during the feasibility study, they could be rectified and prevented. A very low error rate occurred on the sensors due to calibration, but fortunately no data was lost. The researcher proposes a larger sample size, with an equal representation of genders, handedness, and especially a wider range of occupations, since the current sample represented mostly students and cleaners, which impacts on the generalisability of the study results.

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Table 5.12: Supplementary Table 1: Grasp types, maximums, means, standard deviations in Newton and t-test results

ADL Task	Predominant Grasp type	Light tasks	Moderate tasks	Heavy tasks	Fifth digit L	Ring L	Middle L	Index L	Thumb L	Fifth digit Right	Ring R	Middle R	Index R	Thumb R	Test Gender
Personal care and Hygiene															
Washing hair	13. Precision Sphere	**X**			MN:0.63 SD:0.74 MIN:0.05 MX:2.8	MN:0.84 SD:0.83 MIN:0.05 MX:3.04	MN:1.00 SD:1.13 MIN:0.02 MX:4.5	MN:0.93 SD:1.04 MIN:0.06 MX:4.49	MN:0.89 SD:0.71 MIN:0.001 MX:2.37	MN:0.49 SD:0.43 MIN:0.01 MX:1.43	MN:0.69 SD:0.64 MIN:0.01 MX:2.29	MN:0.92 SD:0.66 MIN:0.02 MX:2.68	MN:1.55 SD:1.83 MIN:0.11 MX:9.11	MN:2.06 SD:2.33 MIN:0.09 MX:10.38	p = 0.154
Squeezing water out of a sponge	11. Power Sphere	**X**			MN:1.94 SD:1.79 MIN:0.003 MX:9.34	MN:4.37 SD:2.86 MIN:0.18 MX:13.33	MN:3.6 SD:2.76 MIN:0.07 MX:10.98	MN:2.01 SD:2.46 MIN:0.001 MX:14.34	MN:3.53 SD:3.95 MIN:0.59 MX:13.82	MN:2.1 SD:1.83 MIN:0.04 MX:9.34	MN:1.95 SD:1.03 MIN:0.12 MX:4.49	MN:2.04 SD:1.04 MIN:0.26 MX:4.14	MN:2.58 SD:1.73 MIN:0.24 MX:7.47	MN:3.19 SD:2.06 MIN:0.26 MX:9.58	p = 0.000
Opening and closing a tap (large round shape)	27. Quadpod	**X**			MN:0.82 SD:0.85 MIN:0.001 MX:3.34	MN:1.74 SD:1.77 MIN:0.001 MX:6.55	MN:3.3 SD:3.2 MIN:0.09 MX:12.87	MN:1.69 SD:1.47 MIN:0.78 MX:6.33	MN:1.91 SD:2.2 MIN:0.002 MX:8.3	MN:0.71 SD:0.63 MIN:0.02 MX:2.44	MN:1.06 SD:0.82 MIN:0.08 MX:3.25	MN:1.83 SD:1.68 MIN:0.05 MX:8.49	MN:2.32 SD:2.17 MIN:0.06 MX:8.89	MN:2.71 SD:1.79 MIN:0.15 MX:7.47	p = 0.003
Carrying a bucket containing three litres of water	2. Small Diameter		**X**		MN:0.31 SD:0.41 MIN:0.001 MX:1.14	MN:0.71 SD:1.31 MIN:0.06 MX:5.57	MN:1.02 SD:1.32 MIN:0.001 MX:3.96	MN:0.4 SD:0.53 MIN:0.01 MX:2.03	MN:0.71 SD:0.91 MIN:0.001 MX:3.44	MN:0.09 SD:0.08 MIN:0.004 MX:0.28	MN:1.22 SD:2.26 MIN:0.02 MX:8.69	MN:0.74 SD:0.8 MIN:0.015 MX:2.96	MN:0.53 SD:0.54 MIN:0.04 MX:1.81	MN:0.75 SD:0.83 MIN:0.02 MX:2.56	p = 0.275
Carrying a zinc basin containing three litres of water	15. Fixed Hook		**X**		MN:0.56 SD:0.62 MIN:0.1 MX:1.51	MN:1.41 SD:1.59 MIN:0.06 MX:6.02	MN:1.89 SD:2.3 MIN:0.13 MX:7.78	MN:0.95 SD:0.97 MIN:0.03 MX:3.17	MN:0.7 SD:0.86 MIN:0.007 MX:3.61	MN:0.76 SD:0.77 MIN:0.001 MX:2.94	MN:0.88 SD:0.91 MIN:0.02 MX:3.84	MN:0.88 SD:0.74 MIN:0.02 MX:2.28	MN:1.32 SD:1.38 MIN:0.002 MX:4.78	MN:1.02 SD:0.97 MIN:0.001 MX:2.89	p = 0.326
Using pegs to secure clothes on a washing line	9. Palmar Pinch		**X**		MN:0.16 SD:0.2 MIN:0.001 MX:0.58	MN:0.46 SD:0.47 MIN:0.001 MX:2.14	MN:0.53 SD:0.55 MIN:0.002 MX:1.97	MN:1.12 SD:1.07 MIN:0.08 MX:3.57	MN:3.31 SD:3.93 MIN:0.11 MX:13.83	MN:0.05 SD:0.05 MIN:0.001 MX:0.11	MN:0.13 SD:0.15 MIN:0.001 MX:0.4	MN:0.58 SD:0.63 MIN:0.001 MX:2.58	MN:2.19 SD:1.29 MIN:0.21 MX:4.33	MN:3.44 SD:1.78 MIN:0.8 MX:8.89	p = 0.660

Wringing water out of clothes by hand	3. Medium Wrap	**X**			MN:0.78 SD:0.98 MIN:0.003 MX:3.08	MN:1.52 SD:1.7 MIN:0.001 MX:7.19	MN:2.68 SD:2.5 MIN:0.002 MX:9.58	MN:2.06 SD:2.62 MIN:0.02 MX:9.83	MN:3.19 SD:5.2 MIN:0.06 MX:24.77	MN:0.78 SD:1.23 MIN:0.001 MX:5.26	MN:1.15 SD:1.8 MIN:0.04 MX:9.58	MN:1.45 SD:1.12 MIN:0.07 MX:4.09	MN:2.05 SD:1.61 MIN:0.04 MX:6.44	MN:2.3 SD:1.45 MIN:0.07 MX:6.33	p = 0.099
Brushing teeth with a toothbrush	6. Prismatic 4 Fingers	**X**			MN:0.25 SD:0.02 MIN:0.23 MX:0.27	MN:0.23 SD:0.26 MIN:0.07 MX:1.01	MN:0.7 SD:1.08 MIN:0.01 MX:3.06	MN:0.33 SD:0.22 MIN:0.001 MX:0.63	MN:0.78 SD:0.71 MIN:0.03 MX:1.99	MN:0.62 SD:1.16 MIN:0.003 MX:3.41	MN:1.15 SD:1.45 MIN:0.06 MX:5.26	MN:0.63 SD:0.57 MIN:0.03 MX:2.05	MN:1.23 SD:1.85 MIN:0.004 MX:7.78	MN:2.06 SD:1.98 MIN:0.13 MX:7.62	p = 0.047
Squeezing toothpaste out of a tube standard large	8. Prismatic 2 Fingers	**X**			MN:0.1 SD:0.1 MIN:0.001 MX:0.26	MN:0.56 SD:0.68 MIN:0.06 MX:2.15	MN:1.25 SD:1.69 MIN:0.001 MX:5.57	MN:0.86 SD:1.14 MIN:0.03 MX:5.33	MN:2.72 SD:2.86 MIN:0.008 MX:11.67	MN:0.43 SD:0.57 MIN:0.01 MX:1.57	MN:0.8 SD:1.64 MIN:0.001 MX:6.79	MN:0.73 SD:0.69 MIN:0.02 MX:2.42	MN:2.59 SD:2.12 MIN:0.03 MX:10.4	MN:4.16 SD:2.19 MIN:0.26 MX:10.67	p = 0.131
Putting a t-shirt on	7. Prismatic 3 Fingers	**X**			MN:0.29 SD:0.4 MIN:0.006 MX:1.52	MN:0.45 SD:0.72 MIN:0.001 MX:3.72	MN:0.69 SD:0.77 MIN:0.02 MX:2.36	MN:1.96 SD:2.28 MIN:0.001 MX:9.39	MN:2.74 SD:2.71 MIN:0.04 MX:11.31	MN:0.25 SD:0.32 MIN:0.001 MX:1.13	MN:0.22 SD:0.19 MIN:0.001 MX:0.72	MN:0.59 SD:0.78 MIN:0.01 MX:3.31	MN:2.07 SD:1.94 MIN:0.001 MX:8.69	MN:2.74 SD:1.69 MIN:0.09 MX:7.47	p = 0.281
Buckling a belt	7. Prismatic 3 Fingers		**X**		MN:0.29 SD:0.19 MIN:0.02 MX:0.69	MN:0.52 SD:0.54 MIN:0.001 MX:2.54	MN:0.67 SD:0.7 MIN:0.003 MX:2.89	MN:1.06 SD:1.76 MIN:0.002 MX:7.19	MN:1.11 SD:0.89 MIN:0.001 MX:2.85	MN:0.56 SD:0.65 MIN:0.004 MX:2.69	MN:0.56 SD:0.98 MIN:0.03 MX:4.28	MN:0.49 SD:0.62 MIN:0.001 MX:2.44	MN:1.39 SD:1.48 MIN:0.03 MX:5.57	MN:2.05 SD:1.62 MIN:0.17 MX:5.65	p = 0.164
Transport and Moving around															
ADL Task	**Predominant Grasp type**	**Light tasks**	**Moderate tasks**	**Heavy tasks**	**Fifth digit L**	**Ring L**	**Middle L**	**Index L**	**Thumb L**	**Fifth digit Right**	**Ring R**	**Middle R**	**Index R**	**Thumb R**	**Test Gender**
Opening a door knob (circular)	26. Sphere 4 Fingers		**X**		MN:0.18 SD:0.12 MIN:0.04 MX:0.26	MN:0.85 SD:1.05 MIN:0.02 MX:3.79	MN:1.28 SD:1.16 MIN:0.05 MX:4.18	MN:1.01 SD:1.1 MIN:0.08 MX:3.28	MN:2.4 SD:3.44 MIN:0.005 MX:13.33	MN:0.07 SD:0.09 MIN:0.002 MX:0.21	MN:2.06 SD:2.82 MIN:0.001 MX:7.47	MN:1.3 SD:1.14 MIN:0.01 MX:4.38	MN:2.39 SD:1.99 MIN:0.06 MX:8.69	MN:2.62 SD:3.72 MIN:0.001 MX:15.54	p = 0.519

Home environment (Inside home)															
ADL Task	**Predominant Grasp type**	**Light tasks**	**Moderate tasks**	**Heavy tasks**	**Fifth digit L**	**Ring L**	**Middle L**	**Index L**	**Thumb L**	**Fifth digit Right**	**Ring R**	**Middle R**	**Index R**	**Thumb R**	**Ttest Gender**
Carrying a shopping bag	15. Fixed Hook	**X**			MN:0.34 SD:0.45 MIN:0.005 MX:1.64	MN:0.67 SD:1.06 MIN:0.02 MX:4.91	MN:1.15 SD:1.37 MIN:0.02 MX:5.49	MN:0.24 SD:0.25 MIN:0.03 MX:0.95	MN:0.47 SD:0.4 MIN:0.006 MX:1.54	MN:0.33 SD:0.26 MIN:0.04 MX:0.79	MN:1.03 SD:1.75 MIN:0.04 MX:6.23	MN:0.57 SD:0.46 MIN:0.02 MX:1.61	MN:0.46 SD:0.68 MIN:0.03 MX:2.73	MN:0.79 SD:1.17 MIN:0.003 MX:4.54	p = 0.650
Dusting	5. Light Tool	**X**			MN:0.66 SD:0.42 MIN:0.04 MX:1.42	MN:0.9 SD:0.77 MIN:0.03 MX:3.91	MN:0.48 SD:0.44 MIN:0.02 MX:1.35	MN:0.33 SD:0.4 MIN:0.004 MX:1.41	MN:1.57 SD:2.55 MIN:0.003 MX:9.34	MN:0.84 SD:0.73 MIN:0.05 MX:3.25	MN:0.76 SD:0.72 MIN:0.001 MX:2.99	MN:0.41 SD:0.5 MIN:0.03 MX:1.84	MN:1.02 SD:0.76 MIN:0.02 MX:2.14	MN:2.25 SD:1.33 MIN:0.22 MX:5.18	p = 0.673
Sweeping the floor with a broom	2. Small Diameter	**X**			MN:0.66 SD:0.93 MIN:0.02 MX:3.88	MN:0.65 SD:0.78 MIN:0.003 MX:3.22	MN:0.95 SD:0.85 MIN:0.05 MX:2.47	MN:0.63 SD:0.73 MIN:0.04 MX:2.62	MN:1.09 SD:1.14 MIN:0.002 MX:3.47	MN:0.92 SD:0.94 MIN:0.03 MX:3.09	MN:1.55 SD:1.41 MIN:0.12 MX:4.38	MN:0.75 SD:0.74 MIN:0.07 MX:2.13	MN:0.95 SD:0.71 MIN:0.07 MX:3.14	MN:1.74 SD:1.79 MIN:0.006 MX:7.05	p = 0.024
Packing dishes away	22. Parallel Extension	**X**			MN:0.41 SD:0.6 MIN:0.05 MX:2.85	MN:0.58 SD:0.51 MIN:0.05 MX:2.14	MN:0.89 SD:0.63 MIN:0.02 MX:2.33	MN:0.8 SD:0.8 MIN:0.1 MX:3.38	MN:1.86 SD:1.77 MIN:0.15 MX:6.33	MN:0.42 SD:0.34 MIN:0.03 MX:1.29	MN:0.47 SD:0.91 MIN:0.006 MX:3.54	MN:0.98 SD:0.77 MIN:0.02 MX:3.14	MN:2.00 SD:1.69 MIN:0.29 MX:9.11	MN:2.14 SD:0.98 MIN:0.76 MX:4.78	p = 0.536
Eating with hands	14. Tripod	**X**			MN:0.08 SD:0.06 MIN:0.001 MX:0.15	MN:0.48 SD:0.88 MIN:0.03 MX:3.5	MN:0.9 SD:1.03 MIN:0.03 MX:4.05	MN:0.95 SD:1.05 MIN:0.12 MX:3.84	MN:0.96 SD:1.16 MIN:0.004 MX:4.97	MN:0.12 SD:0.13 MIN:0.001 MX:0.39	MN:0.85 SD:1.58 MIN:0.01 MX:5.41	MN:0.89 SD:0.77 MIN:0.02 MX:3.22	MN:1.36 SD:1.23 MIN:0.001 MX:5.04	MN:1.39 SD:1.47 MIN:0.05 MX:6.33	p = 0.848
Opening a tight or new jar	26. Sphere 4 Fingers/12. Precision Disk		**X**		MN:0.42 SD:0.55 MIN:0.02 MX:1.7	MN:2.49 SD:5.04 MIN:0.12 MX:26.52	MN:2.42 SD:2.64 MIN:0.03 MX:8.69	MN:2.55 SD:3.13 MIN:0.001 MX:11.31	MN:3.27 SD:7.11 MIN:0.001 MX:26.5	MN:0.29 SD:0.39 MIN:0.001 MX:1.53	MN:1.13 SD:1.39 MIN:0.05 MX:4.33	MN:1.31 SD:1.18 MIN:0.03 MX:3.64	MN:3.24 SD:3.15 MIN:0.08 MX:13.33	MN:4.12 SD:5.64 MIN:0.001 MX:30.89	p = 0.0006

Lifting a box (1kg) onto a counter	4. Adducted Thumb	**X**			MN:0.51 SD:0.28 MIN:0.29 MX:0.89	MN:0.76 SD:1.22 MIN:0.03 MX:5.66	MN:0.63 SD:0.7 MIN:0.01 MX:2.51	MN:0.82 SD:0.68 MIN:0.001 MX:1.92	MN:0.16 SD:0.14 MIN:0.001 MX:0.43	MN:0.27 SD:0.28 MIN:0.03 MX:0.88	MN:0.38 SD:0.31 MIN:0.02 MX:0.76	MN:0.76 SD:0.68 MIN:0.12 MX:2.37	MN:0.54 SD:0.57 MIN:0.02 MX:2.00	MN:0.07 SD:0.04 MIN:0.04 MX:0.09	p = 0786
Lifting a box (10kg) onto a counter	4. Adducted Thumb		**X**		MN:1.28 SD:0.88 MIN:0.07 MX:2.76	MN:2.28 SD:1.46 MIN:0.11 MX:6.33	MN:2.34 SD:1.35 MIN:0.06 MX:4.66	MN:1.65 SD:2.02 MIN:0.05 MX:7.95	MN:0.24 SD:0.29 MIN:0.001 MX:0.77	MN:2.45 SD:1.76 MIN:0.001 MX:6.33	MN:1.53 SD:1.23 MIN:0.34 MX:5.11	MN:1.68 SD:1.01 MIN:0.1 MX:3.61	MN:1.85 SD:2.04 MIN:0.01 MX:10.98	MN:0.76 SD:0.97 MIN:0.001 MX:3.47	p = 0.403
Lifting a box (25kg) onto a counter	4. Adducted Thumb			**X**	MN:1.57 SD:1.23 MIN:0.001 MX:4.91	MN:2.56 SD:1.78 MIN:0.22 MX:7.32	MN:2.91 SD:2.25 MIN:0.11 MX:7.62	MN:2.36 SD:2.59 MIN:0.001 MX:9.34	MN:0.55 SD:0.85 MIN:0.001 MX:3.06	MN:2.85 SD:2.54 MIN:0.003 MX:10.67	MN:1.99 SD:2.65 MIN:0.04 MX:10.37	MN:1.98 SD:1.1 MIN:0.003 MX:4.14	MN:2.78 SD:2.01 MIN:0.21 MX:10.38	MN:0.7 SD:1.35 MIN:0.001 MX:5.04	p = 0.009
Lifting a pot and putting it down	30. Palmar	**X**			MN:0.61 SD:0.77 MIN:0.04 MX:2.76	MN:0.96 SD:1.23 MIN:0.01 MX:4.97	MN:0.88 SD:1.18 MIN:0.11 MX:4.78	MN:0.78 SD:0.79 MIN:0.02 MX:3.01	MN:1.11 SD:1.44 MIN:0.001 MX:5.74	MN:0.32 SD:0.51 MIN:0.002 MX:1.69	MN:1.74 SD:2.14 MIN:0.01 MX:6.92	MN:0.66 SD:0.59 MIN:0.03 MX:1.98	MN:0.62 SD:0.68 MIN:0.002 MX:2.99	MN:1.29 SD:1.18 MIN:0.001 MX:4.44	p = 0.788
Opening a can by pulling on the ring	33. Inferior Pincher	**X**			MN:0.26 SD:0.36 MIN:0.001 MX:1.24	MN:0.54 SD:0.65 MIN:0.001 MX:2.36	MN:1.14 SD:1.00 MIN:0.001 MX:3.09	MN:0.78 SD:0.64 MIN:0.03 MX:2.4	MN:0.83 SD:0.65 MIN:0.012 MX:2.02	MN:0.36 SD:0.44 MIN:0.001 MX:1.52	MN:0.65 SD:0.55 MIN:0.07 MX:1.61	MN:1.1 SD:0.95 MIN:0.001 MX:3.28	MN:1.6 SD:1.49 MIN:0.05 MX:6.44	MN:2.02 SD:1.66 MIN:0.08 MX:6.33	p = 0.085
Cutting with scissors	19. Distal	**X**			MN:0.16 SD:0.1 MIN:0.05 MX:0.33	MN:0.23 SD:0.27 MIN:0.02 MX:0.76	MN:0.55 SD:0.61 MIN:0.04 MX:1.73	MN:0.49 SD:0.5 MIN:0.07 MX:1.87	MN:0.91 SD:0.95 MIN:0.006 MX:4.05	MN:0.79 SD:1.05 MIN:0.09 MX:3.61	MN:0.75 SD:0.51 MIN:0.2 MX:1.39	MN:0.41 SD:0.48 MIN:0.03 MX:1.63	MN:0.64 SD:0.74 MIN:0.001 MX:2.62	MN:1.33 SD:2.11 MIN:0.009 MX:8.12	p = 0.584
Turning a salt grinder	3. Medium Wrap		**X**		MN:0.33 SD:0.41 MIN:0.01 MX:1.41	MN:0.62 SD:0.73 MIN:0.02 MX:2.84	MN:1.37 SD:1.52 MIN:0.02 MX:3.96	MN:0.79 SD:0.72 MIN:0.02 MX:2.68	MN:0.84 SD:1.04 MIN:0.001 MX:3.44	MN:0.51 SD:0.55 MIN:0.07 MX:1.47	MN:0.75 SD:1.03 MIN:0.02 MX:3.72	MN:0.79 SD:0.59 MIN:0.01 MX:2.42	MN:2.13 SD:1.94 MIN:0.1 MX:6.92	MN:1.53 SD:1.89 MIN:0.004 MX:7.05	p = 0.039
Moving the couch in the living room	1. Large Diameter		**X**		MN:1.16 SD:0.99 MIN:0.001 MX:3.41	MN:3.23 SD:3.24 MIN:0.09 MX:11.31	MN:3.76 SD:3.9 MIN:0.24 MX:16.2	MN:1.37 SD:1.85 MIN:0.006 MX:7.19	MN:1.6 SD:2.52 MIN:0.001 MX:10.67	MN:1.07 SD:1.19 MIN:0.003 MX:4.54	MN:2.1 SD:3.28 MIN:0.001 MX:13.83	MN:1.56 SD:1.12 MIN:0.18 MX:4.33	MN:2.16 SD:1.38 MIN:0.01 MX:5.11	MN:2.34 SD:1.94 MIN:0.002 MX:6.44	p = 0.002
Gardening and Outside home															

ADL Task	Predominant Grasp type	Light tasks	Moderate tasks	Heavy tasks	Fifth digit L	Ring L	Middle L	Index L	Thumb L	Fifth digit Right	Ring R	Middle R	Index R	Thumb R	Test Gender
Pruning trees	19. Distal		X		MN:0.67 SD:0.84 MIN:0.01 MX:2.96	MN:1.13 SD:1.44 MIN:0.04 MX:4.49	MN:1.19 SD:1.00 MIN:0.1 MX:3.47	MN:1.15 SD:1.13 MIN:0.06 MX:3.84	MN:1.18 SD:1.2 MIN:0.04 MX:4.66	MN:2.33 SD:2.97 MIN:0.02 MX:10.38	MN:1.85 SD:2.54 MIN:0.02 MX:9.83	MN:1.94 SD:2.04 MIN:0.001 MX:8.89	MN:1.27 SD:1.42 MIN:0.02 MX:6.12	MN:1.83 SD:1.39 MIN:0.35 MX:6.12	p = 0.492
Washing a car	17. Index Finger Extension	X			MN:0.41 SD:0.46 MIN:0.002 MX:1.86	MN:1.16 SD:0.9 MIN:0.06 MX:3.64	MN:1.03 SD:0.92 MIN:0.07 MX:4.49	MN:0.91 SD:0.77 MIN:0.03 MX:2.89	MN:1.47 SD:1.61 MIN:0.03 MX:7.19	MN:0.76 SD:0.66 MIN:0.001 MX:2.62	MN:0.79 SD:1.12 MIN:0.001 MX:6.12	MN:1.01 SD:1.15 MIN:0.001 MX:6.55	MN:1.39 SD:0.89 MIN:0.03 MX:3.79	MN:2.1 SD:3.09 MIN:0.42 MX:17.75	p = 0.002
Other (tasks not included in above sections)															
ADL Task	**Predominant Grasp type**	**Light tasks**	**Moderate tasks**	**Heavy tasks**	**Fifth digit L**	**Ring L**	**Middle L**	**Index L**	**Thumb L**	**Fifth digit Right**	**Ring R**	**Middle R**	**Index R**	**Thumb R**	**Test Gender**
Using a manual cellular phone	16. Lateral	X			MN:0.32 SD:0.32 MIN:0.07 MX:1.17	MN:0.53 SD:1.18 MIN:0.03 MX:5.04	MN:0.7 SD:1.18 MIN:0.04 MX:4.05	MN:0.3 SD:0.2 MIN:0.05 MX:0.67	MN:1.69 SD:1.8 MIN:0.002 MX:6.79	MN:0.28 SD:0.27 MIN:0.009 MX:0.66	MN:0.31 SD:0.41 MIN:0.001 MX:1.48	MN:0.57 SD:0.44 MIN:0.09 MX:1.88	MN:0.91 SD:0.72 MIN:0.04 MX:2.72	MN:1.46 SD:0.86 MIN:0.12 MX:3.28	p = 0.430
Using the television remote	32. Ventral	X			MN:0.04 SD:0.04 MIN:0.01 MX:0.09	MN:0.3 SD:0.29 MIN:0.005 MX:0.93	MN:0.54 SD:0.47 MIN:0.04 MX:1.14	MN:0.35 SD:0.27 MIN:0.03 MX:0.86	MN:1.45 SD:1.59 MIN:0.05 MX:6.12	MN:0.44 SD:0.71 MIN:0.001 MX:2.28	MN:0.55 SD:0.67 MIN:0.001 MX:2.12	MN:0.69 SD:0.74 MIN:0.001 MX:3.01	MN:1.15 SD:1.04 MIN:0.05 MX:4.14	MN:2.16 SD:1.13 MIN:0.52 MX:4.78	p = 0.204
Handling money	25. Lateral Tripod	X			MN:0.18 SD:0.18 MIN:0.001 MX:0.53	MN:00.34 SD:0.29 MIN:0.03 MX:1.26	MN:0.69 SD:0.77 MIN:0.02 MX:2.36	MN:0.85 SD:0.85 MIN:0.03 MX:3.06	MN:0.81 SD:0.61 MIN:0.001 MX:1.72	MN:0.25 SD:0.24 MIN:0.001 MX:0.79	MN:0.35 SD:0.43 MIN:0.009 MX:1.29	MN:0.56 SD:0.55 MIN:0.01 MX:2.51	MN:0.83 SD:0.58 MIN:0.07 MX:2.36	MN:0.81 SD:0.69 MIN:0.05 MX:2.99	p = 0.931

5.11 Discussion

The aim of the study was to develop a clinical hand rehabilitation guideline for individuals aged 20 to 59 years who had sustained second to fifth metacarpal fractures. The research question posed was: Can the functional task forces exerted by the human hand in terms of its grasps on the objects manipulated during basic and instrumental daily functional tasks among purposively sampled healthy human adults aged between 20 and 59 years be determined by using FSRs? The two studies in Phase II allowed the researcher to identify 105 basic and instrumental ADLs and the predominant grasp types used during each ADL to be used as free active exercises in the clinical hand rehabilitation guideline. The finger and grasp forces during the ADLs were tested with FSRs on all ten fingers of the hands, allowing for the categorisation of ADLs into light, medium and heavy ADL tasks. Scientific evidence now supports the advice regarding progressive return to pre-injury ADLs. The eDelphi method in the next article includes the light, medium and heavy ADLs for expert opinion and consensus. There is thus an interconnectedness between the Phase II objectives. The first study in Phase II allowed the researcher to categorise 105 basic and instrumental ADLs and identify the grasp types used during ADL manipulation. The 105 ADLs were categorised into light, medium and heavy tasks which informed the return to ADLs in the clinical hand rehabilitation guideline. The ADLs with similar forces per category and per section, namely, personal care and hygiene, transport and moving around, home environment (inside the home), gardening and outside the home activities, were grouped and tested. To further attain the aim of developing a clinical hand rehabilitation guideline, the second study in Phase II provided data specifically for grasp types and free active MCPJ ROM progression to be included in the clinical hand rehabilitation guideline.

The researcher acknowledges the error of including a participant younger than 20 years as per the inclusion criteria of the study. From the outset, the researcher wanted to develop guidelines for an adult or skeletally mature population, as their metacarpal bones have reached a stage of maturity. Skeletal maturity may be prolonged after the age of 18 years, especially in males and

less in females. Research backs the statement of gender skeletal maturity where Eveleth and Tanner (1990) state, “In all populations, girls are more skeletally mature than boys from birth onwards and reach adult bone maturity, on average, two years earlier than boys (1.9 years).” Cole et al (2015) investigated the ethnic and sexual differences related to skeletal maturity amongst a cohort aged between nine and 20 years in South Africa and agreed with Eveleth and Tanner (1990) that girls reached skeletal maturity 1.9 years earlier than boys. No differences were found in skeletal maturity between girls of different ethnicity or black and white, groups. In contrast, boys from black ethnicity reached skeletal maturity seven months later than boys from the white ethnicity group (Cole et al, 2015).

For the reasons as indicated above, the error of including a female participant aged 18 years and five months is argued to not have affected the data due to the participant reaching skeletal maturity by the time the force sensing resistor data was collected. Ethically, the argument is made that the participant aged 18 years and above does not fall into the vulnerable paediatric group, and that no parental consent was required for the participant to participate as she was in the legal position to provide written informed consent. The data relating to the participant were, therefore, included in the dissemination of the results.

5.12 Summary

Chapter 5 reported on the two FSR cross-sectional data collection studies, the first being the feasibility study, to achieve the research aim of developing a clinical hand rehabilitation guideline for individuals who had sustained second to fifth metacarpal fractures. This was achieved by adding scientific data-categorising ADL tasks, identifying the predominant grasp types, and determining the mean maximum grasp forces per categories of light, medium and heavy ADLs in the five sections, as named in the discussion in this chapter, and which were included in the eDelphi method rounds. Chapter 6 covers the third phase, namely the eDelphi method, which is presented in one article.

Chapter 6: Phase III

Development of clinical hand rehabilitation guidelines for second to fifth metacarpal fracture rehabilitation: an eDelphi method

6.1 Introduction

The article, written according to the format and author guidelines as in Addendum DII, is intended for publication in a double peer-reviewed journal entitled, Hand Therapy. The publication specifics of the journal are presented In Table 6.1 that is presented next.

6.2 Journal details

The journal details as to where the publication was submitted can be seen in Table 6.1 below. The second and third authors assisted.

Table 6.1: Publication specifics

Title of publication	**Development of clinical hand rehabilitation guidelines for second to fifth metacarpal fracture rehabilitation: an eDelphi method**
Authors	Monique M. Keller, Roline Barnes, Corlia Brandt
Journal name	Hand Therapy
To be submitted for publication in the Hand Therapy journal.	

6.3 Permissions and rights

The first author submitted this article to the Hand Therapy journal, and should the submission be accepted for publication, she will inform the journal editor of the inclusion of the manuscript in this thesis.

6.4 Article 1: Phase III

Development of clinical hand rehabilitation guidelines for second to fifth metacarpal fracture rehabilitation: an eDelphi method

Abstract

Introduction

Hand injuries, such as metacarpal fractures, are often viewed as minor injuries, potentially leading to a decrease in hand function and loss of productivity, especially in the working class age group. The study aimed to finalise clinical hand rehabilitation guidelines for second to fifth metacarpal fractures as part of a larger study since no guidelines are currently available, specifically in South Africa.

Methods

Fourteen experts specialising in hand injury management, including orthopaedic surgeons, occupational therapists (OTs) and physiotherapists (PTs), completed Research Electronic Data Capture (REDCap) surveys as part of a three-round eDelphi Method. Consensus was set at 75%, with the proposed guideline statements presented as a Likert scale and/or “yes” and “no” answers, and open-ended responses. The recommendations of the Conducting and Reporting of DElphi Studies (CREDES) were utilised in this eDelphi method.

Results

In Round 1, 10 (28.5%), Round 2, six (18%) and Round 3, sixteen (36%) of the guideline statements were accepted by the panel members. The iterative three-round process included a clear distinction being made between rehabilitation phases for conservative, percutaneous Kirshner-wire (K-wire), and surgical interventions, and a wider variety of splints, and was backed by evidence and expert open responses.

Discussion

Consensus was reached in the following respects: the inclusion of grasp types in rehabilitation to promote hand function; the types of activities/tasks classified under light, moderate, and heavy categories; the time period when early active mobilisation should commence (e.g. passive stretching of the affected joint at six weeks); the splint types after conservative management or K-wires for head and base of second to fourth metacarpal neck fractures; the splint used after surgical management for the base of metacarpal fractures; and the splinting time period for shaft, head, base, and neck of second to fourth metacarpal fractures after conservative or K-wire management. The expert opinions informed the final clinical hand rehabilitation guideline to be used for the management of individuals who sustained a second to fifth metacarpal fracture without associated injuries of tendons, vascular structures, nerves, soft tissue, or carpal, thumb, radius, ulna or phalangeal fractures.

Keywords

Boxer's fracture/s, Delphi method, guidelines, metacarpal fractures, rehabilitation

Background and Significance

Second to fifth metacarpal fractures account for 88% of metacarpal fractures, with the fifth metacarpal most often injured.[1] Neck of fifth metacarpal fractures (Boxer's) account for 20% of hand fractures, mainly in the working population, leading to time off work and negative socio-economic implications.[2] No best-evidence guidelines exist for the rehabilitation of second to fifth

metacarpal fractures, potentially leading to disabilities in individuals at a personal, family and community level.

For the past 10 years, the literature indicates that rehabilitation trends for second to fifth metacarpal fractures are moving towards immediate active mobilisation, immediate passive mobilisation, early mobilisation, and early return to light functions.[3-10] However, the programmes are not backed by systematic reviews or scientific evidence to guide the rehabilitation and to optimise outcomes, such as hand function, grip strength, and optimal range of motion, while preventing a delay in fracture healing or non-union. No South African literature could be sourced by the researcher, and therefore, international literature was used to develop the hand rehabilitation guideline.

Constructivist epistemology was the guiding paradigm, where the eDelphi method incorporated the views of expert participants as they brought their unique experiences to the area of hand injury rehabilitation to develop a clinical hand rehabilitation guideline for second to fifth metacarpal fractures.

The researcher compiled a preliminary clinical hand rehabilitation guideline by using the information from systematic reviews and results from the scientific testing of all ten fingers with force sensing resistors (FSRs) to determine the maximum forces produced during 105 everyday tasks. The scientific force testing guided the differentiation of light, moderate and heavy categories that were included in the guidelines. The predominant grasp type used during the daily tasks was identified by the researcher and a grasp-type exercise section was included in the guideline to develop clinical hand rehabilitation guidelines. With the addition of grasp types to the hand rehabilitation process, it is envisaged that hand functioning and earlier return to work will be promoted. The eDelphi method aimed to finalise the proposed clinical hand rehabilitation guideline to manage second to fifth metacarpal fractures post-surgically or conservatively, and,

with the assistance of purposively sampled expert orthopaedic surgeons, PTs, and OTs in the field of hand injuries, hand surgery, and rehabilitation.

Methods/design

Data collection commenced after the researcher had obtained ethical clearance from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State (UFS-HSD2019/0046/2602-0003). A three-round eDelphi method was used to reach consensus, adapt, and finalise a clinical hand rehabilitation guideline for individuals who had sustained second to fifth metacarpal fractures. It should be noted that the eDelphi method has been used extensively in Health Science studies.[11]

Consensus is the primary aim of the eDelphi method, but, according to the literature, [12] the measurement of consensus varies. For the purpose of this study, at least 75% of the panel of experts must have demonstrated the same preference for the clinical hand rehabilitation guideline recommendation before consensus could be reached.[13] For the items where no consensus was reached after the first round, a second round was initiated, with a third and final round then following, to achieve the objectives of the study, but also to avoid sample fatigue. The flow chart of the eDelphi method is presented in Figure 6.1 below.

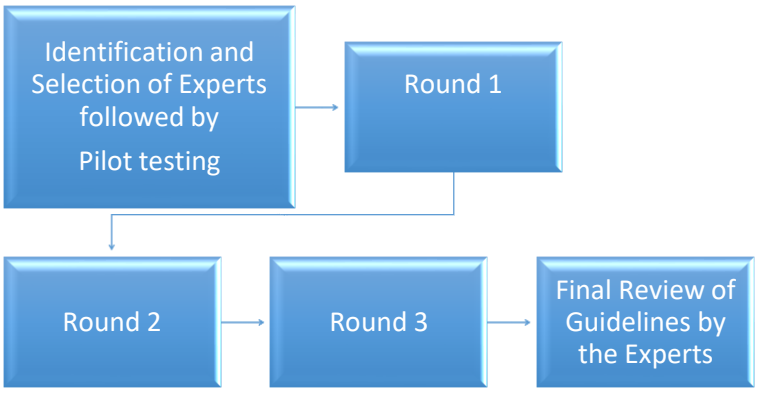

Figure 6.1: eDelphi process flow chart

Participants of the eDelphi panel

For the purpose of the study, a minimum of eight to twelve experts was deemed adequate for participating in the eDelphi method. The panel size of eight to twelve experts was based on a study conducted to develop a tool guide to retrain functional activities in hand therapy.[14] Taking into account possible attrition, fourteen experts were included in the eDelphi method. A third of the participants were orthopaedic surgeons, a third OTs, and a third PTs, all of whom had a special interest in the fields of hand surgery and hand rehabilitation. Study quality was enhanced by ensuring heterogeneity among the expert panel by including experts from different fields of hand rehabilitation.

Inclusion criteria

Experts selected for the panel met a preselected set of inclusion criteria. Table 6.2 below presents the inclusion criteria where experts had to meet at least one criterion before being included in the study.

Table 6.2: Inclusion criteria for expert selection

Orthopaedic surgeons	Occupational Therapists	Physiotherapists
Orthopaedic surgeons with specialisation in hands	Occupational therapists with a special interest in hand therapy	Physiotherapists with a specialisation in hand therapy
At least two peer-reviewed published articles in the field of hand surgery	At least two published articles in an accredited peer-reviewed journal in the field of hand therapy	At least two published articles in an accredited peer-reviewed journal in the field of hand therapy
Minimum of five years' experience in hands	Minimum of five years' experience in the treatment of hand injuries	Minimum of five years' experience in the treatment of hand injuries
Authored textbooks about hand injuries	Authored textbooks or a chapter in a book based on hand injuries	Authored textbooks or a chapter in a book based on hand injuries
A postgraduate degree in hand surgery	Postgraduate degree (Masters/PhD). Has certified hand therapy credentials	Postgraduate degree (Masters/PhD). Has certified hand therapy credentials
Presenter at one or more conferences with the topic related to hand injuries	Speaker at one or more conferences with the topic related to hand injuries	Speaker at one or more conferences with the topic related to hand injuries

Expert identification preceded the panel selection. Experts were identified by the researcher through a search of the academic literature sources in a systematic review.[15] She consulted the registered member lists of the South African Society of Hand Surgeons and Therapists, accessible to the public, and thus in the public domain, which are used for the recruitment of experts. The

first twelve experts, namely, four OTs, four PTs, and four orthopaedic surgeons, as far as possible equally distributed on the national (50%) and international (50%) levels, who consented to participate in the first eDelphi round, were included in the study. A minimum of four experts per group, namely surgeon, PT, and OT, was included. The inclusion of international experts in the eDelphi method provided a comprehensive panel to incorporate best practices in clinical settings. It ensured that the clinical hand rehabilitation guideline is on a par with the latest clinical hand rehabilitation management strategies, nationally and internationally.

eDelphi questionnaire design

The researcher used REDCap software, which is a secure, web-based software platform designed to support data capture for research studies, to develop the questionnaire. A questionnaire template was created on REDCap. The experts indicated their agreement on a five-point Likert scale, where 1 was strongly disagree, 2, disagree, 3, neutral, 4, agree, and 5, strongly agree. Agreement was sought for all the components of the clinical hand rehabilitation guideline. In instances where the experts indicated that they strongly disagreed or were neutral, branching logic in REDCap displayed an open-ended box, where the experts could elaborate on why they did not agree and what they proposed should be included in the clinical hand rehabilitation guideline.

Questions

Questions were designed according to themes to determine consensus regarding the physiological timeframe for commencing the exercises, passive stretching, strengthening, rehabilitation exercises, splints used, splinting timeframes, timelines when patients are advised to return to tasks, and advice regarding the content of the light, medium, difficult and normal pre-injury tasks. Should the experts advise patients regarding their return to light, medium, difficult, and normal pre-injury tasks and functions, they would be required to indicate what

advice they would provide to individuals under each task section and when the individual should commence the light, moderate, difficult and return-to-normal pre-injury tasks and functions.

Pilot testing

Pilot testing preceded the main eDelphi method study. Two participants, who adhered to the inclusion criteria, determined the feasibility of the study and streamlined the procedures and technical aspects of the REDCap questionnaire. The experts were recruited by downloading the registered list of the South African Society of Hand Therapists and Surgeons on the internet and randomly identifying one surgeon and one hand therapist. International experts were sought by the researcher in previous peer-reviewed publications on hand injury management. Informed consent via an email preceded the pilot testing. By following the link on the REDCap survey and selecting "True" to the first question in the questionnaire implied consent. No changes were made to the procedures. Only one technical aspect was identified as erroneous during the pilot testing; the error was corrected, and this allowed the pilot testing experts to complete the survey. The pilot testing results were subsequently included in the main eDelphi results.

Procedures

After the pilot testing, the identification of experts followed. A formal invitation, with information regarding the study, was extended to the selected experts via anonymous emails from the researcher. The selected experts were asked to identify other experts for potential inclusion. The new experts were screened against the inclusion criteria, contacted and invited by the primary author to ensure the correct occupational balance within the expert panel. The layered recruitment eliminated recruitment bias. It should be noted that solicitation in the nomination of field experts is considered best practice.[16]

Following the identification process, the researcher sent separate emails conveying information regarding the aim and procedures of the eDelphi, including a consent section in order to ensure anonymity among the participants. To ensure confidentiality, the same procedure was followed for all correspondence between the researcher and the experts. Once the experts had completed the survey, they were asked to email their names and surnames to the researcher to ensure that she would be able to provide feedback following each eDelphi round and to send reminders. As described previously, the eDelphi method was conducted in rounds using REDCap software. Technical support services were available through the REDCap Help Centre, and information regarding it was communicated to the participants.

Information on withdrawal procedures was included in the initial information. Experts not responding to the first, second and, if required, third eDelphi rounds after seven days, but who had indicated an interest in participating, received two reminders and survey links in emails. If there was no response to the reminders, the researcher viewed the lack of response as non-interest. A two-week time period was allowed for experts to complete the questionnaire.[17] The two-week period between the first and second rounds allowed the researcher time to analyse the results and forward the summary of findings to the experts. A one-week reminder was sent by the primary researcher to the panel prior to each eDelphi round to encourage participation. Information and open-ended responses for data analysis were directly exported by the researcher from REDCap. The information and comments were saved on the researcher's password-protected laptop. The REDCap questions where consensus was reached were removed by the researcher from the next eDelphi round, while those where no consensus was reached were included in the following eDelphi round. Where 75% consensus was not reached across all three rounds, the open-ended suggestions from experts were incorporated into the proposed clinical hand rehabilitation guideline for the next round. The open-ended responses were collated after each round, according to the fracture type and/or location, and shared with all of the experts in the feedback document. The researcher then updated the statements for the next round with open-ended responses in cases where two or more experts had made similar

suggestions and offered the same clinical reasoning. In instances where one expert would offer an open-ended response, the response would be documented and kept for future rounds, to see if a similar response would then be shared. In that case, that response would then be included in the expert feedback in the following eDelphi round or in final feedback to the experts. The experts' comments and suggestions in their open-ended responses were highly valuable in that the research incorporated the clinicians' reasoning into the development of the guideline. In instances where no additional changes were made, the stability of the expert responses was confirmed, thus indicating the end of the eDelphi method.

Those expert participants who, while completing the REDCap questionnaire, had requested a copy of the clinical hand rehabilitation guideline for reference purposes, received an email containing a copy of it.

Data Analysis

The researcher calculated median, mode, minimum and maximum scores, and a summary of the guideline statements and percentages after each of the three rounds was sent to the panel members. Following the final round of the eDelphi method, the clinical hand rehabilitation guidelines were updated and finalised by the researcher.

Results

Fourteen participants agreed to participate and completed the first round of the eDelphi method. The demographics of the participants are included in Table 6.3 below. Among the experts, 236 publications, one book, and nine chapters related to hand injuries and management have been published. In total, 84 years of experience mark their level of expertise in respect of hand rehabilitation.

Table 6.3: Demographic details of the participating experts (n=14)

Gender (n)		Age (years)		Occupation (n)		Experience (total years)	Country (n)	
Female	9	Average	47	Occupational Therapist	5	28 (mode* = 7)	Australia	1
Male	5	Minimum	33	Orthopaedic Surgeon	5	29 (mode* = 7)	South Africa	3
		Maximum	56	Physiotherapist	4	27 (mode* = 7)	Switzerland	2
							United Kingdom	7
							United States of America	1

*Mode indicates the years of experience that occur most frequently.

Round 1

With the consensus percentage set at 75%, the experts agreed with 28.5% of the clinical hand rehabilitation guidelines. Subsequently, the components were removed from the REDCap questionnaire, and the remaining components were adapted with the feedback responses received from the experts during Round 1. The feedback from the experts in respect of REDCap questionnaire Round 1 is presented in Addendum EII. Itincludes statements regarding the types of splints used after second to fifth metacarpal shaft fractures. A question was raised: "Do we talk about conservatively treated metacarpophalangeal fractures or operated ones? Because our rehabilitation regimens differ between them?" (Participant 4).

Following Round 1, the researcher removed the statements where consensus was reached, added a wider variety of splinting options for each fracture type, separated the rehabilitation

phases for surgical and for what Participant 4 termed “operated” and “conservative management”. “Yes”/”No” questions were also introduced.

Round 2

In Round 2, consensus was reached on six (18%) clinical guidelines. Agreed-upon aspects included the types of light and medium functional activities, the time period of six weeks for commencement of Phase III’s passive stretching phase after conservative management, the splinting time period for shaft fractures and the splint and splinting time period used for the necks of second to fourth metacarpal fractures after conservative management. Following Round 2, the researcher sent the feedback to all participating experts. (The feedback shared with the experts is presented in Addendum FII.)

After Round 2, the researcher removed the statements where consensus had been reached, and introduced the following changes to the third-round questionnaire: questions and recommendations with open-ended responses about the overarching principles of the clinical guidelines were added; K-wire (percutaneous) and open reduction internal fixation (ORIF) with plate/stable fixation management were more clearly differentiated; and “Yes” and “No” questions were added to the Likert scale, thus allowing participants to provide their opinions in open-ended responses. Finally, feedback from the experts received in the second eDelphi round was included in the following round.

Round 3

During Round 3, consensus was reached on sixteen (36%) guidelines, as follows: seven statements regarding rehabilitation; four regarding grasp exercises; one regarding base of metacarpal fractures managed with stable ORIF; one regarding the neck of the fifth metacarpal fracture managed with stable ORIF; two regarding the necks of the second to fourth metacarpal

fractures managed with stable ORIF; and one regarding the neck of the second to fourth metacarpal fracture managed with conservative or K-wire fixation. After Round 3, feedback was sent to all of the experts (Addendum GII). The researcher shared the final clinical hand rehabilitation guideline with the participating experts for a final review. Two experts provided feedback, as indicated below, and the other experts agreed with the final clinical hand rehabilitation guideline.

After sharing the clinical hand rehabilitation guideline, one expert, responded with “Well done”, and another expert made a suggestion and a special request. The researcher was asked to include Table 6.4 below with the clinical hand rehabilitation guideline, as the expert found it most helpful, and requested that the table, entitled, “Grasps free active no resistance allowed after injury”, be shared at a national congress. The content of Table 5.4 was informed by two Phase II studies.

Table 6.4: Grasps free active no resistance allowed after injury

Phase 1 Grasps requiring no or very little MCPJ flexion	Phase 2 Grasps requiring minimal to 45° MCPJ flexion	Phase 3 Grasps requiring more than 45° MCPJ flexion	Phase 4 All Grasps with resistance
5. Light Tool 8. Prismatic 2 Fingers 10. Power Disk 12. Precision Disk 15. Fixed Hook 16. Lateral 17. Index Finger Extension (For index finger #) 18. Extension Type 23. Adduction Grip 26. Sphere 4 Fingers 28. Sphere 3 Fingers 32. Ventral (For index finger #) 33. Inferior Pincher Respect pain < 3/10.	1. Large Diameter 3. Medium Wrap 4. Adducted Thumb 6. Prismatic 4 Fingers 7. Prismatic 3 Fingers 9. Palmar Pinch 14. Tripod 21. Tripod variation 24. Tip Pinch 31. Ring Index finger #	2. Small Diameter 11. Power Sphere 13. Precision Sphere 17. Index Finger Extension (For middle-, ring- and little finger #) 19. Distal 20. Writing Tripod 22. Parallel Extension 25. Lateral Tripod 27. Quadpod 29. Stick 30. Palmar 32. Ventral (For middle-, ring- and little finger #)	All Grasps if no pain is present. If pain persists, consult your medical doctor.

The experts did not forward any additional comments related to the clinical hand rehabilitation guideline to the researcher, and the guideline was subsequently accepted and finalised.

Discussion

The management of metacarpal fractures should ensure stability of the fracture, patient comfort, and allow early return to movement of the hand and timely return to work for individuals who have sustained metacarpal fractures.[4] In the compilation of the guideline, and in a separate phase of the study, as well as from the results of the ADL that the participants performed, the researcher was able to extract the predominant grasp types and finger forces. These test results were subsequently used to guide the patients back to an earlier return to movement, while the identified grasp types were used to improve hand function and, as such, the commencement of an early but cautious return to daily tasks.

Incorporating grasps in the clinical guideline is deemed imperative in rehabilitation in that grasps optimise hand function and participation. The experts agreed on the following statements emerging from the eDelphi rounds: "Incorporating grasp types of the hand is valuable in rehabilitation to promote hand function"; "Careful use of grasp types in the rehabilitation [programmes] for second to fifth metacarpal fractures after conservative (and K-wire) management can improve hand function"; and "Use of grasp types in the rehabilitation for the affected metacarpophalangeal joint (MCPJ) second to fifth metacarpal fractures after stable ORIF management can start at two to three days.". Kimmerly et al. (2003) who investigated the functional repertoire hand model, urged all therapists working with individuals who had injured their hands to incorporate hand grasps in their assessment and treatment of hand injuries.[18]

To further attain optimal hand function, thus enabling the performance of light, medium, and heavy activities, and, as such, a return to everyday tasks, objectives relevant to the clinical guideline was, therefore, included in the guideline to ensure graded returns. The experts agreed that examples of light activities include the following: personal care and hygiene tasks, but no wringing of water out of a washcloth or a facecloth with force, no carrying of buckets (weight > 1 kilograms (kg)) or zinc basins, and no wringing of water out of clothes. Light activities also include taking care with putting on socks and opening and closing a belt buckle.

The experts further agreed on the ADLs, which are allowed or not allowed in the home environment and outside. In the home environment: What would not be allowed inside would be the opening of new or tight jar lids or the stirring of mealie pap/heavy porridge; also, no picking up of children, moving of furniture or turning of a salt or pepper grinder. Outside: No gardening should be allowed, and also no driving.

Agreement regarding what should specifically constitute medium (Round 2) and heavy (Round 1) activities was reached. This is by no means an exhaustive list; it is, however, a helpful guide.

Agreement on the timelines to start the activities was also reached in respect of the time period of two weeks for the commencement of light, four weeks for medium, six weeks for heavy, and eight to 10 weeks to return to pre-injury tasks/activities/functions after sustaining second to fifth metacarpal fractures. Despite the recommendations made, the timeline needs to be clinically reasoned, with account being taken of comorbidities affecting the healing of fractures, the type of fracture, and whether conservative K-wire management or surgical intervention should be used to manage the fracture.

Considering the immobilisation of the affected joint, the experts agreed that the MCPJ position in the splint, the splint types and the period in the splint should be guided by clinical reasoning. Toemen and Midgely (2010) echoed that the management of individuals sustaining metacarpal fractures varies, and this was also evident in the responses of the experts involved in the eDelphi rounds.[4] The experts, however, agreed that "after metacarpal head fractures, the MCPJ position depends on the fracture pattern and position of stability"; "splint types should be clinically reasoned and individualised for each patient"; and "the splint time period should be clinically reasoned according to the fracture pattern and individualised for each patient". However, clinical guidelines, backed by best evidence to guide the rehabilitation of the individual after having sustained a second to fifth metacarpal fracture, with the potential of a delayed return to work and everyday functioning, are missing; hence, the motivation for this research.

Kaynak et al. (2019), in a comparison of two types of immobilisation, the ulnar gutter splint and the functional metacarpal hand-based splint, concluded that for the conservative management of a stable Boxer's fracture, and as measured with the Quick Disability of the Arm, Shoulder and Hand (QuickDASH) questionnaire, a functional metacarpal splint for four weeks prevents loss of

reduction with improved clinical hand function, and also improves normal grip strength.[9] Over the long term, however, participants using the ulnar gutter splint and the functional metacarpal splint presented with similar outcomes. Kaynak et al. (2019) concluded that compliance and comfort should be considered during decision-making as to the correct splint choices. Less joint restriction and greater compliance appear to be promoted by the functional hand-based metacarpal splint.

Van Aaken et al. (2016), in their randomised control trial (RCT), suggested a soft wrap bandage and buddy strapping for three weeks, with early mobilisation. This proved to be sufficient, with good outcomes for hand function. The measurements on quickDASH and of the pain level on the Visual Analogue Scale[10] as well as an open comment by a participant, namely "splint for protection: +/- buddy tape." (Participant 4:OT), substantiated this viewpoint. In the eDelphi method applied in this research study, splinting for the conservative management of a Boxer's fracture elicited responses from two participants: "Splintage is just for comfort as the fracture is unlikely to displace. I do prefer a volar splint, though – the head is usually a displaced volar. Often extensor lag is a problem with these fractures. Therefore, a volar splint allows for early active extension" (Participant 12:OrthoSurg); and "A splint is not always required. A padded bandage may be sufficient." (Participant 6:PT). Another participant stated: "Yes, sometimes, but I prefer to provide a splint for protection. If they don't wear it, fine." (Participant 12:OT). Another participant preferred more protection after conservative management for a Boxer's fracture and stated, "[I} would immobilise with [a} rigid splint, and limited active exercise]." (Participant 3:PT). No consensus could be reached regarding the type of splint to be used after conservative management of the neck of a fifth metacarpal fracture. Subsequently, the type of splint was adapted according to the open-ended feedback and added to the next eDelphi rounds. After the third round, the participants agreed with the statement that for the conservative management of a Boxer's fracture, "a neck of the fifth (Boxer's) fracture is generally impacted and therefore stable. Splinting is just for comfort as the fractures are unlikely to displace" (Participant 12:OrthoSurg). These comments were subsequently included in the clinical guideline. Not

immobilising with a splint on account of the inherent stability of the neck of the fifth metacarpal fracture is in fact consistent with the available literature.[19]

Owing to a loss in rotational alignment, angulation exceeding 10° in the index and middle fingers and greater than 30° to 40° in the ring and *digiti minimi*, that all follow on early active mobilisation, metacarpal shaft fractures are managed surgically with locking plates.[19] The experts agreed with the early mobilisation, as suggested by Van Aaken et al. (2016) and Kollitz and Hammert (2014). Consensus was reached that after stable or rigid ORIF has been used for fractures of the neck and shaft of the second to fifth metacarpals, immediate early motion should be commenced to prevent the formation of adhesions. It was agreed that the time frame for commencing early active mobilisation should be two to three days post-surgery.

For the conservative management of fractures of the neck and head of second and fourth metacarpals, consensus was reached regarding the type of splint to be used. A hand-based dorsal gutter splint requires that the MCPJs of the affected and the adjacent finger be positioned in 70° flexion, but that none of the interphalangeal joints and unaffected MCPJs should be included in the splint so that they can move freely. The benefit of the splint is backed by literature.[5] The period for wearing the above-mentioned splint for four weeks, with continued splinting at night and over a further period of two weeks of protection, and for it finally to be discarded at six weeks, is consistent with the literature.[5] Similar to the findings of Toemen and Midgley (2010), consensus was reached for the time period of four weeks post-surgery for neck of second to fourth metacarpal fractures managed surgically with percutaneous K-wires. In conservative management, a volar forearm base splint was the agreed-upon splint for base of second to fifth metacarpal fractures for four weeks post injury.[5] In contrast, Gülke et al. (2018) advocated a dorsal forearm-based splint.[7]

When considering the expert agreement and consensus, the number of guideline statements over the three eDelphi rounds reaching consensus, resulted in a smaller number of guideline recommendations accepted. It could be hypothesised that as the experts completed the rounds, they also offered comments and suggestions which were based more on clinical reasoning than on their own experience. Their clinical expertise was thus provided in the open-ended responses that they gave which were presented to the other experts in the subsequent eDelphi rounds. Thus, the iterative process of the eDelphi method allowed for the experience of the clinicians to be accepted as imperative. Furthermore, owing to the repetitive nature of this method, it was difficult to predict from the outset of each round the number of recommendations that would be accepted at the end of the round. The time period between the eDelphi rounds and the sharing of the open-ended responses with all of the experts may also have given them time to reflect on their own and others' management preferences and reasoning. It is hypothesised that on reading the open-ended responses of their fellow experts between the rounds, reflection by each one might have impacted on the outcomes of the subsequent eDelphi rounds.

Conclusion

Rehabilitation for individuals who sustained second to fifth metacarpal fractures is not currently backed by best evidence, and no guidelines are available. With the eDelphi method, experts in the field of hand injury management participated in an iterative three-round survey to refine and develop a guideline for each type of second to fifth metacarpal fracture without any involvement of soft tissue or of vascular or neural components. High-quality RCTs are advised for the future, to ensure best practices for shaft, head and base of metacarpal fractures.

Limitations

The limitations of the eDelphi method include possible expert fatigue, as well as questions as to its reliability and validity. When undertaking any research study, researchers must consider reliability and validity issues. Reliability is the extent to which a procedure produces similar

results under constant conditions. There is no evidence of the reliability of the eDelphi method; in other words, if the same information were to be given to two or more panels, would the same results be obtained? To overcome this challenge, Lincoln and Guba's (1985) criteria for qualitative studies could be applied to help ensure that credible interpretations of the findings are produced. The criteria are based on four major issues, namely credibility (truthfulness), fittingness (applicability), auditability (consistency) and confirmability. The eDelphi method is based upon the assumption of safety in numbers (i.e. several people are less likely to arrive at a wrong decision than a single individual). Decisions are then strengthened by reasoned argument in which assumptions are challenged, thus helping to enhance validity. Threats to validity arise principally from pressure for the convergence of predictions (Hill & Fowles, 1975) which undermines the eDelphi's forecasting ability. However, using participants who have expert knowledge and an interest in the topic may help to increase the content validity of the eDelphi method (Goodman, 1987); furthermore, the use of successive rounds for presenting the questionnaire would help to increase the concurrent validity of the responses. Nonetheless, it has to be stated that the validity of results is ultimately affected by the response rates. Owing to tight timelines, the researcher did not have the opportunity to share the final guideline with an external board of stakeholders.

Strengths

The strengths of the eDelphi method in the context of this research included anonymity, whereby each expert was allowed to express his/her views openly in their open-ended responses to the REDCap questions. Anonymity also ensured that a dominant participant did not overpower the conversation or pressurise the participants to conform. Including expert PTs, OTs, and orthopaedic surgeons specialising in the field of hand injuries strengthened the consensus findings and as such, the eDelphi-based development of the guideline. Selecting experts both nationally and internationally enriched, solidified, and added robustness to the clinical guideline, as South Africa’s diverse population includes individuals from low, middle and high socio-economic status. The primary author considered the CREDES recommendations in the planning

and execution of the eDelphi method (Junger et al. 2017). To strengthen the reliability and validity of this method, the researcher used the CREDES recommendation table to indicate the manner in which this research adhered to the CREDES reporting recommendations (Addendum HII).

Conflicting interests

The authors, MK, RB, and CB declare no competing interests.

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The author declares that this research proposal is not subject to industrial or any other funding.

Informed consent

Online informed consent was obtained from the participating experts.

Ethical approval

This research has been approved by the HSREC of the University of the Free State, under the number UFS-HSD2019/0046/2602-0003.

Guarantor

MK

Contributions

MK proposed the topic for this research study, wrote the protocol for ethical approval and the first version of the article. The protocol and article were read, elaborated upon, and refined with

the assistance of RB and CB. RB and CB were only involved in an advisory capacity during the data analysis process. MK performed the data analysis across the three rounds.

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Data accessibility

Any request for data pertaining to this research can be obtained by sending an email request to the corresponding author.

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6.5 Summary

Chapter 6 reported on the eDelphi method in an article to finalise the development of the clinical hand rehabilitation guideline for second to fifth metacarpal fractures. The eDelphi method informed the clinical guideline development with expert opinion and consensus, resulting in the accepted guideline recommendations included in Chapter 7 where the clinical hand rehabilitation guideline in the format of an article, is presented.

Chapter 7

Clinical hand rehabilitation guideline for individuals who sustained second to fifth metacarpal fractures

7.1 Introduction

The article, written according to the format and author guidelines as in Addendum III, is intended for publication in a double peer-reviewed journal entitled, Hand. The article is a presentation of the clinical hand rehabilitation guideline developed by the researcher after having completed three phases, including two systematic reviews (Keller et al, 2021; Keller et al, 2022), and two force sensing resistor (FSR) testing studies, namely, a feasibility study and a cross-sectional study, for individuals aged between 20 to 59 years who sustained second to fifth metacarpal fractures, without any associated soft tissue, tendon, vascular or neural injuries. The eDelphi method was used to finalise the content of the clinical hand rehabilitation guideline.

7.2 Journal details

The journal details are presented in Table 7.1 below.

Table 7.1: Publication specifics

Title of publication	**Clinical hand rehabilitation guidelines for individuals who sustained second to fifth metacarpal fractures**
Authors	Monique M. Keller, Roline Barnes, Corlia Brandt
Journal name	Hand
Reviewed for publication with the Hand journal.	

7.3 Permissions and rights

The first author will inform the editor of the journal about the inclusion of the article in this thesis.

7.4 Article

Clinical hand rehabilitation guidelines for individuals who sustained second to fifth metacarpal fractures

Abstract

Background

Metacarpal fractures commonly occur in the adult population, accounting for 10% of all bodily injuries. The concern is that metacarpal fractures predominantly affect the working class, and no guidelines are currently available to guide clinical practice and rehabilitation in South Africa. A prolonged absence and days off work have a negative economic impact on the employer and affect the individual, his/her family and the community. The research aimed to develop clinical hand rehabilitation guidelines for the surgical and conservative management of individuals who

sustained second to fifth metacarpal fractures, and to develop a guideline for each type of second to fifth metacarpal fracture without associated injuries to the soft tissue, vascular or neural components or tendon injuries.

Methods

The Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument was used during the development of these guidelines. It comprised three research phases: firstly, a systematic literature review; secondly, a finger-force sensor-testing phase requiring individuals to perform daily tasks; and lastly, an eDelphi method, where experts, including physiotherapists (PTs), occupational therapists (OTs) and orthopaedic/hand specialists, participated in an iterative three-round survey towards achieving consensus in respect of the clinical guidelines and their final development.

Results

Thirty-one (31) guidelines are presented to guide the clinical practice of healthcare practitioners in the management of individuals who sustained second to fifth metacarpal fractures.

Conclusion

The guidelines add to the existing base of knowledge of studies on second to fifth metacarpal fractures, and work towards a safe early return to work, post-injury, and optimising hand function, thus ensuring that individuals are able to return to their pre-injury functioning.

Keywords

Boxer's fracture/s, guidelines, metacarpal fractures, rehabilitation, hand therapy

Introduction

Metacarpal fractures are among the most prevalent upper limb injuries in adults, while Boxer's and neck of the fifth metacarpal fractures account for 20% of all hand fractures.[1,2] The incidence rate (IR) for metacarpal fractures in the United States of America is 13.6 per 100 000,

with a prevalence rate of 33% [3]. The IR of metacarpal fractures is higher among males (IR 28.4) than females (IR 4.4), with the age group 10 to 19 years displaying the highest IR, followed by the 20 to 29 year age group, but with very few individuals sustaining metacarpal fractures after the age of 59 years. In her clinical experience, the researcher has seen mainly adults, and not children, presenting with second to fifth metacarpal fractures. For this reason, the guideline was developed for a skeletally mature adult population. Metacarpal fractures frequently occur when the hand contacts a solid surface during a fall or in a motor vehicle accident.[3]

A plea to incorporate evidence-based treatment rather than clinical-based opinions or opinion protocols on hand rehabilitation was made.[4] This plea was the motivation for the researcher to review best evidence in the available literature as the first step towards the development of clinical guidelines. The guideline development was guided by the AGREE II instrument[5], a valid and reliable instrument used by PTs in developing clinical practice guidelines.[4]

The purpose of the study was to develop clinical hand rehabilitation guidelines because of the absence of clinical hand rehabilitation guidelines. Practising without a robust, clear and practical guideline may negatively affect individuals who sustained second to fifth metacarpal fractures leading to a delayed return to work, with economic consequences for the employer and employee.

The overarching objective of this research was thus to develop a clinical hand rehabilitation guideline for adult male and female participants in South Africa between the ages of 20 and 59 years following single or multiple second to fifth metacarpal fractures.

Methods

The three phases undertaken to develop the clinical hand rehabilitation guideline were firstly, a systematic literature review; secondly, a feasibility and cross-sectional finger force testing using force sensing resistors (FSRs) during activities of daily living (ADL), and thirdly, an eDelphi method. Ethical clearance, obtained from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State (UFS-HSD2019/0046/2602; UFS-HSD2019/0046/2602-0002; UFS-HSD2019/0046/2602-0003), preceded all three phases of the development of the clinical hand rehabilitation guideline. The systematic literature review was also registered with PROSPERO (UFS-HSD2019/0046/2602-0002). The three research phases undertaken by the researcher, and the components included in developing the clinical hand rehabilitation guideline, are presented in Figure 7.1 below. A description of each phase then follows.

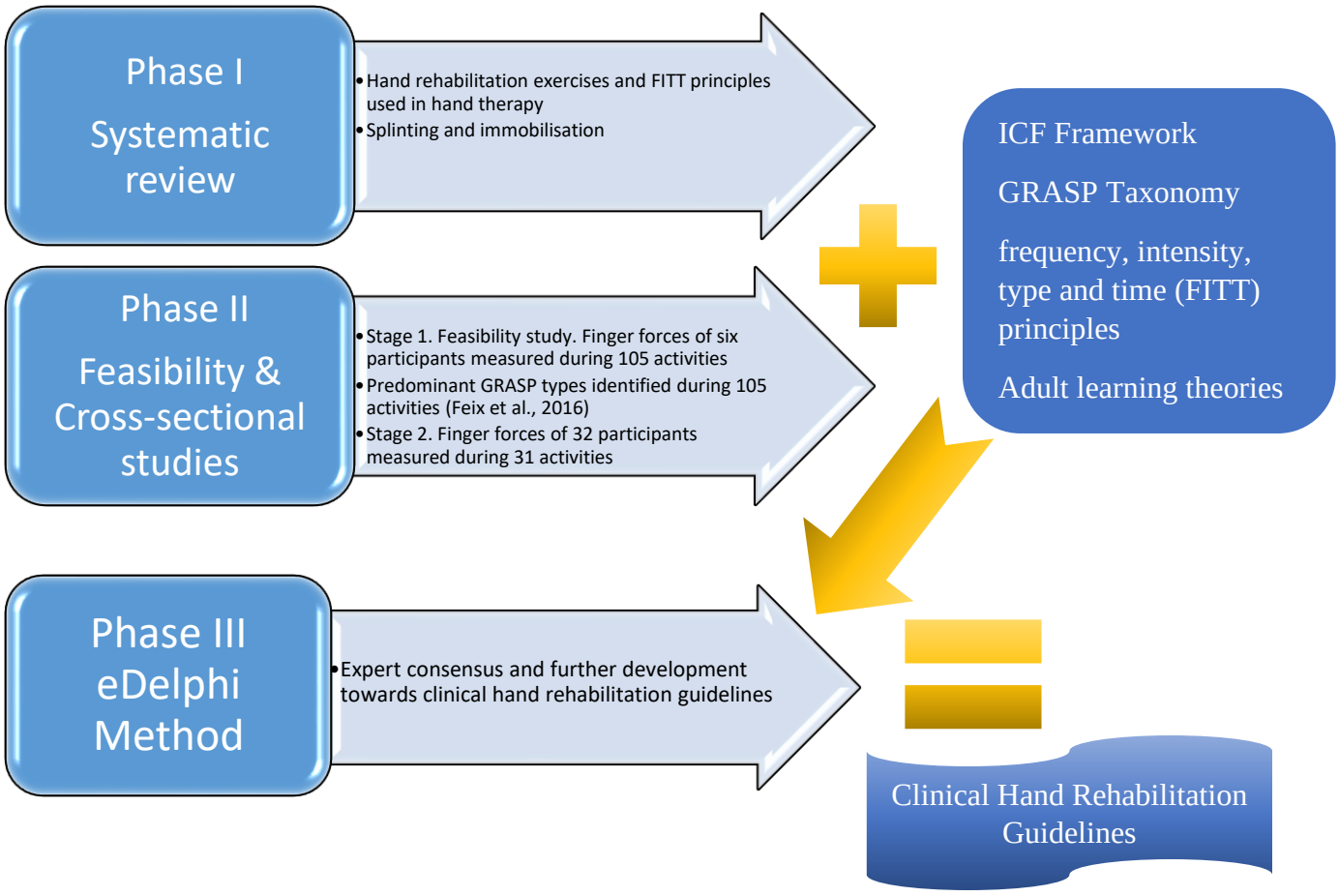


Figure 7.1: Clinical hand rehabilitation guideline development components

In Phase I, a systematic review was undertaken by the researcher to extract data from the available best-evidence literature. The extracted data included, but was not limited to hand rehabilitation exercises, immobilisation/splinting types and the time frames for their use, the time frames for returning to activities of daily living, the types of HE, and prescribed exercises. The lack of exercise principles and advice in the literature to guide the management of individuals after having sustained second to fifth metacarpal fractures was evident. The articles retrieved from the two systematic reviews were used to inform the development of a clinical hand rehabilitation guideline, as explained in the article written by Keller et al. (2021).[6,17]

Phase II, a two-phased, scientific FSR testing of basic and instrumental ADL tasks, was required to inform the clinical hand rehabilitation guideline. This was necessary because of the current lack of evidence pertaining to the return to basic ADL and instrumental daily functional tasks, as well as on the advice of clinicians managing individuals who had sustained second to fifth metacarpal fractures. It is currently unclear in the context of both conservative and surgical management which types of activity an individual should engage in, and the length of time after having sustained a fracture that the individual would need before being able to participate in certain activities, post-injury. By omitting to guide individuals back to their daily tasks might result in a delay in their safe return to work and a reduction in their hand function, both factors necessitating a scientific approach to direct the development of the clinical hand rehabilitation guideline. No evidence could be found on force measurements pertaining to all ten fingers during the bilateral manipulation of activities of daily living and instrumental daily functional activities.

However, the most extensive grasp research instrument, namely, the GRASP taxonomy[7], uncovered an extensive range of activities and grasp types which formed the basis of the scientifically-tested data collection process in which FSRs were used. In the first stage of Phase

II, six healthy adults, three males and three females, performed 105 daily activities with a glove on each hand. A FSR was glued to each finger of the glove and the forces produced during the activities were captured electronically. The 105 daily activities were identified by the researcher when she observed her own hands and documented the activities performed by others in their daily tasks during the waking hours of a 24-hour period. It is worth noting that any tasks not identified during the 24-hour observation period, but listed in the Disability of the Arm, Shoulder and Hand (DASH) questionnaire, were also included in the 105 activities. While the six individuals performed the activities and the finger force measurements were captured on a laptop using Realterm software, the researcher identified the predominant grasp types used to perform the respective activities in each case. Each activity was imported into an Excel spreadsheet, where the data were converted into Newton (N) forces, and the maximum force per finger per activity was determined. The activity was then categorised into a light, moderate or heavy force category. When, during a specific activity, the finger forces measured between 0 and 3 N, the activity would then fall into the light category; between 3 and 7 N, into the moderate category, and more than 7 N, into the heavy force category. After the first part of Phase II had been completed, the researcher identified activities where, according to Feix et al. (2016), similar grasp types were used so that those activities would then fall into the same force category.

The identification process focused the second force sensor testing on grasps, thus aiming at promoting a hand function approach, but also validating the initial force sensor testing phase with a larger sample size. Thirty-two (32) individuals participated in the second force sensor testing stage of Phase II and completed 31 activities, including all of the identified grasp types. Where a certain grasp type fell into more than one force category, one of each activity for that grasp type would then be included for testing.

Phase II's results were reviewed and validated by a specialist in electrical technology, ensuring rigour, consistency in procedures, a data cleaning process, and data representation. Other studies, although minimal, have investigated finger forces[8,9], but not all ten fingers were included in the testing and fewer activities were measured. Although it was challenging to compare the forces produced by ten fingers for 105 activities to those of other studies, owing to a paucity of studies, the first-of-its-kind data collected during the respective phases of the study were used in the clinical hand rehabilitation guideline. The force sensor testing informed the clinical hand rehabilitation guideline by dividing basic and instrumental ADL tasks into categories, thus allowing health practitioners to advise patients on the return to ADL as backed by scientific evidence. The force sensor phase also allowed for the incorporation of grasp types into hand rehabilitation, this being the first of its kind.

In the third research phase, fourteen experts, both surgeons and therapists in the field of hand injury and rehabilitation, participated in a three-round eDelphi method to further develop and finalise the clinical hand rehabilitation guidelines. To maintain confidentiality, the researcher circulated an iterative three-round online Research Electronic Data Capture (REDCap) questionnaire to each individual expert. The aim of each eDelphi round was to reach consensus, which was set at 75%. The items where consensus was reached were removed, and the open-ended responses were thematically analysed by the researcher and included in the questionnaire for the next rounds.

In addition to the three research phases, the International Classification of Functioning, Disability and Health (ICF) framework[10], adult learning principles[11], exercise prescription principles[12], the GRASP taxonomy[7], and the AGREE II instrument[5] informed the development of the clinical hand rehabilitation guidelines. The AGREE II checklist is presented as Addendum JII. The ICF framework and the GRASP taxonomy are frameworks that are generally used in that they consider the highest levels of human hand functioning in the activity limitation domain of

the ICF. Because of this superior quality, they have been adequately addressed in the guidelines that consider grasp types in the assessment and treatment subsequent to the sustaining of metacarpal fractures. Exercise prescription is imperative in the highest levels of rehabilitation, as are adult learning principles, where adult learners have their own learning style, such that rehabilitation measures should cater for unique differences in presenting the guidelines. The AGREE II instrument assisted the researcher in ensuring rigour in the development of the clinical hand rehabilitation guidelines through the inclusion of systematic reviews, in ensuring that the data collection process would produce scientific evidence on human hand forces, and lastly, in obtaining feedback, input and consensus from national and international expert stakeholders in the field of hand injury and rehabilitation.

The guideline recommendations do not apply to patients who have fractured their thumb metacarpal and who are managed with external fixators, or to the paediatric patient population up to 19 years and older than 60. Furthermore, individuals who sustained second to fifth metacarpal fractures with associated infections or injuries to their tendons and nerves should not use the clinical hand rehabilitation guideline.

According to AGREE II, it is suggested that the clinical hand rehabilitation guideline will be updated by future researchers undertaking studies five years subsequent to the implementation of this research study. The guideline recommendations will be used in managing patients who sustain second to fifth metacarpal fractures, without any of the associated injuries, such as vascular injuries, or injuries to the tendons, soft tissue, or nerves. The updated methodology needs to include a literature review and also include randomised control trial (RCT) data of the implementation study, with external stakeholder involvement, including, but not limited to patients, public health sector representatives, medical professionals, and national and international hand societies.

Evidence and recommendations criteria

The European Society of Cardiology (ESC) system[13] was employed in the grading of the guideline according to the level of evidence, as viewed in Table 7.2 below, and according to the classes of recommendation, as viewed in Table 7.3.

Table 7.2: Levels of evidence

Level of evidence A	Data derived from multiple randomised clinical trials or meta-analysis
Level of evidence B	Data derived from a single randomised clinical trial or large non-randomised studies
Level of evidence C	Consensus of expert opinions and/or small studies, retrospective studies, and registries

Table 7.3: Classes of recommendation

Classes of recommendation	Definition	Suggested wording to use
Class I	Evidence and/or general agreement that a given treatment or procedure is beneficial, useful and effective	Is recommended/Is indicated
Class II	Conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of the given treatment or procedure	
Class IIa	Weight of evidence/opinion in favour of usefulness/efficacy	Should be considered
Class IIb	Usefulness/efficacy is less well established by evidence/opinion	May be considered
Class III	Evidence or general agreement that the given treatment or procedure is not useful/effective, and may in some cases be harmful	Is not recommended

Results

The clinical hand rehabilitation guideline for 20 to 59 year old males and females who sustained a second to fifth metacarpal fracture is now presented in sections, as indicated in the underlined section headings.

<u>This section covers the time period and types of light, moderate, and heavy ADL tasks and the return to ADL tasks</u>

The commencement of activities after a person has sustained second to fifth metacarpal fractures depends entirely on whether the individual's fracture was managed surgically, through reduction and Kirshner wire (K-wire) fixation, or conservatively, the fracture pattern,

the type of immobilisation and the time period required for healing, and the injuries sustained. Toemen and Midgley (2010) and Gülke et al. (2018) indicated that after open reduction and internal fixation (ORIF), light tasks can be commenced after two weeks, without a splint or immobilisation, thus allowing the affected metacarpophalangeal joint (MCPJ) to grasp. In terms of the eDelphi method, consensus was reached among the experts, thus, indicating that light tasks can be commenced after two weeks.[14,15] Guidelines 1 to 7 are presented below.

Clinical hand rehabilitation guideline: Recommendation 1		
The time period of two weeks for the commencement of light tasks/activities/functions after 2nd to 5th metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I	B	Consensus

Clinical hand rehabilitation guideline: Recommendation 2		
The types of light tasks/activities/functions in the clinical hand rehabilitation guideline after 2nd to 5th metacarpal fractures: respect of pain 3/10: *Personal care and hygiene tasks*: Acceptable, but no wringing with force of water out of a washcloth/facecloth, no carrying of buckets (weight > 1 kilograms (kg) or sink basins, no wringing of water out of clothes. Take care with putting on socks and opening and closing a belt buckle. *Home environment*: Interior tasks allowed but no opening of new or tight jar lids or stirring of mealie pap/heavy porridge. No picking up of children, no moving of furniture, no turning of a salt or pepper grinder. No gardening allowed. No driving.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

The experts agreed that, as per Guideline 3, progression to medium tasks is allowed at four weeks after injury or surgery. The medium tasks include all previously stated light tasks, with driving added when there is a ring or index metacarpal fracture, and, as seen in Guideline 4, picking up weights of less than two kg can be started.

Clinical hand rehabilitation guideline: Recommendation 3		
The time period of four weeks for the commencement of medium/moderate tasks/activities/functions after 2nd to 5th metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 4		
The types of medium/moderate tasks/activities/functions in the clinical hand rehabilitation guideline after 2nd to 5th metacarpal fractures: Start driving in the case of a metacarpal fracture of the ring or index finger. Pick up weight of < 2kg.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 5		
The time period of six weeks for the commencement of heavy tasks/activities/functions after 2nd to 5th metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I		Consensus (Gülke et al. (2018)

Clinical hand rehabilitation guideline: Recommendation 6		
The types of heavy tasks/activities/functions permitted (as recorded in the rehabilitation programme) after second to fifth metacarpal fractures: For all metacarpal fractures, start driving; do not hang on the overhead rail or hand support in a car or taxi; pick up weights of < 5kg.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 7		
The time period of eight to 10 weeks for commencement of pre-injury tasks/activities/functions after 2nd to 5th metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

<u>Rehabilitation guideline recommendations</u>

Guidelines 8 to 12 are presented in this section. They relate to advice given in respect of general rehabilitation for individuals who sustained second to fifth metacarpal fractures.

Clinical hand rehabilitation guideline: Recommendation 8		
Splint types should be clinically reasoned and individualised for each patient.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 9		
The splint time period should be clinically reasoned according to the fracture pattern and individualised for each patient.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 10		
Splinting types for second to fifth metacarpal fractures managed with percutaneous K-wires should be considered and moulded to respect the K-wire placement.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 11		
Fractures managed with percutaneous K-wires should be splinted for the period when the K-wire is *in situ*.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Gülke et al. (2018) and Toemen and Midgley (2010) agree with starting passive range of motion of the affected MCPJ, as was agreed upon by the experts as per Guideline 12.

Clinical hand rehabilitation guideline: Recommendation 12		
Passive stretching of affected joints after conservative management can commence at the 6/52 time period.		
Class	**Level**	**Reference/Consensus**
I	B	Consensus (Gülke et al. (2018) Toemen and Midgley (2010)

<u>Guidelines for grasp-type exercises</u>

Guidelines 13 to 16, on incorporating grasp types during rehabilitation, are covered in this section.

Clinical hand rehabilitation guideline: Recommendation 13		
The incorporation of grasp types in respect of the hand is valuable in rehabilitation in that grasp types promote hand function.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 14		
Careful use of grasp types in the rehabilitation of 2nd to 5th metacarpal fractures after conservative management can improve hand function.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 15		
Careful use of grasp types in the rehabilitation of 2nd to 5th metacarpal fractures after percutaneous K-wire management can improve hand function.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 16		
Use of grasp types in the rehabilitation of the affected MCPJs of 2nd to 5th metacarpal fractures after stable ORIF. Management can start at two to three days subsequent to the operation.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

<u>Guidelines for shaft and neck of 2nd to 5th metacarpal fractures</u>

Research backing the early mobilisation following the conservative and surgical management of second to fifth metacarpal shaft fractures is scarce. However, in a prospective study, Khan and Giddins (2015) included 30 individuals who were managed conservatively after having sustained closed single or multiple spiral metacarpal fractures with malrotation.[16] Management included no splint and gradual early mobilisation where a fist, as measured from the fingertips to the palm, had to be made up to two centimetres before discharge. Outcomes included no significant malrotation and good hand function. Gülke et al. (2018) agreed with early mobilisation following ORIF[15] in the case of a forearm-based dorsal splint, thus allowing the unaffected fingers the freedom to move but protecting the MCPJ in 70° flexion. Gamble (2015), following a retrospective study on 162 participants, who had sustained extra-articular, closed, with no significant rotational deformity, fifth metacarpal neck and shaft fractures, advocated self-care with the affected finger buddy-strapped to the fourth finger for one week.[17] (Buddy strapping allows for early active mobilisation with the finger supported.) Patient outcomes

measured with the EuroQol-five dimensions (EQ-5D) and Quick Disability of the Arm, Shoulder and Hand (QuickDASH) questionnaire showed no significant difference when the injured hand was compared to the non-injured hand (p=0.307 and p=0.820, respectively)[17]. The experts agreed with early active motion only for stable and rigid ORIF management of neck and shaft fractures, as is evident from the accepted Guidelines 17 and 18 below.

Clinical hand rehabilitation guideline: Recommendation 17		
Initiate immediate early motion after stable or rigid ORIF of metacarpal neck and shaft fractures to prevent the formation of adhesions.		
Class	**Level**	**Reference/Consensus**
I	B	Consensus Khan and Giddins (2015) Gülke et al. (2018)

Clinical hand rehabilitation guideline: Recommendation 18		
Subsequent to stable or rigid ORIF of metacarpal neck and shaft fractures, immediate early active range of motion exercises should start two to three days post-surgery.		
Class	**Level**	**Reference/Consensus**
I	B	Consensus Khan and Giddins (2015) Gülke et al. (2018)

<u>Shaft of 2nd to 5th metacarpal fractures after conservative management</u>

In an evidence-based pathway for shaft of second to fifth metacarpal fractures having been immobilised following conservative management, Midley and Toemen (2011) advocated for an immobilisation period of four weeks and then for continued protection of the fracture with night splinting for two more weeks, and for the splint to be discarded at six weeks.[18] Guideline

19 is presented below. It informs the splinting time period after second to fifth metacarpal shaft fractures following conservative management.

Clinical hand rehabilitation guideline: Recommendation 19		
The splinting time period: wearing the splint for four weeks, splint night use, and protection for another two weeks, splint being discarded after six weeks, after conservative management for a shaft of 2nd to 5th metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Midgley and Toemen (2011)

<u>Head of 2nd to 5th metacarpal fractures</u>

This section provides Guidelines 20 to 22 from the clinical hand rehabilitation guideline for clinical practice for individuals who sustained head of second to fifth metacarpal fractures.

Clinical hand rehabilitation guideline: Recommendation 20		
Subsequent to a head of a metacarpal fracture, the MCPJ position depends on the fracture pattern and the position of stability.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

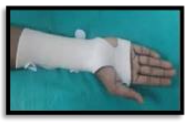
Clinical hand rehabilitation guideline: Recommendation 21		
The splint is used after conservative management of the head of 2nd to 5th metacarpal fractures. Hand-based dorsal hood gutter splint: affected and adjacent finger MCPJs in 70° flexion. Wrist: all IPJ (interphalangeal joints)'s and unaffected MCPJs free 		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Midgley and Toemen (2011)

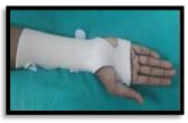
Clinical hand rehabilitation guideline: Recommendation 22		
The splinting time period: Discard splint at four weeks after conservative management of head of second to fifth metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Midgley and Toemen (2011)

Management of base of 2nd to 5th metacarpal fractures with stable ORIF

Guidelines 23 to 26 below relate to base of second to fifth metacarpal fractures managed with stable ORIF.

Clinical hand rehabilitation guideline: Recommendation 23		
The base of a metacarpal fracture managed with stable ORIF fixation requires active mobilisation (including an involved MCPJ) three to five days post-surgery		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 24		
Forearm-based wrist splint: 20° extension (wrist), MCPJ and IPJ free. Used after surgical fixation of base of 2nd to 5th metacarpal fractures. 		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Midgley and Toemen (2011)

Clinical hand rehabilitation guideline: Recommendation 25		
Forearm-based wrist splint at 20° extension (wrist), MCPJ and IPJ free. Used after conservative management of base of 2nd to 5th metacarpal fractures. 		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Midgley and Toemen (2011)

Clinical hand rehabilitation guideline: Recommendation 26		
The splinting time period of four weeks after conservative management for base of 2nd to 5th metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Midgley and Toemen (2011)

Management of neck of 5th (Boxer's) metacarpal fracture with stable ORIF

Keller et al. (2022), in a review,[19] identified 10 articles with the best evidence on immobilisation and splinting strategies for all types of second to fifth metacarpal fractures, with three of the 10 studies focusing on the neck of the fifth metacarpal fracture, called a Boxer's fracture.[20,21,22] Van Aaken et al. (2016), in a multicentre, RCT, included 68 individuals who had sustained Boxer's fractures with no rotational deformities and angulation ≤ 70° degrees.[20] The study compared a soft wrap and buddy strapping of the fourth and fifth fingers for three weeks after no reduction, with early active mobilisation, to reduction with forearm-based wrist immobilisation with plaster of paris for four weeks. The management of the soft wrap and buddy strapping group was as effective as the more prolonged immobilisation in a forearm wrist POP, and no complications were noted.[20] Guideline 27 below informed clinical practice in the case of an individual who sustained a neck of the fifth metacarpal fracture that was managed with stable ORIF.

Clinical hand rehabilitation guideline: Recommendation 27		
Neck of 5th (Boxer's) fractures are generally impacted and therefore stable. Splinting is just for comfort as the fractures are unlikely to be displaced.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Van Aaken et al. (2016) Kaynak et al. (2019)[23]

Management of neck of 2nd to 4th metacarpal fractures with stable ORIF

In their RCT, Gülke et al. (2018) managed individuals with neck of second to fourth metacarpal fractures with stable ORIF. Following the ORIF, the affected hand was placed in a functional forearm-based dorsal wrist splint (light cast) with the MCPJ at 70° flexion, and the PIP and DIP joints left free to move and be used for early allowed function.[15] After two weeks, the splint was removed. Guideline 28 was formulated after the experts agreed that providing that the fixation is stable, early mobilisation, including the affected MCPJ, should commence earlier than two weeks after surgery. Guideline 29 was formulated after the experts agreed that following a stable ORIF fixation, active mobilisation should commence earlier than two weeks and the affected MCPJ should be included.

Clinical hand rehabilitation guideline: Recommendation 28		
Provided that the fixation for the 2nd to 4th neck of metacarpal fractures is stable, early mobilisation should be commenced earlier than 2/52.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Clinical hand rehabilitation guideline: Recommendation 29		
2nd to 4th neck fractures managed surgically with a stable ORIF fixation require active mobilisation (including the involved MCPJ) earlier than two weeks post-surgery.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus

Management of neck of 2nd to 4th metacarpal fractures with conservative treatment or K-wires

When considering the treatment for second to fourth metacarpal neck fractures, a consensus was reached for three recommendations covering the splinting period of four weeks after percutaneous K-wires were inserted for fracture stability (Guideline 30). Experts further agreed that a hand-based dorsal gutter splint, where the affected fingers are included in the splint, should be used for conservative management. In the splint, the two MCPJs are placed in 70° flexion with the IPJs and the unaffected MCPJs left free for use and movement (Guideline 31). As shown in Guideline 32, the splinting time period agreed upon by the experts was four weeks, with protection and night splinting for an additional two weeks, after which the splint should be entirely removed at six weeks.

Clinical hand rehabilitation guideline: Recommendation 30		
2nd to 4th neck fractures managed surgically with percutaneous K-wires require a splinting time period of four weeks post-surgery.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Toemen and Midgley (2011)

Clinical hand rehabilitation guideline: Recommendation 31		
A hand-based dorsal gutter splint (affected and adjacent finger MCPJs in 70° flexion, all IPJs and unaffected MCPJs free) used after conservative management of the neck of 2nd to 4th metacarpal fractures. 		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Toemen and Midgley (2011)

Clinical hand rehabilitation guideline: Recommendation 32		
The splinting time period: The splint should be worn for four weeks, splint night use and splint protection for another two weeks, and be discarded at six weeks, after conservative management of 2nd to 4th neck metacarpal fractures.		
Class	**Level**	**Reference/Consensus**
I	C	Consensus Toemen and Midgley (2011)

Discussion

Management approaches for individuals who sustained second to fifth metacarpal fractures vary. This was confirmed by the eDelphi method, where experts demonstrated differences in their management approaches. The reasons for the different management approaches can be attributed to different mechanisms of injury, the nature of the fracture, the type of fracture, and additional soft tissue injuries unique to each individual. It is, therefore, essential that management approaches should be tailor-made to each individual. Thus, the orthopaedic surgeon, plastic surgeon, OT, and PT should allow their clinical reasoning to guide them in best managing each individual.

The clinical guideline which is now available as a result of the development of the clinical hand rehabilitation guideline presented in the current study can benefit and assist clinical practice, especially in resource-limited clinics and in countries, especially in South Africa, where this is the first-of-its-kind study and resources in especially public hospitals and clinics are scarce. Both financial, and skill resources are limited in South Africa where there is currently no specialisation in hand therapy. Community service OTs and PTs, with some, but not extensive training in hand therapy are often the only professionals to provide hand rehabilitation services in the public hospitals and clinics in South Africa. It is in these areas in particular where best evidence compiled and collated in a clinical hand rehabilitation guideline will prove to be highly

valuable as a guide rather than as a one-size-fits-all treatment map. The guideline should be a guide in management regarding, for example, decisions as to which type of splint or immobilisation would provide stability to a specific type of fracture and for how long the immobilisation would be required. With this information, the OTs and PTs can be confident in offering the best possible management to their patients. The time period indicated in the clinical hand rehabilitation guideline provides an estimate as to the length of the period over which the individual's hand should not be immobilised since extensive periods of immobilisation may cause joint stiffness. The guideline also provides for categories of return to ADLs and recommended points in time as to when to start the ADLs which would assist the orthopaedic surgeon, plastic surgeon, OTs and PTs in their management of the patient. The guideline is especially valuable where skilled healthcare professionals are lacking in public hospitals and clinics but where hand rehabilitation services for individuals who sustained second to fifth metacarpal fractures can still be offered.

The clinical hand rehabilitation guideline, presented as a three-phased development, predominantly includes international evidence obtained from the relevant literature. However, because South African participants were included in the feasibility and cross-sectional data collection studies, South African data in respect of hand force measurements could also be accessed. Also, because both international and national experts were included in the eDelphi method, a wealth of clinical experience could be sourced. Furthermore, the South African voice could also be exploited to contribute to a guideline specifically suited to the South African context, but which could also be easily adopted internationally.

The clinical hand rehabilitation guideline was developed by the researcher specifically for adults aged 20 to 59 years to ensure skeletal maturity has been reached and to avoid osteoarthritis symptoms. Although some recommendations may apply to a younger or older population who sustained second to fifth metacarpal fractures, the clinician should rely on a thorough

evaluation and his/her own sound clinical reasoning skills when deciding on the best management approaches as mentioned above taking into account their unique personal and environmental factors.

Limitations of the study include not testing the clinical hand rehabilitation guideline in a research study. A larger sample size, with equal representation of the genders, handedness, a variety of different occupations (especially labourers, presenting with different occupational demands), and age groups, would have been preferable. The guidelines might also be appropriate for an age group younger than 20 years, which should be noted as a limitation to the study. To generalise the results to a younger age group and an international population, would, however, require further research.

The most notable shift in the last decade has been in the management of individuals after having sustained a neck of the fifth metacarpal fracture. With this type of fracture being predominantly stable, they require minimal immobilisation, with early activity, but protected function in the form of buddy strapping. Stable ORIF also allows for the earlier active mobilisation of the affected MCPJ after approximately three days to prevent joint stiffness and tendon adhesions. Including grasp types in rehabilitation for individuals after second to fifth metacarpal fractures may ensure hand function, early return to function and occupation, and thus fewer days absent from work that would in turn benefit the employer and the employee.

Considerations for the reader

- A careful and thorough assessment should guide the appropriate management.
- Clinical reasoning by clinicians towards the best management of each patient who sustained second to fifth metacarpal fractures should always be the decisive guide to the most appropriate management.

- The clinician should consider associated injuries, for example, injuries to the blood vessels, nerves and tendons, as well as infections, and the fracture type.
- Where individuals have a diagnosis of comorbidities, such as diabetes mellitus type I, osteoporosis, and premorbid conditions, or lack understanding and adherence, the management strategies should be adapted accordingly.
- It is of paramount importance to take into account the fracture type and the associated injuries, as stated above, as well as the environmental and personal factors unique to each injured individual. (A person-centred approach is required.)
- How the clinician chooses to utilise the clinical hand rehabilitation guideline as a guiding treatment map is purely a matter of personal choice but should be based upon critical decision-making and the clinical availability of resources.

Conclusion

Following the identification of a paucity of guidelines and high-quality evidence, this manuscript presents a clinical hand rehabilitation guideline that can be used to inform clinical practice and rehabilitation of individuals who had sustained second to fifth metacarpal fractures. This was achieved by conducting two systematic reviews, a feasibility study, a cross-sectional study and an eDelphi method with the content verified by experts. It should be noted, however, that clinical reasoning skills should ultimately guide clinical decision-making in the presence of specific personal and environmental factors. The guidelines presented different aspects in a single guideline document which may guide orthopaedic surgeons, plastic surgeons, OTs and PTs while using their clinical reasoning, to decide on the best management approach which is currently lacking in South Africa, where no specialisation in hand rehabilitation exists.

Conflicting interests

The authors, MK, RB, and CB declare no competing interests. The experts also had no competing interests.

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Informed consent

Online informed consent was obtained from the participating experts.

Ethical approval

This research has been approved by the Health Science Research Ethics Committee of the University of the Free State.

Guarantor

MK

Contributions

MK proposed the topic of this research study and wrote the protocol for ethical approval and the first version of the article. The protocol and article were read, elaborated upon, and refined with the help of RB and CB.

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Data accessibility

Any request for data pertaining to this research can be obtained by sending an email request to the corresponding author.

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7.5 Summary

The clinical hand rehabilitation guideline was not implemented for individuals who sustained second to fifth metacarpal fractures and should be noted as a limitation of the study. Future research should be directed towards determining the feasibility of the clinical rehabilitation guideline and its impact, and the lived experiences of these individuals. Chapter 7 presented the clinical hand rehabilitation guideline for patients in South Africa who sustained second to fifth metacarpal fractures. Chapter 8 presents he conclusion to this research, where the limitations of the research, as well as the recommendations for future research, clinical practice and policy are included.

Chapter 8

Limitations, recommendations and conclusion

8.1 Introduction

This thesis aimed to develop a clinical hand rehabilitation guideline for adults between the ages of 20 and 59 years who had sustained second to fifth metacarpal fractures and were being managed conservatively or surgically. The need to develop a clinical guideline stemmed from the lack of guidelines identified by the researcher for guiding clinical practice to ensure the safest early return to work, optimal hand function, and quality of life following metacarpal fractures. The researcher undertook and completed three research phases to achieve the aim. The conclusions that stemmed from the current thesis are summarised in this chapter according to the objectives for each phase and are presented under the headings of the two relevant articles. In addition, the limitations, challenges, and recommendations pertaining to the study are presented. The recommendations are divided into clinical and research recommendations. Teaching recommendations for undergraduate and postgraduate levels follow. The implementation of the clinical hand rehabilitation guideline for individuals who sustained second to fifth metacarpal fractures is also alluded to.

8.2 Limitations and challenges

- The Covid-19 pandemic posed a challenge to obtaining ethical clearance for this research study and to making the collection of data possible. An application for permission for ethical clearance for Phase II was met with success before the Covid-19 pandemic, but data collection was put on hold, with Gauteng being one of the provinces in South Africa mainly affected by the pandemic and presenting with increased numbers of Covid-19 infections. After a six-month abeyance period, the researcher amended the protocol by adding Covid-19 precautions to ensure a safe data collection process.

- The force sensing resistors (FSRs) caused further challenges. The glue with which the sensors were attached to the glove was not strong enough, and the sensors tended to bend and break, with the FSRs having to be replaced on numerous occasions. This led to financial challenges which were not anticipated or budgeted for by the researcher. The researcher and the research assistant/Covid-19 marshal, supported by the technical assistance of an engineering technologist, ensured the successful calibration of the instruments and consistency in testing, with the whole process taking longer than anticipated, but enhancing the reliability and validity of the results.
- The researcher acknowledges that although the DASH questionnaire remains a comprehensive measurement tool for the physical assessment of the upper limb's function and symptoms, the DASH is biased towards the dominant hand. The DASH may therefore not highlight the functional implications when the injury is on the non-dominant hand.
- The first stage of data collection in Phase II was performed on six participants who performed 105 activities, which, as a result of the running repairs to the sensors, as mentioned earlier, and the participants having to spend four to five hours over two days completing the tasks required during the testing, took longer than anticipated. This led to a small sample size in the first stage of data collection in Phase II which may affect the generalisability of the study results. An ideal sample size for Stage 1 of Phase II would have been between 30 to 50 participants. However, it was not feasible to include a larger sample size for the 105 tasks used in the testing owing to the technical issues, and the time taken per participant to complete all of the tasks, which took two days. As such, only six participants were tested. The above-mentioned reasons influenced the feasibility of the study, which was not economically justifiable. The researcher adjusted the second part of the data collection process of Phase II to include a larger sample size, which included 32 participants. The value of including a larger sample size was that it was possible then to determine the associations between the genders and the grasp types which would influence hand rehabilitation in the future.

- When considering the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument, a minority of criteria could not be ticked off on the checklist because this research study did not implement the clinical hand rehabilitation guideline for patients. Resource implications, including cost implications, economic evaluations, and the auditing of the criteria, were not objectives of the research.

8.3 Clinical recommendation

The clinical hand rehabilitation guideline directly emanating from this research study is now presented in Table 8.1 below.

Table 8.1: Clinical hand rehabilitation guideline statements during the research phase informing the clinical hand guideline development

Time period and types of light, moderate, heavy activities of daily living (ADL) tasks and the return to ADL tasks	**Phase and Explanation**
1. The time period of two weeks for the commencement of light tasks/activities/functions after 2nd to 5th metacarpal fractures.	Phase I informed first eDelphi method round regarding the time period for the commencement of activities/function, Phase II informed the light tasks and Phase III informed and confirmed the time period for the commencement of activities/functions
2. The types of light tasks/activities/functions in the rehabilitation programme after 2nd to 5th metacarpal fractures: respect of pain 3/10:	Phase II informed the types of light tasks and Phase III confirmed the types of light tasks and the amount of pain

Personal care and hygiene tasks: Acceptable, but no wringing with force of water out of a washcloth/facecloth, no carrying of buckets (weight > 1kg) or sink basins, no wringing of water out of clothes. Take care with putting on socks and opening and closing a belt buckle. *Home environment*: Interior tasks allowed but no opening of new or tight jar lids or stirring of mealie pap/heavy porridge. No picking up of children, no moving of furniture, no turning of a salt or pepper grinder. No gardening allowed. No driving.	experienced should be less than 3/10 when tasks are performed.
3. The time period of four weeks for the commencement of medium/moderate tasks/activities/functions after 2nd to 5th metacarpal fractures.	Phase I informed the first eDelphi method round regarding the time period for the commencement of medium/moderate activities/function, Phase II informed the medium tasks and Phase III informed and confirmed the time period for the commencement of activities /function.
4. The types of medium/moderate tasks/activities/functions in the rehabilitation programme after 2nd to 5th metacarpal fractures: Start driving in the case of a metacarpal fracture of the ring or index finger. Pick up weights of < 2kg.	Phase II informed the types of medium/moderate tasks and Phase III confirmed the types of medium/moderate tasks.
5. The time period of six weeks for the commencement of heavy tasks/activities/functions after 2nd to 5th metacarpal fractures.	Phase I informed the first eDelphi method round regarding the time period for the commencement of heavy tasks/functions, Phase II

	informed the heavy tasks and Phase III informed and confirmed the time period for the commencement of activities /function.
6. The types of heavy tasks/activities/functions in the rehabilitation programme after 2nd to 5th metacarpal fractures: For all metacarpal fractures, start driving. Do not hang on the overhead rail or hand support in a car or taxi. Pick up weights of < 5kg.	Phase II informed the types of heavy tasks and Phase III confirmed the types of heavy tasks.
7. The time period of eight to 10 weeks for commencement of pre-injury tasks/activities/functions after 2nd to 5th metacarpal fractures.	Phase I informed the first eDelphi method round regarding the time period for commencement of pre-injured tasks, Phase II informed and Phase III informed and confirmed the time period for the commencement of activities /function.
Rehabilitation guideline recommendations	
8. Splint types should be clinically reasoned and individualised for each patient.	Phase I informed the type of splint for each different 2nd to 5th metacarpal fracture type, which will be indicated below where agreement was reached in Phase III. Phase III, was informed by the experts' clinical reasoning in the open-ended responses regarding splint types.

9. The splint time period should be clinically reasoned according to the fracture pattern and individualised for each patient.	Phase I informed the splinting time period for each different 2nd to 5th metacarpal fracture type, which will be indicated below where agreement was reached in Phase III through experts' clinical reasoning in the open-ended responses regarding splinting time periods.
10. Splinting types for 2nd to 5th metacarpal fractures managed with percutaneous K-wires should be considered and moulded to respect the K-wire placement.	Phase III through experts' clinical reasoning in the open-ended responses regarding splinting types for 2nd to 5th metacarpal fractures managed with percutaneous K-wires.
11. Fractures managed with percutaneous K-wires should be splinted for the period when the K-wire is *in situ*.	Phase I informed the splinting period after surgical management and Phase III through experts' clinical reasoning in the open-ended responses confirmed that fractures managed with percutaneous K-wires should be splinted for the period when the K-wire is *in situ*.
12. Passive stretching of affected joints after conservative management can commence at the 6/52 time period.	Phase I informed the passive stretching of affected joints' commencement and Phase III confirmed it.
Guideline for grasp-type exercises	

13. The incorporation of grasp types in respect of the hand is valuable in rehabilitation in that grasp types promote hand function.	Phase II informed the grasp types and Phase III informed the final inclusion of the guideline statement number 13 after agreement.
14. Careful use of grasp types in the rehabilitation of 2nd to 5th metacarpal fractures after conservative management can improve hand function.	Phase II informed the grasp types and Phase III informed the final inclusion guideline statement number 14 after agreement.
15. Careful use of grasp types in the rehabilitation of 2nd to 5th metacarpal fractures after percutaneous K-wire management can improve hand function.	Phase II informed the grasp types and Phase III informed the final inclusion guideline statement number 15 after agreement.
16. Use of grasp types in the rehabilitation of the affected metacarpophalangeal joints (MCPJs) of 2nd to 5thmetacarpal fractures after stable Open Reduction and Internal Fixation (ORIF). Management can start at two to three days subsequent to the operation.	Grasp types in informed by Phase II. Phase III, informed by the experts' clinical reasoning in the rounds and in the open-ended responses.
Guideline for shaft and neck of 2nd to 5th metacarpal fractures	
17. Initiate immediate early motion after stable or rigid ORIF of metacarpal neck and shaft fractures to prevent the formation of adhesions.	Phase I informed the initial time period of commencement of mobilisation and experts agreed in Phase III. The guideline statement number 17 was informed by the experts' clinical reasoning in the open-ended responses in Phase III.

18. Subsequent to stable or rigid ORIF of metacarpal neck and shaft fractures, immediate early active range of motion exercises should start two to three days post-surgery.	Phase I informed the initial time period of commencement of immediate early range of motion exercises for neck and shaft 2nd to 5th metacarpal fractures, further informed by the experts' clinical reasoning in the open-ended responses in Phase III.
Shaft of 2nd to 5th metacarpal fractures after conservative management	
19. The splinting time period: wearing the splint for four weeks, splint night use, and protection for another two weeks, splint being discarded after six weeks, after conservative management for a shaft of 2nd to 5th metacarpal fractures.	Phase I informed the splinting time period for shaft of 2nd to 5th metacarpal fractures after conservative management. In Phase III agreement as per guideline statement number 19 was reached by the experts through the rounds and incorporating experts' clinical reasoning in the open-ended responses.
Head of 2nd to 5th metacarpal fractures	
20. Subsequent to a head of a metacarpal fracture, the MCPJ position depends on the fracture pattern and the position of stability.	Phase I informed the MCPJ position following a head of 2nd to 5th metacarpal fracture. In Phase III agreement as per guideline statement number 20 was reached by the experts through the rounds and incorporating experts' clinical reasoning in the open-ended responses.

21. The splint is used after conservative management of the head of 2nd to 5th metacarpal fractures. Hand-based dorsal hood gutter splint: affected and adjacent finger MCPJs in 70° flexion. Wrist: all interphalangeal joint/s (IPJ)s and unaffected MCPJs free	Phase I informed the type of splint used after head of 2nd to 5th metacarpal fracture type, which will be indicated below where agreement was reached in Phase III. Phase III, informed by the experts' clinical reasoning in the open-ended responses.
22. The splinting time period: Discard splint at four weeks, after conservative management of head of 2nd to 5th metacarpal fractures.	Phase I informed the splinting time period for head of 2nd to 5th metacarpal fractures after conservative management. In Phase III agreement as per guideline statement number 22 was reached by the experts through the rounds and incorporating experts' clinical reasoning in the open-ended responses.
Management of base of 2nd to 5th metacarpal fractures with stable ORIF	
23. The base of a metacarpal fracture managed with stable ORIF fixation requires active mobilisation (including an involved MCPJ) three to five days after surgery.	Phase I informed the time period when active mobilisation commencements, further informed by the experts' in the eDelphi method rounds and their clinical reasoning in the open-ended responses in Phase III resulted in the guideline statement number 23.

24. Forearm-based wrist splint: 20° extension (wrist), MCPJ and IPJ free. Used after surgical fixation of base of 2nd to 5th metacarpal fractures.	Phase I informed the type of splint used after surgical fixation of a base of 2nd to 5th metacarpal fracture type. Phase III, informed by the experts' clinical reasoning in the open-ended responses. Agreement was reached in Phase III as per guideline statement number 24.
25. Forearm-based wrist splint at 20° extension (wrist), MCPJ and IPJ free. Used after conservative management of base of 2nd to 5th metacarpal fractures.	Phase I informed the type of splint used after conservative management of a base of 2nd to 5th metacarpal fracture type. Phase III, informed by the experts' clinical reasoning in the open-ended responses. Agreement was reached in Phase III as per guideline statement number 25.
26. The splinting time period of four weeks after conservative management for base of 2nd to 5th metacarpal fractures.	Phase I informed the splinting time period for base of 2nd to 5th metacarpal fractures after conservative management. In Phase III agreement was reached, resulting in guideline statement number 26, by the experts through the rounds. The experts' clinical reasoning in the open-ended responses was incorporated in the eDelphi method rounds.
Management of neck of 5th (Boxer's) metacarpal fracture with stable ORIF	

27. Neck of 5th (Boxer's) fractures are generally impacted and therefore stable. Splinting is just for comfort as the fractures are unlikely to be displaced.	Phase I informed the immobilisation and or splinting type for neck of 5th (Boxer's) metacarpal fractures after a stable ORIF. In Phase III agreement was reached, resulting in guideline statement number 27, by the experts through the rounds. The experts' clinical reasoning in the open-ended responses was incorporated in the eDelphi method rounds.
Management of neck of 2nd to 4th metacarpal fractures with stable ORIF	
28. Provided that the fixation for the2nd to 4th neck of metacarpal fractures is stable, early mobilisation should be commenced earlier than 2/52.	Phase I informed the initial time period of commencement of early mobilisation for stable neck of 2nd to 4th metacarpal fractures, further informed by the experts' clinical reasoning in the open-ended responses in Phase III, with the result being guideline statement number 28
29. 2nd to 4th neck fractures managed surgically with a stable ORIF fixation require active mobilisation (including the involved MCPJ) earlier than two weeks.	Phase I informed the initial time period of commencement of early mobilisation (including the involved MCPJ) following surgical management with ORIF for stable neck of 2nd to 4th metacarpal fractures. In Phase III agreement was reached, resulting in the guideline statement number 29, by

	the experts through the rounds. The experts' clinical reasoning in the open-ended responses was incorporated in the eDelphi method rounds.
Management of neck of 2nd to 4th metacarpal fractures with conservative treatment or K-wires	
30. 2nd to 4th neck fractures managed surgically with percutaneous K-wires require a splinting time period of four weeks.	Phase I informed the splinting time period for neck of 2nd to 4th metacarpal fractures after surgical management. Phase III further informed and confirmed guideline statement number 30 with the help of the experts' clinical reasoning in the open-ended responses.
31. A hand-based dorsal gutter splint (affected and adjacent finger MCPJs in 70° flexion, all IPJs and unaffected MCPJs free) used after conservative management of the neck of 2nd to 4th metacarpal fractures.	Phase I informed the splinting type for neck of 2nd to 4th metacarpal fractures after conservative management. In Phase III agreement was reached, resulting in the guideline statement number 31, by the experts through the rounds. The experts' clinical reasoning in the open-ended responses was incorporated in the eDelphi method rounds.
32. The splinting time period: The splint should be worn for four weeks, splint night use and splint protection for another two weeks, and be discarded	Phase I informed the time period of the splinting for neck of 2nd to 4th metacarpal fractures after conservative management. In Phase III

at six weeks, after conservative management of 2nd to 4th neck metacarpal fractures.	agreement was reached, resulting in the guideline statement number 32, by the experts through the rounds. The experts' clinical reasoning in the open-ended responses was incorporated in the eDelphi method rounds.

The recommendation for using the clinical hand rehabilitation guideline is directed at healthcare practitioners such as physiotherapists (PTs), occupational therapists (OTs), orthopaedic surgeons, rheumatologists, primary care and family medicine physicians, medical associates, and medical officers in the private and public sectors in South Africa. This guideline is particularly relevant during the decision-making process and in the management of individuals who sustained second to fifth metacarpal fractures.

Standardised assessments by healthcare practitioners should be used according to the timeline of healing, where assessments for pain, hand function, range of motion (ROM), and sensation precede those of grip strength, the last-mentioned assessed from only six weeks, with the purpose of promoting fracture healing. The Disability of the Arm, Shoulder and Hand (DASH) questionnaire, a standardised hand function assessment, is an ideal instrument for assessing the activity limiting International Classification of Functioning, Disability and Health (ICF) domain to identify the present, absent or fully utilised grasp types. It is the healthcare practitioners with a specific interest in hand injuries that use the DASH questionnaire to assess hand functions in individuals who sustained second to fifth metacarpal fractures at a stage where active movement and basic and instrumental daily activities can be performed. This can be done by requesting the individual to demonstrate the tasks that the DASH questionnaire explores.

The developed clinical hand rehabilitation guideline should be implemented by healthcare practitioners in private practice and also by those working in the public sector (e.g., in the hand unit itself, in a practice, or in the department of a government hospital). Providing a home rehabilitation programme to an individual who has sustained a hand fracture is imperative if successful outcomes for satisfactory hand functioning and an early and safe return to work are to be achieved. Apart from implementing the clinical hand rehabilitation guideline during consultation sessions at a hospital, the option should also be made available to an individual who sustained a second to fifth metacarpal fracture through telehealth consultations over the phone or via a video call, especially in cases where the individual is unable to attend a consultation because of, for instance, a positive Covid-19 infection or transport challenges. Implementing the clinical hand rehabilitation guideline as a HE programme may have potential cost-saving implications for government institutions, medical funders, and the individual (e.g., travel costs) The distribution of hospital resources can then be directed towards trauma and emergency needs, and the conservation of resources. Telehealth programmes may be unattainable for those individuals who do not have access to smartphones, laptops, or data, but for those who have access to these resources and who are visual leaners, the healthcare practitioner can forward videos of grasp types or make a video call to make sure that the individual understands the exercise programme and executes it correctly. Videos developed by the researcher on the different grasp types can be accessed at:

https://youtu.be/sVsyUDDqMeo

https://youtu.be/LGavsqXfF08

https://youtu.be/Cb0iCHvL6nA

https://youtu.be/3153nSBxK0A

Recommendations in respect of the use of the clinical hand rehabilitation guideline now follow. During hospital consultations by the OT, PT, or a medical doctor, all relevant information about the clinical hand rehabilitation guideline should be timeously provided to the individual who

sustained a hand fracture and in a format that best suits his/her available resources. A handout leaflet, a video recording on smart phone, or a podcast in the language of choice of the injured individual, or other methods, as mentioned previously, can be provided to foster optimal learning. Translations into the language of the injured individuals, potentially the 11 official languages spoken in South Africa would need to be organised by the healthcare practitioners. These would require financial and technical resources, including a strong, stable internet signal, Wi-Fi, and accessibility to devices, all of which are not always available in the South African context, especially not in the public community sectors, and with the rising costs of living challenging the private sector. A patient tick list alongside the exercises, with open-ended sections to write all noteworthy progress, concerns, or any questions, should accompany the handouts. A training diary may not be completed by all, but the use of technology in HE programmes may assist in improving compliance to exercise adherence.

The researcher of this study wrote an article for the American Society of Hand Therapists, Addendum KII, entitled, *Hand assessment after second to fifth metacarpal fractures: ICF framework and taxomony of human hand grasps*. The goal of the article was to promote awareness as to the use of the ICF and grasp taxonomy in the assessment of injured individuals, the aim being to optimise hand function and return to pre-injury functioning. It is to be recommended for clinical use.

8.4 Research recommendations

The recommendation following the study is to test the implementation, feasibility, and impact of the clinical hand rehabilitation guideline in future national and international studies. Consideration should be given to a matched participant design where only certain hospitals and clinics are recruited for the implementation of the clinical hand rehabilitation guideline. Participant outcomes at each hospital and clinic should then be compared. It is further recommended that future research should include an economic evaluation in terms of medical,

direct, indirect and “loss of productivity” costs. An evaluation of the guideline would create a significant impact and potentially cause the clinical hand rehabilitation guideline to be adopted, both nationally and internationally. In instances where a reduction in medical costs and a reduced financial burden at the individual and employer level could be proved, the likelihood of widespread adoption might prove to be considerable.

It is also recommended that the FSR testing of 105 activities be conducted with a larger sample size in order to collect force data, such that statistical tests can be used to draw inferences that can be compared to the results obtained in the first stage of Phase II. Another recommendation for future research would be to conduct studies that produce high-level evidence on individuals who underwent conservative and surgical management after having sustained second to fifth metacarpal fractures. The recommended research should include all types of second to fifth metacarpal areas and intra- and extra-articular fractures. These should be approached in conjunction with the use of clearly specified hand rehabilitation programmes, exercises, grasp-type exercises, HE programmes, frequency, intensity, type and time (FITT) principles, clearly defined outcome measures, standardised assessments, clearly defined splint and immobilisation approaches, and timeframes. A final recommendation is to update the clinical hand rehabilitation guideline that stemmed from this research.

The researcher recommends that future research should also validate force sensor testing as an instrument to be used in the assessment of occupational readiness following a hand injury, and as a future study area, also including thumb metacarpal fractures and the measurement of thumb forces with FSRs. Although the forces of the thumb were not taken into consideration in the categorisation of the ADL tasks in this study, light, moderate, and heavy force categories should employ the same method for categorisation as was used in the current study.

It is also recommended that the clinical hand rehabilitation guideline should be reviewed and updated by those researchers undertaking further studies beyond the implementation studies. Special consideration should be given to the inclusion of patient education, education and guidance in terms of oedema and soft tissue management, as well as laterality, as part of a graded motor imagery. The additions to the clinical hand rehabilitation guideline will indeed contribute to a holistic rehabilitation guideline which will benefit individuals who sustained second to fifth metacarpal fractures.

8.5 Policy recommendation

Owing to the imbalance in resource delivery in the healthcare sector in South Africa, healthcare practitioners will have to advocate for affordable and accessible hand rehabilitation services/therapies and the implementation of the clinical hand rehabilitation guideline, which should be improved through future research and disseminated, with the potential of being implemented into the anticipated National Health Insurance (NHI). The NHI proposal is aimed at fostering change with regard to the following concerns in public healthcare: the safety and security of staff and patients, improved cleanliness standards, more effective infection control, more progressive attitudes to be engendered in the staff, and remedial action to be taken to counter the lengthy waiting periods and the shortage of drug stock (NHI, 2011). The NHI was first mentioned in 2011. Because of the violence and prevalence of trauma in South Africa, and the fact that hand injury is one of the four disease burdens that the government wishes to address, the management of second to fifth metacarpal fractures needs to be prioritised in the proposed NHI (Coovadia et al, 2009). With the potential of hand rehabilitation services/therapies being implemented in the anticipated NHI, the affordability of and accessibility to them would thus be improved. It is recommended that stakeholders, namely, the government hospitals, medical funders, and the upcoming NHI, be guided in the future by the ICF framework and the clinical hand rehabilitation guideline.

8.6 Conclusion

The theoretical framework of the study, namely, motor learning with a positivist ontology, underpinned the three research phases undertaken to achieve the aim of this research study. The aim of developing a clinical hand rehabilitation guideline for individuals aged between 20 and 59 years who sustain a single or multiple second to fifth metacarpal fractures was successfully achieved. The three phases of the research assisted with the development of the guideline in the following manner:

Phase I, two peer-reviewed published systematic reviews of the available evidence using the PRISMA principles, with an open-access protocol, provided a solid base for objectivity in attaining the aim.

In Phase II, the variables in this research question included hand forces measured with FSRs, hand grip strength measured with a dynamometer, and demographic variables, namely, age and gender. The methods involved a quantitative study design, where a sample population of healthy adults was recruited. Their hand forces and hand grip strengths that were measured using FSRs and a grip strength dynamometer, ensured that the scientific results were reliable. Unbiased statistical analyses were run with the assistance of a biostatistician to ensure accuracy in the interpretation of the results. No existing research could be found on the predominant grasp types identified from basic and instrumental ADLs with FSR finger and grasp forces to inform rehabilitation for individuals sustaining second to fifth metacarpal fractures in South Africa, or, as far as the researcher is aware, internationally. The scientifically backed data obtained from Phase II ensured a quantifiable, reliable, reproducible, unbiased clinical hand rehabilitation guideline, backed by motor learning principles.

During Phase III, the researcher ensured unbiased data collection through an eDelphi method, whereby consensus was reached by applying the recommendations proposed by CREDES

(Conducting and Reporting of DElphi Studies (CREDES) recommendations. Experts in the field of hand injury and rehabilitation consented to participate in three eDelphi rounds where they could confidentially share their perspectives in open-ended responses. Figure 8.1 below illustrates how the three research phases informed the clinical hand rehabilitation guideline.

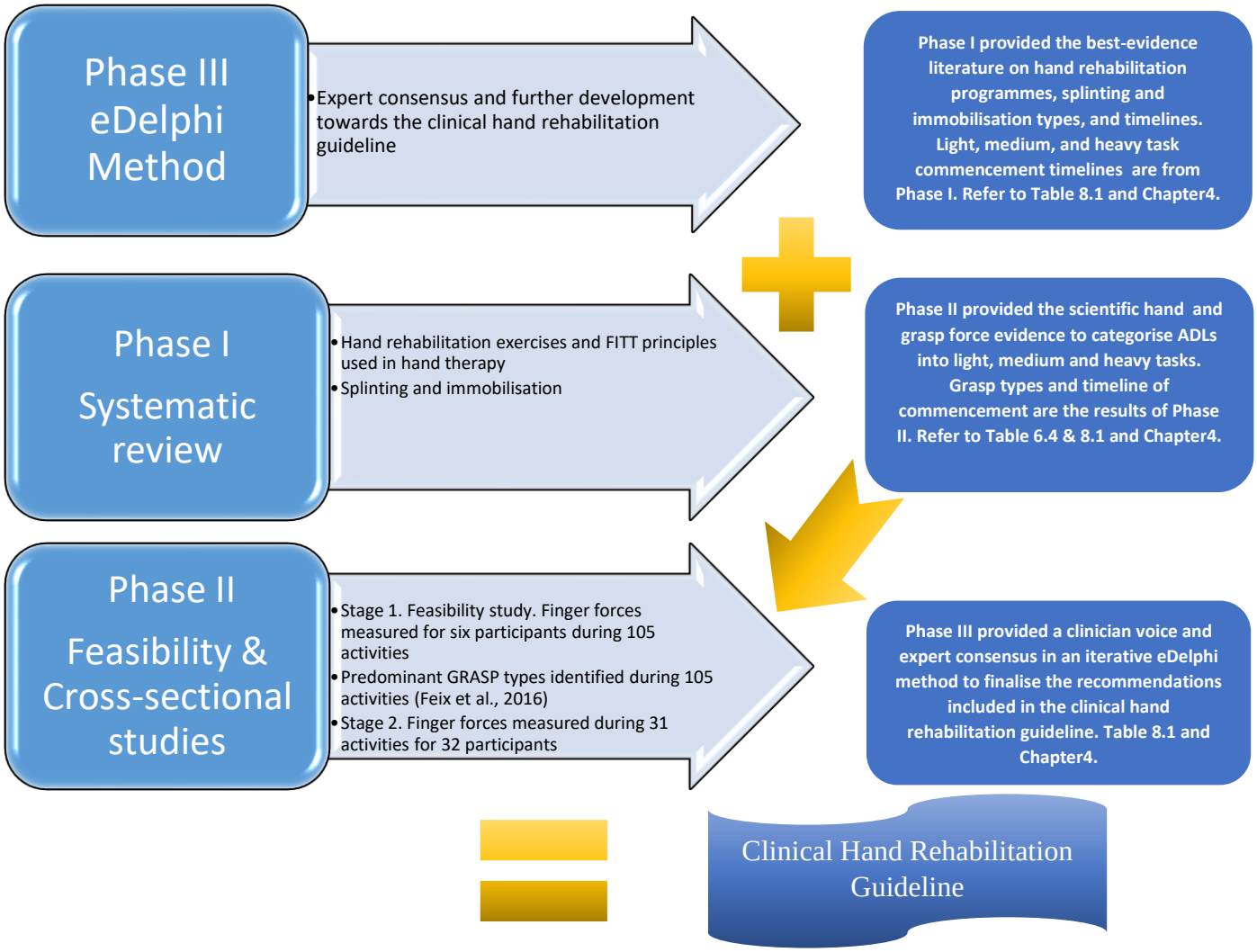

Figure 8.1: Three research phases informing the clinical hand rehabilitation guideline

The final clinical hand rehabilitation guideline was developed using the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument, which provides another layer of transparency and accuracy in reporting. Using the AGREE II instrument provides for the selection of recommendations in the guideline by looking at the quality.

The problem statement, objectives, methodology selection and using instruments such as the PRISMA, FSRs, CREDES and AGREE II, indicates a positivist ontology for achieving the aim of the research study. The motor learning principles in Section 2.14 and the recommendations of how the guideline may be implemented clinically in Section 9.3 demonstrate how the aim was achieved.

In conclusion, it should be realised that the incorporation of the clinical guideline in hand rehabilitation, backed by rigorous development strategies such as the AGREE II instrument, is imperative for ensuring optimal return to pre-injury functioning, where the hand is used with optimal ROM, strength, and no pain. Early return to work ensures that the financial implications to the person sustaining a second to fifth metacarpal fracture and his/her employer would be limited. Although still to be tested in future research, the clinical hand rehabilitation guideline developed in this study is a valuable tool to ensure that all domains of the ICF relating to quality of health are attained.

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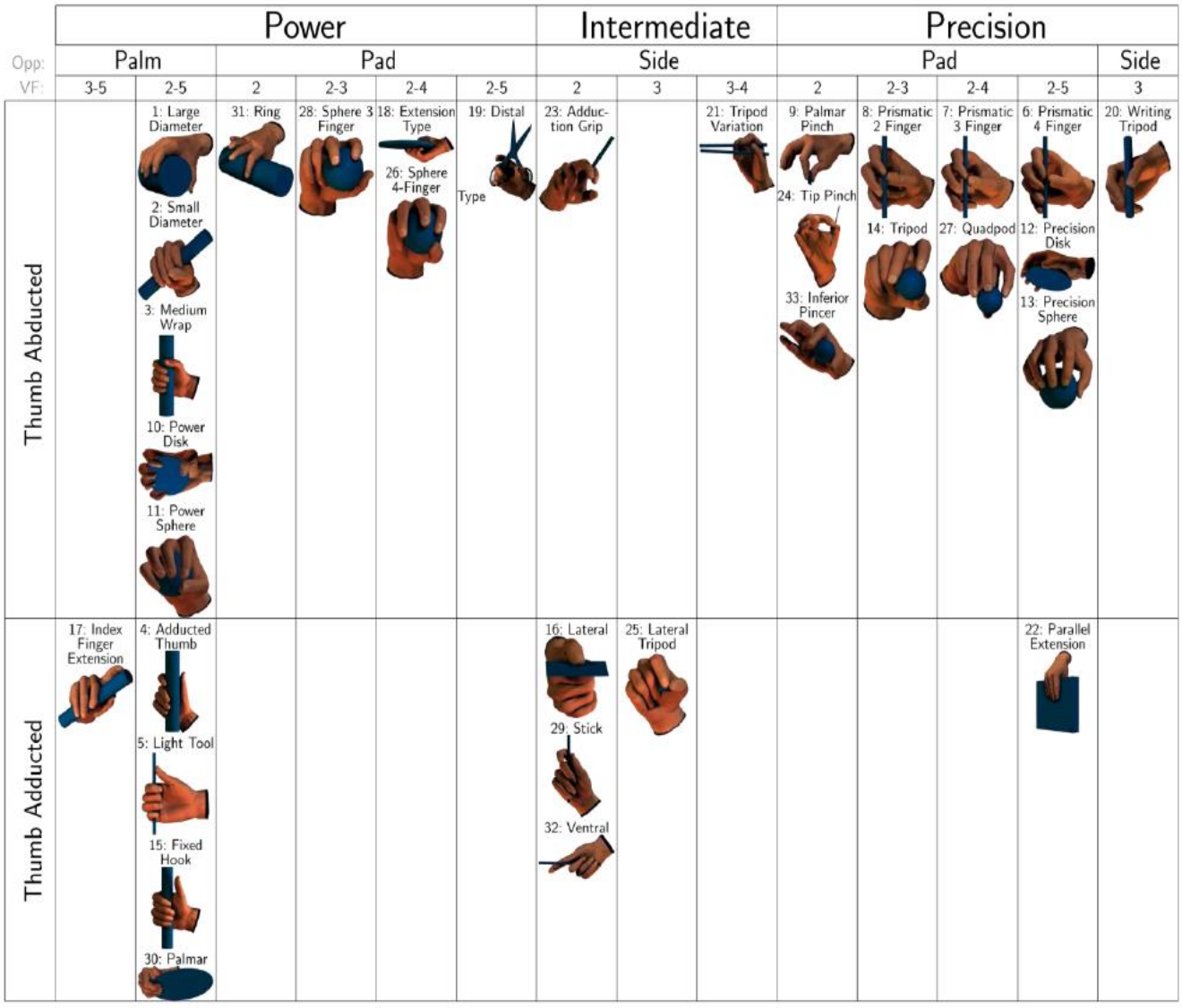
Addenda

Addendum A

The GRASP taxonomy



Addendum B

Test sheet with predominant grasp types and results

	Functional Task	Predominant type of Grasp used (predominantly)	Light Forces (0-3 N) (Tick if appropriate)	Moderate Forces (3-7 N) (Tick if appropriate)	Heavy/ High demand Forces (7-20 N) (Tick if appropriate)
1	Washing body with washcloth	25. Lateral tripod	**X**		
2	Washing hair	13. Precision Sphere	**X**		
3	Squeezing water out of a sponge	11. Power Sphere	**X**		
4	Wringing water out of a washcloth/ facecloth	2. Small Diameter		**X**	
5	Opening and closing a tap (small round shape)	14. Tripod	**X**		
6	Opening and closing a tap small (cylindrical shape)	7. Prismatic 3 Finger	**X**		
7	Opening and closing a tap (large round shape)	27. Quadpod	**X**		
8	Opening and closing a tap (large	11. Power Sphere	**X**		

	cylindrical shape)				
9	Carrying a bucket containing three litres of water	2. Small Diameter		**X**	
10	Carrying a zinc basin containing three litres of water	15. Fixed Hook		**X**	
11	Drying your body with a towel	25. Lateral tripod	**X**		
12	Drying hair with a hairdryer	3. Medium Wrap	**X**		
13	Drying hair with a towel	25. Lateral tripod	**X**		
14	Brushing hair	2. Small Diameter	**X**		
15	Tying up hair with an elastic	27. Quadpod	**X**		
16	Putting on base make up	8. Prismatic 2 Fingers	**X**		
17	Appling mascara on the eyelashes	8. Prismatic 2 Fingers	**X**		
18	Washing clothes using hands and soap	25. Lateral tripod	**X**		
19	Hanging washing up on the washing line	8. Prismatic 2 Fingers	**X**		

20	Using pegs to secure clothes on the washing line	9. Palmar Pinch		**X**	
21	Dry water out of clothes by hand	3. Medium Wrap	**X**		
22	Brushing teeth with a toothbrush	6.Prismatic 4 Fingers	**X**		
23	Squeezing toothpaste out of a tube ML	8. Prismatic 2 Fingers	**X**		
24	Dressing	7. Prismatic 3 Fingers	**X**		
25	Putting t-shirt on	7. Prismatic 3 Fingers	**X**		
26	Taking t-shirt off	7. Prismatic 3 Fingers	**X**		
27	Undoing buttons on a long sleeved shirt	7. Prismatic 3 Fingers	**X**		
28	Doing up buttons on a long sleeved shirt	7. Prismatic 3 Fingers	**X**		
29	Putting tie on	7. Prismatic 3 Fingers	**X**		
30	Trousers on	8. Prismatic 2 Fingers	**X**		
31	Trousers off	6.Prismatic 4 Fingers	**X**		
32	Zipping of trousers up	8. Prismatic 2 Fingers	**X**		

33	Zipping of trousers down	8. Prismatic 2 Fingers	**X**		
34	Putting socks on	7. Prismatic 3 Fingers		**X**	
35	Taking socks off	7. Prismatic 3 Fingers	**X**		
36	Putting shoes on	7. Prismatic 3 Fingers	**X**		
37	Taking shoes off	7. Prismatic 3 Fingers	**X**		
38	Tying laces	8. Prismatic 2 Fingers	**X**		
39	Putting belt on	8. Prismatic 2 Fingers	**X**		
40	Buckling a belt	7. Prismatic 3 Fingers		**X**	
	Functional Task	**Type of Grasp or Pinch used (predominantly)**	**Light Forces (0-3 N)**	**Moderate Forces (3-7 N)**	**Heavy/ High demand Forces (7-20 N)**
41	Closing car door	15. Fixed hook	**X**		
42	Turning the key to start the car	16. Lateral	**X**		
43	Turning the steering wheel	15. Fixed hook		**X**	
44	Shifting the gears (Manual)	26. Sphere 4 Fingers	**X**		

45	Opening a door knob (circular)	26. Sphere 4 Fingers		**X**	
46	Opening a door (long horisontal handle)	4. Adducted Thumb		**X**	
47	Holding onto a rail in a taxi	4. Adducted Thumb			**X**
48	Closing a taxi door	4. Adducted Thumb	**X**		
	Functional Task	**Type of Grasp or Pinch used (predominantly)**	**Light Forces (0-3 N)**	**Moderate Forces (3-7 N)**	**Heavy/ High demand Forces (7-20 N)**
49	Making a bed	25. Lateral Tripod	**X**		
50	Carrying a shopping bag	15. Fixed Hook	**X**		
51	Mopping	2. Small Diameter	**X**		
52	Dusting	5.Light Tool	**X**		
53	Sweeping floors with a broom	2. Small Diameter	**X**		
54	Vacuum cleaning	3. Medium Wrap	**X**		
55	Washing dishes	30. Palmar	**X**		
56	Drying dishes	30. Palmar	**X**		

57	Packing dishes away	22. Parallel Extension	**X**		
58	Ironing	3. Medium Wrap	**X**		
59	Eating with hands	14. Tripod	**X**		
60	Holding a pint glass	15. Fixed Hook	**X**		
61	Open a tight or new jar	26. Sphere 4 Fingers/12. Precision Disk		**X**	
62	Eating using utensils	17. Index Finger Extension	**X**		
63	Opening a heavy door	2. Small Diameter	**X**		
64	Lifting a box (1kg) onto counter	4. Adducted Thumb	**X**		
65	Lifting a box (2kg) onto counter	4. Adducted Thumb	**X**		
66	Lifting a box (3kg) onto counter	4. Adducted Thumb	**X**		
67	Lifting a box (4kg) onto counter	4. Adducted Thumb	**X**		
68	Lifting a box (5kg) onto counter	4. Adducted Thumb	**X**		
69	Lifting a box (10kg) onto counter	4. Adducted Thumb		**X**	
70	Lifting a box (15kg) onto counter	4. Adducted Thumb		**X**	

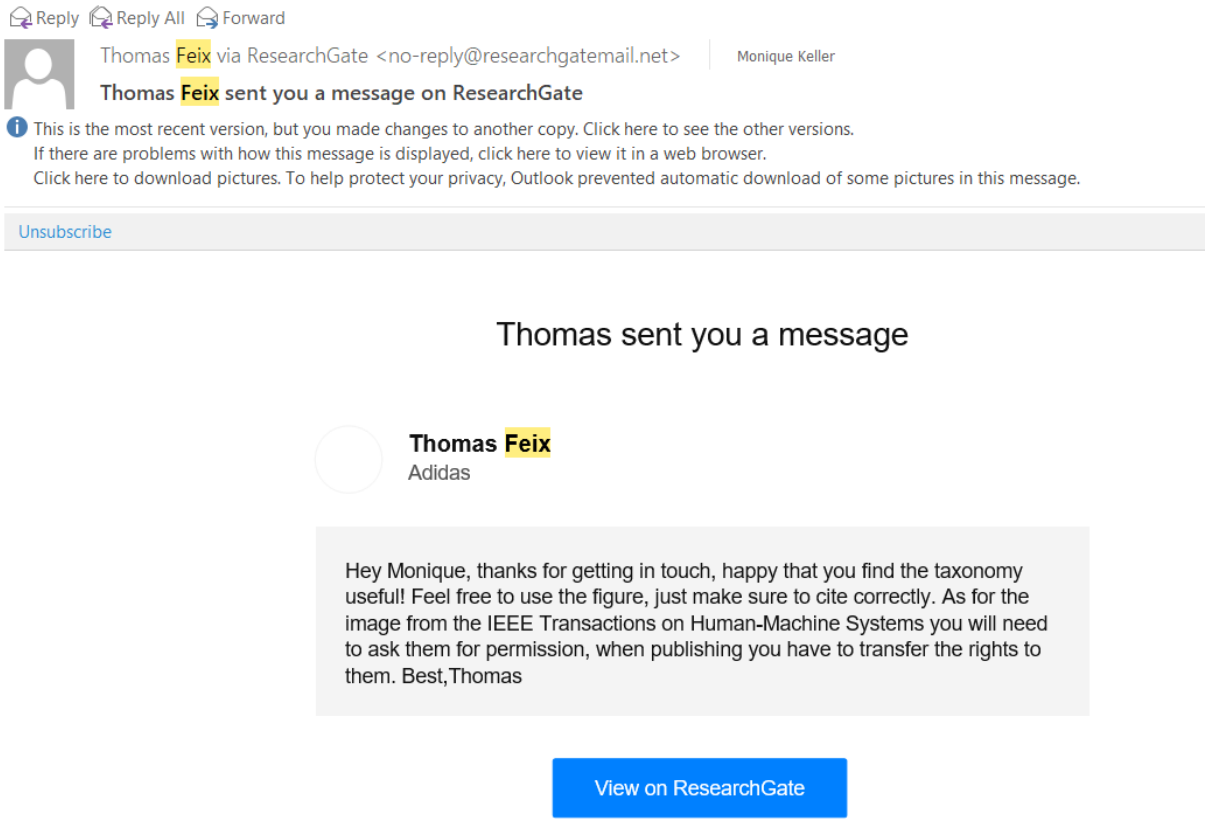
71	Lifting a box (20kg) onto counter	4. Adducted Thumb		**X**	
72	Lifting a box (25kg) onto counter	4. Adducted Thumb			**X**
73	Lifting a box (30kg) onto counter	4. Adducted Thumb			**X**
74	Stirring pap in a pot	2. Small Diameter		**X**	
75	Lifting a pan and putting it down	4. Adducted Thumb	**X**		
76	Lifting a pot and putting it down	30. Palmar	**X**		
77	Filling a kettle with water and lifting it	3. Medium Wrap	**X**		
78	Pouring water into a cup to make tea	3. Medium Wrap		**X**	
79	Changing a lightbulb overhead	26. Sphere 4 Fingers	**X**		
80	Opening a can by pulling on the ring	33. Inferior Pincher	**X**		
81	Cutting potatoes with a knife	25. Lateral Tripod	**X**		
82	Peeling carrots with a peeler	25. Lateral Tripod	**X**		
83	Grating cheese with a grater	25. Lateral Tripod	**X**		
84	Cutting with scissors	19. Distal	**X**		

85	Turning a salt grinder	3. Medium Wrap		**X**	
86	Picking up a child	1.Large Diameter		**X**	
87	Moving couch in living room	1.Large Diameter		**X**	
	Functional Task	**Type of Grasp or Pinch used (predominantly)**	**Light Forces (0-3 N)**	**Moderate Forces (3-7 N)**	**Heavy/ High demand Forces (7-20 N)**
88	Sweeping pavement	2. Small Diameter			**X**
89	Raking leaves	2. Small Diameter		**X**	
90	Pruning trees	19. Distal		**X**	
91	Cutting branches	19. Distal	**X**		
92	Washing car	17. Index Finger Extension	**X**		
93	Use wheelbarrow	4. Adducted Thumb	**X**		
94	Shovelling ground	4. Adducted Thumb		**X**	
95	Useing fork in flower bed	4. Adducted Thumb		**X**	
	Functional task	**Type of Grasp or Pinch used (predominantly)**	**Light Forces (0-3 N)**	**Moderate Forces (3-7 N)**	**Heavy/ High demand Forces**

					(7-20 N)
96	Shaking hands	22. Parallel Extension	**X**		
97	Using a manual cellular phone	16. Lateral	**X**		
98	Using touch screen cellular phone	32. Ventral	**X**		
99	Using remote of the television	32. Ventral	**X**		
100	Typing on laptop	22. Parallel Extension	**X**		
101	Use the mouse on computer	25. Lateral Tripod	**X**		
102	Typing on desktop	22. Parallel Extension	**X**		
103	Writing a handwritten letter	20. Writing Tripod	**X**		
104	Lifting a 400 page book and reading it	30. Palmar		**X**	
105	Lifting a magazine up and reading it	17. Index Finger Extension	**X**		
106	Handling money	25. Lateral Tripod	**X**		

Addendum C

Permission obtained for use by Thomas Feix (Feix et al, 2016)



Addendum D

PRISMA-P 2015 Checklist

Section/topic	#	Checklist item	Information reported		Line number(s)*
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	X	☐	Pg15
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	☐	X	N/A
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	☐	X	N/A Pg23
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	X	☐	Pg1

Section/topic	#	Checklist item	Information reported		Line number(s)*
			Yes	No	
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	☐	X	N/A
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	☐	X	N/A
Support					
Sources	5a	Indicate sources of financial or other support for the review	☐	X	Pg24
Sponsor	5b	Provide name for the review funder and/or sponsor	☐	X	Pg24 N/A
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	☐	X	Pg24 N/A
INTRODUCTION					

Section/topic	#	Checklist item	Information reported		Line number(s)*
			Yes	No	
Rationale	6	Describe the rationale for the review in the context of what is already known	X	☐	Pg8-12,15
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	X	☐	Pg13
METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	X	☐	Pg16-18
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	X	☐	Pg18-19

Section/topic	#	Checklist item	Information reported		Line number(s)*
			Yes	No	
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	X	☐	Pg19
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	X	☐	Pg19
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	X	☐	Pg19
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	X	☐	Pg20

Section/topic	#	Checklist item	Information reported		Line number(s)*
			Yes	No	
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	X	☐	Pg17
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	X	☐	Pg16-17
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	X	☐	Pg20
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	X	☐	Pg22

Section/topic	#	Checklist item	Information reported		Line number(s)*
			Yes	No	
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2, Kendall's tau)	X	☐	Pg22
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	☐	X	
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	X	☐	Pg23
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	X	☐	Pg20

Section/topic	#	Checklist item	Information reported		Line number(s)*
			Yes	No	
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	X	☐	Pg22

*Page numbers according to the HSREC ethics application protocol

Addendum E

Data extraction instrument

Study ID:	**Report ID :**	Date form completed:
First author:	Year of study:	Data extractor:
Citation:		

1. General Information

Publication type Journal Article ☐ Abstract ☐ Other (specify e.g. book chapter)_____	
Country of study:	
Funding source of study:	Potential conflict of interest from funding? Y / N / unclear

2. Study Eligibility

Study Characteristics			**Page/ Para/ Figure #**
Type of study	☐ Randomised Controlled Trial (RCT) ☐ Quasi-experimental study	☐ Cohort study ☐ Case control study	
	☐ A process evaluation of an included study design	Does the study design meet the criteria for inclusion? Yes ☐ No ☐ →**Exclude** Unclear ☐	
	Description in text:		

Participants (Review authors insert inclusion criteria as defined in Protocol)	Describe the participants included + how many participants + missing participants and reasons given: Gender: Female ☐ Male ☐ Ages: Mean ☐ Maximum ☐ Minimum ☐ Metacarpal # 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ Metacarpal # Base ☐ Shaft ☐ Neck ☐ Boxers ☐		
	Are participants defined as a group having specific social or cultural characteristics?	Yes ☐ No ☐ Unclear ☐ Details:	
	How is the geographic boundary defined?	Details: Specific location (e.g. state / country):	
	Do the participants meet the criteria for inclusion?	Yes ☐ No ☐ →**Exclude** Unclear ☐	

Types of intervention	Strategies included in the intervention List all comparators:		Rehabilitation programme Home education Immobilisation: POP Splints	
	Focus of the intervention			
	Does the intervention meet the criteria for inclusion?		Yes ☐ No ☐ →**Exclude** Unclear ☐	
Duration of intervention	Start date:	Stop date:	Intervention duration:	
	Number of/and follow up data collection periods:	1st 2nd 3rd 4th		
	Is the duration of intervention adequate for inclusion?		Yes ☐ No ☐ →**Exclude** Unclear ☐	

Types of outcome measures	List outcomes	Hand Function Health related quality of life Disability Digital ROM Grip strength Fine motor dexterity Other: Describe	
	Outcome measured at a population level or individual level?	Details:	
	Do the outcome measures meet the criteria for inclusion?	Yes ☐ No ☐ →**Exclude** Unclear ☐	

Summary of Assessment for Inclusion

Include in review ☐	**Exclude from review** ☐
Independently assessed, and then compared? Yes ☐ No ☐	Differences resolved Yes ☐ No ☐

Intervention characteristics									
Sampling Strategy	**Description of Rehab/Exercise / Splint Modality**	**Follow-up time periods**	**Profession delivering intervention**	**How is treatment delivered**	**Outcome measures used (for each outcome)**	**Results on outcomes 1st Assessment (Copy for each outcome)**	**Results on outcomes 2nd Assessment (Copy for each outcome)**	**Cofounding factors**	**Types of Analysis**

Control characteristics									
Sampling Strategy	**Description of Rehab/Exercise / Splint Modality/Placebo**	**Follow-up time periods**	**Profession delivering intervention**	**How is treatment delivered**	**Outcome measures used (for each outcome)**	**Results on outcomes 1st Assessment (Copy for each outcome)**	**Results on outcomes 2nd Assessment (Copy for each outcome)**	**Cofounding factors**	**Types of Analysis**

Addendum F

JBI Critical appraisal tools

JBI Critical Appraisal Checklist for Cohort Studies

Reviewer LM Hepworth Date 01/07/2019

Author Al - Qattan et al Year 2008 Record Number

	Yes	No	Unclear	Not applicable
1. Were the two groups similar and recruited from the same population?	□	□	□	**X**
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	□	□	□	**X**
3. Was the exposure measured in a valid and reliable way?	**x**	□	□	□
4. Were confounding factors identified?	□	**x**	□	□
5. Were strategies to deal with confounding factors stated?	□	□	□	**X**
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	**x**	□	□	□
7. Were the outcomes measured in a valid and reliable way?	**x**	□	□	□
8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	**x**	□	□	□
9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	□	**x**	□	□
10. Were strategies to address incomplete follow up utilized?	□	**x**	□	□
11. Was appropriate statistical analysis used?	**x**	□	□	□

Overall appraisal: Include x Exclude □ Seek further info □

Comments (Including reason for exclusion)

Addendum G

JBI Critical Appraisal Checklist for Cohort Studies

Reviewer LM Hepworth Date 01/07/2019

Author Gamble et al Year 2015 Record Number

	Yes	No	Unclear	Not applicable
1. Were the two groups similar and recruited from the same population?	□	□	□	**X**
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	□	□	□	**X**
3. Was the exposure measured in a valid and reliable way?	**x**	□	□	□
4. Were confounding factors identified?	**x**	□	□	□
5. Were strategies to deal with confounding factors stated?	**x**	□	□	□
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	**x**	□	□	□
7. Were the outcomes measured in a valid and reliable way?	**x**	□	□	□
Was the follow up time reported and sufficient to be long enough for outcomes to occur?	□	□	□	**X**
9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	□	□	□	**X**
10. Were strategies to address incomplete follow up utilized?	□	□	□	**X**
11. Was appropriate statistical analysis used?	**x**	□	□	□

Overall appraisal: Include x Exclude □ Seek further info □

Comments (Including reason for exclusion)

Addendum H

JBI Critical Appraisal Checklist for Randomized Controlled Trials

Reviewer LM Hepworth _____ Date 9th May _____

Author Gülke et al _____ Year 2018 _____ Record Number

	Yes	No	Unclear	NA
1. Was true randomization used for assignment of participants to treatment groups?	**x**	□	□	□
2. Was allocation to treatment groups concealed?	□	**x**	□	□
3. Were treatment groups similar at the baseline?	**x**	□	□	□
4. Were participants blind to treatment assignment?	□	**x**	□	□
5. Were those delivering treatment blind to treatment assignment?	□	**x**	□	□
6. Were outcomes assessors blind to treatment assignment?	□	**x**	□	□
7. Were treatment groups treated identically other than the intervention of interest?	**x**	□	□	□
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	**x**	□	□	□
9. Were participants analyzed in the groups to which they were randomized?	**x**	□	□	□
10. Were outcomes measured in the same way for treatment groups?	**x**	□	□	□
11. Were outcomes measured in a reliable way?	**x**	□	□	□
12. Was appropriate statistical analysis used?	**x**	□	□	□
13. Was Ithe trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	**x**	□	□	□

Overall appraisal: Include x Exclude □ Seek further info □

Comments (Including reason for exclusion)

Addendum I

Ethical clearance certificate Phase 1

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

Health Sciences Research Ethics Committee

16-Apr-2019

Dear Mrs **Monique Keller**

Ethics Clearance: **DEVELOPMENT OF A REHABILITATION PROGRAMME FOR SECOND TO FIFTH METACARPAL FRACTURES IN SOUTH AFRICA.**

Principal Investigator: **Mrs Monique Keller**

Department: **Physiotherapy Department (Bloemfontein Campus)**

APPLICATION APPROVED

Please ensure that you read the whole document

With reference to your application for ethical clearance with the Faculty of Health Sciences, I am pleased to inform you on behalf of the Health Sciences Research Ethics Committee that you have been granted ethical clearance for your project.

Your ethical clearance number, to be used in all correspondence is:**UFS-HSD2019/0046/2602**

The ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the HSREC for approval to ensure we are kept up to date with your progress and any ethical implications that may arise. This includes any serious adverse events and/or termination of the study.

A progress report should be submitted within one year of approval, and annually for long term studies. A final report should be submitted at the completion of the study.

The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

For any questions or concerns, please feel free to contact HSREC Administration: 051-4017794/5 or email EthicsFHS@ufs.ac.za.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours Sincerely

Dr. SM Le Grange
Chair : Health Sciences Research Ethics Committee

Health Sciences Research Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | E: ethicsfhs@ufs.ac.za
IRB 00006240; REC 230408-011; IORG0005187; FWA00012784

Addendum J

Permission obtained from the owner of the laboratory for data collection

The Helping Hand Amplified Team
Education in Abundance

31 Wynand Street

Glen Marais

Kempton Park

1619

Gauteng

South Africa

NPO number: 181-986NPO

Income tax exemption number: PBO NO 930060448

Email: helpingmattersamplified@gmail.com

4 May 2021

Development of a hand rehabilitation programme for second to fifth metacarpal fractures with Force Sensing Resistor testing

Dear Mr Paul Gunter Keller

My name is Monique Keller and I am conducting a research study in fulfilment for a PhD with specialisation in Physiotherapy at the University of the Free State under the supervision of Dr Roline Barnes (University of the Free State) and Dr Corlia Brandt (University of the Witwatersrand).

Ethical clearance

I have received ethical clearance from the Health Science Research Ethics Committee of the University of the Free State for the first phase with the number: UFS-HSD2019/0046/2602 and will apply for ethical clearance for phase two in the next two week prior to commencement of this proposed research data collection phase.

Aim of the research

The aim of the research is to develop a hand rehabilitation programme for second to fifth metacarpal fractures specifically to guide therapists and doctors in the SA population treat individuals with metacarpal fractures cost efficiently and optimally. A testing phase with finger sensors on a glove is the next phase to be conducted on healthy adults between the ages of 20 to 59. The aim of this testing is to inform the already developed rehabilitation programme with force measurements that will be used when giving advice to patients about what daily tasks is safe to start doing while the metacarpal fracture is healing. For this phase II am requesting permission to conduct the force measurements at the laboratory at your premises in Kempton Park.

Description of procedures including Covid-19 safety precautions

A total of fifty participants will be recruited for this study. The researcher and research assistant will do a Covid-19 screening, similar as to the procedure described below for prospective participants, every morning prior to going to CHBAH, the data collection site. The researcher and research assistant will wear surgical masks, aprons and gloves during the entire data collection. Information will be given to prospective participants regarding the research study and if they are not wearing a face mask one will be provided by the research assistant to ensure safety. If interest is shown a Covid-19 screening tool will be completed to ensure that the prospective participant do not have Covid-19 related symptoms (Addendum X and XI).

The Covid-19 screening tool will contain yes and no responses to the question, do you have the following symptoms: cough, loss or change in sense of smell or taste, a sore throat and in immediate contact with someone who has tested positive for Covid-19. The research assistant will write Yes or No next to each question on the Covid-19 screening tool to ensure that pens are not shared. Immediately following the informed consent and Covid-19 screening document has been completed and if the prospective participant has no Covid-19 related symptoms will their temperature be taken with a thermometer. In the instance where the temperatures higher than 37.5°C taken as a high risk of Covid-19 and the prospective participant will not be included into the research but will be given advice to seen urgent medical attention. If the prospective participant has none of the Covid-19 related symptoms or a high temperature reading, the prospective participant will be requested to sign the informed consent document and the temperature of the participant will be documented on the Participant Informed consent document (Addendum V and VI). Sanitiser will be sprayed on each participants' hands by the research assistant prior to obtaining consent. The researcher and research assistant will also wash their hands, spray their hands with sanitiser between each participant and put a new pair of gloves on.

The informed consent document will include detailed information regarding the study aims and objectives, ensuring anonymity, explaining their right to refrain from participating in the study if they so desire and testing procedures. Once informed consent has been obtained the self-administered questionnaire will be completed. The researcher, a qualified PT with a Masters degree in Hand Rehabilitation would have trained a qualified PT technician with ten years of experience to be the research assistant but due to medical illness the PT technician has been medically boarded and will not be able to work as a research assistant. In her place, a male who is fluent in Zulu and English languages will be trained prior to data collection to act as the Covid-19 marshal and a research assistant. He will receive training to perform the Covid-19 screening. He will also assist the researcher with the informed consent process and questionnaire completion if the participants require assistance or explanation.

After signing the informed consent document, the family member or friend, will be asked to complete a short questionnaire asking about demographic, occupation and any previous injuries. The testing phase will commence with instructions to firstly put on a pair of surgical gloves that will keep the sensors away from the participants' skin, which decreases risk further of spreading Covid-19. The researcher, research assistant and participants will be wearing face masks at all times and if the participants do not have a face mask, one will be provided by the research assistant. The length of the wires attaching the FSR to the Arduino is 1,5 metres long and social distance between the participant and researcher will be maintained throughout data collection. Their grip strength will be measured before and during the session and will be asked to put on two glove which will fit comfortably. On each finger of the glove, a sensor will be pasted with glue. No glue will come into contact with the skin or fingers. The sensors will be connected to a board which in turn will be connected to a laptop. They will be requested to do tasks which they are familiar with and perform daily. The tasks will include but not be limited to opening bottles, opening cans, dressing, cutting vegetables. During the dressing, a screen will be placed between them and the research team, to ensure privacy. The tasks may be challenging but will not be painful or cause any discomfort. The sensors will detect the forces which the fingers exert while doing the tasks. The voltages will be visible on the software programme on the laptop. After a task they will be asked to do another task till all the functional tasks on the testing sheet is completed.

A pilot study, including six participants will be undertaken fist. In the instances where no statistical differences were found but similarities for the maximum forces in the functional tasks where the same grasps are used, the tasks will be collated in a list, and only one task will be used for further data collection. This is consistent with the aim of the proposal to find the grasp forces produced during functional hand tasks. The reason for this, is also to minimise the contact time between the researcher, research assistant and participants during the Covid-19 pandemic. In the instance where significant differences were found in maximum grasp forces these tasks will be tested for each participant in the data collection.

The testing will last for an estimate period 15 working days to test all 50 participants (including the pilot study). The testing period per participant will last for a maximum of 2 working days (one day added is re-testing is required) and one hour testing per day. The participant will be asked to return for the second day tests if re-testing is required. The testing will be performed by a Physiotherapy working as a lecturer at the University of the Witwatersrand. The lecturer, Monique Keller, is also the main researcher and a specialist in the field of electrical engineering present.

Risks and discomforts

The activity instructions will be given by a qualified physiotherapist. Although knives and tin lids will be part of the tasks and pose potential risk, the nature of the tasks should not cause pain or discomfort. Safety precautions will always be taken, however the researcher, promotors, specialist, University of the Free State and the University of the Witwatersrand will not be responsible for any injury or costs incurred during an injury sustained while participating in the testing.

Voluntary participation

Your participation is completely voluntary, and they will not be negatively affected by your choice. They have the right to withdraw from the research at any point.

Participant responsibility

The responsibility of the participants will include: performing the tasks as they would usually do them at home and complete all the functional tasks on the testing sheet. In the instance where a certain activity measurement was not accurate they may be asked to repeat an activity

and it may be on another date and time. They will be informed timeously, and a suitable time and date will be discussed.

Payment

No payment will be issued for your participation.

Confidentiality

The results of the testing will be kept confidential and their name will not be seen on any documentation. The results will be published in an article and thesis, but they will remain confidential.

With this document I, Monique Keller, request permission to conduct the proposed research at the laboratory that will be erected in Kempton Park at your premises that is conducive to the technical demands. Your signature at the bottom of the page will be considered as permission to conduct the research.

Sincerely,

Monique Keller
011 717 3517
monique.keller@wits.ac.za

I Paul Keller (Name and Surname) give permission for the above research study to be conducted in our laboratory during the Covid-19 pandemic in 2021.

	Kempton Park	4 May 2021
Laboratory expert signature	Place	Date
	Kempton Park	4 May 2021
Witness signature	Place	Date

7

Addendum K

English self-administered questionnaire

QUESTIONNAIRE ENGLISH

INSTRUCTIONS

Please answer **all** questions by marking a tick (✓) in the appropriate block(s) **OR** by referring to the specific instruction provided with certain questions.

SECTION A: BACKGROUND INFORMATION

1. What is your age…….(years)

2. What is your gender?

	1 Male	
	2 Female	

---

3. What is your current education level (Tick as many as apply)

	1 No schooling completed	
	2 Completed schooling up to 8th grade	
	3 High school completed	
	4 Some college credit, no degree	
	5 Trade/technical/vocational training	

	6 Technical support	
	7 Bachelors degree	
	8 Masters degree	
	9 Doctorate degree	
	10 Other (Please specify)	

5. What is your current occupation?

   .....

6. What is your dominant hand?

1	Right handed	
2	Left handed	

7. Have you had any of the following injuries or have you been diagnosed with any of these conditions:

   (Tick as many as applicable and give the year of diagnoses)

		YES	NO	YEAR
	1. Hand infections			
	2. Arm injuries			
	3. Hand injuries			
	4. Fractures of any bones in the arm or hand			
	5. Brain injuries			
	6. Diagnosed with developmental delay			
	7. Other injuries and conditions			

	Please specify other injuries and conditions:

Addendum L

IsiZulu self-administered questionnaire

Participant number:

IMIBUZO YA LESIFUNDO ZULU

IMIYALELO

Sicela uphendule yonke imibuzo ubhale (✓) ebokisini noma ulandelevimibuzovkuyangemibuzo.

1. Uneminyaka emingakhi…….(years)

2.

1	Ukewashada
2	Ushadile
3	Uhlala nomasihlalisane
4	Ungumfelokazi
5	Usuhlukene
6	Anisahlalisani

3. Buyini ubulili bakho?

1	Mlisa
2	Sifazane

4. Liphi izinga lakho lamanje lemfundo

1	Uqedile isikolo
2	Iliphi izinga lesifundo ophelele kulo

3	Uqedile isikolo esiphezulu
4	Unemiphumela e college, noma u ne degree
5	Ufundele umsebeziwezandla e technical noma vocational training
6	Uyalekelelwa e Technical
7	Une Bachelors degree
8	Une Master degree
9	Une Doctorate degree
10	Eyiphi onayo ngaphandle kwalezi eziphezulu

5. Uyini umsebenzi wakho wamanje?
.....

6. Usuke waba nalezi zingozi ezibhalwe ngezansi? Faka uyebo noma ucha eduzane kwazo, uma uthe yebo, bhala unyaka owabanazo ngawo. (Thikha okuningi njengoba kusebenza bese unikeza unyaka wokuxilongwa)

		Yebo	Cha	Unyaka
	1. umhabulo ezandleni			
	2. ukulimala engalweni			
	3. ukulimala esandleni			
	4. ukuphuka kwamathambo asesandleni noma engalweni			

	5. ukulimala komqondo			
	6. inkinga yokukhula noma ukukhula ngendlela engajwayelekile			
	7. okunye okulimala noma izifo			
	bhala lezi ezinye izifo osuke waba nazo			

Addendum M

English informed-consent document

Participant number:

Temperature:

PARTICIPANT INFORMATION AND INFORMED CONSENT DOCUMENT

ENGLISH

Development of a clinical hand rehabilitation guideline for second to fifth metacarpal fractures in South Africa with Force Sensing Resistor testing

Dear prospective participant.

My name is Monique Keller and I am conducting a research study in fulfilment for a PhD with specialisation in Physiotherapy at the University of the Free State under the supervision of Dr Roline Barnes and Dr Corlia Brandt.

Ethical clearance

I have received ethical clearance for Phase I from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State number: UFS-HSD2019/0046/2602. Phase II of the clinical trial was approved by the HSREC.

Aim of the research

The aim of the research is to develop a hand rehabilitation programme for second to fifth metacarpal fractures specifically to guide therapists and doctors in the SA population treat individuals with metacarpal fractures efficiently and optimally. A testing phase with finger sensors on a glove will be conducted for which your participation is requested.

Description of procedures

After signing the informed consent document, you will be asked to complete a short questionnaire asking about demographic, occupation and any previous injuries. Your grip strength will be measured before and during the session. You will be asked to put on two glove which will fit comfortably. On each finger of the glove, a sensor will be pasted with glue. No glue will come into contact with your skin or fingers. The sensors will be connected to a board which in turn will be connected to a laptop. You will be requested to do tasks which you familiar with and perform daily. The tasks will include but not be limited to opening bottles, opening cans, dressing, cutting vegetables. During the dressing, a screen will be placed between you and the research team, to ensure privacy. The tasks may be challenging but will not be painful or cause any discomfort. The sensors will detect the forces which your fingers exert while doing the tasks. The voltages will be visible on the software programme on the laptop. After an activity you will be asked to do another activity till all the functional tasks on the testing sheet is completed. The testing will be performed in the laboratory in Kempton Park, with the researcher Monique Keller and a specialist in the field of electrical engineering present. The testing will last for a maximum period of 2 work days, one hour per day. A suitable date and time will be discussed with you.

Risks and discomforts

The activity instructions will be given to you by a qualified physiotherapist. Although knives and tin lids will be part of the tasks and pose potential risk, the nature of the tasks should not cause pain or discomfort. Safety precautions will always be taken, however the researcher, promotors, specialist, University of the Free State and the University of the Witwatersrand will not be responsible for any injury or costs incurred during an injury sustained while participating in the testing.

Voluntary participation

Your participation is completely voluntary, and you will not be negatively affected by your choice. You have the right to withdraw from the research at any point.

Participant responsibility

Your responsibility will include: performing the tasks as you would usually do them at home and complete all the functional tasks on the testing sheet. In the instance where a certain activity measurement was not accurate you may be asked to repeat an activity and it may be on another date and time. You will then have to return for the second day tests. You will be informed timeously, and a suitable time and date will be discussed.

Payment

No payment will be issued for your participation.

Confidentiality

The results of the testing will be kept confidential and your name will not be seen on any documentation. The results will be published in an article and thesis, but confidentiality will be maintained.

Your signature at the bottom of the page will be considered as your consent to participate.

Sincerely,

Monique Keller	Dr Roline Barnes	Dr Corlia Brandt
011 717 3517	051 401 3295	011 717 2014
monique.keller@wits.ac.za	BarnesRY@ufs.ac.za	corlia.brandt@wits.ac.za
Principle investigator/Researcher	Promotor	Promotor

The informed consent will be conducted by either the Principle investigator or:

Mr Oliver Ndlovu

Research assistant

_____

Signature

I _____ (Name and surname) give consent to participate in the above study.

_____ _____ _____

Research participant signature Place Date

_____ _____ _____

Impartial witness signature Place Date

Addendum N

IsiZulu informed consent document

Participant number:

Temperature:

PARTICIPANT INFORMATION AND INFORMED CONSENT ZULU

HAND REHABILITATION FOR TRAUMATIC PHALANGEAL AND METACARPAL FRACTURES IN A PUBLIC HEALTH SETTING IN SOUTH AFRICA

Mhlonipheki ovumelana nesifundo engisenzayo.

Igama lami nginguMonique Keller ngenza lesisifundo ukuze ngifezekise izimfanelo zeziqu zami zePhD, engiyenza enyuvesi yase Free State, emnyangweni wePhysiotherapy ngaphantsi kuka Dokotela Corlia Brandt noDokotela Roline Barnes.

Ucwaningo olunobuntu

Ngithole imvume ebusayo yesiGaba I evela kwiKomidi lezeSayensi Yezempilo (i-HSREC) le-University of the Free State inombolo: UFS-HSD2019/0046/2602. Isigaba II sesivivinyo somtholampilo savunywa yi-HSREC.

Isizathu salesifundo

Inhloso yalesisifundo ukuqala noma ukwenza uhlelo oluzolandelwa ngabalaphi ekulapheni iminwe ephukile (umunwe wesibili kuya kowesihlanu) ngokushesha nangempumelelo.

Incazelo yalesisifundo

Emva kokusayina ukuthi uyavuma ukubamba iqhaza kulesisifundo, uzocelwa ukuthi uphendule imibuzo embalwa ephathelene nawe, umsebenzi owenzayo kanye nezingoze oke wabanazo ngaphambilini.

Ingozi nokungaphathekikahle

Konke ozokwenza kuzochazwayiphysiotherapist ewufundele lomsebenzi. Kungahle kube nobungozi ngenxa yemimese nezivalo zamathini ezizoshetshenziswa kulesisifundo, kodwa konke ozokwenza akulindelekile ukuthi kukuzwise ubuhlungu. Sizoqinisekisa ukuphepha kwakho ngaso sonke isikhathi kodwa uma kubakhona ingozi umcwaningi kanye nenyuvesi yase Free State, kanye nenyuvesi yaseWitwatersrand angeke bebekwe icala noma bakhokhe ngengozi eyenzekile

Ukuzinikela kwakho kulesisifundo

Ukuzinikela kwakho kulesisifundo kuyisinqumo sakho kuphela. Akukho okubi okuzokwenzeka uma ukhetha ukungaqhubeki nokubamba iqhaza kulesisifundo. Unelungelo lokuhoxa nanoma ngayisiphi isikhathi ngisho engabe ubusuqalile.

Olindeleke ukuba ukwenze kulesisifundo

Emva kokusayina ukthi uyavuma ukuthatha iqhaza kulesisifundo, uzocelwa ukuba ugcwalise imibuzo eqondene nawe, umsebenzi wakho kanye nezingozi osuke waba nazo ngaphambilini.

Sizohlola amandla okubamba kulesandla sakho esiphukile ngaphambi kokuba siqale iseshini siphinde sihlole futhi emva kweseshini. Uzocelwa ukuba ufake amagilavu akunela kahle. Yonke iminwe yegilavu izoba nezinzwa (sensors) ezizonamathiselwa ngesinamathelisi. Isinamathelisi angeke sithintane nesikhumba noma neminwe yakho. Izinzwa zizoxhumana nebhodi elizobe lixhumene nekhompyutha. Uzocelwa ukuthi wenze imisebenzi ojwayele ukuzenza nsukuzonke. Imisebenzi efana nokuvula isigubhu, ikani, ukugqoka kanye nokuqoba imifino. Sizofaka isikrini (ikhethini noma ibhodi) esizokuvala ngesikhathi ugqoka khona ungeke ubonwe abacwaningi. Imisebenzi ozocelwa ukuthi uyenze ingaba inselelo kodwa angeke ikuzwise ubuhlungu noma ikwenze uzizwe ungaphathekile kahle. Izinzwa zizokala Amandla obamba ngawo ngesikhathi wenza lemisebenzi. Isikalo samandla osisebenzisile sizobonakala kuyikhompyutha. Uzokwenza imisebenzi ehlukene ngokulandelana kwayo kuze kuphele yonke imisebenzi ebhaliwe ephepheni elinezivivinyo. Lokhu kuhlolwa kuzokwenziwa elabhorethri emnyangweni wamathambo e-Kempton Park, umcwaningi uMonique Keller nochwepheshe emkhakheni wobunjiniyela bakagesi abakhona. Ukuhlolwa kuzohlala isikhathi esiphezulu sezinsuku ezi-2 zomsebenzi, ihora elilodwa ngosuku. Usuku nesikhathi esifanele kuzoxoxwa nawe. Ngemuva kwalokho kuzodingeka ubuye ukuze uhlolwe ngosuku lwesibili.

Ukubhadala

Angeke ukhokhelwe ngokubamba iqhaza kulesisifundo.

Ukuvikelwa kobambe iqhaza

Imiphumela yemibuzo nezinhlolo eqondene nawe izofihlwa futhi negamalakho angeke livezwe emaphepheni, esikhundleni segama lakho kuzofakwa inombolo yesifundo. Imiphumela izoshicilelwa ku-athikili ne-thesis, kepha izimfihlo zizogcinwa.

Kufanele usayine ukupheleni kwaleliphepha ukuze kubenesiqiniseko sokuthi uyavuma.

Sincerely,

Monique Keller	Dr Roline Barnes	Dr Corlia Brandt
011 717 3517	051 401 3295	011 717 2014
monique.keller@wits.ac.za	BarnesRY@ufs.ac.za	corlia.brandt@wits.ac.za
Principle investigator/Researcher	Promotor	Promotor

Imvume enolwazi izokwenziwa ngumphenyi wezinqubomgomo noma:

Mr Oliver Ndlovu

Research assistant

_____

Signature

Mina _____ ngiyavuma ukubakulesifundo

_____	_____	_____
Research participant signature	Indawo	Usuku

_____	_____	_____
Impartial witness signature	Indawo	Usuku

Addendum O

English Covid-19 screening tool

Dear Prospective Participant

To ensure your safety in the Covid-19 pandemic we want to ask you to answer “yes” or “no” to the following questions:

1. Are you suffering from high temperature, temperature flactuations or fever?

2. Do you have a dry cough?

3. Is your throat sore?

4. Do you experience difficulty in breathing or shortness of breath?

5. Do you have a loss of smell or taste?

6. Have you been exposed to someone with a positive Covid-19 diagnosis?

7. Have you been in contact with someone who is in self-isolation and awaiting a Covid-19 test result?

8. Have you been in quarantine or self-isolation for the past 14 days?

Addendum P

IsiZulu Covid-19 screening tool

Ofanele Ukuhlanganyela Umbambiqhaza

Ukuqinisekisa ukuphepha kwakho kubhadane lweCovid-19 sifuna ukukucela ukuthi uphendule ngo "yebo" noma "cha" kule mibuzo elandelayo:

1. Ingabe uhlushwa ukushisa okuphezulu, ukushintsha kwamazinga okushisa noma umkhuhlane?

2. Unesikhwehlela esomile?

3. Ingabe umphimbo wakho ubuhlungu?

4. Ingabe uba nenkinga ekuphefumuleni noma ekuphefumuleni okuncane?

5. Ingabe ulahlekelwe yiphunga noma ukunambitha?

6. Ngabe uke wachayeka kumuntu one-positive Covid-19 diagnostic?

7. Uke waxhumana nomuntu ozimele wedwa futhi olindele imiphumela yokuhlolwa kweCovid-19?

8. Uke wavalelwa wedwa noma wazihlukanisa wedwa ezinsukwini eziyi-14 ezedlule?

Addendum Q

Grasp types tested per type and per category

Grasp type	Activity number	Light forces	Moderate forces	Heavy forces
4_adducted thumb (17)	A64 Lifting a box (1kg) onto the counter	x		
	A69 Lifting a box (10kg) onto counter Or A70 Lifting a box (15kg) onto counter Or A71 Lifting a box (20kg) onto counter		X X X	
	A47 Holding onto a rail in a taxi/car Or **A72 Lifting a box (25kg) onto counter** Or A73 Lifting a box (30kg) onto counter			X X X
25_lateral tripod (10)	A106 Handling money	x		
7_prismatic three fingers (12)	A25 T-Shirt on	x		
	A34 Putting socks on Or **A40 Buckle of belt use**		X x	
2_small diameter (9)	A53 Sweeping floors with a broom	x		
	A4 Wringing water out of a sponge Or		X X	

	A 9 Carrying a bucket containing three litres of water Or A74 Stirring pap in a pot		X	
8_prismatic two fingers (9)	A23 Squeezing toothpaste out of a tube ML	X		
3_medium wrap (7)	A21 Dry water out of clothes by hand	X		
	A78 Pouring water into a cup to make tea Or A85 Turning a salt grinder		X X	
15_fixed hook (5)	A50 Carrying a shopping bag	X		
	A43 Turning the steering wheel **Or** **A10 Carry a zink basin containing three L of water**		X X	
26_sphere four fingers (4)	A61 Opening a tight or new jar	X		
	A45 Opening a door know circular		X	
30_palmar (4)	A76 Lifting a pot up and placing it down	X		
22_parallel extension (4)	A57 Packing dishes away	X		
17_index finger extension (3)	A92 Washing car	X		
19_distal (3)	A84 Cut with scissors	X		
	A90 Pruning tree		X	

14_tripod (2)	A59 Eating with hands	X		
27_quadpod (2)	A7 Opening and closing a tap (large round shape)	X		
6_prismatic four fingers (2)	A22 Brushing teeth with a toothbrush	X		
16_lateral (2)	A97 Use a manual cellular phone	X		
1_large diameter (2)	A86 Picking up a child Or **A87 Moving a couch in living room**		X X	
32_ventral (2)	A99 Using the remote of the television	X		
12_Precision Disk	A61 Opening a tight or new jar		X	
11_power sphere (1)	A3 Squeezing water out of a sponge	X		
13_precision sphere (1)	A2 Washing hair	X		
9_palmar pinch (1)	A20 Using pegs to secure clothes on the washing line		X	
5_light tool (1)	A52 Dusting	X		
33_inferior pincher (1)	A80 Opening a can by pulling on the ring	X		

*The bold ADL tasks were selected for the specific type of grasp

Addendum R

Ethical clearance certificate Phase II

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

Health Sciences Research Ethics Committee

06-May-2021

Dear **Mrs Monique Keller**

Ethics Number: UFS-HSD2019/0046/2602-0002

Ethics Clearance: **DEVELOPMENT OF A REHABILITATION PROGRAMME FOR SECOND TO FIFTH METACARPAL FRACTURES IN SOUTH AFRICA.**

Principal Investigator: **Mrs Monique Keller**

Department: **Physiotherapy Department (Bloemfontein Campus)**

Submission Page

SUBSEQUENT SUBMISSION APPROVED

With reference to your recent submission for ethical clearance from the Health Sciences Research Ethics Committee. I am pleased to inform you on behalf of the HSREC that you have been granted ethical clearance for your request as stipulated below:

Due to the Gauteng Department of Health online backlog of research proposals, the study setting had to be changed. The study population will remain healthy adults performing daily task thus a minor amendment is made to move out of a hospital setting and also limit potential contraction of Covid infection for participants and researchers. Due to Covid-19 pandemic the need exists to add safety precautions to the proposed data collection to ensure the health and safety of the participants, research assistant and researcher. The precautions has been added including but not limited to, personal protective equipment (masks, gloves, santising, physical distance, covid screening tool, collation of tasks where forces are in a similar range after the pilot study to minimise the time spent in testing and thus limiting contact duing Covid-19 pandemic).
Clarity is given on how the screening will be enforced and how the referral works if the person has Covid-19 symptoms.
Permission was again asked and received from CHBAH medical advisory committee and the Orthopaedic department HOD with Covid-19 safety precautions. Uploaded below.
The initial research assistant has also became ill during the lockdown period and has been medically boarded. The researcher will now do all the testing and assessments while new research assistant, who is fluent in English and Zulu will act as the Covid marshall and ensure all precautions and safety are adhered to as well as assist with questionnaire completion in Zulu.

The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; International Council for Harmonisation (ICH) Harmonised Guideline, Integrated Addendum to ICH E6(R1), Guideline for Good Clinical Practice (GCP) E6(R2), 2016, SAHPRA Guidelines as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

For any questions or concerns, please feel free to contact HSREC Administration: 051-4017794/5 or email EthicsFHS@ufs.ac.za.

Thank you for submitting this request for ethical clearance and we wish you continued success with your research.

Yours Sincerely

Prof. A. Sherriff
Chairperson : Health Sciences Research Ethics Committee

Health Sciences Research Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | E: ethicsfhs@ufs.ac.za

Addendum S

REDcap Questionnaire: Round One

Link:

https://redcap.core.wits.ac.za/redcap/surveys/?s=RKM9FCJYXYAM47E3

Hand Rehabilitation Guideline for 2nd to 5th Metacarpal fractures

Dear potential participant.

My name is Monique Keller, and I am conducting a research study in fulfilment for the degree Doctor in
Physiotherapy at the University of the Free State under the supervision of Dr Roline Barnes and Dr Corlia Brandt.

Ethical clearance

I have received ethical clearance for Phase I and II from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State number: UFS-HSD2019/0046/2602 and UFS-HSD2019/0046/2602-0002 respectively. Phase III of the clinical trial was approved by the HSREC with the number.

Aim

The aim of Phase III is to finalise the proposed clinical hand rehabilitation guideline for second to fifth metacarpal fractures.

Objectives

The objectives of Phase III are:

To determine the consensus among purposively sampled expert surgeons, PT's and OT's in the field of hand injuries, hand surgery and hand rehabilitation, with the use of a REDCap questionnaire, investigating their consensus on the developed clinical hand rehabilitation guideline.To adapt and finalise the clinical hand rehabilitation guideline based on the information obtained from the expert panel members of the Delphi.

Description of procedures

Informed consent will be requested in an email. Upon receiving the signed consent document the researcher will email the REDcap questionnaire link asking you to complete the REDCap questionnaire. A three round Delphi method will be used to reach consensus and if consensus is not reached after three rounds, a final fourth Delphi round will be run, to inform the objectives. In the instance where there are no additional changes, stability will be assumed. Upon completion of the first round Delphi, statistical analysis will be performed and you will receive a summary of the results in a feedback email. A two week time period will be allowed for the completion of the questionnaire. In addition a two week period between the first and second round will occur to allow the researcher time to analyse the results and forward the summary of findings to you. A one week reminder will be sent to all participants prior to each Delphi round. Questions included in the questionnaire are demographical questions, to better understand to which population the hand rehabilitation guideline can be generalised to, followed by questions to establish the agreement of participating experts on included questions on a five-point Likert scale ranging from 1 strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly agree. Themes in the questionnaire will include: physiological healing timeframes and commencement of exercises, rehabilitation exercises, splints used, splinting timelines, timelines when patients are advice to return to tasks and advice regarding light, medium, hard and pre-injured tasks included.

Voluntary participation

Your participation is entirely voluntary, and you will not be negatively affected by your choice. You have the right to withdraw from the research at any point. Explicit withdrawal must be sent to Monique Keller (contact details below) and only after receiving the written withdrawal will correspondence be stopped. Absent responses will be seen as non-interest and no further information will be sent. Experts not responding to the first round Delphi, but

who indicated an interest to participate, will receive two reminders and questionnaire links in the form of emails before this will be viewed as non-participation. No remuneration will be offered to participating experts.

Participant responsibility

Your responsibility will include: Complete a RedCap questionnaire in a three round Delphi technique.

Payment

No payment will be issued for your participation.

Feedback

Upon completion of the first round Delphi, each participating expert will receive a summary of the results.

Anonymity and Confidentiality

Anonymity among participants will be ensured by using separate emails in all communication. The results of the questionnaire will be kept confidential, and your name will not be seen on any documentation. The results will be published in an article and thesis, but confidentiality will be maintained. With your consent to participate, you also agree to not distribute the clinical guideline till it has been accepted or published.

Technical support

Technical support services namely, Redcap's Help Centre, can be contacted if there are any technical support required.

To complete the questionnaire select "true" in the first option. Sincerely,

Monique
Keller
0117173715
monique.keller
@wits.ac.za
Please
complete the
survey below.

Thank you!

Hand rehabilitation guideline for 2nd to 5th metacarpal fractures_General Questions

I have read and understood the contents of theTrue information sheet. I am participating voluntarily inFalse this study. I understand that I may be able to withdrawn from this study at any time without bias. I consent to participate in this survey. (If you do not wish to participate, select False)	○ ○

A1

Gender	○ Male ○ Female

What is your age?

A	In which professional capacity do you work?	○ Orthopaedic surgeon ○ Orthopaedic surgeon with specialty ○ Physiotherapist ○ Occupational Therapist

A How many years experience do you have in management of hand injuries.

- ○ 1 - 2
- ○ 3 - 4
- ○ 5 - 6
- ○ 7 - 8
- ○ 8 - 10
- ○ More than 10
- ○ More than 15

A4 In which country are you practicing hand injury management in? _____

How many articles, related to hand injuries or management have you published in peer-reviewed articles? _____

Have you authored a book relating to hand injuries or management?

- ○ Ye
- ○ No

How many books in hand injury management have you authored?

_____

Have you written chapters in a book relating to hand injuries or management?

- ○ Ye
- ○ No

This section covers the time period and types of light, moderate, heavy and pre-injured tasks/functions/activities return to daily activities.

To determine consensus regarding the developed hand rehabilitation programme for second to fifth metacarpal fractures, look at the uploaded image before answering the questions.

tasks_permitted

2/52 Light tasks allowed	4/52 Moderate tasks allowed	6/52 Heavy tasks allowed	8-10/52 Resume pre-injured tasks
Respect pain < 3/10.Personal care and Hygiene tasks but no Wringing water out of washcloth with force, carry buckets (weight > 2kg) or zink basins, dry water out of clothes and take care with putting socks on and opening and closing a belt buckle. Home environment: Inside allowed but no opening new or tight jars or stir mealie pap/heavy porridge. No picking up children, move furniture or turning a salt or pepper grinder. No gardening allowed. No driving.	Start driving when ring or index finger metacarpal fracture. Pick up weight < 4kg.	Start driving for all metacarpal fractures. Do not hang on the overhead rail or hand support in a car or taxi. Pick up weight less than 5kg.	Resume all tasks If no pain is present. If pain persists consult your medical doctor.

This section covers the time period and types of light, moderate, heavy and pre-injured tasks/functions/activities return to daily activities. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The time period of 2 weeks for of light	○	○	○	○	○commencement

tasks/activities/function after
2nd to 5th metacarpal fractures.

The time period of 4 weeks for ○ ○ ○ ○ ○
commencement of
medium/moderate
tasks/activities
/function after
2nd to 5th
metacarpal
fractures.

The time period of 6 weeks for ○ ○ ○ ○ ○commencement
of heavy
tasks/activities
/function after
2nd to 5th
metacarpal
fractures.

The time period of 8 to 10 weeks ○ ○ ○ ○ ○
for commencement of
pre-injured
tasks/activities
/function after
2nd to 5th
metacarpal
fractures.

The types of light ○ ○ ○ ○ ○tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.

The types of medium/moderate ○ ○ ○ ○ ○
tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.

The types of heavy ○ ○ ○ ○ ○tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.

This section covers time period of rehabilitation used in the second to fifth metacarpal fractures guideline after surgical fixation. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

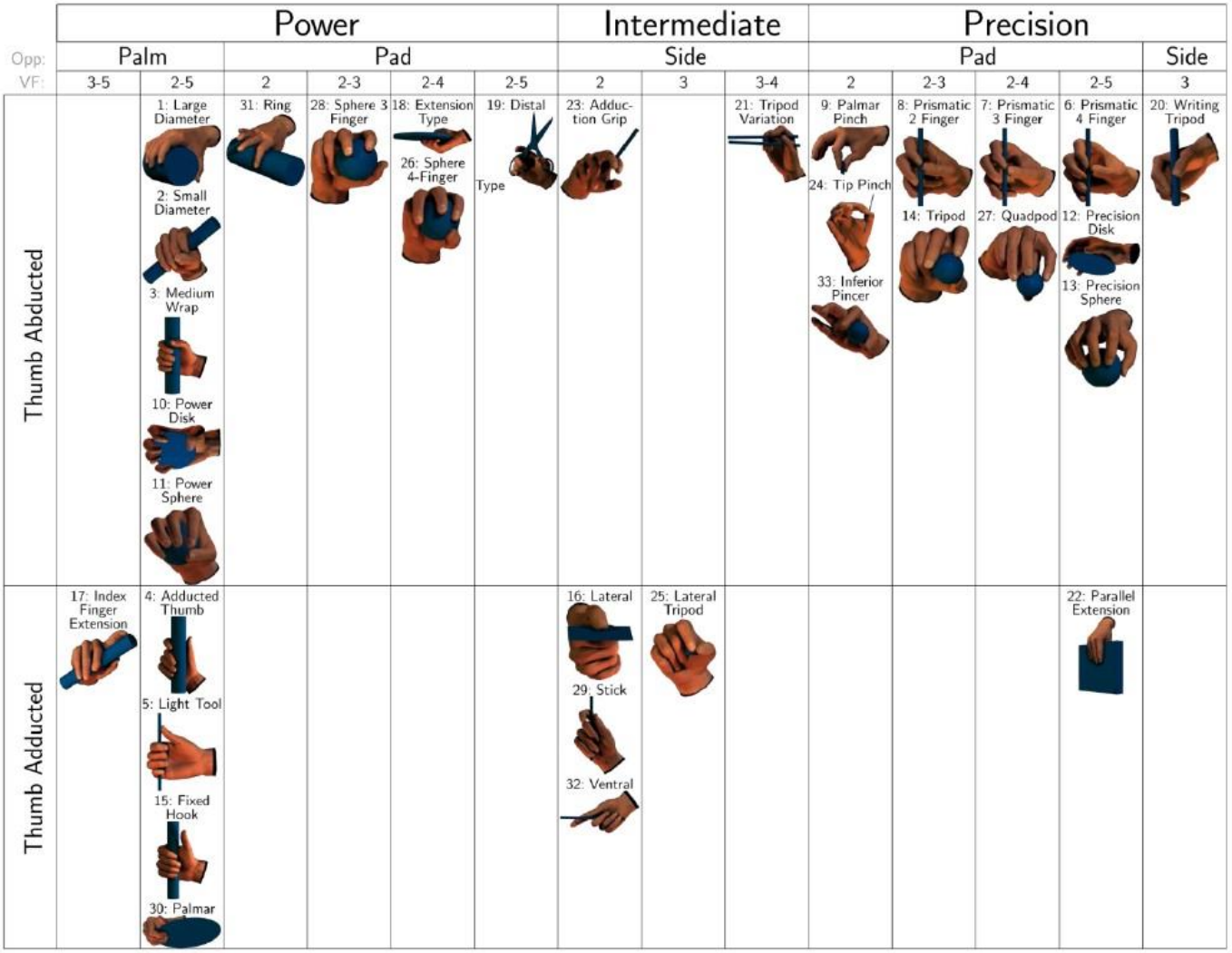
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The time period of 2/52 for Rehabilitation Phase 1 (physiological active movement of unaffected joints) after surgical fixation of 2nd to 5th shaft metacarpal fractures?	○	○	○	○	○commencement of the
The time period of 4/52 for Rehabilitation Phase 2 controlled movement of affected joints after surgical fixation of 2nd to 5th shaft metacarpal fractures?	○	○	○	○	○commencement of the

The time period of 6/52 for ○ ○ ○ ○ ○commencement of the Rehabilitation Phase 3 passive stretching of affected joints?

The time period of 8/52 for ○ ○ ○ ○ ○commencement of the Rehabilitation Phase 4 graded strengthening commences after surgical fixation of 2nd to 5th shaft metacarpal fractures?

Grasps (free active no resistance) allowed per week after injury

2/52 Grasps requiring no or very little MCPJ flexion	4/52 Grasps requiring minimal to 45° MCPJ flexion	6/52 Grasps requiring more than 45° MCPJ flexion	8-10/52 All Grasps with resistance
5. Light Tool 8. Prismatic 2 Fingers 10. Power Disk 12. Precision Disk 15. Fixed Hook 16. Lateral 17. Index Finger Extension (For index finger #) 18. Extension Type 23. Adduction Grip 26. Sphere 4 Fingers 28. Sphere 3 Fingers 32. Ventral (For index finger #) 33. Inferior Pincher Respect pain < 3/10.	1. Large Diameter 3. Medium Wrap 4. Adducted Thumb 6. Prismatic 4 Fingers 7. Prismatic 3 Fingers 9. Palmar Pinch 14. Tripod 21. Tripod variation 24. Tip Pinch 31. Ring Index finger #	2. Small Diameter 11. Power Sphere 13. Precision Sphere 17. Index Finger Extension (For middle-, ring- and little finger #) 19. Distal 20. Writing Tripod 22. Parallel Extension 25. Lateral Tripod 27. Quadpod 29. Stick 30. Palmar 32. Ventral (For middle-, ring- and little finger #)	All Grasps if no pain is present. If pain persists, consult your medical doctor.



This section covers the time period of grasp rehabilitation exercises with the grasp type according to the Feix et al., 2016 above in the clinical hand rehabilitation guideline for second to fifth metacarpal fractures guideline. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The inclusion of grasp types ○ ○ ○ ○ ○requiring no or very little MCPJ flexion (types included above) at 2/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?					

The inclusion of grasp types ○ ○ ○ ○ ○requiring requiring minimal to 45° MCPJ flexion (types included above) at 4/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?

The inclusion of grasp types ○ ○ ○ ○ ○requiring requiring more than 45° MCPJ flexion (types included above) at 6/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?

The inclusion of grasp types ○ ○ ○ ○ ○requiring full MCPJ flexion (all grasp types) at 8/52 for commencement of graded strengthening exercises for 2nd to 5th metacarpal fractures?

Splinting type and time period following 2nd to 5th SHAFT metacarpal fracture after surgical fixation or reduction and conservative management are covered in this section.

Shaft 2nd to 5th metacarpal fracture rehabilitation programme after fixation or reduction and immobilisation.

Splint, timeframe of use and rehabilitation in splint after Second to fifth SHAFT metacarpal fractures after Fixation with ORIF or K-wire

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Shaft	Fixation: ORIF or K-wire	Forearm-based wrist 20° extension, dorsal hood place MCPJ in 70°, IPJ free Or 	Wear for 2/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension. IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

Splint, timeframe of use and rehabilitation in splint after Second to fifth SHAFT metacarpal fractures after Reduction with immobilization or immobilization.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Shaft	Reduction with Immobilisation Or Immobilisation alone	Forearm-based wrist 20° extension, dorsal hood place MCPJ in 70°, IPJ free Or 	Wear for 4/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension. IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

This section covers the rehabilitation guideline after SHAFT of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splint used after surgical fixation of a SHAFT of 2nd to 5th metacarpal fractures?	○	○	○	○	○
The splinting time period after surgical fixation for a SHAFT of 2nd to 5th metacarpal fracture management?	○	○	○	○	○
The splint used after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?	○	○	○	○	○
The splinting time period after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?	○	○	○	○	○

Explain why you don't agree with the splint used after surgical fixation of 2nd to 5th shaft metacarpal fractures? What type of splint do you use? Provide _____ exact joints included in the splint and what degrees the joints are positioned in.	
Describe why you don't agree with the splinting time period after surgical fixation 2nd to 5th shaft metacarpal fractures? For how long will you keep the splint on?	_____
Explain why you don't agree with the splint used after conservative management of 2nd to 5th shaft metacarpal fractures? And what type of splint you use. Provide exact joints included in the splint and what degrees the joints are positioned in.	_____
Explain why you don't agree with the splinting time period after conservative management of 2nd to 5^{th} shaft metacarpal fractures? And what how long you instruct the splint to be on.	_____

This section covers the rehabilitation guideline after BASE of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management.

BASE of 2nd to 5th Metacarpal fracture rehabilitation programme.

Splint, timeframe of use and rehabilitation in splint after Second to fifth BASE metacarpal fractures after Fixation with ORIF or K-wire.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Base	Fixation: ORIF or K-wire	Forearm-based wrist 20° extension, MCPJ and IPJ free 	Wear for 2/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

Splint, timeframe of use and rehabilitation in splint after Second to fifth BASE metacarpal fractures after Reduction with immobilization or immobilization

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Base	Reduction with Immobilisation Or Immobilisation alone	Forearm-based wrist 20° extension, MCPJ and IPJ free 	Wear for 4/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension. MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

This section covers the rehabilitation guideline after BASE of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splint used after surgical fixation of a BASE of 2nd to 5th metacarpal fractures?	○	○	○	○	○
The splinting time period after surgical fixation for a BASE of 2nd to 5th metacarpal fracture management?	○	○	○	○	○
The splint used after conservative management for a BASE of 2nd to 5th metacarpal fractures?	○	○	○	○	○
The splinting time period after conservative management for a BASE of 2nd to 5th metacarpal fractures?	○	○	○	○	○

Explain why you don't agree with the splint used after surgical fixation of 2nd to 5th base metacarpal fractures? What type of splint do you use? Provide _____ exact joints included in the splint and what degrees the joints are positioned in.

Describe why you don't agree with the splinting time period after surgical fixation 2nd to 5th base metacarpal fractures? For how long will you keep the splint on? _____

Explain why you don't agree with the splint used after conservative management of 2nd to 5th base metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in. _____

Describe why you don't agree with the splinting time period after conservative management 2nd to 5th base metacarpal fractures? For how long will you keep the splint on? _____

This section covers the rehabilitation guideline after a HEAD of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management.

Head of 2nd to 5th Metacarpal fracture rehabilitation programme.

Splint, timeframe of use and rehabilitation in splint after second to fifth HEAD metacarpal fractures after Fixation with a K-wire.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Head	Fixation: K-wire	Hand based dorsal hood gutter splint: affected and adjacent finger MCPJ in 70° flexion. Wrist, all IPJ and unaffected MCPJ free 	Discard Splint after 2/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., wrist flexion, extension, ulnar and radial deviation, pronation and supination, unaffected MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

Splint, timeframe of use and rehabilitation in splint after second to fifth HEAD metacarpal fractures after Reduction with immobilisation or immobilisation.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Head	Reduction with Immobilisation Or Immobilisation alone	Hand based dorsal hood gutter splint: affected and adjacent finger MCPJ in 70° flexion. Wrist, all IPJ and unaffected MCPJ free 	Discard Splint 4/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., wrist flexion, extension, ulnar and radial deviation, pronation and supination, unaffected MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

This section covers the rehabilitation guideline after a HEAD of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splint used after surgical fixation of 2nd to 5th HEAD metacarpal fractures?	○	○	○	○	○
The splinting time period after surgical fixation 2nd to 5th HEAD metacarpal fracture management?	○	○	○	○	○
The splint used after conservative management of 2nd to 5th HEAD metacarpal fractures?	○	○	○	○	○

The splinting time period after management of 2nd to 5th HEAD metacarpal fractures? ○ ○ ○ ○ ○conservative

Explain why you don't agree with the splint used after surgical fixation of 2nd to 5th head metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in. _____

Describe why you don't agree with the splinting time period after surgical fixation 2nd to 5th head metacarpal fractures? For how long will you keep the splint on? _____

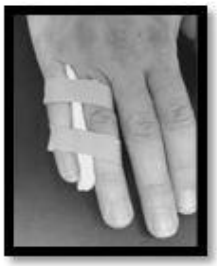
Explain why you don't agree with the splint used after conservative management of 2nd to 5th shaft metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in. _____

Describe why you don't agree with the splinting time period after conservative management of 2nd to 5th head metacarpal fractures? For how long will you keep the splint on? _____

This section covers the rehabilitation guideline after a NECK of 5th (BOXERS) metacarpal fracture after surgical fixation or reduction and conservative management.

NECK of 5th (BOXERS) Metacarpal fracture rehabilitation programme.

Splint, timeframe of use and rehabilitation in splint after NECK OF 5TH (BOXERS) metacarpal fractures after Fixation with a K-wire.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Neck: Boxers 5th Metacarpal	Fixation: K-wire	Buddy strapping of affected and adjacent finger 	Wear for 2/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., wrist flexion, extension, ulnar and radial deviation, pronation and supination, unaffected MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

Splint, timeframe of use and rehabilitation in splint after NECK OF 5TH (BOXERS) metacarpal fractures after Reduction with immobilization or immobilization

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Neck: Boxers 5th Metacarpal	Reduction with Immobilisation Or Immobilisation alone	Buddy strapping of affected and adjacent finger 	Wear buddy strapping for 2-3/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., wrist flexion, extension, ulnar and radial deviation, pronation and supination, unaffected MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

This section covers the rehabilitation guideline after a NECK of 5th (BOXERS) metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splint used after surgical fixation of NECK5th_BOXERS _metacarpal fractures?	○	○	○	○	○
The splinting time period after surgical fixation NECK_5th_BOXERS metacarpal	○	○	○	○	○

fracture
management?

The splint used after ○ ○ ○ ○ ○conservative management for NECK of 5th_BOXERS metacarpal fractures?

The splinting time period after ○ ○ ○ ○ ○conservative management of NECK of 5th BOXERS metacarpal fractures?

Explain why you don't agree with the splint or immobilisation used after conservative management of a Boxers neck of 5th shaft metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in.

Describe why you don't agree with the splinting time period after conservative management of a Boxers neck of 5th head metacarpal fractures? For how long will you keep the splint on?

Explain why you don't agree with the splint used after surgical fixation of a Boxers neck of 5th shaft metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in.

Describe why you don't agree with the splinting time period after surgical fixation of a Boxers neck of 5th metacarpal fractures? For how long will you keep the splint on?

This section covers the rehabilitation guideline after a NECK of 2nd to 4th metacarpal fracture after surgical fixation or reduction and conservative management.

NECK of 2nd to 4th Metacarpal fracture rehabilitation programme.

Splint, timeframe of use and rehabilitation in splint after second to fourth NECK metacarpal fractures after Fixation with a K-wire.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
2nd to 4th Neck	Fixation: K-wire	Hand based volar gutter splint: affected and adjacent finger MCPJ in 70° flexion. All IPJ and unaffected MCPJ free  Or Buddy strapping of affected and adjacent finger 	Wear for 2/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., wrist flexion, extension, ulnar and radial deviation, pronation and supination, unaffected MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

Splint, timeframe of use and rehabilitation in splint after second to fourth NECK metacarpal fractures after Reduction with immobilisation or immobilization.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
2nd to 4th Neck	Reduction with Immobilisation Or Immobilisation alone	Hand based volar gutter splint: affected and adjacent finger MCPJ in 70° flexion. All IPJ and unaffected MCPJ free  Or Buddy strapping of affected and adjacent finger 	Wear for 2/52 if splint used then change to buddy strapping for 2/52 additional weeks	Free active movement of thumb opposition, abduction, adduction, flexion, extension., wrist flexion, extension, ulnar and radial deviation, pronation and supination, unaffected MCPJ and IPJ extension and flexion Dosage: 3 sets x 10 reps x 3 sessions per day

This section covers the rehabilitation guideline after a NECK of 2nd to 4th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splint used after surgical fixation of 2nd to 4th NECK metacarpal fractures?	○	○	○	○	○

The splinting time period after 2nd to 4th NECK metacarpal fracture management? ○ ○ ○ ○ ○surgical fixation

The splint used after to 4th NECK metacarpal fractures? ○ ○ ○ ○ ○conservative management of 2nd

The splinting time period after management of 2nd to 4th NECK metacarpal fractures? ○ ○ ○ ○ ○conservative

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Explain why you don't agree with the splint or immobilisation used after surgical fixation of 2nd to 5th Neck metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in. _____

Explain why you don't agree with the splint or immobilisation used after conservative management of 2nd to 5th Neck metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in. _____

Describe why you don't agree with the splinting time period after conservative management of a 2nd to 5^{th} neck metacarpal fractures? For how long will you keep the splint on? _____

Describe why you don't agree with the splinting time period after surgical fixation of a 2nd to 5th neck metacarpal fracture management? For how long will you keep the splint on?	_____

Addendum T

REDCap Questionnaire: Round Two

Second to fifth metacarpal fracture clinical hand rehabilitation guideline_Round Two

Dear potential participant.

My name is Monique Keller, and I am conducting a research study in fulfilment for the degree Doctor in

Physiotherapy at the University of the Free State under the supervision of Dr Roline Barnes and Dr Corlia Brandt.

Ethical clearance

I have received ethical clearance for Phase I and II from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State number: UFS-HSD2019/0046/2602 and UFS-HSD2019/0046/2602-0002 respectively. Phase III of the clinical trial was approved by the HSREC with the number.

Aim

The aim of Phase III is to finalise the proposed clinical hand rehabilitation guideline for second to fifth metacarpal fractures.

Objectives

The objectives of Phase III are:

To determine the consensus among purposively sampled expert surgeons, PT's and OT's in the field of hand injuries, hand surgery and hand rehabilitation, with the use of a REDCap questionnaire, investigating their consensus on the developed clinical hand rehabilitation guideline.To adapt and finalise the clinical hand rehabilitation guideline based on the information obtained from the expert panel members of the Delphi.

Description of procedures

Informed consent will be requested in an email. Upon receiving the signed consent document the researcher will email the REDcap questionnaire link asking you to complete the REDCap questionnaire. A three round Delphi method will be used to reach consensus and if consensus is not reached after three rounds, a final fourth Delphi round will be run, to inform the

objectives. In the instance where there are no additional changes, stability will be assumed. Upon completion of the first round Delphi, statistical analysis will be performed and you will receive a summary of the results in a feedback email. A two week time period will be allowed for the completion of the questionnaire. In addition a two week period between the first and second round will occur to allow the researcher time to analyse the results and forward the summary of findings to you. A one week reminder will be sent to all participants prior to each Delphi round. Questions included in the questionnaire are demographical questions, to better understand to which population the hand rehabilitation guideline can be generalised to, followed by questions to establish the agreement of participating experts on included questions on a five-point Likert scale ranging from 1 strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly agree. Themes in the questionnaire will include: physiological healing timeframes and commencement of exercises, rehabilitation exercises, splints used, splinting timelines, timelines when patients are advice to return to tasks and advice regarding light, medium, hard and pre-injured tasks included.

Voluntary participation

Your participation is entirely voluntary, and you will not be negatively affected by your choice. You have the right to withdraw from the research at any point. Explicit withdrawal must be sent to Monique Keller (contact details below) and only after receiving the written withdrawal will correspondence be stopped. Absent responses will be seen as non-interest and no further information will be sent. Experts not responding to the first round Delphi, but who indicated an interest to participate, will receive two reminders and questionnaire links in the form of emails before this will be viewed as non-participation. No remuneration will be offered to participating experts.

Participant responsibility

Your responsibility will include: Complete a RedCap questionnaire in a three round Delphi technique.

Payment

No payment will be issued for your participation.

Feedback

Upon completion of the first round Delphi, each participating expert will receive a summary of the results.

Anonymity and Confidentiality

Anonymity among participants will be ensured by using separate emails in all communication. The results of the questionnaire will be kept confidential, and your name will not be seen on any documentation. The results will be published in an article and thesis, but confidentiality will be maintained. With your consent to participate, you also agree to not distribute the clinical guideline till it has been accepted or published.

Technical support

Technical support services namely, Redcap's Help Centre, can be contacted if there are any technical support required.

To complete the questionnaire select "true" in the

first option. Sincerely,

Monique

Keller

0117173715

monique.keller

@wits.ac.za

Please

complete the

survey below.

Thank you!

Hand rehabilitation guideline for 2nd to 5th metacarpal fractures_General Questions	
I have read and understood the contents of theTrue information sheet. I am participating voluntarily inFalse this study. I understand that I may be able to withdrawn from this study at any time without bias. I consent to participate in this survey. (If you do not wish to participate, select False)	◯ ◯

Have you participated in Round One? If yes, tick the yes option. Thank you and you may proceed to Round Two. If no, thank you for your interest. Round Two is only for returning participants. Please do not proceed.	◯ Yes ◯ No

A1

Gender	◯ Male ◯ Female

What is your age?

_____

_____

A	In which professional capacity do you work?	◯ Orthopaedic surgeon ◯ Orthopaedic surgeon with specialty ◯ Physiotherapist ◯ Occupational Therapist

A4 In which country are you practicing hand injury management in? _____

This section covers the time period and types of light, moderate, heavy and pre-injured tasks/functions/activities return to daily activities.

A testing phase of 105 activities of daily living with force sensing resistors on all 10 fingers precluded the compilation of what tasks to add to which category. Force voltages were converted to newtons. The thumb outweighed forces as preempted by the thumbs importance in functioning. My reasoning for the inclusion of tasks stems from the results. When guiding patients to respect pain the bilateral hand use with the splint in place provides safe early return to function and not allowing fear avoidance behaviour. An example snippet of the test sheet can be seen below.

Test sheet with predominant grasp types and results

	Functional Task	Predominant type of Grasp used (predominantly)	Light Forces (0-3 N) (Tick if appropriate)	Moderate Forces (3-7 N) (Tick if appropriate)	High demar Forces (7-20 N) (Ti if appropriat
1	Wash body with washcloth	25. Lateral tripod	X		
2	Wash hair	13. Precision Sphere	X		
3	Squeezing water out of a sponge	11. Power Sphere	X		
4	Wringing water out of a washcloth	2. Small Diameter		X	

To determine consensus regarding the developed hand rehabilitation programme for second to fifth metacarpal fractures, look at the uploaded image before answering the questions.

tasks_permitted

Tasks allowed per week after surgery or after the injury

Light tasks allowed from 2/52 post surgical fixation without a splint & 2/52 after date of injury for conservative management with SPLINT ON.	**Moderate tasks allowed from 4/52 post surgical fixation without a splint & 4/52 after date of injury for conservative management with SPLINT ON.**	**Heavy tasks allowed from 6/52 Without splint for both surgical and conservative groups.**	**Resume pre-injured tasks from 8-10/52**
Respect pain < 3/10.Personal care and Hygiene tasks but no Wringing water out of washcloth with force, carry buckets (weight > 1kg) or sink basins, dry water out of clothes and take care with putting socks on and opening and closing a belt buckle. Home environment: Inside allowed but no opening new or tight jars or stir mealie pap/heavy porridge. No picking up children, move furniture or turning a salt or pepper grinder. No gardening allowed. No driving.	Start driving when ring or index finger metacarpal fracture. Pick up weight < 2kg.	Start driving for all metacarpal fractures. Do not hang on the overhead rail or hand support in a car or taxi. Pick up weight less than 5kg.	Resume all tasks If no pain is present. If pain persists, consult your medical doctor.

This section covers the time period and types of light, moderate, heavy and pre-injured tasks/functions/activities return to daily activities. Please indicate your agreement on

the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The types of light tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.	○	○	○	○	○
The types of medium/moderate tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.	○	○	○	○	○

Do you agree with the types of light tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures?	○ Ye ○ No
Do you agree with the types of medium/moderate tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures?	○ Ye ○ No

Monique's Reasoning:
Rehabilitation Phase 1 starts at 2 weeks post surgery _____ and 2 weeks after the date of injury. The rehab phase includes free active range of motion exercises for unaffected joints not influencing the injured MCPJ but encouraging joint motion and gliding of soft tissues. For this reason, it is deemed safe.

Rehabilitation Phase 2 starts at 4 weeks post surgery and 4 weeks after the date of injury. The rehab phase includes controlled motion of the affected MCPJ guided by a control X-ray and clinical features pain and tenderness with palpation.

Rehabilitation Phase 3 starts at 6 weeks post surgery and 6 weeks after the date of injury. The rehab phase includes passive stretching of the affected MCPJ. At the 6 week phase literature La Stayo, Winter and Hardy (2003) observed sufficient callus formation at 6 weeks and supported in recent

literature. Gülke et al (2018) and Midgley and Toemen (2010 & 2011) added stretching exercises at this timeframe.

Rehabilitation Phase 4 starts between 8-10 weeks and includes graded strengthening exercises. At eight weeks bone union is stronger and literature supports strengthening at 8 weeks. Gülke et al (2018) even started strengthening with pegs at 6 weeks post surgical intervention. By starting grading the strengthening from lighter resistance to heavier from 8 weeks is thus deemed safe.

This section covers time period of rehabilitation used in the second to fifth metacarpal fractures guideline after surgical fixation and conservative managment. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The time period of 2/52 for the Rehabilitation Phase 1 (physiological active movement of unaffected joints) for 2nd to 5th metacarpal fractures?	○	○	○	○	○
The time period of 4/52 for the Rehabilitation Phase 2 controlled movement of affected joints for 2nd to 5th metacarpal fractures?	○	○	○	○	○
The time period of 6/52 for the Rehabilitation Phase 3 passive stretching of affected joints after for 2nd to 5th metacarpal fractures?	○	○	○	○	○

The time period of 8/52 for the Rehabilitation Phase 4 graded strengthening commences for 2nd to 5th metacarpal fractures?	○commencement of	○	○	○	○

Do you agree with the time period of 2/52 for commencement of the Rehabilitation Phase 1 (physiological active movement of unaffected joints) for 2nd to 5th metacarpal fractures after surgical fixation?

○ Ye
○ No

Do you agree with the time period of 2/52 for commencement of the Rehabilitation Phase 1 (physiological active movement of unaffected joints) for 2nd to 5th metacarpal fractures after conservative management?

○ Ye
○ No

Do you agree with the time period of 4/52 for commencement of the Rehabilitation Phase 2 controlled No movement of affected joints for 2nd to 5th metacarpal fractures after surgical fixation?

○ Yes
○

Do you agree with the time period of 4/52 for commencement of the Rehabilitation Phase 2 controlled No movement of affected joints for 2nd to 5th metacarpal fractures after conservative management?

○ Yes
○

Do you agree with the time period of 6/52 for commencement of the Rehabilitation Phase 3 passive stretching of affected joints after surgical fixation for 2nd to 5th metacarpal fractures?	○ Yes ○ No
Do you agree with the time period of 6/52 for commencement of the Rehabilitation Phase 3 passive stretching of affected joints after conservative management?	○ Yes ○ No
Do you agree with the time period of 8/52 for commencement of the Rehabilitation Phase 4 graded strengthening commences for 2nd to 5th shaft metacarpal fractures after surgical fixation?	○ Yes ○ No
Do you agree with the time period of 8/52 for commencement of the Rehabilitation Phase 4 graded strengthening commences for 2nd to 5th shaft metacarpal fractures after conservative management?	○ Yes ○ No

Grasp types exercises.

This section covers the time period of grasp rehabilitation exercises with the grasp type according to the Feix et al., 2016 above in the clinical hand rehabilitation guideline for second to fifth metacarpal fractures guideline. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

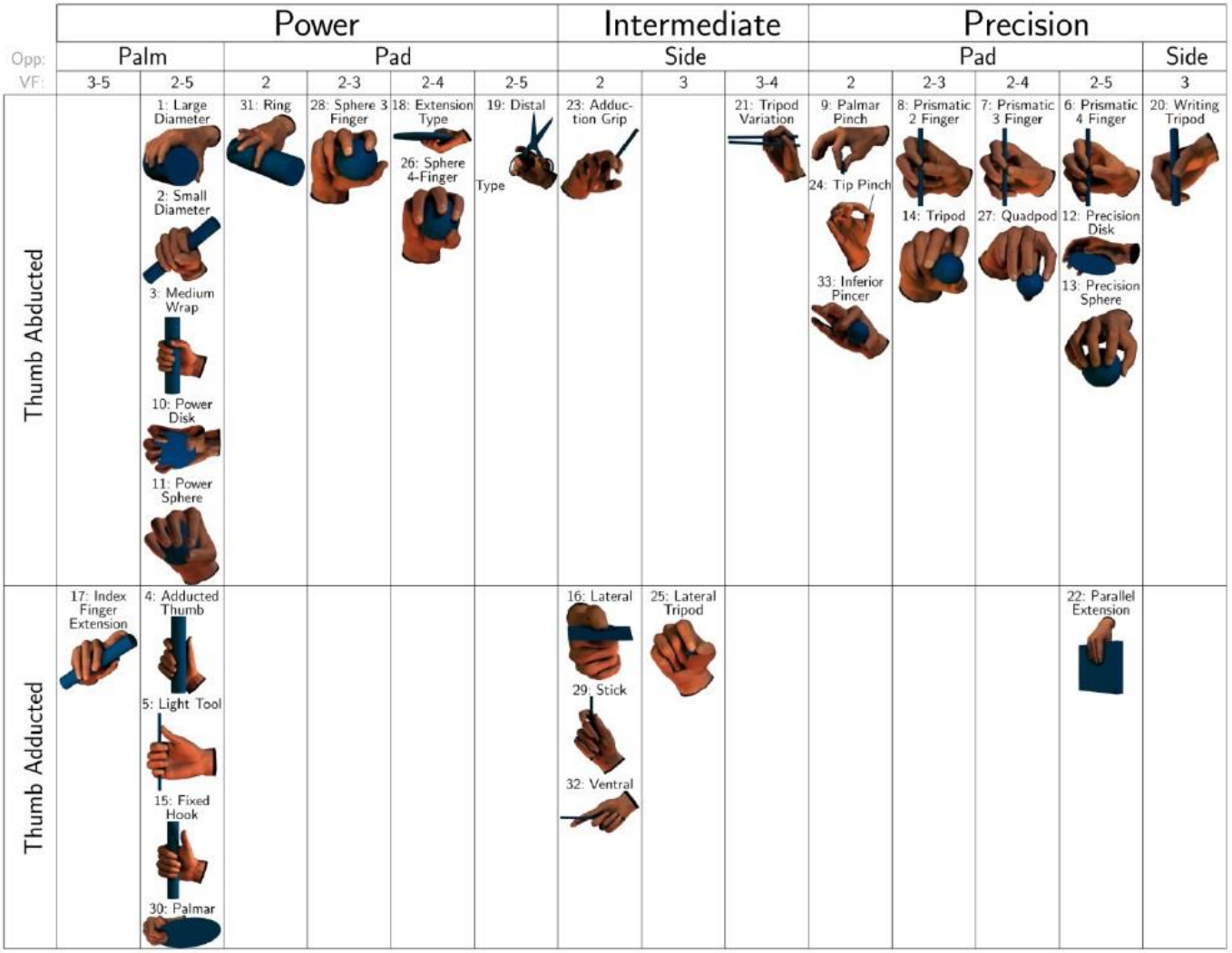
Monique's reasoning:

Gülke et al 2018 in their randomised control trial investigated participants presenting with second to fifth metacarpal fractures after surgical fixation. From two weeks the participants started with an exercise programme where the MCPJ's are actively flexed to about 80degrees at two weeks within limits of pain with no complications. The suggested graded MCPJ range of motion in this guideline is thus deemed safer.

Midgley and Toemen 2011 allowed light activities from two weeks without grading the MCPJ ROM. When considering a task for example dressing putting on a shirt the MCPJ's are in excess of flexion than what this guideline suggests. Thus safety is ensured as the grasps are free active and no resistance till eight weeks.

Grasps (free active no resistance) allowed per week after injury

2/52 Grasps requiring no or very little MCPJ flexion	4/52 Grasps requiring minimal to 45° MCPJ flexion	6/52 Grasps requiring more than 45° MCPJ flexion	8-10/52 All Grasps with resistance
5. Light Tool 8. Prismatic 2 Fingers 10. Power Disk 12. Precision Disk 15. Fixed Hook 16. Lateral 17. Index Finger Extension (For index finger #) 18. Extension Type 23. Adduction Grip 26. Sphere 4 Fingers 28. Sphere 3 Fingers 32. Ventral (For index finger #) 33. Inferior Pincher Respect pain < 3/10.	1. Large Diameter 3. Medium Wrap 4. Adducted Thumb 6. Prismatic 4 Fingers 7. Prismatic 3 Fingers 9. Palmar Pinch 14. Tripod 21. Tripod variation 24. Tip Pinch 31. Ring Index finger #	2. Small Diameter 11. Power Sphere 13. Precision Sphere 17. Index Finger Extension (For middle-, ring- and little finger #) 19. Distal 20. Writing Tripod 22. Parallel Extension 25. Lateral Tripod 27. Quadpod 29. Stick 30. Palmar 32. Ventral (For middle-, ring- and little finger #)	All Grasps if no pain is present. If pain persists, consult your medical doctor.



This section covers the time period of grasp rehabilitation exercises with the grasp type according to the Feix et al., 2016 above in the clinical hand rehabilitation guideline for second to fifth metacarpal fractures guideline. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The inclusion of grasp types ○ ○ ○ ○ ○requiring no or very little MCPJ flexion (types included above) at 2/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?					

The inclusion of grasp types requiring requiring minimal to 45° MCPJ flexion (types included above) at 4/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?

The inclusion of grasp types ○ ○ ○ ○ ○requiring requiring more than 45° MCPJ flexion (types included above) at 6/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?

The inclusion of grasp types ○ ○ ○ ○ ○requiring full MCPJ flexion (all grasp types) at 8/52 for commencement of graded strengthening exercises for 2nd to 5th metacarpal fractures?

In this section covering SHAFT metacarpal fractures TWO Splinting types (Option 1 & 2) and time periods following 2nd to 5th SHAFT metacarpal fracture after surgical fixation or reduction and conservative management are covered.

Monique's reasoning:

Time period of immobilisation

Immobilisation period following surgical fixation in Gülke et al. 2018 Randomised control trial lasted for 2 weeks before commencing physiotherapy and a home exercise programme. Very good outcomes for metacarpophalangeal range of motion, grip strength and hand function were achieved with no complications. Midgley and Toemen (2010 & 2011) immobilised second to fifth metacarpal fractures treated conservatively for 4 weeks and thereafter protective and night splinting for a further 2 weeks with good outcomes.

Option 1 after Surgical fixation

Shaft	**Fixation: ORIF or K-wire**	Dorsal and volar hand-based (Sandwich type) splint placing MCPJ in 70° flexion, IPJ and wrist free. 	Wear for 2/52

Option 1 after Conservative management

Shaft	**Reduction with Immobilisation Or Immobilisation alone**	Dorsal and volar hand-based (Sandwich type) splint placing MCPJ in 70° flexion, IPJ and wrist free 	Wear for 4/52, splint night use and protection for further 2/52, discard after 6/52

This section covers the rehabilitation guideline splinting (Option 1) after SHAFT of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

Strongly Disagree Neutral Agree Strongly Agree

Disagree

The splint used after surgical ○ ○ ○ ○ ○fixation of a SHAFT of 2nd to 5th metacarpal fractures?

The splinting time period after surgical fixation for a SHAFT of 2nd to 5th metacarpal fracture management?

The splint used after ○ ○ ○ ○ ○conservative management for a SHAFT of 2nd to 5th metacarpal fractures?

The splinting time period after ○ ○ ○ ○ ○conservative management for a SHAFT of 2nd to 5th metacarpal fractures?

Do you agree with the splint used after surgical fixation of 2nd to 5th shaft metacarpal fractures? What type of splint do you use?
○ Ye
○ No

Explain why you don't agree with the splint used after surgical fixation of 2nd to 5th shaft metacarpal fractures? What type of splint do you use? Provide _____ exact joints included in the splint and what degrees the joints are positioned in.

Do you agree with the splinting time period after surgical fixation 2nd to 5th shaft metacarpal fractures?
○ Ye
○ No

Describe why you don't agree with the splinting time period after surgical fixation 2nd to 5th shaft metacarpal fractures? For how long will you keep the _____ splint on?

Do you agree with the splint used after conservative management of 2nd to 5th shaft metacarpal fractures?
○ Ye
○ No

Explain why you don't agree with the splint used after conservative management of 2nd to 5th shaft metacarpal

fractures? And what type of splint you use. Provide _____ exact joints included in the splint and what degrees

the joints are positioned in.

Do you agree with the splinting time period after conservative management of 2nd to 5th shaft metacarpal fractures?

○ Ye
○ No

Explain why you don't agree with the splinting time period after conservative management of 2nd to 5th

shaft metacarpal fractures? And what how long you _____ instruct the splint to be on.

Option 2 after Surgical fixation

Shaft	**Fixation: ORIF or K-wire**	Forearm-based wrist 20° extension, dorsal hood place MCPJ in 70°, IPJ free. 	Wear for 2/52

Option 2 after Conservative management

Shaft	**Reduction with Immobilisation Or Immobilisation alone**	Forearm-based wrist 20° extension, dorsal hood place MCPJ in 70°, IPJ free 	Wear for 4/52, splint night use and protection for further 2/52, discard after 6/52

This section covers the rehabilitation guideline splinting (Option 2) after SHAFT of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splint used after surgical fixation of a SHAFT of 2nd to 5th metacarpal fractures?					
The splinting time period after surgical fixation of a SHAFT of 2nd to 5th metacarpal fractures?	○	○	○	○	○
The splint used after conservative management of a SHAFT of 2nd to 5th metacarpal fractures?	○	○	○	○	○
The splinting time period after conservative management of a SHAFT of 2nd to 5th metacarpal fractures?	○	○	○	○	○

This section covers the rehabilitation guideline after BASE of 2nd to 5th metacarpal fracture after surgical fixation or reduction.

Monique's reasoning:

Immobilisation period following surgical fixation in Gülke et al. 2018 Randomised control trial lasted for 2 weeks before commencing a physiotherapy and a home exercise programme. Immobilisation was achieved by using a palmar wrist extension splint with unaffected fingers left free. Very good outcomes for metacarpophalangeal range of motion, grip strength and hand function were achieved with no complications.

BASE of 2nd to 5th Metacarpal fracture rehabilitation programme.

Splint, timeframe of use and rehabilitation in splint after Second to fifth BASE metacarpal fractures after Fixation with ORIF or K-wire.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Base	Fixation: ORIF or K-wire	Forearm-based wrist 20° extension, MCPJ and IPJ free 	Wear for 2/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

This section covers the rehabilitation guideline after BASE of 2nd to 5th metacarpal fracture after surgical fixation. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splinting time period after surgical fixation for a BASE of 2nd to 5th metacarpal fracture management?	○	○	○	○	○

Do you agree with the splinting time period after surgical fixation 2nd to 5th base metacarpal fractures?

○ Ye
○ No

Describe why you don't agree with the splinting time period after surgical fixation 2nd to 5th base

metacarpal fractures? For how long will you keep the _____ splint on?

This section covers the rehabilitation guideline after a HEAD of 2nd to 5th metacarpal fracture after surgical fixation or reduction.

Immobilisation period following surgical fixation in Gülke et al. 2018 Randomised control trial lasted for 2 weeks before commencing a physiotherapy and a home exercise programme. Immobilisation was achieved by using a palmar wrist extension splint with unaffected fingers left free. Very good outcomes for metacarpophalangeal range of motion, grip strength and hand function were achieved with no complications.

Head of 2nd to 5th Metacarpal fracture rehabilitation programme.

Splint, timeframe of use and rehabilitation in splint after second to fifth HEAD metacarpal fractures after Fixation with a K-wire.

Location of Metacarpal Fracture	Medical management Surgical or Conservative	Immobilisation/ Splint type	Splint use instructions	Rehabilitation in Splint
Head	Fixation: K-wire	Hand based dorsal hood gutter splint: affected and adjacent finger MCPJ in 70° flexion. Wrist, all IPJ and unaffected MCPJ free 	Discard Splint after 2/52	Free active movement of thumb opposition, abduction, adduction, flexion, extension., wrist flexion, extension, ulnar and radial deviation, pronation and supination, unaffected MCPJ and IPJ flexion and extension Dosage: 3 sets x 10 reps x 3 sessions per day

This section covers the rehabilitation guideline after a HEAD of 2nd to 5th metacarpal fracture after surgical fixation. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree
The splint used after surgical fixation of 2nd to 5th HEAD metacarpal fractures?	○	○	○	○	○				
The splinting time period after surgical fixation 2nd to 5th HEAD metacarpal fracture management?	○	○	○	○	○				

Do you agree with the splint used after surgical fixation of 2nd to 5th head metacarpal fractures?
○ Ye
○ No

Explain why you don't agree with the splint used after
surgical fixation of 2nd to 5th head metacarpal

fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in.

Do you agree with the splinting time period after surgical fixation 2nd to 5th head metacarpal fractures?

○ Ye
○ No

Describe why you don't agree with the splinting time period after surgical fixation 2nd to 5th head metacarpal fractures? For how long will you keep the splint on?

This section covers the rehabilitation guideline after a NECK of 5th (BOXERS) metacarpal fracture after surgical fixation or reduction and conservative management.

Monique's reasoning:

Time period of immobilisation

Immobilisation period following surgical fixation in Gülke et al. 2018 Randomised control trial lasted for 2 weeks before commencing physiotherapy and a home exercise programme. Very good outcomes for metacarpophalangeal range of motion, grip strength and hand function were achieved with no complications. Midgley and Toemen (2010 & 2011) immobilised second to fifth metacarpal fractures treated conservatively for 4 weeks and thereafter protective and night splinting for a further 2 weeks with good outcomes.

NECK of 5th (BOXERS) Metacarpal fracture rehabilitation programme.

Neck: **Boxers 5th** **Metacarpal**	**Fixation: K-wire**	Hand based dorsal gutter splint: affected and adjacent finger MCPJ in 70° flexion. All IPJ and unaffected MCPJ free. 	Wear for 2/52

Neck: **Boxers 5th** **Metacarpal**	**Reduction with** **Immobilisation** **Or** **Immobilisation** **alone**	Hand based dorsal gutter splint: affected and adjacent finger MCPJ in 70° flexion. All IPJ and unaffected MCPJ free. 	Wear for 2/52, splint night use and protection for further 2/52, discard after 6/52

This section covers the rehabilitation guideline after a NECK of 5th (BOXERS) metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The splint used after surgical fixation of NECK5th_BOXERS_metacarpal fractures?	○	○	○	○	○
The splinting time period after surgical fixation NECK_5th_BOXERS metacarpal fracture management?	○	○	○	○	○
The splint used after conservative management for NECK of 5th_BOXERS metacarpal fractures?	○	○	○	○	○
The splinting time period after conservative management of NECK of 5th BOXERS metacarpal fractures?	○	○	○	○	○

Do you agree with the splint used after surgical fixation of a Boxers neck of 5th shaft metacarpal fractures?	Yes No	○ ○
Explain why you don't agree with the splint used after surgical fixation of a Boxers neck of 5th shaft		

metacarpal fractures? What type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in.

_____

Do you agree with the splinting time period after surgical fixation of a Boxers neck of 5th metacarpal fractures?

○ Ye
○ No

Describe why you don't agree with the splinting time period after surgical fixation of a Boxers neck of 5th metacarpal fractures? For how long will you keep the splint on?

_____

Do you agree with the splint or immobilisation used after conservative management of a Boxers neck of 5th shaft metacarpal fractures?

○ Ye
○ No

Explain why you don't agree with the splint or immobilisation used after conservative management of a Boxers neck of 5th shaft metacarpal fractures? What _____ type of splint do you use? Provide exact joints included in the splint and what degrees the joints are positioned in.

Do you agree with the splinting time period after conservative management of a Boxers neck of 5th head metacarpal fractures?

○ Ye
○ No

Describe why you don't agree with the splinting time period after conservative management of a Boxers neck of 5th head metacarpal fractures? For how long will _____ you keep the splint on?

This section covers the rehabilitation guideline after a NECK of 2nd to 4th metacarpal fracture after surgical fixation or reduction and conservative management.

Monique's reasoning:

Time period of immobilisation

Immobilisation period following surgical fixation in Gülke et al. 2018 Randomised control trial lasted for 2 weeks before commencing physiotherapy and a home exercise programme. Very good outcomes for metacarpophalangeal range of motion, grip strength and hand function were achieved with no complications. Midgley and Toemen (2010 & 2011) immobilised second to fifth metacarpal fractures treated conservatively for 4 weeks and thereafter protective and night splinting for a further 2 weeks with good outcomes.

NECK of 2nd to 4th Metacarpal fracture rehabilitation programme.

2nd to 4th Neck	**Fixation: K-wire**	Hand based dorsal gutter splint: affected and adjacent finger MCPJ in 70° flexion. All IPJ and unaffected MCPJ free. 	Wear for 2/52

2nd to 4th Neck	**Reduction with Immobilisation Or Immobilisation alone**	Hand based dorsal gutter splint: affected and adjacent finger MCPJ in 70° flexion. All IPJ and unaffected MCPJ free. 	Wear for 4/52, splint night use and protection for further 2/52, discard after 6/52

This section covers the rehabilitation guideline after a NECK of 2nd to 4th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates

strongly agree. Select one option per statement.

Strongly Disagree

Disagree

Neutral Agree Strongly Agree

○ ○ ○ ○ ○

The splint used after surgical fixation of 2nd to 4th NECK metacarpal fractures?

The splinting time period after ○ ○ ○ ○surgical fixation ○
2nd to 4th NECK metacarpal fracture management?

The splint used after ○ ○ ○ ○conservative management of 2nd ○
to 4th NECK metacarpal fractures?

The splinting time period after ○ ○ ○ ○conservative
management of 2nd to 4th NECK metacarpal fractures? ○

Do you agree with the splint or immobilisation used after surgical fixation of 2nd to 5th Neck metacarpal fractures? ○ Ye ○ No

---

Explain why you don't agree with the splint or immobilisation used after surgical fixation of 2nd to

5th Neck metacarpal fractures? What type of splint do
_____ you use? Provide exact joints included
in the splint

and what degrees the joints are positioned in.

Do you agree with the splinting time period after surgical fixation of a 2nd to 5th neck metacarpal fracture management? ○ Ye ○ No

---

Describe why you don't agree with the splinting time period after surgical fixation of a 2nd to 5th neck

metacarpal fracture management? For how long will you
_____

keep the splint on?

Do you don't agree with the splint or immobilisation used after conservative management of 2nd to 5th Neck metacarpal fractures? ○ Ye ○ No

---

Explain why you don't agree with the splint or immobilisation used after conservative management of

2nd to 5th Neck metacarpal fractures? What type of
_____ splint do you use? Provide exact joints
included in the splint and what degrees the joints are positioned

in.

Do you agree with the splinting time period after conservative management of a 2nd to 5th neck metacarpal fractures?

○ Ye
○ No

Describe why you don't agree with the splinting time period after conservative management of a 2nd to 5th

neck metacarpal fractures? For how long will you keep
_____ the splint on?

Addendum U

REDCap Questionnaire: Round Three

Delphi_Third Round_Second to fifth metacarpal fracture clinical hand rehabilitation guideline

Dear potential participant.

My name is Monique Keller, and I am conducting a research study in fulfilment for the degree Doctor in

Physiotherapy at the University of the Free State under the supervision of Dr Roline Barnes and Dr Corlia Brandt.

Ethical clearance

I have received ethical clearance for Phase I and II from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State number: UFS-HSD2019/0046/2602 and UFS-HSD2019/0046/2602-0002 respectively. Phase III of the clinical trial was approved by the HSREC with the number.

Aim

The aim of Phase III is to finalise the proposed clinical hand rehabilitation guideline for second to fifth metacarpal fractures.

Objectives

The objectives of Phase III are:

To determine the consensus among purposively sampled expert surgeons, PT's and OT's in the field of hand injuries, hand surgery and hand rehabilitation, with the use of a REDCap questionnaire, investigating their consensus on the developed clinical hand rehabilitation guideline.To adapt and finalise the clinical hand rehabilitation guideline based on the information obtained from the expert panel members of the Delphi.

Description of procedures

Informed consent will be requested in an email. Upon receiving the signed consent document the researcher will email the REDcap questionnaire link asking you to complete the REDCap questionnaire. A three round Delphi method will be used to reach consensus and if consensus is not reached after three rounds, a final fourth Delphi round will be run, to inform the

objectives. In the instance where there are no additional changes, stability will be assumed. Upon completion of the first round Delphi, statistical analysis will be performed and you will receive a summary of the results in a feedback email. A two week time period will be allowed for the completion of the questionnaire. In addition a two week period between the first and second round will occur to allow the researcher time to analyse the results and forward the summary of findings to you. A one week reminder will be sent to all participants prior to each Delphi round. Questions included in the questionnaire are demographical questions, to better understand to which population the hand rehabilitation guideline can be generalised to, followed by questions to establish the agreement of participating experts on included questions on a five-point Likert scale ranging from 1 strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly agree. Themes in the questionnaire will include: physiological healing timeframes and commencement of exercises, rehabilitation exercises, splints used, splinting timelines, timelines when patients are advice to return to tasks and advice regarding light, medium, hard and pre-injured tasks included.

Voluntary participation

Your participation is entirely voluntary, and you will not be negatively affected by your choice. You have the right to withdraw from the research at any point. Explicit withdrawal must be sent to Monique Keller (contact details below) and only after receiving the written withdrawal will correspondence be stopped. Absent responses will be seen as non-interest and no further information will be sent. Experts not responding to the first round Delphi, but who indicated an interest to participate, will receive two reminders and questionnaire links in the form of emails before this will be viewed as non-participation. No remuneration will be offered to participating experts.

Participant responsibility

Your responsibility will include: Complete a RedCap questionnaire in a three round Delphi technique.

Payment

No payment will be issued for your participation.

Feedback

Upon completion of the first round Delphi, each participating expert will receive a summary of the results.

Anonymity and Confidentiality

Anonymity among participants will be ensured by using separate emails in all communication. The results of the questionnaire will be kept confidential, and your name will not be seen on any documentation. The results will be published in an article and thesis, but confidentiality will be maintained. With your consent to participate, you also agree to not distribute the clinical guideline till it has been accepted or published.

Technical support

Technical support services namely, Redcap's Help Centre, can be contacted if there are any technical support required.

To complete the questionnaire select "true" in the

first option. Sincerely,

Monique

Keller

0117173715

monique.keller

@wits.ac.za

Please

complete the

survey below.

Thank you!

Record ID

_____

_____

Hand rehabilitation guideline for 2nd to 5th metacarpal fractures_General Questions

I have read and understood the contents of theTrue ○

information sheet. I am participating voluntarily inFalse ○ this study. I understand that I may be able to withdrawn from this study at any time without

bias. I consent to participate in this survey. (If you do not wish to participate, select False)

Have you participated in the previous round/s? If yes, tick the yes option. Thank you and you may proceed to Round Three. If no, thank you for your interest. Round Three is only for returning participants. Please do not proceed.

○ Yes
○ No

A1

Gender

○ Male
○ Female

What is your age?

_____

A In which professional capacity do you work?

○ Orthopaedic surgeon
○ Orthopaedic surgeon with specialty
○ Physiotherapist
○ Occupational Therapist

A4 In which country are you practicing hand injury management in? _____

Rehabilitation recommendations.

This section covers rehabilitation recommendations for 2nd to 5th metacarpal fractures. Please indicate your agreement by answering Yes or No to the statements below. In the instance, you select No, provide your reasoning in the open box below the question.

Initiate immediate early motion after stable or rigid ORIF of metacarpal neck and shaft fractures to prevent adhesion formation.

○ Ye
○ No

Do you agree with the statement? Initiating immediate early motion after stable or rigid ORIF of metacarpal neck and shaft fractures to prevent adhesion _____

formation. If not please provide your reasons.

Immediate early active range of motion exercises after stable or rigid ORIF of metacarpal neck and shaft fractures starts 2-3 days post-surgery

○ Ye
○ No

Do you agree with the statement? Immediate early active range of motion exercises after stable or rigid ORIF of metacarpal neck and shaft fractures starts 2-3 days post-surgery. If not please provide your reasons.

After metacarpal head fractures the MCPJ position depends on the fracture pattern and position of stability.

○ Ye
○ No

Do you agree with the statement? After metacarpal head fractures the MCPJ position depends on the fracture pattern and position of stability. If not please provide your reason.

○ Ye
○ No

After metacarpal head fractures the affected MCPJ and an adjacent finger's MCPJ is splinted/immobilised in flexion of 70°.

○ Ye
○ No

Do you agree with the statement? After metacarpal head fractures the affected MCPJ and an adjacent finger's MCPJ is splinted/immobilised in flexion of 70°. If not please provide your reasons.

Splint types should be clinically reasoned and individualised for each patient.

○ Ye
○ No

Do you agree with the statement? Splint types should be clinically reasoned and individualised for each patient. If not please provide your reasons.

The splint time period should be clinically reasoned according to the fracture pattern and individualised for each patient. ○ Ye ○ No

Do you agree with the statement? The splint time period should be clinically reasoned according to the fracture pattern and individualised for each patient. If not please provide your reasons.

Splinting types for second to fifth metacarpal fractures managed with percutaneous K-wires should consider and be moulded to respect the K-wire placement. Yes ○ ○

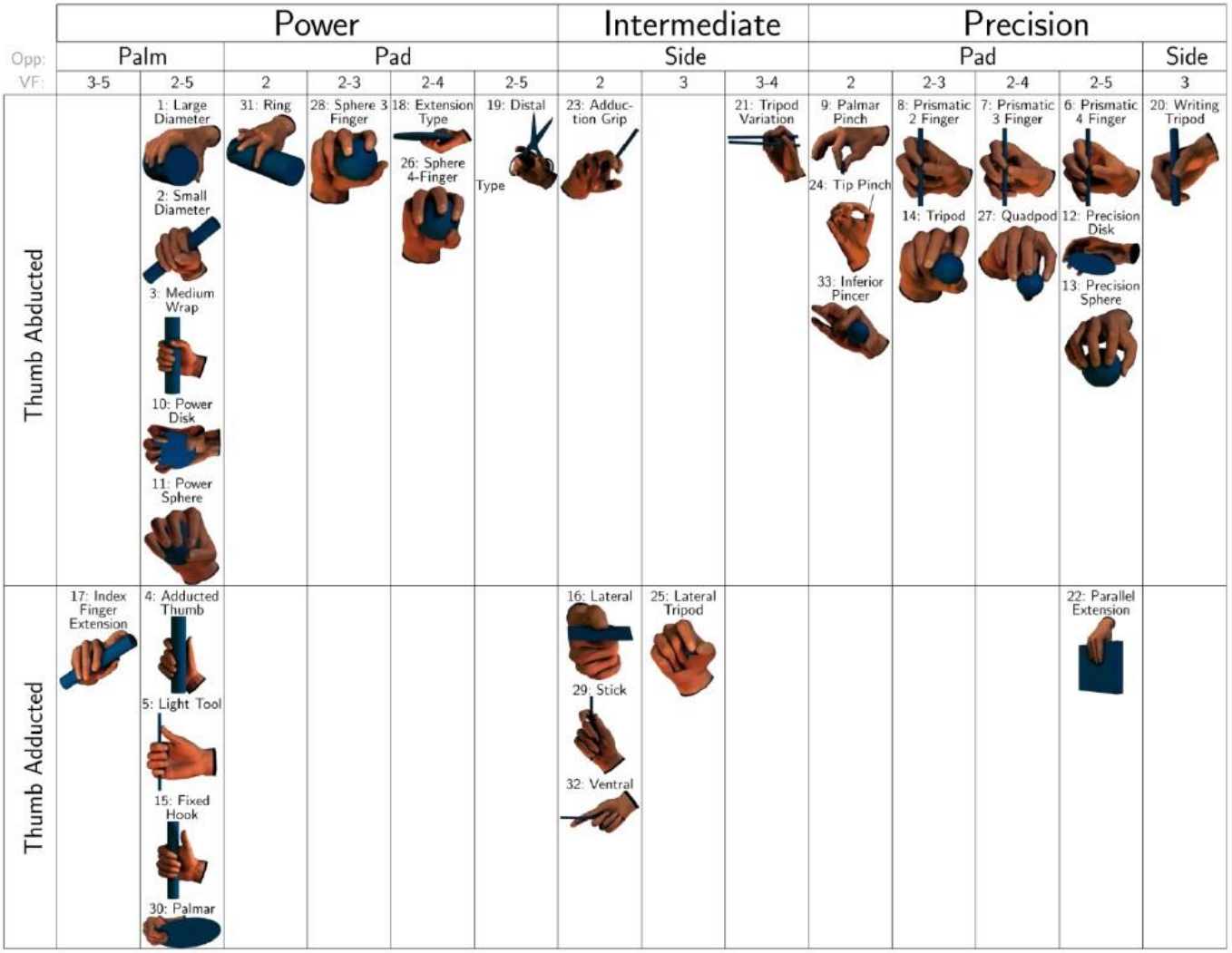
Do you agree with the statement? Splinting types for second to fifth metacarpal fractures managed with percutaneous K-wires should consider and be moulded to respect the K-wire placement. If not please provide your reasons.

Fractures managed with percutaneous K-wires should be splinted for the period when the K-wire is in situ. ○ Ye ○ No

Do you agree with the statement? Fractures managed with percutaneous K-wires should be splinted for the period when the K-wire is in situ. If not please provide your reasons.

Grasp types exercises.

This section covers recommendations about including GRASP types, according to the Feix et al., 2016, into the rehabilitation of 2nd to 5th metacarpal fractures to improve hand function through a careful progression of the affected and unaffected MCPJ flexion. Please indicate your agreement by answering Yes or No to the statements below. In the instance, you select No, provide your reasoning in the open box below the question.


Power
Intermediate
Precision
Opp:
Palm
Pad
Side
Pad
Side
VF:
3-5
2-5
2
2-3
2-4
2-5
2
3
3-4
2
2-3
2-4
2-5
3
Thumb Abducted
1: Large Diameter
2: Small Diameter
3: Medium Wrap
10: Power Disk
11: Power Sphere
31: Ring
28: Sphere 3 Finger
18: Extension Type
26: Sphere 4-Finger
19: Distal Type
23: Adduc-tion Grip
21: Tripod Variation
9: Palmar Pinch
24: Tip Pinch
33: Inferior Pincer
8: Prismatic 2 Finger
14: Tripod
7: Prismatic 3 Finger
27: Quadpod
6: Prismatic 4 Finger
12: Precision Disk
13: Precision Sphere
20: Writing Tripod
Thumb Adducted
17: Index Finger Extension
4: Adducted Thumb
5: Light Tool
15: Fixed Hook
30: Palmar
16: Lateral
29: Stick
32: Ventral
25: Lateral Tripod
22: Parallel Extension

Phase 1 Grasps requiring no or very little MCPJ flexion	Phase 2 Grasps requiring minimal to 45° MCPJ flexion	Phase 3 Grasps requiring more than 45° MCPJ flexion	Phase 4 All Grasps with resistance
5. Light Tool 8. Prismatic 2 Fingers 10. Power Disk 12. Precision Disk 15. Fixed Hook 16. Lateral 17. Index Finger Extension (For index finger #) 18. Extension Type 23. Adduction Grip 26. Sphere 4 Fingers 28. Sphere 3 Fingers 32. Ventral (For index finger #) 33. Inferior Pincher Respect pain < 3/10.	1. Large Diameter 3. Medium Wrap 4. Adducted Thumb 6. Prismatic 4 Fingers 7. Prismatic 3 Fingers 9. Palmar Pinch 14. Tripod 21. Tripod variation 24. Tip Pinch 31. Ring Index finger #	2. Small Diameter 11. Power Sphere 13. Precision Sphere 17. Index Finger Extension (For middle-, ring- and little finger #) 19. Distal 20. Writing Tripod 22. Parallel Extension 25. Lateral Tripod 27. Quadpod 29. Stick 30. Palmar 32. Ventral (For middle-, ring- and little finger #)	All Grasps if no pain is present. If pain persists, consult your medical doctor.

Incorporating grasp types of the hand is valuable in rehabilitation to promote hand function. ○ Ye ○ No

Do you agree with the statement? Incorporating grasp types of the hand is valuable in rehabilitation to promote hand function. If not, please provide your reasoning.

Careful use of grasp types in the rehabilitation for 2nd to 5th metacarpal fractures after conservative management can improve hand function. ○ Ye ○ No

Do you agree with the statement? Careful use of grasp types in the rehabilitation for 2nd to 5th metacarpal fractures after conservative management can improve

hand function. If not, please provide your reasoning.

Careful use of grasp types in the rehabilitation for 2nd to 5th metacarpal fractures after percutaneous K-wire management can improve hand function.	○ Ye ○ No

Do you agree with the statement? Careful use of grasp types in the rehabilitation for 2nd to 5th metacarpal fractures after percutaneous K-wire management can _____ improve hand function. If not, please provide your reasoning.

Use of grasp types in the rehabilitation for the affected stable Open Reduction Internal Fixation (ORIF) management can start at 2-3 days.	Yes ○ ○

Do you agree with the statement? Use of grasp types in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management can start at 2-3 _____

MCPJ 2nd to 5th metacarpal fractures after days. If not, please provide your reasoning.	No

Use of grasp types in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after K-wire management can start after K-wire removal.	○ Ye ○ No

Do you agree with the statement? Use of grasp types in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after K-wire management can start after K-wire removal. If not, please provide your reasoning. _____

to 5th metacarpal fractures after conservative management can start after 2-3 weeks of immobilisation. The splint is removed for exercises and reapplied afterwards.	

Incorporating the grasp types Phase 1 (Image provided above) in the rehabilitation for the affected MCPJ 2nd	

to 5th metacarpal fractures after conservative management can start after 2-3 weeks of immobilisation. The splint is removed for exercises and reapplied afterwards.

Incorporating the grasp types Phase 1 (Image provided Yes above) in the rehabilitation for the affected MCPJ 2nd No

Incorporating the grasp types Phase 2 (Image provided) Yes in the rehabilitation for the affected MCPJ 2nd to 5th No

metacarpal fractures after conservative management can start after 4 weeks of immobilisation where the splint is removed for exercises.

Do you agree with the statement? Incorporating the Yes

grasp types Phase 2 (Image provided) in the No

rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after conservative management can start after 4 weeks of immobilisation where the splint is removed for exercises. If not, please provide your reasoning.

Incorporating the grasp types Phase 3 (Image provided) Yes in the rehabilitation for the affected MCPJ 2nd to 5th No

metacarpal fractures after conservative management can start after 6 weeks of immobilisation.

Do you agree with the statement? Incorporating the

grasp types Phase 3 (Image provided) in the

rehabilitation for the affected MCPJ 2nd to 5th _____ metacarpal fractures after conservative management can start after 6 weeks of immobilisation. If not, please provide your reasoning.

SHAFT 2nd to 5th metacarpal fractures management with stable ORIF

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of 2nd to 5th SHAFT metacarpal fractures after stable surgical Open Reduction and Internal Fixation (ORIF). Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

Shaft fractures managed surgically a stable ORIF fixation require a Futuro wrist extension brace without immobilisation of the MCPJ's.

○ Ye
○ No

Do you agree with the statement? Shaft fractures managed surgically with a stable ORIF fixation require a Futuro wrist extension brace without immobilisation of the MCPJ's. If not, please provide your reasons.

In Shaft fractures managed surgically with a stable

○
○

immobilisation of the MCPJ's is sufficient immobilisation.

Do you agree with the statement? In Shaft fractures managed surgically with a stable ORIF fixation, a Futuro wrist extension brace without immobilisation of the MCPJ's is sufficient immobilisation. If not, please provide your reasoning.

Yes ORIF fixation, a Futuro wrist extension brace without No

bone is in a good position and fracture configuration is simple.

Do you agree with the statement? In Shaft fractures managed surgically with a stable ORIF fixation, a Futuro wrist extension brace without immobilisation of the MCPJ's is sufficient immobilisation. If not,

Shaft fracture managed surgically with a stable locking plate fixation wouldn't need a splint if the

Yes ○
No ○

please provide your reasoning.

Shaft fracture managed surgically with a stable ORIF fixation wouldn't need a splint if bone good position and fracture configuration are simple.

○ Ye
○ No

Do you agree with the statement? Shaft fracture managed surgically with a stable ORIF fixation wouldn't need a splint if bone good position and _____ fracture configuration are simple. If not, please indicate your reasoning.

SHAFT 2nd to 5th metacarpal fractures managed with CONSERVATIVE or K-WIRES

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of 2nd to 5th SHAFT metacarpal fractures after conservative and percutaneous K-wire management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

Shaft fractures with no rotation and scissoring a example Futuro with the affected finger buddy strapped to the unaffected neighbouring finger.

Yes ○
No ○

Do you agree with the statement? Shaft fractures with no rotation and scissoring a commercially manufactured wrist extension brace for example Futuro with the affected finger buddy strapped to the unaffected neighbouring finger. If not, please provide your reasoning.

commercially manufactured wrist extension brace for

Shaft metacarpal fractures managed with percutaneous K-wires requires a volar hand-based splint.

Ye ○
No ○

Do you agree with the statement? Shaft metacarpal fractures managed with percutaneous K-wires requires a volar hand-based splint. If not, please provide your reasoning.

BASE 2nd to 5th metacarpal fractures management with stable ORIF

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of BASE of 2nd of 5th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

Base of metacarpal fractures managed with percutaneous K-wires requires an immobilisation period of four weeks.	○ Ye ○ No	
Do you agree with the statement? Base of metacarpal fractures managed with percutaneous K-wires requires an immobilisation period of four weeks. If not, please provide your reasoning.		_____
Base of metacarpal fractures managed with stable ORIF fixation requires immobilisation for three days.	○ Ye ○ No	
Do you agree with the statement? Base of metacarpal fractures managed with stable ORIF fixation requires immobilisation for three days. If not, please provide your reasoning.		_____
Base of metacarpal fracture managed with stable ORIF fixation requires active mobilisation (including involved MCPJ) after 3 to 5 days after surgery.	○ Ye ○ No	
Do you agree with the statement? Base of metacarpal fracture managed with stable ORIF fixation requires active mobilisation (including involved MCPJ) after 3 to 5 days after surgery. If not, please provide your reasoning.		_____

HEAD 2nd to 5th metacarpal fractures management with stable ORIF

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of HEAD of 2nd of 5th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

For head of metacarpal fractures managed surgically with an ORIF fixation a volar hand base splint is used.	○ Ye ○ No

Do you agree with the statement? For head of

metacarpal fractures managed surgically with an ORIF fixation a volar hand base splint is used. If not, _____ please provide your reasoning.

For head of metacarpal fractures managed surgically with an ORIF fixation a clam/sandwich hand-base splint (photo provided below this question) is used.

○ Ye
○ No

Do you agree with the statement? For head of metacarpal fractures managed surgically with an ORIF fixation a clam/sandwich hand-base splint (photo provided below this question) is used. If not, please provide your reasoning.

_____

For head of metacarpal fractures managed surgically with an ORIF fixation a 4 week splinting time period is advised.

○ Ye
○ No

Do you agree with the statement? For head of metacarpal fractures managed surgically with an ORIF fixation a 4 week splinting time period is advised. If _____ not, please provide your reasoning.

For head of metacarpal fractures managed surgicallyYes ○
○

and light function from 2 weeks is advised. (Midgley & Toemen 2011)

Do you agree with the statement? For head of metacarpal fractures managed surgically with an ORIF fixation removal of splint for exercises and light function from 2 weeks is advised. (Midgley & Toemen 2011). If not, please provide your reasoning.

_____

---

with an ORIF fixation removal of splint for exercisesNo

HEAD 2nd to 5th metacarpal fractures management with percutaneous K-WIRES

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of HEAD of 2nd of 5th metacarpal fractures after percutaneous K-wires management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

For head of metacarpal fractures managed with percutaneous K-wires a volar hand-base splint is used. ○ Ye ○ No

Do you agree with the statement? For head of

metacarpal fractures managed with percutaneous K-wires a volar hand-base splint is used. If not, please _____ provide your reasoning.

NECK of 5th (BOXERS) metacarpal fractures management with stable ORIF

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of NECK of 5th (BOXERS) metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

treated with no reduction, a palm soft wrap and buddy strapping of fourth and fifth fingers for three weeks. (Level 1b, Van Aaken et el (2016))

Do you agree with the statement? Neck of 5th (Boxers) metacarpal fractures with ≤ 70° angulation and no rotational deformity are to be treated with no reduction, a palm soft wrap and buddy strapping of fourth and fifth fingers for three weeks. If not, please provide your reasoning.

_____

Neck of 5th (Boxers) metacarpal fractures with ≤ 70° angulation and no rotational deformity are to be treated with no reduction, a palm soft wrap and buddy strapping of fourth and fifth fingers for three weeks. (Level 1b, Van Aaken et el (2016))

Yes ○
No ○

Do you agree with the statement? Neck of 5th (Boxers) metacarpal fractures with ≤ 70° angulation and no rotational deformity are to be treated with no reduction, a palm soft wrap and buddy strapping of fourth and fifth fingers for three weeks. (Level 1b, Van Aaken et el (2016)). If not, please provide your reasoning.

_____

Neck of 5th (Boxers) fractures are generally impacted and therefore stable. Splinting is just for comfort as the fractures are unlikely to displace.

Ye ○
No ○

Do you agree with the statement? Neck of 5th (Boxers) fractures are generally impacted and therefore stable. Splinting is just for comfort as the fractures are _____ unlikely to displace. If not, please provide your reasoning.

NECK of 2nd to 4th metacarpal fractures management with stable ORIF

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of NECK of 2nd to 4th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

Neck of 2nd to 4th fracture managed surgically with a stable ORIF fixation wouldn't need a splint.

○ Ye
○ No

Do you agree with the statement? 2nd to 4th neck fracture managed surgically with a stable ORIF fixation wouldn't need a splint. If not please state provide your reasons.

_____

2nd to 4th Neck fracture managed surgically with a stable ORIF fixation requires a splinting time period of 2 weeks.

○ Ye
○ No

Do you agree with the statement? 2nd to 4th Neck fracture managed surgically with a stable ORIF fixation requires a splinting time period of 2 weeks.

_____

If not, please provide your reasons.

Provided the fixation for 2nd to 4th Neck of metacarpal fractures are stable, early mobilisation should be commenced earlier than 2/52.

○ Ye
○ No

Do you agree with the statement? Provided the fixation for 2nd to 4th Neck of metacarpal fractures are stable, early mobilisation should be commenced earlier than 2/52. If not, please provide your reasons.

_____

2nd to 4th neck fracture managed surgically with a stable ORIF fixation requires active mobilization (including the involved MCPJ) earlier than 2 weeks.

Yes ○
No ○

Do you agree with the statement? 2nd to 4th neck fracture managed surgically with a stable ORIF fixation requires active mobilization (including the involved MCPJ) earlier than 2 weeks. If not, please provide your reasons.

_____

(including the involved MCPJ) earlier from 3 to 5 days after surgery.

Do you agree with the statement? 2nd to 4th neck	○ ○
fracture managed surgically with a stable ORIF fixation requires active mobilization (including the involved MCPJ) earlier from 3 to 5 days after surgery. If not, please provide your reasoning.	_____
2nd to 4th neck fracture managed surgically with a stable ORIF fixation requires active mobilization	Yes No

NECK 2nd to 4th metacarpal fractures managed with CONSERVATIVE or K-WIRES

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of 2nd to 4th NECK metacarpal fractures after conservative and percutaneous K-wire management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.

2nd to 4th Neck fractures managed surgically with percutaneous K-wires require a splinting time period of 4 weeks.	○ Ye ○ No
Do you agree with the statement? 2nd to 4th Neck fractures managed surgically with percutaneous K-wires require a splinting time period of 4 weeks. If not, please provide your reasoning.	_____
2nd to 4th neck fracture managed conservatively requires a volar hand-based splint.	○ Ye ○ No
Do you agree with the statement? 2nd to 4th neck fracture managed conservatively requires a volar hand-based splint. If not, please provide your reasoning.	_____
Is there anything else on your mind that you wish to share?	○ Ye ○ No
If you selected yes, you have something else on your	

mind to share with me, please go ahead.

Addendum V

Ethical clearance certificate for Phase III eDelphi Method

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Health Sciences Research Ethics Committee

01-Dec-2021

Dear **Mrs Monique Keller**

Ethics Number: UFS-HSD2019/0046/2602-0003
Ethics Clearance: **DEVELOPMENT OF A REHABILITATION PROGRAMME FOR SECOND TO FIFTH METACARPAL FRACTURES IN SOUTH AFRICA**
Principal Investigator: **Mrs Monique Keller**
Department: **Physiotherapy Department (Bloemfontein Campus)**
Submission Page

SUBSEQUENT SUBMISSION APPROVED

With reference to your recent submission for ethical clearance from the Health Sciences Research Ethics Committee. I am pleased to inform you on behalf of the HSREC that you have been granted ethical clearance for your request as stipulated below:

- This protocol is the third and final phases to develop a clinical hand rehabilitation guideline for individuals who sustained second to fifth metacarpal fractures. A Delphi method will be undertaken to reach consensus on the developed clinical guideline components by an expert panel of hand therapists, Occupational- and physiotherapists, as well as surgeons with a special interest in the field of hand injuries and rehabilitation. A three-round Delphi will allow the final completion of the clinical guideline.

The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; International Council for Harmonisation (ICH) Harmonised Guideline, Integrated Addendum to ICH E6(R1), Guideline for Good Clinical Practice (GCP) E6(R2), 2016, SAHPRA Guidelines as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

For any questions or concerns, please feel free to contact HSREC Administration: 051-4017794/5 or email EthicsFHS@ufs.ac.za.

Thank you for submitting this request for ethical clearance and we wish you continued success with your research.

Yours Sincerely

Prof. A. Sherriff
Chairperson : Health Sciences Research Ethics Committee

Health Sciences Research Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | E: ethicsfhs@ufs.ac.za

IRB 00011992; REC 230408-011; IORG 0010096; FWA 00027947
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa
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Addendum W

Author guidelines: South African Journal of Physiotherapy

Link: https://sajp.co.za/index.php/sajp/pages/view/submission-guidelines

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- Manuscript files can be in the following formats: DOC, DOCX, or RTF. Microsoft Word documents should not be locked or protected.
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Ensure that formatting for headings is consistent in the manuscript. Limit manuscript sections and sub-sections to four heading levels. To avoid confusion during the review and production process, ensure that the different heading levels used in your work are visually distinct from one

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Footnotes are not ideal. If your manuscript contains footnotes, move the information into the main text or the reference list, depending on the content.

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Acknowledgements structure

Acknowledgements

The acknowledgement section follows the conclusions section and addresses formal, required statements of gratitude and required disclosures. It includes listing those who contributed to the work but did not meet authorship criteria, with the corresponding description of the contribution. Acknowledge anyone who provided intellectual assistance, technical help (including with writing and editing), or special equipment and/or materials. Authors are responsible for ensuring that anyone named in the Acknowledgements agrees to be named.

Also provide the following, each under their own subheading:

- Competing interests
- Author contributions
- Funding information
- Data availability statement

- Disclaimer

Competing interests

This section should list specific competing interests associated with any of the authors. If authors declare that no competing interests exist, the article will include a statement to this effect. Read our **policy on competing interests**.

The following are examples of competing interest statements. If you use one of the examples, you should modify it to fit your specific relationship.

Scenario	Suggested competing interest statements
Example 1	The author(s) declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.
Example 2	The author reported that they [have a financial and/or business interests in] [are a consultant to] [received funding from] a company that may be affected by the research reported in the enclosed publication. They have disclosed those interests fully and have in place an approved plan for managing any potential conflicts arising from [that involvement].
Example 3	A.B. developed the theoretical formalism, performed the analytic calculations and performed the numerical simulations. Both A.B and B.C. contributed to the final version of the manuscript. B.C. supervised the project.
Example 4	A.B., B.C., C.D., D.E., E.F., F.G., and G.H. conceived and planned the experiments. A.B., B.C., C.D. and D.E. carried out the experiments. A.B., F.G. and E.F. planned and carried out the simulations. J.K., K.L., A.B., B.C., D.E., C.D., F.J., and F.G. contributed to sample preparation. A.B., B.C., C.D., D.E., FJ, E.F., F.G. and G.H. contributed to the interpretation of the results. A.B. took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.
Example 5	A.B. and B.C. designed the model and the computational framework and analysed the data. A.B. and C.D. carried out the implementation. A.B. performed the

	calculations. A.B. and B.C. wrote the manuscript with input from all authors. D.E. and E.F. conceived the study and were in charge of overall direction and planning.
Example 6	A.B. designed and performed the experiments, derived the models and analysed the data. B.C. assisted with XYZ measurements and C.D. helped carry out the XYZ simulations. A.B. and D.E. wrote the manuscript in consultation with C.D., B.C. and E.F..
Example 7	A.B. devised the project, the main conceptual ideas and proof outline. B.C. worked out almost all of the technical details, and performed the numerical calculations for the suggested experiment. C.D. worked out the bound for quantum mechanics, with help from D.E.. E.F. verified the numerical results of the XYZ by an independent implementation. F.G. and G.H. proposed the XYZ experiment in discussions with A.B.. B.C., C.D., G.H. and A.B. wrote the manuscript.
Example 8	A.B., B.C. and C.D. designed the study. A.B., D.E. and E.F. performed the XYZ experiments. F.G. and G.H. performed XYZ simulations. I.H. and M.C. expressed and purified all proteins. A.B., H.J., B.C. and C.D. analysed the data. A.B., B.C. and C.D. wrote the paper with input from all authors.
Example 9	A.B. and B.C. designed and directed the project; C.D., D.E., A.B. and B.C. performed the experiments; C.D. and B.C. analysed spectra; A.B. and E.F. made the simulations; B.C. developed the theoretical framework; C.D., A.B. and B.C. wrote the article.
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Author contributions

All authors must meet the criteria for authorship as outlined in the **authorship** policy and **author contribution** statement policies.

The following are examples of an author contribution statement. If you use one of the examples, you should modify it to fit your specific relationship.

Scenario	Suggested author contribution statements
Example 1	A.B. and B.C. conceived of the presented idea. A.B. developed the theory and performed the computations. C.D. and D.E. verified the analytical methods. B.C. encouraged A.B. to investigate [a specific aspect] and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.
Example 2	A.B. and B.C. carried out the experiment. A.B. wrote the manuscript with support from C.D.. D.E. and E.F. fabricated the XYZ sample. F.G. and G.H. helped supervise the project. G.H. and H.I. conceived the original idea. H.I. supervised the project.
Example 3	A.B. developed the theoretical formalism, performed the analytic calculations and performed the numerical simulations. Both A.B and B.C. authors contributed to the final version of the manuscript. B.C. supervised the project.
Example 4	A.B., B.C., C.D., D.E., E.F., F.G., and G.H. conceived and planned the experiments. A.B., B.C., C.D. and D.E. carried out the experiments. A.B., F.G. and E.F. planned and carried out the simulations. J.K., K.L., A.B., B.C., D.E., C.D., F.J., and F.G. contributed to sample preparation. A.B., B.C., C.D., D.E., FJ, E.F., F.G. and G.H. contributed to the interpretation of the results. A.B. took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.
Example 5	A.B. and B.C. designed the model and the computational framework and analysed the data. A.B. and C.D. carried out the implementation. A.B. performed the calculations. A.B. and B.C. wrote the manuscript with input from all authors. D.E. and E.F. conceived the study and were in charge of overall direction and planning.

Example 6	A.B. designed and performed the experiments, derived the models and analysed the data. B.C. assisted with XYZ measurements and C.D. helped carry out the XYZ simulations. A.B. and D.E. wrote the manuscript in consultation with C.D., B.C. and E.F..
Example 7	A.B. devised the project, the main conceptual ideas and proof outline. B.C. worked out almost all of the technical details, and performed the numerical calculations for the suggested experiment. C.D. worked out the bound for quantum mechanics, with help from D.E.. E.F. verified the numerical results of the xyz by an independent implementation. F.G. and G.H. proposed the xyz experiment in discussions with A.B.. B.C., C.D., G.H. and A.B. wrote the manuscript.
Example 8	A.B., B.C. and C.D. designed the study. A.B., D.E. and E.F. performed the xyz experiments. F.G. and G.H. performed XYZ simulations. I.H. and M.C. expressed and purified all proteins. A.B., H.J.., B.C. and C.D. analysed the data. A.B., B.C. and C.D. wrote the paper with input from all authors.
Example 9	A.B. and B.C. designed and directed the project; C.D., D.E., A.B. and B.C. performed the experiments; C.D. and B.C. analysed spectra; A.B. and E.F. made the simulations; B.C. developed the theoretical framework; C.D., A.B. and B.C. wrote the article.
Example 10	A.B., B.C. and C.D. performed the measurements, D.E. and E.F. were involved in planning and supervised the work, A.B. and B.C. processed the experimental data, performed the analysis, drafted the manuscript and designed the figures. F.G., and G.H. performed the xyz calculations. H.I., and I.J. manufactured the samples and characterized them with xyz spectroscopy, J.K. performed the xyz characterization. K.L. aided in interpreting the results and worked on the manuscript. All authors discussed the results and commented on the manuscript.
Example 11	A.B., B.C., C.D. and D.E. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

Funding information

All research articles should have a funding acknowledgement statement included in the manuscript in the form of a sentence under a separate heading entitled ‘Funding information’. The funding agency should be written out in full, followed by the grant number in square brackets.

The following are examples of a funding statement. If you use one of the examples, you should modify it to fit your specific relationship.

Scenario	Suggested funding statements
Example 1	The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Medical Research Council [grant number xxx].
Example 2	This work was supported by the Trust [grant numbers xxxx, yyyy]; the Natural Environment Research Council [grant number zzzz]; and the Economic and Social Research Council [grant number aaaa].
Example 3	The author(s) received no financial support for the research, authorship, and/or publication of this article.

Data availability statement

All research articles should have a data availability statement included in the manuscript in the form of a sentence under a separate heading entitled ‘Data availability statement’.

The following are examples of a data availability statement. If you use one of the examples, you should modify it to fit your specific relationship.

Availability of data	Suggested data availability statements
Data openly available in a public repository that issues datasets with DOIs	The data that support the findings of this study are openly available in [repository name e.g ‘figshare’] at http://doi.org/[doi], reference number [reference number].

Data openly available in a public repository that does not issue DOIs	The data that support the findings of this study are openly available in [repository name] at [URL], reference number [reference number].
Data derived from public domain resources	The data that support the findings of this study are available in [repository name] at [URL/DOI], reference number [reference number]. These data were derived from the following resources available in the public domain: [list resources and URLs]
Data available within the article or its supplementary materials	The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.
Data generated at a central, large-scale facility, available upon request	Raw data were generated at [facility name]. Derived data supporting the findings of this study are available from the corresponding author [initials] on request.
Embargo on data due to commercial restrictions	The data that support the findings will be available in [repository name] at [URL / DOI link] following a [6 month] embargo from the date of publication to allow for the commercialisation of research findings.
Data available on request due to privacy/ethical restrictions	The data that support the findings of this study are available on request from the corresponding author, [initials]. The data are not publicly available due to [restrictions, e.g. their containing information that could compromise the privacy of research participants].
Data subject to third party restrictions	The data that support the findings of this study are available [from] [third party]. Restrictions apply to the availability of these data, which were used under licence for this study. Data are available [from the authors / at URL] with the permission of [third party].

Data available on request from the authors	The data that support the findings of this study are available from the corresponding author, [author initials], upon reasonable request.
Data sharing not applicable – no new data generated	Data sharing is not applicable to this article, as no new data were created or analysed in this study.

Disclaimer

A statement that the views expressed in the submitted article are his or her own and not an official position of the institution or funder.

Blinding your manuscript

Ensuring a blind review

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Removing identifying information from your manuscript

Although thoroughly masking a manuscript requires some revision, the journal seeks to reduce the burden on authors and suggests the following masking procedures.

Check 1: Mask the Title Page attached to the manuscript

Masking the title page is simply a matter of omitting identifying information. The title page attached to the manuscript should contain three pieces of information:

- Journal Name
- Article Title
- Word Count, rounded to the nearest thousand.

This title page should omit all identifying information (e.g., authors' names, affiliations and contact information). Do not add any running headers or footers that would identify authors.

Check 2: Complete our separate COVER PAGE file with Author-Identifying information

Our **cover page** title page with full identifying information should be completed as a separate file and uploaded for the editor's eyes only. This page includes the following information, and more:

- Full name and institution/university for each co-author.
- Email address for each co-author.
- Name of designated Corresponding Author, with full contact information (email and physical address, telephone).
- Authors' Note, including the current position of each co-author.
- Acknowledgements, including funding and ethical clearance statement.
- Author Account information (if applicable)
- Date of submission.

Check 3: Mask Location and University Affiliation

Referring to the research site or the university's review board by proper names is likely to be second nature for most researchers/authors. Therefore, the journal suggests that authors perform a word search of their manuscript for location, and when found, make revisions as shown in the examples. Instead of writing, 'These data were collected from incoming master's level students at the University of Johannesburg…,' mask the location using one of the following options:

- 'Data were collected from first-year social work students enrolled in a graduate-level program at a university in North-eastern South Africa.'
- 'Data were collected from first-year students enrolled in the M.Sc. program at [location masked for blind review].'

Check 4: Mask University Affiliation in Statements of Review Board Approval

Instead of writing, 'This research was approved by the North-West University Research Ethics Committee,' give the region of the university or research site: 'The Institutional Review Board at a large North-western public university approved the research.'

Check 5: Mask Authors' Self-Citations of Published Work

Most researchers' current work builds from previous investigations, requiring self-citation of published findings. Typically, double-blind reviews require authors to replace their names in self-citations with 'Authors' in both in-text citations and reference entries. However, given the relatively small size researchers in some communities, this masking method singles out publications. It makes it more, rather than less, likely that a reviewer might discern an author's identity. Therefore, self-citations are best masked by leaving the names but ensuring that you use the third person to discuss the work. See the examples of typical self-citations and revisions.

Instead of writing in the first person, as shown in examples below:

- Typical self-citation: 'One major problem experienced is that learners who are meant to be accommodated in mainstream schools often find themselves as a "guest" in the classroom (Walton 2013).'
- Typically masked self-citation that doesn't really hide identities: 'One major problem experienced is that learners who are meant to be accommodated in mainstream schools often find themselves as a "guest" in the classroom (Author 2013).'

The journal suggests using the third person to mask self-citations, as shown in the examples. Third-person reference to self-citation: ‘In the evaluation of major problems experienced, Walton (2013) found that learners who are meant to be accommodated in mainstream schools often find themselves as a “guest” in the classroom.’ OR ‘In the evaluation of major problems experienced, the researcher found that learners who are meant to be accommodated in mainstream schools often find themselves as a “guest” in the classroom (Walton 2013).’

Check 6: Self-Citation of Unpublished Findings, Manuscripts, or Conference Presentations

Authors rarely have access to materials that are ‘in press,’ ‘under review,’ ‘unpublished, on file with author,’ or a ‘manuscript in preparation’ unless they are affiliated with the research in some way. In cases when you are citing unpublished materials, masking follows the standard course of replacing your name or co-authors’ names with ‘Author’ in both the in-text citation and the reference entry. As an example: ‘In the evaluation of major problems experienced, the researcher found that learners who are meant to be accommodated in mainstream schools often find themselves as a “guest” in the classroom (Authors, in press).

Reference entries for Author self-citations should be re-alphabetised under ‘A for Authors’ rather than leaving the entries in their original placement in the section. Reference entries for ‘Author’ should show only Author and the year. DO NOT include article titles, DOIs, or other identifying information.

Check 7: Make Masked References Available in Cover Page

Information for the masked references should be included in the cover letter to the journal editor. Making that information available will speed the review process in the event that a reviewer deems it necessary to consult a specific reference in making her or his decision about the manuscript.

Check 8: Removing Meta-Data Hidden in Electronic Files

If you have collaborated with others on writing a manuscript, used Track Changes to make revisions or add comments, or exchanged the manuscript through email, it is likely that your manuscript contains hidden personal data that you will not want to share with your reviewers. Directions for scrubbing your documents of hidden data are given below for the most commonly used versions of Word.

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- In the **Document Inspector** dialog box, select the checkboxes to choose the types of hidden content that you want to be inspected.
- Click **Inspect**.
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Quick check for your submissions

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The publication costs for members of the South African Society of Physiotherapy receives financial support with an annual limit. Only members, therefore, benefit from this subsidy. You can find details about the society membership and charges via the **'Publication fees'** link that appears on every journal website.

Check 2: Tailor your article for this journal
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Do not self-plagiarise by ensuring that your manuscript has no relationship to previous research you published. If an article relationship does exist with previously published research, verify whether you require copyright permission for extensive quotations or paraphrasing. It is your responsibility to have gotten written permission for the reproduction of any images/ figures/tables before submitting your manuscript. Please read our policy **permission to use copyright material**.

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Confirm that the entire manuscript is organised and neatly prepared, spell-checked, and adhere to the **formatting requirements** stipulated in our submission guidelines:

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The journal follows a **double-blinded peer-review process**, and you need to make your manuscript anonymous. This is to ensure that reviewers would not be able to identify you, your

co-authors, or the institution where the research was carried out, ensuring that the review process is as objective as possible. Don't know how to make your article anonymous, **follow these instructions**.

Check 6: Complete our cover page

The cover letter contains all the information we will need to process your submission upon acceptance, which includes the author account information. The cover letter must be completed in full. We recommend authors to have ORCID iDs, which can only be assigned by the **ORCID Registry**. Submit the complete cover page in Step 4 of the submission process.

Check 7: Your final manuscript files

Authors are requested to submit two versions of their manuscript:

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Submit the completed forms on the journal website during the manuscript submission process (Step 4). **The corresponding author should always be the submitter of the manuscript.**

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This approval letter, known as an ethical clearance certificate/letter, is submitted with a manuscript as a supplementary file. Include all ethical statements in the Authorship, disclosure statements, copyright, and license agreement form.

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Doing research using secondary data or archives which do not involve human or animal subjects, you may be eligible to receive an ethics waiver from the Committee for Research Ethics & Integrity at your organisation or affiliated institution. They will consider:

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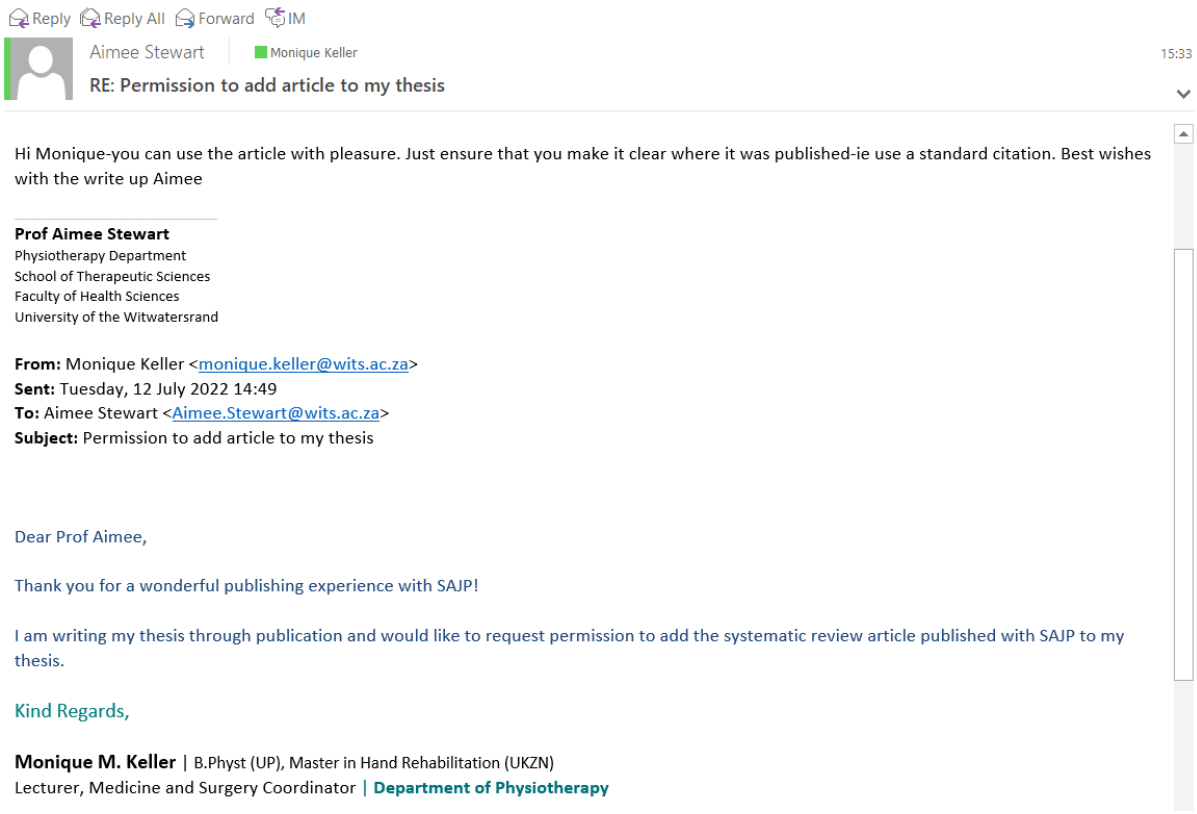
Authors of the published article must inform AOSIS promptly by submitting a correction online if they become aware of an error needing correcting. If the correction is approved, we will publish its notice and link it to the original article online. Kindly proceed to download the forms below:

- **Correction Submission Form**
- **Author Change Request Form** (if applicable)
- **Corresponding Author Change Request Form** (if applicable)

All change request forms must be submitted with the corrections submission form as supplementary files, as dictated by the correction type.

Addendum X

South African Journal of Physiotherapy editor permission



Reply Reply All Forward IM

Aimee Stewart | Monique Keller 15:33

RE: Permission to add article to my thesis

Hi Monique-you can use the article with pleasure. Just ensure that you make it clear where it was published-ie use a standard citation. Best wishes with the write up Aimee

Prof Aimee Stewart
Physiotherapy Department
School of Therapeutic Sciences
Faculty of Health Sciences
University of the Witwatersrand

From: Monique Keller <monique.keller@wits.ac.za>
Sent: Tuesday, 12 July 2022 14:49
To: Aimee Stewart <Aimee.Stewart@wits.ac.za>
Subject: Permission to add article to my thesis

Dear Prof Aimee,

Thank you for a wonderful publishing experience with SAJP!

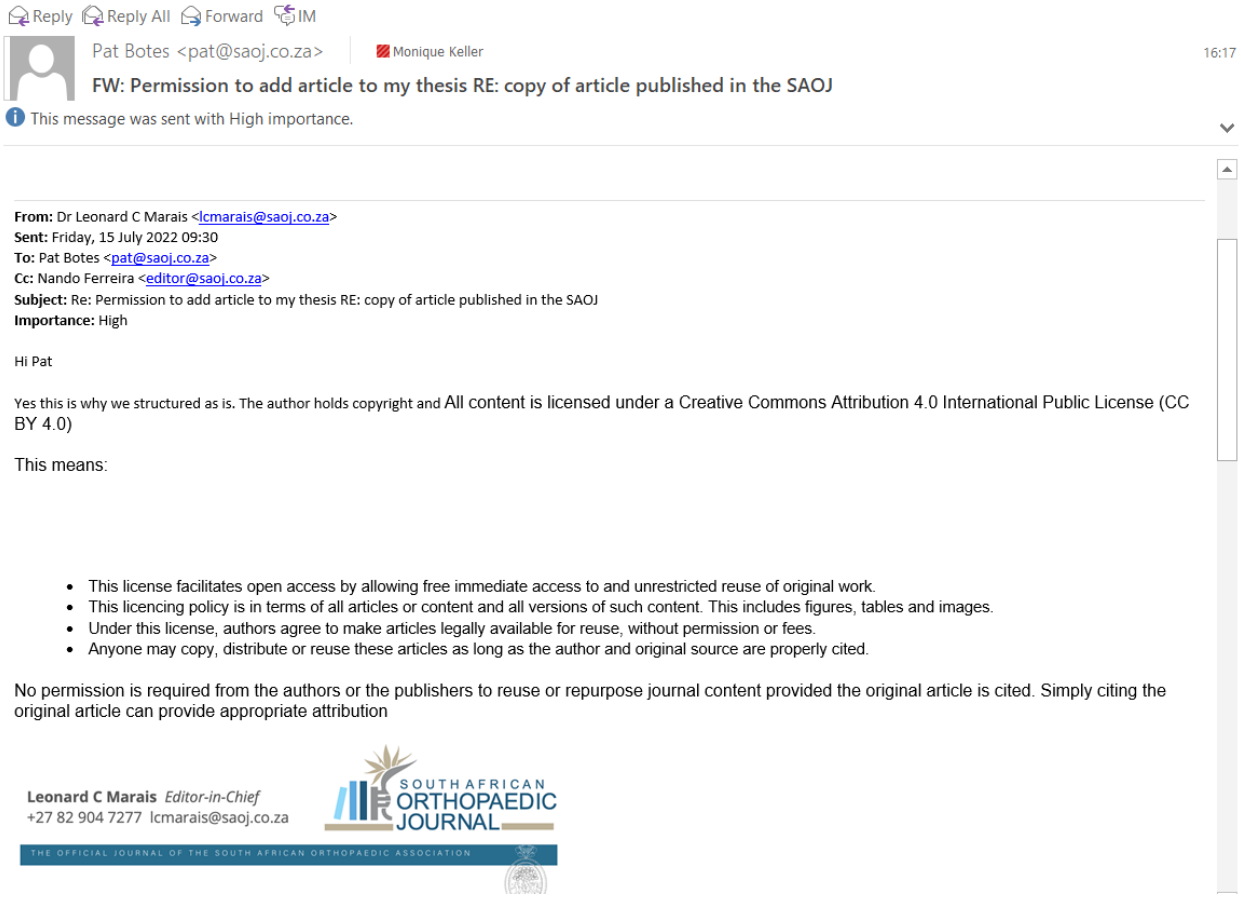
I am writing my thesis through publication and would like to request permission to add the systematic review article published with SAJP to my thesis.

Kind Regards,

Monique M. Keller | B.Physt (UP), Master in Hand Rehabilitation (UKZN)
Lecturer, Medicine and Surgery Coordinator | **Department of Physiotherapy**

Addendum Y

South African Journal of Orthopaedics editor permission



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Pat Botes <pat@saoj.co.za> Monique Keller 16:17

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To: Pat Botes <pat@saoj.co.za>
Cc: Nando Ferreira <editor@saoj.co.za>
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Leonard C Marais *Editor-in-Chief*
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SOUTH AFRICAN ORTHOPAEDIC JOURNAL

THE OFFICIAL JOURNAL OF THE SOUTH AFRICAN ORTHOPAEDIC ASSOCIATION

Addendum Z

Author guidelines: of South African Journal of Orthopaedics

Instructions for Authors

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Authors submitting articles for consideration for publication by the journal are required to familiarise themselves with the journal Ethics and Malpractice policy prior to submission. The policy is available on the journal website: https://www.saoj.org.za

Criteria for publication

- The article falls within the scope of the journal.
- Methods, statistics, and other analyses are performed to a high technical standard and are described in sufficient detail.
- Results reported have not been published elsewhere.
- Conclusions are presented appropriately fashion and are supported by the data.
- The article is presented in an intelligible fashion and is written in standard English (British usage).
- The research meets all applicable ethical standards.
- The article adheres to guidelines provided in the instructions for authors section.

Guidelines for authorship

- Each author should participate and is responsible for the content and design of the study, the preparation of the manuscript and its revisions, and final approval.
- In order to qualify for authorship, authors should satisfy all four the criteria for authorship as specified by the ICMJE:
    1. Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND

2. Drafting the work or revising it critically for important intellectual content; AND
3. Final approval of the version to be published; AND
4. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

- Other 'contributors' or 'collaborators' can be acknowledged at the end of the manuscript together with their contribution. Those whose contributions do not justify authorship may be acknowledged individually or together as a group under a single heading (e.g., "Clinical Investigators" or "Participating Investigators"), and their contributions should be specified (e.g., "served as scientific advisors," "critically reviewed the study proposal," "collected data," "provided and cared for study patients", "participated in writing or technical editing of the manuscript".
- The South African Orthopaedic Journal accepts a maximum of 8 authors per article. If there are more than eight authors, the first eight authors must be listed along with the group name at the end. The remaining authors and their affiliations must then be listed in an appendix.
- On submission of your article, the ORCID (Open Researcher and Contributor ID) identifier of at least the corresponding author will be required. ORCID provides a persistent digital identifier that distinguishes you from every other researcher and supports automated linkages between you and your professional activities, ensuring that your work is recognised. To register and find more information, please visit: http://orcid.org

Registration of clinical trials

- A clinical trial is defined as any research study that prospectively assigns human participants or groups of humans to one or more health-related interventions to evaluate the effects of health outcomes. Interventions include drugs, surgical procedures, devices, behavioural treatments, dietary interventions, and process-of-care changes.
- Clinical trials should be registered in a public trials registry in accordance with International Committee of Medical Journal Editors
- Trials must be registered and approved by the relevant authorities before the onset of patient enrolment.

- The Medicines Control Council (MCC) reference number and the SA National Clinical Trial Register (SANCTR) registration number should be included at the end of the abstract of the article.
- Purely observational studies (those in which the assignment of the medical intervention is not at the discretion of the investigator) do not require registration.

Reporting guidelines

- All articles should be prepared in accordance with the guidelines relevant to the study design, as described in the Equator Network Guidelines (https://www.equator-network.org/reporting-guidelines/)
- Randomised trials should be accompanied by a flow diagram that illustrates the progress of patients through the trial, including recruitment, enrolment, randomisation, withdrawal and completion, and a detailed description of the randomisation procedure.

Reporting of statistics

In terms of the statistical reporting, the Equator Network advises on the use of the SAMPL guideline: https://www.equator-network.org/2013/02/11/sampl-guidelines-for-statistical-reporting/

The SAMPL guidelines provide two guiding principles

1. "Describe statistical methods with enough detail to enable a knowledgeable reader with access to the original data to verify the reported results." When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Avoid relying solely on statistical hypothesis testing, such as P values, which fail to convey important information about effect size.
2. Provide enough detail that the results can be incorporated into other analyses. This requires reporting the descriptive statistics from which other statistics are derived, such as the numerators and denominators of percentages, especially in risk, odds, and hazards ratios. Likewise, P-values are not sufficient for re-analysis. Needed instead are descriptive statistics for the variables being compared, including sample size of the groups involved,

the estimate (or effect size) associated with the P-value, and a measure of precision for the estimate, usually a 95% confidence interval.

Some specific guidelines applicable to the SAOJ:

- Consistency is one of the most important factors in presenting a well-formatted, professional manuscript.
- The nature of the measurements and variables reported on will often dictate the amount of precision required. Report numbers - especially measurements? with an appropriate degree of precision. For ease of comprehension and simplicity, round to a reasonable extent.
- The recommendation is to report the number of decimals that have both clinical and statistical meaning and consistently reporting all other variables in the same manner.
- Note: Generally, for descriptive purposes, percentages are reported as whole numbers except when dealing with really large sample sizes
- At least for the primary outcomes, report a measure of precision (a confidence interval).
- Although not preferred to confidence intervals, if desired, p values should be reported as equalities to three decimal places (e.g., $p = 0.031$ and not as inequalities: e.g., $p < 0.05$). Do NOT report NS; give the actual P-value. The smallest P-value that needs to be reported is $P < 0.001$.
- Report numerators and denominators for all percentages
- Summarize data that are approximately normally distributed with means and standard deviations (SD). Use the format: mean (SD) not mean ?
- Summarize data that are not normally distributed with medians and interpercentile ranges, ranges, or both.
- Do NOT use the standard error of the mean (SE) to indicate the variability of a data set. Use standard deviations, inter-percentile ranges, or ranges instead.

Formatting examples:

- $p = 0.028$ or $p < 0.001$
- (43% vs 21%; $p = 0.002$)

- (odds ratio (OR) 0.38; 95% confidence interval (CI) 0.71 to 1.82; p = 0.822) or after first use (OR 1.62; 95% CI 1.41 to 1.86; p < 0.001)
- Descriptive stats normal distribution: mean age 36 years (SD 4 years) or 36 years (SD 4; range 40 to 97 years)
- Descriptive stats non-normal distribution: median age 36 years (IQR 44 to 88 years) or 36 years (IQR 44 to 88 years; range 40 to 97 years)
- Descriptive stats percentage: (149 of 202; 74%)

Formatting of submissions

Text formatting

- Use Helvetica or Arial font, size 11.
- Use double line spacing throughout the document.
- Number the pages of the blinded manuscript consecutively.
- Use italics for emphasis.
- When referring to an article with multiple authors, please use the following format: Rabinowitz et al. published their retrospective review.
- Do not use field functions.
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.
- Use the equation editor or MathType for equations.
- Save your file in docx format (Word 2007 or higher) or doc format (older Word versions).

Headings

- Use no more than three levels of displayed headings.

Abbreviations

- Define abbreviations and acronyms at first mention and use consistently thereafter.

Units

- Follow internationally accepted rules and conventions: use the international system of units (SI). If other units are mentioned, please give their equivalent in SI.

Figures

- Figures should be numbered consecutively with illustration Arabic numbers 1, 2, 3, etc.
- The figure should be listed in the text as follows: … wound irrigation and splinting (Figure 1).
- Figures should be clear and easily understandable with a full descriptive legend stating any areas of interest and explaining any markings, letterings or notations. All figures and figure legends should be understandable as a stand-alone item, without having to read the main body of the text.
- For radiographs, please ensure you state the view used and the time point at which it was taken, as well as the demographic details of the patient if applicable.
- Please submit the original JPEG (300 dpi) or TIFF of all photographs, as well as the figure saved as a Word document. The Word version of the figure should be complete with the legend and any necessary markings such as letters or arrows.
- Figures such as graphs and algorithms should be in Word or PowerPoint in order to be editable.
- Figures should not be imbedded in the text file but should be submitted as separate individual files. Each figure should be a separate file, entitled Figure 1, Figure 2, etc.
- Remove all markings, such as patient identification, from radiographs before photographing. Clinical photos must be adequately anonymised.
- A statement of patient consent for clinical photographs must be provided on the title page.
- In images depicting X-rays of children there should exhibit adequate shielding of radiation.
- All line or original drawings must be done by a professional medical illustrator.
- We accept a maximum of six figures. You may apply to the Editor-in-Chief for permission to include more figures if considered critical to the clarity and completeness of the submission.

- Do not submit any figures, photos, tables, or other works that have been previously copyrighted or contain proprietary data unless you have obtained and can supply written permission from the copyright holder to use that content.

Tables

- Tables should carry uppercase Roman numerals, I, II, III, etc.
- Tables should always be cited in the text in consecutive numerical order.
- The table should be identified in the text as follows: Details of results are listed in Table I. Or, alternatively,? high-energy trauma that is often associated with these fractures (Table II).
- Tables should be used to present information in a clear and concise manner. All tables should be understandable without the main text.
- For each table, please supply a table heading explaining the components of the table.
- Identify any previously published material by giving the original source in the form of a reference at the end of the table heading.
- Footnotes to tables should be indicated by superscript lower-case letters and included beneath the table body.
- Please submit tables as editable text and not as images. They should be created using the Table tool in Word.
- Do not embed tables in the text file but submit them as separate individual files. Each table should be a separate file, entitled Table I, Table II, etc.
- We accept a maximum of eight tables.
- Do not duplicate information given already in the text.
- Do not submit any figures, photos, tables or other works that have been previously copyrighted or contain proprietary data unless you have obtained and can supply written permission from the copyright holder to use that content.

References

- References should be numbered consecutively in the order that they are first mentioned in the text and listed at the end in numerical order of appearance.

- Identify references in the text by Arabic numerals in superscript after punctuation.
- References should not be a listing of a computerised literature search but should have been read by the authors and have pertinence to the manuscript.
- Accuracy of references is the authors' responsibility, and the author is to verify the references against the original documents.
- Manuscripts in preparation, unpublished data (including articles submitted but not in the press) and personal communications may not be included in the reference listing. They may be listed in the text in parentheses only if absolutely necessary to the contents and meaning of the article.
- The titles of journals should be abbreviated according to the style used in Index Medicus, obtainable through the website http://www.nlm.nih.govshould
- The following format should be used for references:

Journal article:

Sidhu GS, Ghag A, Prokuski V, Vaccaro AR, Radcliff KE. Civilian gunshot injuries of the spinal cord: a systematic review of the current literature. Clin Orthop Relat Res 2013;**471**:3945-55.

Ideally, the names of all authors should be provided, but the usage of et al. in long author lists (more than six authors) will also be accepted: Fong K, Truong V, Foote CJ, et al. Predictors of nonunion and reoperation in patients with fractures of the tibia: an observational study. BMC Musculoskelet Disord 2013;**14**:103.

Online journal article:

Caetano-Lopes J, Lopes A, Rodrigues A, et al. Upregulation of inflammatory genes and downregulation of sclerostin gene expression are key elements in the early phase of fragility fracture healing. PLoS One 2011;**6**:e16947.

Web reference (with authors):

Cierny G, DiPasquale D. Adult osteomyelitis protocol. http://www.osteomyelitis.com/pdf/treatment_protocol.pdf.

(date last accessed 05 March 2013).

Web reference (no authors listed):

No authors listed. International commission on radiological protection. http://www.icrp.org (date last accessed 20 September 2009).

Chapter in a book:

Young W. Neurophysiology of spinal cord injury. In: Errico TJ, Bauer RD, Waugh T (eds). Spinal Trauma. 3rd ed. Philadelphia: JB Lippincott; 1991: 377-94.

Dissertation:

Borkowski MM. Infant sleep and feeding: a telephone survey of Hispanic Americans [dissertation]. Mount Pleasant (MI): Central Michigan University; 2002.

Abstract:

Peterson L. Osteochondritis of the knee treated with autologous chondrocyte transplantation [abstract]. ISAKOS Congress, 2001.

Structure and content of submission

- We accept a maximum of 3 500 words, including the abstract and body of the text (excluding references).
- Exceptions to this rule may be made for systematic reviews and meta-analysis at the discretion of the Editor-in-Chief.
- Please follow the following structure when preparing your submission. Each of the following should be submitted as a separate file.
- Title page (title, authors and affiliations, corresponding author and declarations)
- Blinded manuscript (Abstract, keywords, introduction, methods, results, discussion, funding sources, conflict of interest statement, ethics statement, acknowledgements and references)

- Tables (with headings), each table as a separate file.
- Figures (with legends), each figure as a separate file.

Title page

Title

- The title should be concise and informative.

Author names and affiliations

- Please provide the following information for each author:
    - Full names and surname, as well as title
    - Qualifications
    - Designation
    - Affiliation and address
    - ORCID ID (see Article Submission section)
- Please check that all names are accurately spelled.
- Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate affiliation details.
- Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.

Corresponding author

- Clearly indicate who will handle correspondence at all stages of refereeing and publication, including post-publication.
- Ensure that the e-mail address and permanent address is given and that contact details are kept up to date by the corresponding author.
- Please note that the corresponding author's contact details will be provided in the final article.
- Provide the following information for the corresponding author:
    - Full names and title

- Affiliation
- Physical address
- Postal address
- Telephone number
- E-mail address

Declarations

Authors are to insert a section at the end of the title page entitled declarations (please provide the author's name, signature and date). The following statements are required under the declarations section:

Authorship

The authors confirm that all authors have made substantial contributions to all of the following:

- The conception and design of the study, or acquisition of data, or analysis and interpretation of data.
- The drafting of the article or its critical revision for important intellectual content.
- Final approval of the version to be submitted.

Sound scientific research practice

The authors further confirm that:

- The manuscript, including related data, figures and tables, has not been previously published and is not under consideration elsewhere.
- No data have been fabricated or manipulated (including images) to support conclusions.
- This submission does not represent part of a single study that has been split up into several parts to increase the quantity of submissions and submitted to various journals or to one journal over time (e.g. ‘salami-publishing’).

Plagiarism

The authors confirm that the work submitted is original and does not transgress the plagiarism policy of the journal.

- No data, text or theories by others are presented as if they were the authors' own.
- Proper acknowledgements of others' work have been given (this includes material that is closely copied, summarised and/or paraphrased); quotation marks are used for verbatim copying of material.
- Permissions have been secured for copyrighted material.

Conflict of interest statement

A conflicting interest exists when professional judgment concerning a primary interest (such as the patient's welfare or the validity of research) may be influenced by a secondary interest (such as financial gain or personal rivalry). It represents a situation in which financial or other personal considerations from authors, reviewers or editors have the potential to compromise or bias professional judgment and objectivity. It may arise for the authors when they have a financial interest that may influence their interpretation of their results or those of others. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, grants or other funding. All potential conflicts of interest need to be declared. The conflict of interest statement should list each author separately by name, e.g.,

'Author A.B. (use initials of relevant author, not full name in order for the document to remain blinded) has received research grants from Company A. Author B.C. has received a speaker honorarium from Company X and owns stock in Company Y. Author C.D. is a member of committee Z.'

If no conflicts of interest exist, state this as follows:

'The authors declare they have no conflicts of interest that are directly or indirectly related to the research.'

Funding sources

All sources of funding should be declared. Also, define the involvement of study sponsors in the study design, collection, analysis and interpretation of data; the writing of the manuscript; and the decision to submit the manuscript for publication.

List all funding sources as follows:

'This work was supported by the xxxx (grant numbers xxxx, yyyy).'

When funding is from a block grant or other resources available to a university, college or other research institution, submit the name of the institute or organisation that provided the funding.

If no funding was received, state as follows:

'No funding was received for this study.'

Compliance with ethical guidelines

- For all publications:

'The author/s declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.'

Available from: http://publicationethics.org/resources/international-standards-for-editors-and-authors

Institutional Review Board (IRB) ethical approval must have been given if the study involves human subjects or animals. Please provide the approval number. IRB documentation should be available upon request.

'Prior to the commencement of the study ethical approval was obtained from the following ethical review board: Provide name and reference number'

- For studies with human subjects include the following:

‘All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.’

‘Informed written consent was or was not obtained from all patients for being included in the study.’

‘Consent was obtained from patients for the use of clinical photographs and these images were adequately anonymised.'

- For studies with animals, include the following sentence:

‘All institutional and national guidelines for the care and use of laboratory animals were followed.’

- For articles that do not contain studies with human or animal subjects:

‘This article does not contain any studies with human or animal subjects.’

- If doubt exists whether the research was conducted in accordance with the Helsinki Declaration, the authors must explain the rationale for their approach and demonstrate that the institutional review body explicitly approved the doubtful aspects of the study. If any identifying information about patients is included in the article, the following sentence should also be included: Additional informed consent was obtained from all patients for which identifying information is included in this article. The Helsinki Declaration 2008 can be found at http://www.wma.net/en/30publications/10policies/b3/

Please provide the names and email addresses of two reviewers.

Title Page Example

Title of Submission

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Declarations:

Authorship

The authors confirm that all authors have made substantial contributions to all of the following:

- The conception and design of the study, or acquisition of data, or analysis and interpretation of data.
- The drafting of the article or its critical revision for important intellectual content.
- Final approval of the version to be submitted.

Sound scientific research practice

The authors further confirm that:

- The manuscript, including related data, figures and tables, has not been previously published and is not under consideration elsewhere.
- No data have been fabricated or manipulated (including images) to support conclusions.
- This submission does not represent part of a single study that has been split up into several parts to increase the quantity of submissions and submitted to various journals or to one journal over time (e.g. ‘salami-publishing’).

Plagiarism

The authors confirm that the work submitted is original and does not transgress the plagiarism policy of the journal.

- No data, text or theories by others are presented as if they were the authors’ own.
- Proper acknowledgements of others’ work have been given (this includes material that is closely copied, summarised and/or paraphrased); quotation marks are used for verbatim copying of material.
- Permissions have been secured for copyrighteed material.

Conflict of interest statement

John Smith declares that he has no conflict of interest. Paula Taylor has received research grants from Drug Company A.

Funding sources

No funding was received for the purposes of performing this study.

Compliance with ethical guidelines

The author/s declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to the commencement of the study ethical approval was obtained from the following ethical review board: Provide name and reference number.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Informed written consent was or was not obtained from all patients for being included in the study.

Consent were obtained from patients for the use of clinical photographs/ and these images were adequately anonymised.

Author Name	**Signature**	**Date**
J Smith		15/8/2017
P Taylor		16/8/2017

Blinded manuscript

To ensure a blinded review, the main body of the manuscript should not contain any identifying information, including author's names, institutions or affiliations. Please do not include the name of the ethics committee, this information should be provided in the title page.

Abstract

- A structured abstract (maximum of 350 words) summarising the most important points in the article is required.
- The abstract consists of four paragraphs with the subheadings:

    - Background (must include the aim of the study)
    - Patients and methods
    - Results
    - Conclusion
- References should be avoided. Avoid uncommon abbreviations. If essential, they must be defined at their first mention in the abstract itself.

Keywords

- Immediately after the abstract, provide a maximum of six keywords using standard searchable terms. These keywords will be used for indexing purposes.

Level of evidence

- Level 1 to 5.
- Please follow the level of evidence guidelines provided by the Oxford Centre for Evidence-Based Medicine (OCEBM); version 2.1.
- Available from: OCEBM Levels of Evidence Working Group. 'The Oxford Levels of Evidence 2'.Oxford Centre for Evidence-Based Medicine. http://www.cebm.net/index.aspx?o=5653

Introduction

- The introduction should contextualise the study by providing the background to the research; explain the problem that is to be addressed, and provide the rationale for the study.
- Briefly outline the relevance of the study with respect to the current literature. Avoid a detailed literature survey or a summary of the results.
- The last sentence should outline the research question or hypothesis.

Patients (or Materials) and methods

- State the methods, outcome measures, and selection criteria. The following aspects need to be described:
    - The study design and research methodology
    - Whether randomisation (with methods) was applied
    - If case-controlled, how the controls were selected
    - The time period under review
    - Number of patients/subjects under investigation and why this number was chosen
    - Inclusion and exclusion criteria
    - Case and outcome definitions
    - A description of the procedure or intervention, including post-operative protocol
    - The outcome measures or scores used
    - The minimum follow-up period
    - Statistical analysis paragraph. This should be included at the end of this section to detail statistical tests and package used, the reasons why these tests were used, and what p-value was considered statistically significant. A power analysis is recommended for studies comparing two or more groups.
- Provide sufficient detail so that another researcher can replicate the study.
- The reader should understand from this description all potential sources of bias such as referral, diagnosis, exclusion, recall or treatment bias. This includes the manner in which investigators selected the patients. Consecutive inclusion implies all patients with a given diagnosis are included, while selective implies patients with a given diagnosis but selected according to certain explicit criteria (e.g., state of disease, choice of treatment).
- Do not describe standard procedures for common operations. Only include new procedures or adaptations to standard procedures.
- If you name any specific product, it requires the manufacturer's name, city and state/country.
- Present information in the narrative format and use the past tense.
- Where relevant, tables or figures may be included to provide information more clearly.
- Generally, no data should be presented in this section.

Results

- Describe the relevant results and analysis thereof.
- Provide details of the number of patients included and excluded, as well as the reason for exclusion.
- It is important to state the follow-up period (mean and range).
- The results can be broken down into separate sections, e.g. Treatment, Functional outcome, Complications, etc.
- Tables may be used but avoid repeating data reported in the text in the tables.
- All appropriate data should be presented as means with ranges, not with standard deviations (SDs). Medians should only be used when the data is skewed, accompanied by an interquartile range (IQR).
- Avoid using percentages in studies involving well under 100 subjects.
- All results must be backed up with p-values or survivorship analysis. All Kaplan-Meier data should be presented with confidence intervals. Always present exact absolute p-values, whether significant or not, unless $p<0.001$.
- However, P-values do not always convey the entire picture and where relevant, the confidence interval will also be required (in addition to the power of the study reported in the methods section).

Discussion

- The question or hypothesis stated at the end of the introduction should be discussed and either supported or rejected.
- The results must be interpreted clearly, and any deficiencies expressed. All possible confounding factors, sources of bias or weaknesses in the study should be identified.
- Explore the significance of the results of the work rather than repeating the results.
- The discussion must point out the relevance of the work described in the paper and its contribution to current knowledge.
- Explain what can be deduced from the results and how will it affect clinical practice.
- Include a review of the relevant literature, placing the results of the study in the context of previous work in this area.

- Discussion of relevant prior research and references must be concise. Avoid extensive citations and discussion of published literature emphasize previous findings that agree (or disagree) with those of the present study.
- Do not repeat the introduction.
- Present the limitations of the study and suggest how the study could have been improved for a future study.
- Avoid making inferences from non-significant trends unless you believe your study is adequately powered to answer the question; in that case, provide a power analysis.

Conclusion

- Provide a summary statement that conveys the conclusions of the findings.
- Do not draw conclusions not supported by the data obtained from the specific study presented.

Ethics statement

- For studies involving human subjects, please include an ethics statement as follows: 'All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.'
- For animal studies, please include the following ethical statement: 'All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.'
- If the study did not involve human or animal subjects, state that: 'This article does not contain any studies with human participants or animals performed by any of the authors.'
- Please also include an informed consent statement: 'Informed consent was obtained from all individual participants included in the study.'
- Alternatively, for retrospective studies, please add the following sentence: 'For this study formal consent was not required.'

- If identifying information about participants is available in the article, the following statement should be included: ‘Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.’

Acknowledgements

- Acknowledgements should be placed at the end of the discussion and before the references.
- In this section, persons who were involved but did not earn authorship can be acknowledged.
- Statements should be brief. A person can be thanked for assistance or comments.
- Do not include contributions by editors or referees.

Author contributions

- Please state the contributions of each author
- For example: ‘A.B contributed to the study conceptualisation, design, data analysis and manuscript preparation. C.D. contributed to data collection and manuscript preparation. E.F. contributed to ....’
- The types of contributions are:
    - Conceptualisation and design
    - Data collection or contribution
    - Data analysis
    - Manuscript preparation
    - Other contributions (please specify)

References

- Please refer to the section on Formatting of submissions.

Tables and figures

- Tables and figures should not be imbedded in the text file but should be submitted as separate individual files. Each table should be a separate file, entitled Table I, Figure 2, etc.

- Each table and figure should be provided with a heading or legend.
- Please refer to the ‘Formatting of submission’ section for further guidelines.

Case reports

In addition to the preceding guidelines the following applies:

- The following headings need to be adhered to in the body of the manuscript:
    - Abstract
    - Keywords
    - Background
    - Case report
    - Discussion
    - Conclusion
    - Ethics statement
    - References

- Abstract: Minimum 250 words (350 maximum), using the following headings:

    - Background
    - Case report
    - Discussion
    - Conclusion
- Statement of informed consent must be included in the ethics statement.

Current Concepts Review Article (by invitation only)

General Guidelines:

- A narrative review will suffice (and systematic or scoping review not necessary)
- A thorough literature review needs to be done prior to writing the manuscript to ensure that the author is well acquainted with the current concepts related to the topic (with emphasis on the most recent developments)

- A balanced and unbiased view of the current clinical aspects of the topic.
- Focus on clinical aspects like diagnosis and treatment.
- Discuss controversies and state both sides of the argument.
- Avoid extensive discussion of basic science (anatomy/physiology/pathology) aspects, except for some really novel and clinically relevant new developments in the field.
- The topic may be adapted, but only with the permission of the Editor-in-Chief.

Outline of Article:

- Abstract = One paragraph, no headings, ≤350 words.
- Introduction = Brief introduction to the topic
- Contents = Please use headings (in bold) and sub-headings (in italics) to structure the manuscript in a reader-friendly manner
- South African context = Discuss matters which may be particularly relevant or unique to the South African clinical setting.
- Learning points = Make use of tables to summarize important learning points
- Conclusion = Brief evidence-based conclusion and summary
- Conflict of interest statement
- References = As usual

Addendum AII

Author guidelines: Occupational Health South Africa

Guidelines for authors

OVERVIEW

Occupational Health Southern Africa adheres to the guidelines of the following organisations: the International Committee for Medical Journal Editors (the Uniform Requirements for Manuscripts Submitted to Biomedical Journals)(http://www.icmje.org/#author), the Committee on Publication Ethics (COPE) (http://publicationethics.org/), and the National Health Research Ethics Council (NHREC) (https://health.gov.za/nhrec-home/).

Review process

All manuscripts (except correspondence and, in some cases, opinions) are sent for peer review, unless they do not comply with the Guidelines for Authors, or are not relevant to this journal. The review is blinded, meaning that neither the referees nor the authors know each other's identities. Authors are informed of the outcome of the review process by the editor.

Ethics

In accordance with stipulations of COPE and the NHREC (see above), Occupational Health Southern Africa requires evidence of ethical approval of all research studies involving human subjects or animals, by an accredited research ethics committee, before a manuscript can be published. The committee that approved the study, and the clearance certificate number, should be included in the manuscript.

Authorship, factual accuracy and copyright

Authors are solely responsible for the factual accuracy of their work and must ensure that their work does not infringe copyright. Submission of the completed Statement of acceptance of conditions and responsibilities pertaining to the publication of a manuscript by all authors is required prior to the publication of the manuscript. All, and only, the legitimate authors must be listed. This journal subscribes to the criteria for authorship of research articles, developed by the International Committee of Medical Journal Editors (ICMJE) (http://www.icmje.org/#author). In order to be acknowledged as an author, individuals must have satisfied all of the following three criteria:

1. Contributed substantially to the conception and design of the study, or acquisition of data, or analysis and interpretation of data;
2. Drafted the manuscript or revisited it critically for important intellectual content; and
3. Approved the final version to be published.

"Examples of activities that alone (without other contributions) do not qualify a contributor for authorship are acquisition of funding; general supervision of a research group or general administrative support; and writing assistance, technical editing, language editing and proofreading."

Medical writer

The use of a medical writer must be acknowledged.

Statement of acceptance

Before the manuscript can be sent for review, all the authors are required to acknowledge and agree to the following conditions pertaining to ethical issues related to the publication of a manuscript (Statement of acceptance of conditions and responsibilities pertaining to the publication of a manuscript):

1. Authors are required to declare any potential conflicts of interest. These include financial or personal relationships in the form of dual commitments, competing interests, or competing loyalties (http://www.icmje.org/#author).

2. It is the authors' responsibility to determine whether agreement is required from any parties for the use of material in their manuscript, and to ensure that such permission is obtained, so that copyright is not infringed.
3. Authors are required to give the assurance that the content of the manuscript is their own work and, where it is not, that appropriate acknowledgement is given.
4. Authors are responsible for ensuring that statistical analyses contained within the manuscript have been checked for appropriateness and accuracy by a person with a sound knowledge of statistics.
5. Authors must inform the editor of the existence of any other manuscripts that they have submitted to, or had published by, other journals, or that are in the public domain, and that overlap with this manuscript. Copies of such papers must be supplied to the editor.
6. The publishers, editors, SASOM, SASOHN, SAIOH and MMPA are not liable for any damages or losses incurred as a result of any statement contained in Occupational Health Southern Africa. Whilst every effort is made to ensure accuracy of manuscripts published, neither the publishers, editors, SASOM, SASOHN, SAIOH or MMPA accept any responsibility for errors or omissions in the content, and reserve the right to edit all contributions. The views expressed in this journal are not necessarily those of the publishers, editors, SASOM, SASOHN, SAIOH or MMPA; neither do these Societies, publishers or editors endorse or guarantee the products advertised in the journal or claims made by the manufacturers.
7. Once a manuscript is accepted for publication, the exclusive copyright of the manuscript is assigned to Occupational Health Southern Africa. Material from the manuscript may subsequently be used by the authors, provided that paraphrasing is applied.

REQUIREMENTS AND FORMAT FOR SUBMISSION OF A MANUSCRIPT

In addition to complying with the Uniform Requirements for Manuscripts Submitted to Biomedical Journals (http://www.icmje.org/#author), all manuscripts and articles should conform to the style requirements for publication in Occupational Health Southern Africa, which are indicated hereafter.

General requirements

- Scientific writing style, as well as good grammar, must be used.
- Content must be organised in a logical sequence.
- Articles must be relevant and scientifically significant.
- In the case of research and review articles, the methodology must be sound.

Style requirements

- The manuscript must be written in Microsoft Word format.
- Use Arial font, size 11, and 1.5 line spacing.• Margin widths must be 2.54 cm all around.
- Round percentages accurately to one decimal point.
- Include leading zeros, e.g. $p < 0.050$, not $p < .050$.
- Scientific measurements must be expressed in SI units.
- Abbreviations and acronyms must only be used if absolutely necessary and must be defined on first use, but not in the Abstract.
- Only proper names must start with upper-case letters.
- Quotation marks must only be used for direct quotes.
- Footnotes must not be used, other than in tables and figures.
- Pages must be numbered consecutively.

References

- All statements must be appropriately referenced.
- Citations and references must be written following the Vancouver referencing style according to the International Committee of Medical Journal Editors: https://fk.ui.ac.id/download/ejki/Vancouver_format.pdf
- Citation numbers must be inserted in the text as superscript numbers, after the full stop, and listed at the end of the article in numerical order (not alphabetically), as per Vancouver referencing style.
- Only approved abbreviations of journal titles should be used (https://www.ncbi.nlm.nih.gov/nlmcatalog/journals/).

- References must be of good quality (use primary sources from peer-reviewed journals, rather than secondary sources, wherever possible).
- Personal communications and unpublished observations must be cited in the text, but not in the reference list.
- The accuracy of references is the author's responsibility.

CONTENT Title page

- This page should contain the Title, the author(s)' full names, all the author(s)' position(s) in public sector departments and/or affiliations to academic institutions (if relevant), and the physical address and contact details (telephone number and e-mail address) of the corresponding author. Authors who are members of SASOM, SASOHN, SAIOH or MMPA must indicate this membership.
- The Title must reflect the contents of the manuscript, without being overly long.
- A word count should be included on this page.

SUBMIT THIS PAGE SEPARATELY TO THE MANUSCRIPT SO THAT ALL IDENTIFIERS ARE REMOVED FOR THE REVIEWERS.

Abstract

- Abstract: see article categories below for detailed instructions.
- Provide a maximum of five keywords or terms that can be used for searches for electronic retrieval of information. They must be specific, and reflect what is essential about the paper. It is preferable to use keywords that do not appear in the Title of the manuscript.

Main body of manuscript

- This should include Introduction, Methods, Results, Discussion, and Conclusions and recommendations sections.
- Introduction: see article categories below for detailed instructions.
- Methods: see article categories below for detailed instructions.
- Results: see article categories below for detailed instructions.

- Discussion: see article categories below for detailed instructions. Include recommendations in the Discussion. These should be logical and feasible. Areas for further study and implications for practice must be indicated in the recommendations.
- Conclusion: this section must be logical, reasonable and practical, and be supported by evidence from the article. Do not start a new topic, present new information that is not in the Discussion, or repeat the Introduction. Conclusions must relate to the findings.

Funding

All sources of funding must be declared and the role of the funding source must be described, where applicable (e.g. costs of specimen analysis, data analysis, manuscript submission, etc.).

Declaration

Declarations of conflicts of interest and affiliation should be indicated after the Conclusions and recommendations. Any affiliations to commercial organisations should be declared, in accordance with the policy on conflicts of interest provided by the World Association of Medical Editors (http://www.wame.org/about/conflict-of-interest-in-peer-reviewed-medical).

Acknowledgements

Acknowledgements, if stated, should be placed after the Declaration.

Key messages

Three to five key points (numbered) from the study must be provided.

Statistical analysis of results

- When comparing groups or samples, measures of the estimated magnitude of effect or association, such as rate ratios or differences in means, should be used.
- Comparisons of disease or injury frequency should use epidemiologic measures of association such as the rate ratio, odds ratio, rela-tive risk or risk difference.
- Provide confidence intervals and p values for measures of association.

Tables and figures

Tables and figures should be understandable without the reader having to consult the text. They should be numbered using Arabic numerals. For tables: the title must be above the table; for figures: the title must be below the figure.

Illustrations and photographs

Photographs (without identifying details of patients, products or places) must be submitted as images of at least 300 dpi.

Photographs must include the name of the photographer to be credited. Illustrations should be submitted separate to text, in electronic format. All accompanying materials should be clearly identified by means of titles that are also indicated in the text of the manuscript.

Supplementary materials

Additional materials to accompany manuscripts must be clearly labelled as such. These materials must not be essential for understanding the paper; they are intended to complement the manuscript. These materials will be included with the manuscript for peer review.

Submission

All pages of the manuscript must be submitted as a single document, in Microsoft Word format, including figures and tables. However, illustrations and photographs must be submitted as individual documents. Submission must be made online via Scholastica.

ARTICLE CATEGORIES

ORIGINAL RESEARCH

Manuscripts reporting original, relevant research with sound methodology are welcomed. Studies with poor methodology, such as quantitative studies with small sample sizes, short follow-up times (longitudinal studies), or inadequate controls, are likely to receive adverse peer reviews. Similarly, qualitative studies with poor methodology, such as incongruence between the research tradition and the data collection and analysis methods, inappropriate sampling strategy, and

inadequate measures for trustworthiness, will also lead to poor reviews. Original research articles should not exceed 3 500 words (excluding the Title, authors' details, Abstract, keywords, Declaration, Acknowledgments, References, tables and figures). The following elements must be included:

Title

Abstract

This must be structured, wherever possible (Background, Objectives, Methods, Results, Conclusion), and be less than 300 words. It should be a concise summary of the essential aspects of the article. As this may be published on its own, it should be understandable without the need to read the main text.

Introduction

Clearly indicate the main issues to be covered, the definition and delimitation of the research problem, the need for the study (i.e. the gap in knowledge), the importance of the study, and the purpose/aim and objectives/hypotheses of the research. The cited literature (which may be part of the Introduction or a separate section) must be relevant, of good quality, critically discussed and correctly acknowledged.

Methods

The date(s) when the research was conducted must be provided. The research design and methodology employed must be clearly described and justified. The latter includes a description of the study site, the study population, sampling strategy (method, selection criteria and size), and data collection (type of data, type of tool and its development and testing, if relevant). In the case of intervention studies, the protocol or intervention must be clearly described. Results for randomised trials must be reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) available at http://www.consort-statement.org/consort-statement/overview0/. For quantitative studies, validity and reliability issues must be described and the statistical tests for analysis must be relevant and appropriately interpreted. For qualitative studies, the trustworthiness of the findings must be described and the analytical methods must be appropriate. A brief description of how ethical issues were addressed, as well as evidence of ethical clearance

by an accredited research ethics committee, must be provided (include the name of the committee and the ethics certificate clearance number).

Results

Results must be accurate, comprehensive, unbiased and relate to the purpose and objectives/hypotheses of the research. For quantitative studies, authors may be requested to obtain statistical assistance if reviewers are concerned about the accuracy and appropriateness of the analyses. For qualitative studies, quotes from study participants (where relevant) must be provided to support conclusions. Provide the results for all measures stated in the Methods section. Present summarised data in tables and figures. Report the results in the same order as the research questions/objectives/hypotheses and measures. Do not include discussion, explanation, or references. Avoid reporting results that are not part of the research questions/objectives/hypotheses.

Discussion

The findings should be discussed in the light of the literature, in relation to the purpose and objectives/hypotheses, and should indicate how the study has contributed to the body of knowledge. Compare the results with other studies. Acknowledge study limitations that might have influenced the results. Avoid detailed repetition of the results, the introduction of new or irrelevant information, and discussion of results that are not part of the study's research questions/objectives/hypotheses. Include recommendations, where relevant.

Conclusion

Key messages

Declaration

Acknowledgements

References

REVIEW ARTICLE

Articles involving a state-of-the-art review of the literature, including systematic reviews, must contribute to the body of knowledge on a specific topic, and not just repeat previously documented findings. The articles should not exceed 3 500 words (excluding the Title, authors' details, Abstract, keywords, Declaration, Acknowledgments, References, tables and figures). The following elements must be included:

Title

Abstract

The Abstract should include the purpose of the paper, and a brief description of the search strategy, main findings, conclusions and recommendations.

Introduction

This should clearly indicate the nature of data gathering, the main issues to be covered, definitions, the need for the review (i.e. the gap in knowledge), the importance of the paper, and the purpose/objectives of the review.

Methods

The search strategy to identify good-quality and relevant literature must be clearly described and justified. This includes the search terms, the databases, journals and books that were searched, the time period searched, and the selection criteria used.

Body of the paper (wording will be determined by the topic)

The review should be comprehensive in terms of including seminal papers and articles written by experts on the topic, critically appraising and comparing their findings, highlighting methodological flaws, identifying gaps in the literature, and indicating how the paper has contributed to the body of knowledge. It can be thematically or methodologically organised. The literature must be correctly acknowledged and cited/referenced. Include recommendations, where relevant.

Conclusion

In addition to the guideline under Content above, the Conclusion should summarise the major contributions, and identify gaps and contradictions.

Key messages

Declaration

Acknowledgements

References

CASE STUDY

The case must be related to occupational health. Case studies should be written in less than 500 words (excluding the Title, authors' details, Abstract, keywords, Declaration, Acknowledgments, References, tables and figures), and should describe: unexpected associations and events; unique cases in terms of the condition/event/problem/setting/exposure/management; cases that highlight legal or ethical issues; or new findings that contribute to an understanding of the condition/event/problem/management strategy. The case study should be written in the active voice and in the first person. For example, "we treated the patient" instead of "the patient was treated". The following elements must be included:

Title

Abstract

The Abstract should include the purpose of the paper; that it is a case study; the findings, conclusions and recommendations.

Introduction

This must provide a brief reason for reporting the case, with a clear statement of the problem. Include a statement indicating how ethical issues have been addressed, particularly informed consent from relevant parties and measures to ensure confidentiality. Written patient consent must

be obtained by the authors for clinical material submitted for publication. A signed statement that this consent is held by the authors is required before publication. Evidence of ethical clearance by an accredited research ethics committee must be provided (the name of the committee and the ethics clearance certificate number).

Case description

This should consist of an adequate, clear description of the case. Clinical case studies should include demographic details, the chief complaint, the history of the present complaint, relevant health history, diagnosis, treatment, clinical course and outcome.

Results

Results of all investigations, with normal reference values, should be provided. The case can be illustrated with the use of charts, figures, graphs and photographs (with identifying details removed). Permission must be obtained to use these. Supplementary material may be included for placement on the website.

Discussion

The Discussion must include a concise discussion of the case, with supportive evidence in the form of scientific literature, including legislation, guidelines and systematic reviews. Alternative explanations or controversies must be considered/rejected on the grounds of supportive evidence. Include recommendations, where relevant.

Conclusion

Key messages

Declaration

Acknowledgements

References

BACK TO BASICS

This is an informative article on a relevant practice-related occupational health topic. The main aim is to enhance professional practice. The article should not exceed 3 500 words (excluding the Title, authors' details, Abstract, keywords, Declaration, Acknowledgments, References, tables and figures). The following elements must be included:

Title

Abstract

Introduction

This should clearly indicate the main issues to be covered, the reason for the paper and its purpose. The cited literature (which may be part of the Introduction or a separate section) must be relevant and correctly acknowledged.

Body of the paper (wording will be determined by the topic)

The information should include basic principles, concepts, guidelines and evidence-based knowledge underlying the topic; be up to date; highlight emerging issues; and be conducive to continuing education. The contents must be supported by literature. Include recommendations, where relevant.

Conclusion

Key messages

Declaration

Acknowledgements

References

OPINION

This is an opinion article related to occupational health. The main aim is to engage readers and stimulate debate. It should not exceed 2 500 words (excluding the Title, authors' details, Abstract, keywords, Declaration, Acknowledgments, References, tables and figures). The following elements must be included:

Title

Introduction

This should clearly indicate the main issues to be covered and the purpose of the article. The cited literature (which may be part of the Introduction or a separate section) must be relevant and correctly acknowledged.

Body of the paper (wording will be determined by the topic)

The contents must be supported by literature. Include recommendations, where relevant.

Conclusion

Declaration

Acknowledgements

References

ISSUES IN OCCUPATIONAL HEALTH

This is an informative article related to any aspect of occupational health that does not obviously fall into one of the other categories. The main aim is to inform and educate readers about new developments in their specialties or in areas that affect them (e.g. legislation, guidelines, formation of working groups, feedback from workshops). The paper should not exceed 2 500 words (excluding the Title, authors' details, Abstract, keywords, Declaration, Acknowledgments, References, tables and figures).

The following elements must be included:

Title

Introduction

This should clearly indicate the main issues to be covered, and the purpose of the paper. The cited literature (which may be part of the Introduction or a separate section) must be relevant and correctly acknowledged.

Body of the paper (wording will be determined by the topic) Include recommendations, where relevant.

Conclusion

Declaration

Acknowledgements

References

SHORT REPORT

A short report on a research study is one that does not add important new knowledge on a topic, but is considered worthy of publication because it contains results pertaining to the southern African region that are worthy of dissemination. Pilot studies with useful results but small samples might also be considered for publication as a short report. Authors whose manuscripts are considered to fall into this category will be requested to supply an abbreviated paper that includes an Abstract, keywords, Introduction, Methods, Results, Discussion, and Conclusion. It should contain only one table or figure, a maximum of 12 references and not exceed 1 000 words.

CORRESPONDENCE

Scholarly correspondence in the form of letters to the editor, or a commentary related to an article recently published in Occupational Health Southern Africa, will be considered. The purpose might be to facilitate interpretation of the findings of a published study through additional explanation, information or illustration, provide constructive criticism, and/or stimulate debate. Such correspondence should not exceed 500 words, and statements must be supported with good-

quality literature, where relevant. Correspondence is not peer reviewed, although, in some instances, the editor may request an opinion from a relevant researcher/expert. Authors' details must include their current positions and full addresses. Competing interests must be declared. The author(s) of the original article will be invited to reply to the correspondence, where relevant.

BOOK REVIEW

In-depth reviews of new books related to occupational health will be published, provided that the review is positive, relevant for the readership, and the book is recommended. The review must be conducted by a peer reviewer of integrity with good knowledge of the subject and without a vested interest. It should not exceed 1 000 words.

The following elements must be included:

- authors'/editors' names and initials, title of the publication, edition, date of publication, publisher and place of publication, ISBN number, format (hardback or paperback), number of pages, price, website/publisher's contact details for purchasing the book;
- authors' or editors' expertise;
- intended audience;
- description and critique of the structure and content of the book;
- use of tables/diagrams/illustrations;
- evaluation of the scientific quality, comprehensiveness, readability and usefulness for the target audience; and• in the case of new editions of existing books, a description of the new content.

PROOFS

Corrected manuscripts, once approved for publication by the editor and the author(s), will be submitted to the publisher. Thereafter, the publisher will complete the layout of the material, and will provide the author(s) with an electronic proof of the final pages in Adobe portable document format (PDF). Alterations to proofs must be limited to misprints or factual errors. Major alterations or new material cannot be accepted.

Addendum BII

Author guidelines: South African Society of Occupational Therapy

http://userguide.sajot.co.za/guidelines-for-publishing-in-the-south-african-journal-of-occupational-therapy/

Guidelines for Publishing in the South African Journal of Occupational Therapy

The South African Journal of Occupational Therapy (SAJOT) accepts scientific articles, scientific letters, scoping /systematic/integrative reviews, commentaries, opinion pieces and book reviews for publication.

The language of the Journal is South African English (abstracts may be provided in Afrikaans or the Vernacular as well as in English).

All articles that are published in SAJOT may be found at www.sajot.co.za, www.sceilo.org.za, EBSCOHost, Google Scholar or OTDBASE. In addition, articles are preserved via Portico which is a digital preservation service provided by ITHAKA, a not-forprofit organisation with a mission to help the academic community use digital technologies to preserve the scholarly record and to advance research and teaching in sustainable ways.

POST-ACCEPTANCE PUBLICATION FEES:

In line with the policy of most Open Access Journals, all submissions to the SAJOT are subject to a publication fee of R5000-00 (Approx US$350) per article once the submission is accepted for publication.

This post-acceptance publication fee will be applied to cover both retrospective and prospective processes involved in peer-reviewed articles, including:

- Peer-review management
- Manuscript preparation (e.g., copy editing)
- Journal production (e.g., layout)
- Open-access online publication and hosting
- Indexing (e.g., PubMed)
- Archiving

The fee is waivered in the following instances:

- If at least one of the listed authors of the article is a member of the Occupational Therapy Association of Southern Africa (OTASA). (Proof of OTASA membership will be verified by the OT office prior to publication.)

- If an application for exemption is submitted and subsequently granted by the OTASA Chairman of the Publications Committee (see details below). ● If the submission is either a book-review, commentary or opinion piece.

Applications for exemption from the publication fee can be made to the chair of the publications committee Helen Buchanan (helen.buchanan@uct.ac.za)

Those authors eligible for payment of fees will receive an invoice from the OTASA office and payment will need to be made to OTASA within the stipulated time.

GUIDELINES FOR SUBMISSION

The following are included in these instructions:

1. General guidelines and instructions – procedure and presentation
2. Summary of Guidelines for authors
    - 2.1 Guidelines for authors of scientific articles
    - 2.2 Guidelines for authors of scientific letters
    - 2.3 Guidelines for publishing a literature, scoping or systematic review
    - 2.4 Guidelines for writing an opinion piece
    - 2.5 Guide to writing a commentary 2.6 Instructions for reviewers of books
3. Guide to submitting an article online.

The relevant guidelines to authors (which follow) must be consulted for the layout and the format of the article, tables, diagrams and referencing.

1. GENERAL GUIDELINES & INSTRUCTIONS – PROCEDURE AND PRESENTATION (APPLICABLE TO ALL SUBMISSIONS)

- Manuscripts must be submitted via the SAJOT web site (www.sajot.co.za); the author must retain a copy of the script.
- **New authors must submit the title page of the submission to the editor at sajot@mweb.co.za. A username and password will then be provided to enable the author to complete the online article submission.** (See Guide to submitting an article online). **Users already registered as authors do not need to go through a repeat of the registration process but simply use their existing username and password.**
- Users who are having problems with the username and password should contact the Editor-in-Chief at sajot@mweb.co.za.
- Please insert a note in the **'footer' that gives the title of the article and the date at each submission.** This is important for tracking purposes and will ensure that the correct version of the script is used for publication. This footnote will be removed at publication.
- Submission of the following separate files needs to be done.
- The Manuscript (scientific article, scientific letter, scoping/systematic review, commentary, opinion piece) including the illustrations, tables, graphs.
- 4 Supplementary files o A title page

o 15 multiple choice questions (MCQ's) (not for book reviews) o Contribution of Authors o Plagiarism Check report / certificate

The Manuscript

1. The manuscript needs to be uploaded first. This should include the abstract if applicable and all the illustrations, tables, graphs should be included in the correct place within the manuscript.
2. Please include the **ethics clearance number** if applicable to the study. The ethical clearance certificate must be available if requested. The ethical clearance number must also be recorded in the article when it is submitted for publication **as part of the methodology section of the article.**
3.

Supplementary files

1. Title Page

Each Manuscript must include a separate Title Page loaded as a Supplementary File. When submitting the article do not include any author information on the article itself

This page **must** include:

The title of the article
For each author full name **all** academic degrees and where these were obtained present post held status as undergrad student or postgrad student at time of research and affiliation complete address, telephone number, e-mail address, **ORCID** number, HPCSA number and OTASA membership number if applicable**.** Ethical clearance number – Institution where obtained. Acknowledgments, sources of funding and conflict of interests of two people who they believe have the skills and expertise to review the article .

The **ORCID** number must also be recorded in the relevant place on the SAJOT web site when the article is being submitted using **http//: and not https://** on the electronic submission page**.** To obtain an ORCID reference number and to learn about the benefits of being registered, go to: **www.orcid.org .** The orchid number will be included as part of the metadata of your article when it goes to publication. Please check that the ORCID number resolves to the author's name.

2. Contribution of the authors

Contribution of the author in the manuscript/research process needs to be described in a separate document to be uploaded as a supplementary file. This is a requirement of SciELO.

4. The Multiple Choice questions (MCQs)

3.1 For CPD purposes 15 multiple choice questions with the correct answer clearly marked should be set. See format in Appendix A

3.2 Criteria for the setting of the MCQ content as prescribed by the HPCSA are that they should be

- clear and concise, reflecting understanding
- each MCQ question must contain one correct answer and may be o multiple choice stem with multiple or single answers, o true/ false – maximum 20%;
- should contain commercial product promotion and/ or satire

4. Plagiarism Check report / certificate

'Cross Ref' or 'Turn-it-in' or 'Authenticate' certificate must be attached with an acceptable level (usually 15% or less depending on the use of terminology in the manuscript)

Referencing

Vancouver style referencing is used and each reference in the text must be indicated by a number in the text. This number should be inserted in superscript without brackets e.g.**12**. A reference list should be provided on a separate numbered page following the article text. References must be cited **in the order that they appear in the text**.. Please check references from predatory journals are avoided. Predatory journals can be checked at https://predatoryjournals.com/journals/ or https://beallslist.net/.

ALL references must be linked through **CrossRef ie each reference must show its DOI number** (if it has one). To find the DOI number go to **https://search.crossref.org/**. A window that askes to copy and paste or type in the title of the article or book and search. The full information on the article will appear. **Please note** that the DOI reference must be spaced so that it falls on one line and is not split between two lines. See examples of referencing below:

See what styles to use in Mendeley and Endnote to format references and examples of referencing in Appendix B.

General Requirements

	Abstract (words)	Pages	Tables and figures	Words (without tables and references)	References
Scientific Articles	200	±16-19	8	5000- 7000	Max 35 for the literature review section. Max 60 references
Scientific Letters	n/a	±5-8	2	1400-2500	Max 15
Integrative, Scoping or Systematic Review	200	±16-19	8	5000- 7000	Max 60 references
Opinion Piece	200	±5-8	2	1500-2000	Max 15
Commentary	200	±5-8	2	1500-2000	Max 15
Book Reviews	n/a	n/a	n/a	500	

Manuscripts must be clearly typed in **MS Word 1.5 spacing with a legible font (Arial, size 11 is preferable)**. Set English (South Africa) as the default language. Occupational therapy and occupational therapists should not be capitalised or abbreviated.

If quoting from a reference the following format must be used: Gibson[2:30] stated that "Occupational therapy is an important service for the rehabilitation of persons suffering from HIV/AIDS". where 2 is the reference number and 30 is the page number on which the quote appears. All quotes from literature must be in quotation marks " ". Quotes from participants in qualitative research should be in quotation marks and italics

Tables should have the heading at the top of the table and labelled with Roman letters e.g. Table II.

Figures should be labelled at the bottom of the figure with Arabic numbers e.g. Figure.

2.

Tables and figures (which may include graphs) **should not be scanned** but formatted and included in place in the manuscript. Figures should be clear to the reader when photocopied.

Figures which consist of illustrations, diagrams or photographs may be of any size. They must be very sharp, taken close-up, and photographs should have a lightish overall tone and without dark backgrounds. If the photograph, diagram and illustrations photocopy well, they will print well. Please check this before you send the manuscript.

The following web sites may be helpful for authors to consult either during the research process or during the write up process:

1. Equator Network (http://www.equator-network.org/), a database library that allows you to find and use reporting guidelines for different study designs. Provides a decision tree and examples that assist you with choosing the most appropriate reporting guideline for your study.
2. Typeset (https://www.typeset.io/), an online research communication platform that autoformats documents and helps ensure they are 100% compliant with journal submission guidelines.
3. Authoraid (http://www.authoraid.info/en/), a free global network that provides online mentoring, collaboration, and support for researchers in low and middle-income countries.
4. Standards for Reporting Qualitative Research: A Synthesis of Recommendations

(https://journals.lww.com/academicmedicine/fulltext/2014/09000/standards_for_reporting_qualitative_research__a.21.aspx)

Review of submissions

All manuscripts undergo an anonymous double blind peer review process. The reviewers are required to comment on the scientific worth of the article and its suitability for publication in SAJOT. (To ensure a blind review see section below). The comments are returned to the authors by the editor with a directive for further action required. Articles may be accepted without change, changes may be requested or the article may be rejected.

Editing

Please note that the article will be checked by the Editor and the English Language editor and when necessary, the author(s) before going to print.

Intellectual Property and Copyright

Checking the Manuscript before Submission

Confirmation that the following items **have been attended to** will be required as part of the submission process.

- The submission has not been previously published, nor has it been before another journal for consideration (or an explanation has been provided in Comments to the Editor).
- The submission file is in Microsoft Word file format.
- All references have been checked to see that they comply with the requirements (see References above).
- The text is Arial 11, 1.5 spaced; employs italics, rather than underlining (except with URL addresses); and all figures and tables have been placed in the text. ● The text adheres to the stylistic and bibliographic requirements outlined above ● The instructions for **Ensuring a Blind Review** have been followed.
- A colleague has read the article to provide objective peer input, inconsistencies, spelling and grammar in addition to running a spell-check with English, South Africa as the default setting. Authors for whom English is a second language should have their article edited by a professional English-language editor or editing service. During the review process, articles may be returned to the author to arrange such a service, if improvements to language and clarity are required.
- 15 Multiple Choice Questions (MCQs) based on the article content are prepared in the supplementary file section of the article submission. In addition, it is advisable to email these to the managing editor at sajot@mweb.co.za . **NB The article will not be sent for review until these have been received or posted on the web site.**
- The details of all the authors have been included in the submission.
- Ethical approval for the study has been sought and explained in the article and an approval number is given but the institution where obtained is replaced by XXX to ensure a blind review.
- The title of the article is on the article submission- see Title page
- The abstract has separately been included in the submission block on the webpage and is also included in the **Manuscript.**
- The article has undergone a **plagiarism check.**
- Permission has been obtained from the co-authors to publish the article and to use their names.
- The relevant acknowledgements have been provided at the end of the manuscript.
- As a special request the author is asked to provide the names, place of work, and email contact details of two people who they believe have the skills and expertise to review the article.

Ensuring a blind review

To ensure the integrity of the blind peer review of the submission to this journal, every effort is made to prevent the identities of the authors and reviewers from being known to each other.

It is the primarily the duty of the author to remove any possible identification from the text submitted as indicated below. The reviewer is obliged to keep his/her comments/opinions about the article confidential and communicate these only to the editor; should the reviewer have prior knowledge of or involvement with (incidental or otherwise) the author or the article in question, the editor should be informed of the situation and the situation reviewed if needed.

The editor is the only person who has access to all the information about authors and reviewers. Any issues concerning a review / edit/ authorship / copyright etc. about a SAJOT submission must be brought to the attention of the editor directly – the editor is the only person authorised to deal with these issues and will do so in a strictly confidential manner.

This process applies to the authors, editors and reviewers (who upload documents as part of their review), checking to see that the following steps have been taken with regard to the text and the file properties:

- The authors of the document have deleted their names from the text, and substituted "Author". . This includes ensuring that the names used in the acknowledgements section have also been substituted with an X. Names will be inserted just prior to publication.
- With Microsoft Office documents, author identification should also be removed from the properties of the file.

See how to remove your Identity from track changes and comments on documents in Appendix C

Continuing education points

CEU points are accredited as follows:

- Principal authors of a scientific article, literature (scoping/systematic/integrative) review: 15 CEUs and co-authors 5 CEUs.
- Principal authors of scientific letters, commentaries, book reviews or opinion pieces: 5 CEU's and co-authors 3 CEU's.

2.SUMMARY OF GUIDELINES FOR AUTHORS

2.1 GUIDELINES FOR AUTHORS OF SCIENTIFIC ARTICLES

Articles submitted to the SAJOT must be original and must not have been published elsewhere. Articles should contain new information, add to existing knowledge, resolve controversy or provoke thought and discussion. The content of the article must justify the length, which should be about **16-19 pages (**between **5000- 7000 words)**.

Authors should consult the article "The pitfalls of "salami slicing": focus on quality not quantity of publications" by Fenseca M. Editage Insights. Nov 4;

2013.https://www.editage.com/insights/the-pitfalls-of-salami-slicing-focus-on-qualityand-not-quantity-of-publications

Abstract and Key Words

The article must be accompanied by an abstract not **exceeding 200 words** in length. The abstract must contain a succinct structured summary of the study- headings may be used in the abstract (introduction, methodology, results, conclusion). There should be no references or abbreviations in the abstract.

Key words: a list of "key words" which contain words that might be helpful for tracking your article. Try not to 'repeat' key words from the title of the article, as this will limit the search opportunities.

Introduction

This should provide a brief rationale for the study and an outline of the aims or questions. The introduction should present a clear indication of the need for and purpose addressed by the article. Authors should not assume that the readers know the **context** in which the article is set. The content needs to be organised in a coherent and logical manner and may require concise descriptions and definitions of terms to elucidate the content as well as the aim of the study. The literature review may be included in the introduction.

Literature Review

A separate review of the **relevant literature** can be provided. This should be a **critical** appraisal of the current relevant literature identifying the limitations in the work already conducted on the subject and a rationale for the study. **A maximum of 35** references should be included.

The aim or objectives of the study should appear at the end of the literature review

Method

The section on **research methods** should include if appropriate: ● the research design used,

- the population and manner of selecting the population sample,
- the research tools used,
- the method of data collection,
- the methods used to analyse the data including details of the statistical methods, information on validity, reliability, trustworthiness and credibility.

Details of the ethical clearance and informed consent must be provided without the name of the institution at this stage (replace name with XXXX)

Results/Findings

The results must be presented in a way that makes them accessible to the readers and are clearly linked to the aims and methods of the research.

Discussion

The discussion should summarise the main findings and explore the reasons for these. New knowledge must be highlighted, and the limitations of the study given. The implications for occupational therapists and or other health professionals/groups/ contexts must be outlined and the contribution that the study makes to the current state of knowledge of the profession/s stated. Limitations must also be discussed.

Conclusion

The conclusion must be brief, drawing the article to a close by relating the results to the aim of the research and indicating the key findings this research has added.

Acknowledgements and conflict of interests

All assistance and funding for the research must be acknowledged and any conflict of interests stated.

Tables and figures

Articles may include up **to eight (8) tables or figures** and should be numbered and **clearly labelled and included in the manuscript** in the appropriate place.

2.2 GUIDELINES FOR AUTHORS OF SCIENTIFIC LETTERS

Letters submitted to the SAJOT must be original and must not have been published elsewhere. Letters should contain new information, add to existing knowledge, resolve controversy or provoke thought and discussion. Use the outline of the scientific article as a guide.

Requirements

The requirements of a scientific letter are as follows:

- The letter must have the same scientific format as an article, but should be much shorter -. **1400 – 2500 words**, to fill only a few pages of the Journal but does not have an abstract.
- It may have only **two (2) tables** of results.
- There should not be more than **15 references**. ● It must be original research.

Peer evaluation will take place as with all other articles submitted to SAJOT.

2.3 GUIDELINES FOR PUBLISHING AN INTEGRATIVE, SCOPING OR SYSTEMATIC REVIEW

Literature reviews including integrative, scoping reviews and systematic reviews submitted to the SAJOT must be original and must not have been published elsewhere. The content of the article must justify the length, which should be about **16-19 pages, with 1.5 spacing (5000-7000 words)**

Follow the PRISMA requirements/guidelines for when submitting an integrative, scoping or systematic review. The manuscript should contain the following:

Title

The title must be concise enough to reflect the 'Population', 'Concept', and 'Context' (PCC) of the review, which are the elements of a scoping review used to establish a priori inclusion and exclusion criteria.

Abstract and Key Words

Then review must be accompanied by an abstract not **exceeding 200 words** in length. The abstract must contain a succinct structured summary of the study- headings may be used in the abstract (background, aim, methods, results, conclusion). There should be no references or abbreviations in the abstract.
Key words: a list of "key words" which contain words that might be helpful for tracking your article. Try not to 'repeat' key words from the title of the article, as this will limit the search opportunities.

Background

The background of the review should be comprehensive and should cover the main elements of the topic, important definitions, and the existing knowledge in the field. An integrative review would identify and organise a combination of diverse methodologies into themes or a framework whereas a scoping review would examine emerging evidence and a systematic review would identify and synthesise existing evidence.

Review question/objective

The review objective(s) must be clearly stated. The objective will guide the scope of the enquiry.

Method

Include the framework on which the review was based. Depending on the framework headings may include –

- Inclusion and exclusion criteria (PCC)
- Search strategy,
- Study selection,
- Extracting and charting the results,
- Validity **Results.**

This section should present the main evidence and a summary of the quality of research.

Discussion.

This section should outline the implications of the findings for occupational therapy practice, the methodological limitations of the review, identify gaps in the literature and recommend future action.

Conclusion.

A clear summary of the main findings should be provided.

Illustrations

Articles may include up **to eight (8) tables or figures** and should be numbered and clearly labelled with their place in the text indicated as a guide to the editor. These must include a diagram of the search strategy as well as a summary of the articles/ publications included in the review.

2.4 GUIDELINES FOR WRITING AN OPINION PIECE

Opinion pieces provide authors with the opportunity to express an opinion concerning any aspect of occupational therapy. They are designed to encourage topical debate and the exchange of ideas. Contributors may discuss specific aspects of occupational therapy practice or debate the impact of occupational therapy on the health of people. Opinion Pieces may also deal with health care and relevant social practice/issues in general such as consumer rights that may impact on the profession. They may also debate the impact of the current political and financial climate on the practice of the profession and its ability to meet all in need.

The following provides some guidance:

- Focus tightly on the issue or idea — in your first paragraph. Be brief.
- Express your opinion, and then base it on factual, researched or first hand information.
- Be timely, controversial, but not outrageous. Be the voice of reason.
- Be personal and conversational; it can help you make your point. No one likes a stuffed shirt.
- Be humorous, provided that your topic lends itself to humour. Irony can also be effective.
- Have a clear editorial viewpoint – come down hard on one side of the issue. Do not equivocate.
- Provide insight, understanding; educate your reader without being preachy.
- Near the end, clearly re-state your position and issue a call to action. Do not philosophise.
- Have verve, and “fire in the gut” indignation to accompany your logical analysis.
- Do not ramble or let your piece unfold slowly, as in an essay.
- Use clear, powerful, direct language.
- Avoid clichés and jargon.
- Appeal to the average reader. Clarity is paramount.

1. **Collect research to support your opinion.** Make sure that your supporting statements match the topic. You should include examples and evidence that demonstrate a real understanding of your topic. This includes any potential counterclaims. To truly understand what you are arguing for or against, it is imperative that you understand the opposing arguments of your topic.

2. **Acknowledge the previous opinions or arguments that have been made.** More than likely, you are writing about a controversial topic that has been debated before. Look at the arguments made in the past and see how they fit in with your opinion in the context in which you are writing. How is your point of view similar or different from previous debaters? Has something changed in the time others were writing about it and now? If not, what does lack of change mean?

3. **Use a transition statement that shows how your opinion adds to the argument or suggests those previous statements and arguments are incomplete or faulty.** Follow up with a statement that expresses your opinion.

4. **Next, list supporting evidence to back up your position.** It is important to keep the tone of your essay professional, by avoiding emotional language and any language that expresses an accusation. Use factual statements that are supported by sound evidence.

5. **Note:** Any time you develop an argument, you should start by thoroughly researching your opposition's point of view. This will help you to anticipate any potential holes or weaknesses in your own opinion or argument.

6. **Lastly there must be a conclusion** in which you restate your opinion using different words.

In summary: Irrespective of the topic discussed, opinions should be supported by evidence or theory. They should include:

- An abstract **(200 words**)
- Headings which give structure to the paper **(1400-2000 words)** ● References **(a maximum of 15).**

Opinion pieces are subject to the same critical review process as other submissions.

The following references were consulted and the information incorporated into the above guidelines:

- Shapiro S.10 Rules for Writing Opinion Pieces. Writer's Digest. July, 2009.www.writersdigest.com/writing-articles/by-writing-goal/improve-mywriting/10-rules-for-writing-opinion-pieces.
- Astone. Ten tips to write an opinion piece people read. Climate system science. Australian Government, 2010 ttps://www.climatescience.org.au/content/1053ten-tips-write-opinion-piece-people-read. (Sept 2010).
- Opinion Essays. Academic writing. http://academicwriting.wikidot.com/opinionessays

Opinions are not necessarily those of the Occupational Therapy Association of South Africa nor SAJOT but never-the-less may provide information for debate.

2.5 GUIDELINES FOR WRITING A COMMENTARY

These are similar to opinion pieces, but a commentary is written on a current event or topic by a person with the background to make an informed comment and should report on an issue or topic of interest and relevance to OT practitioners, educators and researchers.

Commentaries usually bring to the attention of the reader new ideas and advances in a particular subject or field of practice. In this case the commentary will compare past practices and new ideas and will point out any research related to it. The commentary may also present criticism of the new in relation to the old or vice versa. Personal experiences with the new can also be presented and add to the discussion. Commentaries do not include original data or the research findings of the author but are dependent on the author's perspective.

The commentary will also examine the way in which the subject or intervention can be applied to local settings and circumstances and comment on the value that the new idea may have in relation to the past. A final statement or conclusion must be provided ie there must be a "take home" message.

Irrespective of the information being commented upon, commentaries **(1400-2000 words)** should include:

- An abstract **(200 words)**
- Introduction
- Coherent body with headings that give structure to the paper ● Recommendations and conclusion ● References (**a maximum of 15**).

Commentaries are subject to the same critical review process that other submissions undergo.

The following reference was consulted while drawing up these guidelines:

- Berterö C. Guidelines for writing a commentary. Int J Qual Stud Health Wellbeing. 2016; 11:10. https://doi.org/10.3402/qhw.v11.31390

2.6 INSTRUCTIONS FOR BOOK REVIEWS

A book review (700 words) published in SAJOT should be focused on the relevance of the book's content to occupational therapy, withing the South African and African context but also beyond this. It should contain the following information:

- The full title of the book
- A book cover illustration
- Information on the author(s) / editor(s) o Qualifications, positions they hold.
    - Their connection with occupational therapy
- Information on the book.
    - Publication date
    - Name of publisher and city of publication
    - ISBN number
    - Price in Rand (ZAR) and formats it is available in; paperback, hardcopy, e-version
    - Number of pages
- The Review
    - Give the context and aim of the book. This is usually in the form of a **brief** summary of the book.
    - The way in which the content is structured.
    - Discus the most important aspects of the book. Either in chapter format or themes or as it appears to you. Include short quotes to illustrate, if/ as relevant to the review.
    - Brief discussion on its relevance to occupational therapy, within the African context, and in general.
    - If relevant mention similar books or books along the same theme line.
    - Conclude the review with a professional opinion of the book. The positive and negative aspects thereof.
- Information on the Reviewer o Title, name, qualifications, affiliation, and work position at the time of review. o Contact details: email
    - Declaration of bias towards the author(s) or any relevant parties mentioned in the book.

3 GUIDE TO SUBMITTING AN ARTICLE ONLINE

The Guide to submitting an article online is featured under the tab Guide for authors in the header of the SAJOT web site.

Prepare the article as described above.

The following are the steps to follow:

Go to www.sajot.co.za. Log in using the "username" and "password" that has been given to you. Click on the tab **"New Submission**". The following are the steps as enumerated on the web site:

Step I – Starting the submission

Journal section
Select the relevant category of the submission in this section from the drop-down box.

Submission check list

Ensure that you, the author, have done **ALL t**he things mentioned in the submission check list and confirm this by placing a check in the relevant box. See the section **Checking the manuscript before submission** . Please note that failure to comply with all the items mentioned could result in the article being returned to you and thus an unnecessary delay in the publication process.

Copyright notice

Click to accept the copyright provisions as seen on the web site.

You may also send a note to the editor in the box provided.

Click **save and continue** at the bottom of the page, this will enable you to move on to the next stage of the submission process.

Step 2 – Upload the submission

Follow the steps for uploading your article.

Upload manuscript file

NB it is important that you upload the file containing the complete article here. Do not include any information about the authors on the article.

To upload – Click on the browse button, locate the file containing the article on your computer, click on it so that the name of the file appears in the window, and then click the **upload** button. This is the only place where the main article can be uploaded. Click **save and continue.**

Step 3 – Entering the submissions metadata:

Authors– Information about **all** the authors must be provided here.

The bio statement box should be used to complete the details of all the qualifications of the authors (i.e. degree and where obtained.) as well as the place of work and position held. Please include each author's ORCID number in the relevant box.

Title and abstract – Please copy / type in the full title of your article into the box provided. Paste in a copy of the abstract into the block provided.

Indexing –ignore this section.

Supporting agencies – complete if relevant e.g. funding organisation. Click **save and continue**

Step 4 – Uploading supplementary information:

Please note that there are two steps here:

Step 4 and Step 4a. In step 4 all four (4) Supplementary files must be uploaded: a title page, plagiarism report, the 15 MCQs, and a document outlining the role of the authors and any other information that you wish to give the editor. Each file is uploaded separately and saved. Click save and continue to upload each file which will bring up step 4a where you can add the information needed to identify the supplementary information. The only compulsory window is the title window.

Click save and continue. This will bring you back to step 4 again where another file can be uploaded. Each supplementary piece of information is added as new file

Step 5 – Confirming the Submission

Click **Finish Submission**. Please remember to do this otherwise your submission will not be recorded. It is very important to note that once you have confirmed the submission you will be unable to make changes to your main document. However, you will be able to add supplementary files. This should be done before the article is sent into the review stage by the editor.

Any changes that you wish to make to the article itself will need to be done via a completely new submission.

Resubmission of Manuscript after Desk Edit
The article will be desk edited by the journal editor after submission. The article may be returned to you by email within a week to amend issues such as formatting, referencing and obvious issues with content. The article or may require major revision or be rejected at this stage if it is not suitable for SAJOT**.**

If there are issues that need to be addressed before the manuscript can be sent for peer review and you should be complete these and return the manuscript to the editor by email as soon as possible (2 weeks) so the review process can start.

Resubmission of Article after Revisions/Amendments

The outcome of the review will be emailed to you and will be available on the SAJOT webpage under **Review** on your article page. **A list of changes made or highlighted changes in the text of the article must be included so revisions can be reviewed or edited.** The article should be resubmitted within 4 weeks. Make sure any comments and track changes are unidentified id submitted for rereview (Appendix C)

Once the author has dealt with these amendments suggested by the editor, a new version of the article must be uploaded. Scroll to the section at the bottom of the **Review page** of your article to the section labelled **Editor Decision.** There you will see the box **Upload author version**. Please post your revised copy here **-.**

Help with this submission process can be obtained by emailing the managing editor at www.sajot.co.za.

APPENDIX A - FORMAT FOR MCQ's

EXAMPLE 1:

STEM WITH ALTERNATE ANSWERS

Multiple correct answers (combine these into only ONE possible correct answer).

	QUESTION	POSSIBLE ANSWERS	CORRECT
5	**The advantages of standardised testing to assess visual perception include:**		
a	short, quick assessment times	a, b and d	
b	an objective score on which to base decisions about the need for therapy	b and d	**X**
c	that tests can be carried out by untrained individuals	b, c and d	
d	they can evaluate progress and determine the effectiveness of interventions	c, d and e	
e	the tests take fatigue and test anxiety into account in the scoring	all the above	

EXAMPLE 2:

STEM WITH ALTERNATE ANSWERS

One correct answer

	Question	Possible answers	Correct

11	**In order to obtain an equal distribution of children from each of the four age groups included in the sample, the researchers used:**		
a		A random sampling method	
b		A convenient sampling method	
c		A stratified sampling method	**X**
d		Saturation sampling	

EXAMPLE 3:

TRUE/FALSE

	Question	Possible answers	Correct
8	**Disability rights enforcement strategy are important in advancing disability rights and occupational freedom.**		
		True	**X**
		False	

APPENDIX B STYLES TO USE WHEN REFERENCING AND EXAMPLES OF REFERENCING

In **Mendeley** - the **Council of Science Editors – Citation Sequence (numeric)** provides the correct referencing. DOI numbers must be entered with the http://dx.doi.org/ prefix into the Mendeley programme and these need to be linked in the reference list using CNTL K in the reference list. All **date of access, URLs and publishers** must be **removed** from Mendeley reference programme for journal articles.

In **Endnote** - use **Council of Science Editors (CSE**) or **PLOS** (you will need to change the style to remove brackets and superscript numbers –

https://libguides.library.cqu.edu.au/c.php?g=760903&p=6317474) to provide the correct referencing. In endnote DOI numbers will also have to be added to references in Endnote with a http://dx.doi.org/ prefix.

Examples of referencing

Journal article

Format: Author. Article title. Journal. Year; Volume (No): Page numbers. DOI number
Barnard-Ashton P, Adams F, Rothberg A, McInerney P. Digital apartheid and the effect of mobile technology during rural fieldwork**.** South African Journal of Occupational Therapy. 2018; 48(2): 20-25. doi: https:// doi.org/10.17159/23103833/2018/vol48n2a4 **or** http://dx.doi.org/10.17159/23103833/2018/vol48n2a4.

Journal names must be written out in full and capitalised but not italicised. Please not that this format must be used NOT doi:10.17159/23103833/2018/vol48n2a4,

Book

Format: Author(s)**.** Book title. Edition. City: Publisher; Year. DOI if one is available

De Vos AS, Strydom H, Fouché CB, Delport CSL. Research at Grass Roots: A primer for the Social Sciences and Human Service Professions. Pretoria: Van Schaik Publishers; 2011. https://doi.org/10.4102/hsag.v2i3.337

Chapter (Section) in a Book

Format: Author(s). Chapter title. Book title. Editor. City: publisher; Date/Year published: page numbers. DOI number

Amis, M. Silk, M. Eisenhart, M. Freeman, K. deMarrais, J. Preissle, R. Roulston, E. St. Pierre, K. Howe, P. Lather, Y. Lincoln, G. C. In: Annella, D. Polkinghorne & H. Torrance. Chapter 10, Standards for Evaluating Qualitative Research. In: Understanding and Evaluating Qualitative Educational Research. M Lichtman, Editor. New York: Sage Knowledge; 2011: 253-260. doi: https://dx.doi.org/10.4135/9781483349435.n10

Webpages

Format: Author(s)(may be corporation or organisation).Name or title of webpage. the **date accessed and the URL.**

South African Government. Special Needs Education: Education White Paper 6. 2021 [accessed 2021 Jan 12]. https://www.gov.za/documents/special-needs-educationeducation-white-paper-6

APPENDIX C REMOBVING IDENTITY FROM COOMENTS AND TRACK CHAGES ON DOCMENTS

For **Microsoft2010-2019**(Windows):

- Under the File menu select “Info”.
- Click on the “Inspect Document” icon.

- Uncheck all the checkboxes except “Document Properties and Personal information”.
- Run the document inspector, which will then do a search of the document properties and indicate if any document property fields contain any information.
- If the document inspector finds that some of the document properties contain information it will notify you and give you the option to “Remove all,” which you will click to remove the document properties and personal information from the document.

For **MacIntosh Word** (and future versions)

- Under the File menu select “Properties.”
- Under the Summary tab remove all of the identifying information from all of the fields.
- Save the File.
- For **PDF files**:
- With PDFs, the authors’ names should also be removed from Document Properties found under File on Adobe Acrobat’s main menu.

Addendum CII

Grasps free active no resistance allowed after injury

Phase 1 **Grasps requiring no or very little MCPJ flexion**	**Phase 2** **Grasps requiring minimal to 45° MCPJ flexion**	**Phase 3** **Grasps requiring more than 45° MCPJ flexion**	**Phase 4** **All Grasps with resistance**
5. Light Tool 8. Prismatic 2 Fingers 10. Power Disk 12. Precision Disk 15. Fixed Hook 16. Lateral 17. Index Finger Extension (For index finger #) 18. Extension Type 23. Adduction Grip 26. Sphere 4 Fingers 28. Sphere 3 Fingers 32. Ventral (For index finger #) 33. Inferior Pincher Respect pain < 3/10.	1. Large Diameter 3. Medium Wrap 4. Adducted Thumb 6. Prismatic 4 Fingers 7. Prismatic 3 Fingers 9. Palmar Pinch 14. Tripod 21. Tripod variation 24. Tip Pinch 31. Ring Index finger #	2. Small Diameter 11. Power Sphere 13. Precision Sphere 17. Index Finger Extension (For middle-, ring- and little finger #) 19. Distal 20. Writing Tripod 22. Parallel Extension 25. Lateral Tripod 27. Quadpod 29. Stick 30. Palmar 32. Ventral (For middle-, ring- and little finger #)	All Grasps if no pain is present. If pain persists, consult your medical doctor.

Addendum DII

Author guidelines: Hand Therapy

Hand Therapy Author guidelines

Manuscript Submission Guidelines:

Manuscript Submission Guidelines: Hand Therapy

This Journal is a member of the Committee on Publication Ethics.

Please read the guidelines below then visit the Journal's submission site https://mc.manuscriptcentral.com/ht to upload your manuscript. Please note that manuscripts not conforming to these guidelines may be returned.

Only manuscripts of sufficient quality that meet the aims and scope of Hand Therapy will be reviewed.

There are no fees payable to submit or publish in this journal.

As part of the submission process you will be required to warrant that you are submitting your original work, that you have the rights in the work, and that you have obtained and can supply all necessary permissions for the reproduction of any copyright works not owned by you, that you are submitting the work for first publication in the Journal and that it is not being considered for publication elsewhere and has not already been published elsewhere. Please see our guidelines on prior publication and note that Hand Therapy will consider submissions of papers that have been posted on preprint servers; please alert the Editorial Office when submitting (contact details are at the end of these guidelines) and include the DOI for the preprint in the designated field in the manuscript submission system. Authors should not post an updated version of their paper on the preprint server while it is being peer reviewed for possible publication in the Journal. If the article is accepted for publication, the author may re-use their work according to the Journal's author archiving policy. If your paper is accepted, you must include a link on your preprint to the final version of your paper.

If you have any questions about publishing with SAGE, please visit the SAGE Journal Solutions Portal

1. What do we publish?
   1.1 Aims & Scope
   1.2 Article types
   1.3 Writing your paper
2. Editorial policies
   2.1 Peer review policy
   2.2 Authorship
   2.3 Acknowledgements
   2.4 Funding
   2.5 Declaration of conflicting interests
   2.6 Research ethics and patient consent
   2.7 Clinical trials
   2.8 Reporting guidelines
   2.9 Research Data
   2.10 Guarantor
   2.11 Contributorship
3. Publishing policies
   3.1 Publication ethics
   3.2 Contributor's publishing agreement
   3.3 Open access and author archiving
4. Preparing your manuscript
   4.1 Formatting
   4.2 Artwork, figures and other graphics
   4.3 Supplemental material
   4.4 Journal Layout
   4.5 Reference style
   4.6 English language editing services
   4.7 Video Materials
5. Submitting your manuscript
   5.1 ORCID

5.2 Social media – Twitter @BAHTHandtherapy
5.3 Information required for completing your submission
5.4 Permissions
6. On acceptance and publication
6.1 SAGE Production
6.2 Online First publication
6.3 Access to your published article
6.4 Promoting your article
7. Further information

1. What do we publish?

1.1 Aims & Scope

Before submitting your manuscript to Hand Therapy, please ensure you have read the Aims & Scope.

1.2 Article Types

The overall length of any manuscript should not exceed 4,000 words. Contributions in the following categories will be considered:

Original articles (primary research, audits and service evaluation): Primary research studies should be reported using appropriate reporting guidelines e.g CONSORT guidelines for randomised controlled trials, A copy of the completed reporting checklist must be uploaded as a supplementatry file when submitting your manuscript. Further guidance on Reporting guidelines can be found below in section 2.8. Structured headings should be used (Introduction, Methods, Results, Discussion). We request a maximum of six tables and figures (combined) in total unless there are special circumstances. Large tables or other additional supplementary data can be hosted online only by SAGE. See Journal layout for requirements on preparation of Tables and Figures. Hand Therapy also welcomes original articles based on audits, service reviews and service innovations where these go beyond description, have clear evaluative components and represent an important contribution to hand therapy practice and knowledge.

Reviews: These can include systematic reviews as well as narrative reviews of literature. Authors are advised to follow reporting guidelines such as PRISMA (available at http://www.equator-network.org/) to ensure the quality of reporting. Prospective registration of a systematic review protocol on PROSPERO or similar registries is likewise recommended.

Case reports: These are normally limited to 2,000 words and may include novel assessment and treatment techniques, evaluations of equipment or material based on patient case(s). Material should not be limited to description and must include an evaluation of techniques used and outcomes.

Study protocols: Protocols of proposed or ongoing clinical trials which have not completed recruitment at the time of submission and which have Ethics approval will be considered. Study protocols should follow SPIRIT guidelines: http://www.spirit-statement.org/spirit-statement/.

Hand Therapy also accepts Letters to the editor which relate to articles published in the journal.

Declarations

Please note that all manuscripts should be accompanied by a separate document entitled 'Declarations'.

Please read the Declarations guideline for authors available here: hth_declaration_policy_document.docx carefully before submitting your Declarations document.

This should be submitted under the file designation 'Declarations'. This must include each of the below headings with the corresponding information. Please note that manuscripts which do not include these Declarations will be returned. These headings will be published at the end of every accepted manuscript, where one of these headings is not applicable please indicate as such under the heading. Please see section 2.2 for additional information regarding declarations.

DECLARATIONS

1. Conflicting interests
2. Funding
3. Informed consent
4. Ethical approval
5. Guarantor
6. Contributorship
7. Acknowledgements

1.3 Writing your paper

The SAGE Author Gateway has some general advice and on how to get published, plus links to further resources.

1.3.1 Make your article discoverable

When writing up your paper, think about how you can make it discoverable. The title, keywords and abstract are key to ensuring readers find your article through search engines such as Google. For information and guidance on how best to title your article, write your abstract and select your keywords, have a look at this page on the Gateway: How to Help Readers Find Your Article Online.

Back to top

2. Editorial policies

2.1 Peer review policy

Hand Therapy adheres to a rigorous double-anonymize reviewing policy in which the identity of both the reviewer and author are always concealed from both parties. All articles are reviewed by at least two independent reviewers. Where major change is required, recommendations will be made by the Editor and the paper returned, to be re-submitted with appropriate changes. Please note that submission of a paper is not a guarantee of publication. Publication is at the Editor's discretion.

As part of the submission process you will be asked to provide the names of peers who could be called upon to review your manuscript. Recommended reviewers should be experts in their fields and should be able to provide an objective assessment of the manuscript. Please be aware of any conflicts of interest when recommending reviewers. Examples of conflicts of interest include (but are not limited to) the below:

- The reviewer should have no prior knowledge of your submission
- The reviewer should not have recently collaborated with any of the authors
- Reviewer nominees from the same institution as any of the authors are not permitted

Please note that the Editors are not obliged to invite/reject any recommended/opposed reviewers to assess your manuscript.

Covering letter:
The covering letter is important. To help the Editor in her preliminary evaluation, please indicate why you think the paper is suitable for publication. The covering letter should be signed by all authors confirming (1) that they consent to publication, (2) have made a substantial contribution to the article through conception, design and/or drafting of the manuscript, and (3) that the paper or parts of it, have NOT been and will NOT be submitted elsewhere for publication. If submitting by email please scan the signed cover letter and send it as a PDF or fax it to the Editorial office (Fax: +44 (0)1603 593166). If your paper should be considered for fast-track publication, please explain why.

2.1.1 Declarations

The following statements should be uploaded under the file type ‘Declarations’ for every manuscript submitted. These will be published at the end of every paper accepted for publication.

Please read theHTH Declaration Guidelines for Authorscarefully before submitting your Declarations document.

DECLARATIONS

1. Conflicting interests
2. Funding

3. Informed consent
4. Ethical approval
5. Guarantor
6. Contributorship
7. Acknowledgements

Please see the below example of a completed declarations section:

DECLARATIONS

Conflicting interests: MS is an employee of XXX. BF has received grants from XXX.

Funding: This work was supported by the Medical Research Council [grant number XXX]

Informed consent: Written informed consent was obtained from the patient(s) for their anonymized information to be published in this article.

Ethical approval: The ethics committee of XXXX approved this study (REC number: XXXX)

Guarantor: BF

Contributorship: BF and NP researched literature and conceived the study. MS was involved in protocol development, gaining ethical approval, patient recruitment and data analysis. BF wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript

Acknowledgements: We would like to thank XXX XXXX for his assistance and guidance in this research.

Hand Therapy is committed to delivering high quality, fast peer-review for your paper, and as such has partnered with Publons. Publons is a third party service that seeks to track, verify and give credit for peer review. Reviewers for Hand Therapy can opt in to Publons in order to claim their reviews or have them automatically verified and added to their reviewer profile. Reviewers claiming credit for their review will be associated with the relevant journal, but the article name,

reviewer's decision and the content of their review is not published on the site. For more information visit the Publons website.

2.2 Authorship

Papers should only be submitted for consideration once consent is given by all contributing authors. Those submitting papers should carefully check that all those whose work contributed to the paper are acknowledged as contributing authors.

The list of authors should include all those who can legitimately claim authorship. This is all those who:

1. Made a substantial contribution to the concept or design of the work; or acquisition, analysis or interpretation of data,
2. Drafted the article or revised it critically for important intellectual content,
3. Approved the version to be published,
4. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

Authors should meet the conditions of all of the points above. When a large, multicentre group has conducted the work, the group should identify the individuals who accept direct responsibility for the manuscript. These individuals should fully meet the criteria for authorship.

Acquisition of funding, collection of data, or general supervision of the research group alone does not constitute authorship, although all contributors who do not meet the criteria for authorship should be listed in the Acknowledgments section. Please refer to the International Committee of Medical Journal Editors (ICMJE) authorship guidelines for more information on authorship.

2.3 Acknowledgements

All contributors who do not meet the criteria for authorship should be listed in an Acknowledgements section. Examples of those who might be acknowledged include a person who provided purely technical help, or a department chair who provided only general support.

2.3.1 Third party submissions

Where an individual who is not listed as an author submits a manuscript on behalf of the author(s), a statement must be included in the Acknowledgements section of the manuscript and in the accompanying cover letter. The statements must:

- Disclose this type of editorial assistance – including the individual's name, company and level of input
- Identify any entities that paid for this assistance
- Confirm that the listed authors have authorized the submission of their manuscript via third party and approved any statements or declarations, e.g. conflicting interests, funding, etc.

Where appropriate, SAGE reserves the right to deny consideration to manuscripts submitted by a third party rather than by the authors themselves.

2.3.2 Writing assistance

Individuals who provided writing assistance, e.g. from a specialist communications company, do not qualify as authors and so should be included in the Acknowledgements section. Authors must disclose any writing assistance – including the individual's name, company and level of input – and identify the entity that paid for this assistance. It is not necessary to disclose use of language polishing services.

2.4 Funding

Hand Therapy requires all authors to acknowledge their funding in a consistent fashion under a separate heading. Please visit the Funding Acknowledgements page on the SAGE Journal Author Gateway to confirm the format of the acknowledgment text in the event of funding, or state that: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

2.5 Declaration of conflicting interests

It is the policy of Hand Therapy to require a declaration of conflicting interests from all authors enabling a statement to be carried within the paginated pages of all published articles.

Please ensure that a ‘Declaration of Conflicting Interests’ statement is included at the end of your manuscript, after any acknowledgements and prior to the references. If no conflict exists, please state that ‘The Author(s) declare(s) that there is no conflict of interest’. For guidance on conflict of interest statements, please see the ICMJE recommendations here.

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Medical research involving human subjects must be conducted according to the World Medical Association Declaration of Helsinki.

Submitted manuscripts should conform to the ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals, and all papers reporting animal and/or human studies must state in the methods section that the relevant Ethics Committee or Institutional Review Board provided (or waived) approval. Please ensure that you have provided the full name and institution of the review committee, in addition to the approval number.

For research articles, authors are also required to state in the methods section whether participants provided informed consent and whether the consent was written or verbal.

Information on informed consent to report individual cases or case series should be included in the manuscript text. A statement is required regarding whether written informed consent for patient information and images to be published was provided by the patient(s) or a legally authorized representative. Please do not submit the patient’s actual written informed consent with your article, as this in itself breaches the patient’s confidentiality. The Journal requests that you confirm to us, in writing, that you have obtained written informed consent but the written consent itself should be held by the authors/investigators themselves, for example in a patient’s hospital record. The confirmatory letter may be uploaded with your submission as a separate file.

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All research involving animals submitted for publication must be approved by an ethics committee with oversight of the facility in which the studies were conducted. The journal has

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Hand Therapy conforms to the ICMJE requirement that clinical trials are registered in a WHO-approved public trials registry at or before the time of first patient enrolment as a condition of consideration for publication. The trial registry name and URL, and registration number must be included at the end of the abstract.

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The relevant EQUATOR Network reporting guidelines should be followed depending on the type of study. For example, all randomized controlled trials submitted for publication should include a completed CONSORT flow chart as a cited figure and the completed CONSORT checklist should be uploaded with your submission as a supplementary file. Systematic reviews and meta-analyses should include the completed PRISMA flow chart as a cited figure and the completed PRISMA checklist should be uploaded with your submission as a supplementary file. The EQUATOR wizard can help you identify the appropriate guideline.

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Hand Therapy requests all authors submitting any primary data used in their research articles alongside their article submissions to be published in the online version of the journal, or provide detailed information in their articles on how the data can be obtained. This information should include links to third-party data repositories or detailed contact information for third-party data sources. Data available only on an author-maintained website will need to be loaded onto either the journal's platform or a third-party platform to ensure continuing accessibility. Authors should also follow data citation principles. For more information please visit the SAGE Author

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For multi-authored papers this statement should outline what each party contributed to the authorship of the paper. Authors should be identified by their initials. An example is shown below.
BF and NP researched literature and conceived the study. MS was involved in protocol development, gaining ethical approval, patient recruitment and data analysis. BF wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Back to top

3. Publishing Policies

3.1 Publication ethics

SAGE is committed to upholding the integrity of the academic record. We encourage authors to refer to the Committee on Publication Ethics' International Standards for Authors and view the Publication Ethics page on the SAGE Author Gateway.

3.1.1 Plagiarism

Hand Therapy and SAGE take issues of copyright infringement, plagiarism or other breaches of best practice in publication very seriously. We seek to protect the rights of our authors and we always investigate claims of plagiarism or misuse of published articles. Equally, we seek to protect the reputation of the journal against malpractice. Submitted articles may be checked with duplication-checking software. Where an article, for example, is found to have plagiarised other work or included third-party copyright material without permission or with insufficient acknowledgement, or where the authorship of the article is contested, we reserve the right to take action including, but not limited to: publishing an erratum or corrigendum (correction); retracting the article; taking up the matter with the head of department or dean of the author's institution and/or relevant academic bodies or societies; or taking appropriate legal action.

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Back to top

4. Preparing your manuscript for submission

4.1 Formatting

The preferred format for your manuscript is Word. LaTeX files are also accepted. Word and (La)Tex templates are available on the Manuscript Submission Guidelines page of our Author Gateway.

4.2 Artwork, figures and other graphics

For guidance on the preparation of illustrations, pictures and graphs in electronic format, please visit SAGE's Manuscript Submission Guidelines.

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This journal is able to host additional materials online (e.g. datasets, podcasts, videos, images etc) alongside the full-text of the article. For more information please refer to our guidelines on submitting supplementary files.

4.4 Journal Layout

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Title page
The first page should contain the full title of the manuscript, a short title, the author(s) name(s) and affiliation(s), and the name, postal and email addresses of the author for correspondence, as well as a full list of declarations. The acknowledgements should also be included here – these should state clearly who is being acknowledged and why. Identifying information about the authors should not be included on any subsequent pages of the manuscript.
The title should be concise and informative, accurately indicating the content of the article. The short title should be no more than six words long.

Abstract
A structured abstract of no more than 250 words, emphasizing the main features of the contribution must accompany all articles. The abstract should normally use four headings: Introduction (context and rationale); Methods (type of study, patients, materials, techniques); Results (main numerical data and statistical information); and Discussion (main objective and verifiable conclusions). Letters to the Editor do not require an abstract.

Keywords
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Tables must be prepared using the Table feature of the word processor and presented on separate pages at the end of the document. Tables should not duplicate information given in the text, should be numbered in the order in which they are mentioned in the text, and should be given a brief title. Abbreviations should be written out in full in a legend placed at the end of the table. We normally request a maximum of six tables and figures (combined) in total unless there are special circumstances, which must be explained in your cover letter (or by emailing us to discuss). Large tables or other additional supplementary data can be hosted online only by SAGE.

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All figures should be numbered in the order in which they are mentioned in the text. All figures must be accompanied by a figure legend. If figures are supplied in separate files, the figure legends must all be listed at the end of the main text file.

Line drawings should be produced electronically and clearly labelled using a sans serif font such as Arial. Graphs may be supplied as Excel spreadsheets (one per sheet). Other line drawings should be supplied in a suitable vector graphic file format (e.g. .eps)

All photographic images should be submitted in camera-ready form (i.e. with all extraneous areas removed), and where necessary, magnification should be shown using a scale marker. Photographic images must be supplied at high resolution, preferably 600 dpi. Images supplied at less than 300 dpi are unsuitable for print and will delay publication. The preferred file format is .tif.

Abbreviations

Symbols and abbreviations should be those currently in use. Authors should not create new abbreviations and acronyms. The RSM's book Units, Symbols and Abbreviations provides lists of approved abbreviations.

Units
All measurements should be expressed in SI units.

Statistics
If preparing statistical data for publication, please read the statistical guidelines here

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Hand Therapy adheres to the SAGE Vancouver reference style. View the SAGE Vancouver guidelines to ensure your manuscript conforms to this reference style.

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Please note that only essential references should be included and should represent the most recent and pertinent literature available. Only references quoted in the text should be included in the reference list. Authors are responsible for verifying them against the original source material.

Automatic numbering should be avoided. References should include the names and initials of up to six authors. If there are more than six authors, only the first three should be named, followed by et al. Publications for which no author is apparent may be attributed to the organization from which they originate. Simply omit the name of the author for anonymous journal articles – avoid using 'Anonymous'.

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4.7 Video Materials

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value. Please consult the Hand Therapy guidelines and are followed for video materials as stated below.

Video Materials

Video Abstracts

Back to top

5. Submitting your manuscript

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IMPORTANT: Please check whether you already have an account in the system before trying to create a new one. If you have reviewed or authored for the journal in the past year it is likely that you will have had an account created. For further guidance on submitting your manuscript online please visit ScholarOne Online Help.

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your work attributable to you and only you. Your ORCID iD is published with your article so that fellow researchers reading your work can link to your ORCID profile and from there link to your other publications.

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As an example of how to supply this information please see the example below:

Joe Bloggs, Department of Neuroscience, University Hospital, Town, Zip code, USA
Email: JoeBloggs@email.com
Twitter: @drjoebloggs

5.3 Information required for completing your submission

You will be asked to provide contact details and academic affiliations for all co-authors via the submission system and identify who is to be the corresponding author. These details must match what appears on your manuscript. The affiliation listed in the manuscript should be the institution where the research was conducted. If an author has moved to a new institution since completing the research, the new affiliation can be included in a manuscript note at the end of the

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Back to top

6. On acceptance and publication

6.1 SAGE Production

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Online First allows final articles (completed and approved articles awaiting assignment to a future issue) to be published online prior to their inclusion in a journal issue, which significantly reduces the lead time between submission and publication. Visit the SAGE Journals help page for more details, including how to cite Online First articles.

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Addendum EII

REDcap questionnaire round one expert feedback

Dear Expert,

Your involvement in developing a clinical hand rehabilitation guideline for second to fifth metacarpal fracture is much appreciated. You completed the first out of three Delphi rounds. The consensus percentage is set at 75%. Consensus refers to the percentage of experts who agreed with the clinical guideline component. I now share the results from Round One.

Clinical guideline component	Was consensus reached?		Consensus Percentage
	Yes	No	
This section covers the time period and types of light, moderate, heavy and pre-injured tasks/functions/activities return to daily activities. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The time period of 2 weeks for commencement of light tasks/activities/function after 2nd to 5th metacarpal fractures.	Yes		79%
The time period of 4 weeks for commencement of medium/moderate tasks/activities/function after 2nd to 5th metacarpal fractures.	Yes		79%
The time period of 6 weeks for commencement of heavy tasks/activities/function after 2nd to 5th metacarpal fractures.	Yes		79%
The time period of 8 to 10 weeks for commencement of pre-injured tasks/activities/function after 2nd to 5th metacarpal fractures.	Yes		79%
The types of light tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.		No	71%
The types of medium/moderate tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.		No	64%

The types of heavy tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.	Yes		86%
This section covers time period of rehabilitation used in the second to fifth metacarpal fractures guideline after surgical fixation and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The time period of 2/52 for commencement of the Rehabilitation Phase 1 (physiological active movement of unaffected joints) for 2nd to 5th metacarpal fractures?		No	43%
The time period of 4/52 for commencement of the Rehabilitation Phase 2 controlled movement of affected joints for 2nd to 5th metacarpal fractures?		No	43%
The time period of 6/52 for commencement of the Rehabilitation Phase 3 passive stretching of affected joints?		No	50%
The time period of 8/52 for commencement of the Rehabilitation Phase 4 graded strengthening commences for 2nd to 5th metacarpal fractures?		No	36%
This section covers the time period of grasp rehabilitation exercises with the grasp type according to the Feix et al., 2016 above in the clinical hand rehabilitation guideline for second to fifth metacarpal fractures guideline. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The inclusion of grasp types requiring no or very little MCPJ flexion (types included above) at 2/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?		No	57%
The inclusion of grasp types requiring requiring minimal to 45° MCPJ flexion (types included above) at 4/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?		No	57%
The inclusion of grasp types requiring requiring more than 45° MCPJ flexion (types included above) at 6/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?		No	57%

The inclusion of grasp types requiring full MCPJ flexion (all grasp types) at 8/52 for commencement of graded strengthening exercises for 2nd to 5th metacarpal fractures?		No	71%
This section covers the rehabilitation guideline after SHAFT of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of a SHAFT of 2nd to 5th metacarpal fractures?		No	50%
The splinting time period after surgical fixation for a SHAFT of 2nd to 5th metacarpal fracture management?		No	57%
The splint used after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?		No	64%
The splinting time period after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?		No	71%
This section covers the rehabilitation guideline after BASE of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of a BASE of 2nd to 5th metacarpal fractures?	Yes		79%
The splinting time period after surgical fixation for a BASE of 2nd to 5th metacarpal fracture management?		No	57%
The splint used after conservative management for a BASE of 2nd to 5th metacarpal fractures?	Yes		86%
The splinting time period after conservative management for a BASE of 2nd to 5th metacarpal fractures?	Yes		79%
This section covers the rehabilitation guideline after a HEAD of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of 2nd to 5th HEAD metacarpal fractures?		No	71%

The splinting time period after surgical fixation 2nd to 5th HEAD metacarpal fracture management?		No	43%
The splint used after conservative management of 2nd to 5th HEAD metacarpal fractures?	Yes		79%
The splinting time period after conservative management of 2nd to 5th HEAD metacarpal fractures?	Yes		79%
This section covers the rehabilitation guideline after a NECK of 5th (BOXERS) metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of NECK5th_BOXERS_metacarpal fractures?		No	36%
The splinting time period after surgical fixation NECK_5th_BOXERS metacarpal fracture management?		No	64%
The splint used after conservative management for NECK of 5th_BOXERS metacarpal fractures?		No	36%
The splinting time period after conservative management of NECK of 5th BOXERS metacarpal fractures?		No	64%
This section covers the rehabilitation guideline after a NECK of 2nd to 4th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of 2nd to 4th NECK metacarpal fractures?		No	50%
The splinting time period after surgical fixation 2nd to 4th NECK metacarpal fracture management?		No	64%
The splint used after conservative management of 2nd to 4th NECK metacarpal fractures?		No	57%
The splinting time period after conservative management of 2nd to 4th NECK metacarpal fractures?		No	64%

Round Two: What to expect.

- The survey link for round two will be sent on **20 January 2022.** You have two weeks to complete the survey.
- In round two, the clinical component guidelines where consensus has been reached will be removed except those where I will ask for clarity regarding splint types.
- Yes and No questions added to the Likert scale allowing you to give your opinion in open-ended response.
- I will be sharing my reasoning for including types of activities in the guideline backed by the second phase of the research, where force sensing resistors were used to test finger forces.
- I will be giving my reasoning of types of splints backed by best evidence literature.
- A change in the splint for the neck of 5^{th} metacarpal fractures.
- You have the opportunity to openly share your thoughts and bring us a step closer to developing the clinical hand rehabilitation guideline for second to fifth metacarpal fractures.

Many thanks for your time and commitment to this project!

Kind regards,

Monique

Addendum FII

REDcap questionnaire round two expert feedback

Dear Expert,

Your involvement in developing a clinical hand rehabilitation guideline for second to fifth metacarpal fracture is much appreciated. You completed the second out of three Delphi rounds. The consensus percentage is set at 75%. Consensus refers to the percentage of experts who agreed with the clinical guideline component. I now share the results from Round Two with the Open-ended responses following after the table.

Clinical guideline component	Was consensus reached?		Consensus Percentage
	Yes	No	
This section covers the time period and types of light, moderate, heavy and pre-injured tasks/functions/activities return to daily activities. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The types of light tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.	Yes		83%
The types of medium/moderate tasks/activities/function in the rehabilitation programme after 2nd to 5th metacarpal fractures.	Yes		75%
This section covers time period of rehabilitation used in the second to fifth metacarpal fractures guideline after surgical fixation and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
Do you agree with the time period of 2/52 for commencement of the Rehabilitation Phase 1 (physiological active movement of unaffected joints) for 2nd to 5th metacarpal fractures after surgical fixation?		No	50%
Do you agree with the time period of 2/52 for commencement of the Rehabilitation Phase 1 (physiological active movement of unaffected joints) for 2nd to 5th metacarpal fractures after conservative management?		No	67%

Do you agree with the time period of 4/52 for commencement of the Rehabilitation Phase 2 controlled movement of affected joints for 2nd to 5th metacarpal fractures after surgical fixation?		No	50%
Do you agree with the time period of 4/52 for commencement of the Rehabilitation Phase 2 controlled movement of affected joints for 2nd to 5th metacarpal fractures after conservative management?		No	67%
Do you agree with the time period of 6/52 for commencement of the Rehabilitation Phase 3 passive stretching of affected joints after surgical fixation?		No	58%
Do you agree with the time period of 6/52 for commencement of the Rehabilitation Phase 3 passive stretching of affected joints after conservative management?	Yes		83%
Do you agree with the time period of 8/52 for commencement of the Rehabilitation Phase 4 graded strengthening commences for 2nd to 5th metacarpal fractures after surgical fixation?		No	50%
Do you agree with the time period of 8/52 for commencement of the Rehabilitation Phase 4 graded strengthening commences for 2nd to 5th metacarpal fractures after conservative management?		No	67%
This section covers the time period of grasp rehabilitation exercises with the grasp type according to the Feix et al., 2016 above in the clinical hand rehabilitation guideline for second to fifth metacarpal fractures guideline. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The inclusion of grasp types requiring no or very little MCPJ flexion (types included above) at 2/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?		No	42%
The inclusion of grasp types requiring requiring minimal to 45° MCPJ flexion (types included above) at 4/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?		No	42%

The inclusion of grasp types requiring requiring more than 45° MCPJ flexion (types included above) at 6/52 for commencement of free active exercises for 2nd to 5th metacarpal fractures?		No	67%
The inclusion of grasp types requiring full MCPJ flexion (all grasp types) at 8/52 for commencement of graded strengthening exercises for 2nd to 5th metacarpal fractures?		No	67%
This section covers the rehabilitation guideline after SHAFT of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
Option 1 (Sandwich/clam hand-based): The splint used after surgical fixation of a SHAFT of 2nd to 5th metacarpal fractures?		No	58%
Option 1: The splinting time period after surgical fixation for a SHAFT of 2nd to 5th metacarpal fracture management?		No	42%
Option 1: The splint used after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?		No	50%
Option 1: The splinting time period after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?	Yes		83%
Option 2 (Dorsal forearm based splint): The splint used after surgical fixation of a SHAFT of 2nd to 5th metacarpal fractures?		No	33%
Option 2: The splinting time period after surgical fixation for a SHAFT of 2nd to 5th metacarpal fracture management?		No	42%
Option 2: The splint used after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?		No	33%
Option 2: The splinting time period after conservative management for a SHAFT of 2nd to 5th metacarpal fractures?		No	67%
This section covers the rehabilitation guideline after BASE of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			

The splinting time period after surgical fixation for a BASE of 2nd to 5th metacarpal fracture management?		No	58%
This section covers the rehabilitation guideline after a HEAD of 2nd to 5th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of 2nd to 5th HEAD metacarpal fractures?		No	58%
The splinting time period after surgical fixation 2nd to 5th HEAD metacarpal fracture management?		No	42%
This section covers the rehabilitation guideline after a NECK of 5th (BOXERS) metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of NECK5th_BOXERS_metacarpal fractures?		No	67%
The splinting time period after surgical fixation NECK_5th_BOXERS metacarpal fracture management?		No	33%
The splint used after conservative management for NECK of 5th_BOXERS metacarpal fractures?		No	67%
The splinting time period after conservative management of NECK of 5th BOXERS metacarpal fractures?		No	67%
This section covers the rehabilitation guideline after a NECK of 2nd to 4th metacarpal fracture after surgical fixation or reduction and conservative management. Please indicate your agreement on the five point Likert scale with 1 indicating strongly disagree to 5 that indicates strongly agree. Select one option per statement.			
The splint used after surgical fixation of 2nd to 4th NECK metacarpal fractures?		No	67%
The splinting time period after surgical fixation 2nd to 4th NECK metacarpal fracture management?		No	50%
The splint used after conservative management of 2nd to 4th NECK metacarpal fractures?	Yes		75%

The splinting time period after conservative management of 2nd to 4th NECK metacarpal fractures?	Yes		83%

/33

Open-ended responses:

Thank you for your patience. I have wanted to allow open-ended responses for all questions but it was not possible ,and I will continue to add open-responses in Round Three. I appreciate the feedback you have sent via email and adding your opinions to the available open-ended options.

Overarching treatment principles

- Early motion, for example after open reduction and internal fixation (ORIF), is necessary to maintain mobility and gliding of the surrounding soft-tissue structures. It is critical to initiate immediate early motion after stable or rigid ORIF of metacarpal neck and shaft fractures because these procedures can violate the extensor surface of the hand, which can result in dense adhesion formation to the extensor digitorum communis (EDC) tendon. Therefore, we start active ROM exercises 2-3 days post-surgery.
- MCPJ position might depend on fracture pattern and position of stability – head of metacarpal fracture.
- Splinting for second to fifth metacarpal fractures managed with percutaneous K-wires should be splinted for the period when the K-wire is in situ.
- Splinting types for second to fifth metacarpal fractures managed with percutaneous K-wires should consider and be molded to respect the K-wire placement.
- Boxers fractures are generally impacted and therefore stable. Splinting is just for comfort as the fractures are unlikely to displace.
- Splint/ treatment should be clinically reasoned/ individualised to each patient.

Recommendations that will be included in Round Three:

Type of splint Surg Shaft

- In a stable shaft fracture without rotation or scissoring I would use either an off the shelf wrist splint such as a futuro with finger buddy taping
- Dependent on strength/ quality of fixation - may not require any splint or just a simple futura. Wouldn't always splint MCPjs into flex.
- A locking plate fix wouldn't necessarily need splint if bone good and fracture configuration is simple
- For surgical patients (plated) I wouldn't include the MCP joint in a splint

- With K-wires because in our centre these aren't buried, therefore they would require a volar splint.
- It will depend on the fracture pattern, the surgery and the patient presentation and preferences for their lifestyle/work

Spint time period Surg Base

- The recommended splinting time for k-wire fixation for second to fifth metacarpal base fractures is four weeks.
- The recommended splinting time for stable ORIF fixation for second to fifth metacarpal base fractures is for the first three days. Mobilise after 3-5 days.

Type of splint Surg Head

- MCPJ position might depend on fracture pattern and position of stability
- Same size splint but a volar splint so the hand is rested more. Patients remove for exercises
- We apply a circumferential hand-based bracing as presented here for SHAFT fractures Option 1.
- Volar might be more comfortable if dorsal k-wires. MCPJ position might depend on fracture pattern and position of stability.

Splint time period Surg Head

- We discard the splint at 4/52 as recommended by Midgley 2011.
- Depends on clinical assessment of fracture healing, pain, movement etc. Would be more likely to advise a longer duration in the splint, but to remove for movement exercises and light function.

Type of splint Surg Boxers

- Volar hand based splint for K-wire management
- Neck of 5^{th} metacarpal (boxers) fractures with rotation, managed conservatively can be treated in a soft wrap and buddy strapping due to the inherent stability.

Time period of splinting Surg for Boxers

- We discard the splint at 4/52 as recommended by Midgley 2011. (Remove the splint for exercises)
- If k-wire removal at (e.g) 3 - 4 weeks, would need to splint until removal of k-wire and then still use for protection for a short period after this, but remove for exercise.
- Provided the fixation is stable, we would move them earlier than 2/52.

Type splint Cons Boxers

- Splint not always required. Padded bandage may be sufficient.
- Splintage is just for comfort as the fracture is unlikely to displace. I do prefer a volar splint though - head is usually displaced volar and therefore dorsal splint, in theory, could worsen deformity (unlikely though as fracture is stable). Often extensor lag is a problem with these fractures, therefore volar splint allows early active extension

Time period of splinting Surg for Boxers

- May get them to progress quicker. Wean splint when painfree usually 2 weeks post injury and increase ADL then. Most patients back to normal 4 weeks
- Two weeks as pain allows

Type of splint Surg 2nd to 4th NECK

- If simple fracture might not splint at all after ORIF if good fixation
- dorsal k-wires would prevent
- Depends on position of k-wires if remain percutaneous

Splint time period Surg 2nd to 5th NECK

- 2/52 okay if ORIF/buried k-wires, but will be needed until k-wire removal if percutaneous.
- I don't feel k-wires are stable enough and would splint as for conservatively managed fracture
- Seems too short for k-wire fixation. Would agree for ORIF or screw.
- 4 weeks
- Provided the fixation is stable, we would move them earlier than 2/52.

Type of splint Cons 2nd to 4th NECK

- Volar displacement is more of an issue, and these, unlike boxers fractures are not always stable, and therefore prefer a volar based splint.

Round Three: What to expect.

- The survey link for round three will be sent on **4 March 2022.** You have two weeks to complete the survey.
- Round two questions pertaining to the clinical guidelines overarching principles and recommendations with open-ended responses can be expected.
- A clear separation between K-wire (percutaneous) and ORIF with plate/stable fixation management.
- The components where consensus has been reached will be removed except those where I will ask for clarity regarding rehabilitation phases, grasps and splint types.
- Yes and No questions added to the Likert scale allowing you to give your opinion in open-ended response.
- You have the opportunity to openly share your thoughts and bring us a step closer to developing the clinical hand rehabilitation guideline for second to fifth metacarpal fractures.

Many thanks for your time and commitment to this project!

Kind regards,

Monique

Addendum GII

REDcap questionnaire round three expert feedback

Dear Expert,

Your involvement in developing a clinical hand rehabilitation guideline for second to fifth metacarpal fracture is much appreciated. You completed the third Delphi round. Thank you! The consensus percentage is set at 75%. Consensus refers to the percentage of experts who agreed with the clinical guideline component. I now share the results from Round Three with the Open-ended responses following after the table.

Clinical guideline component	Was consensus reached?		Consensus Percentage
	Yes	No	
Rehabilitation recommendations. **This section covers rehabilitation recommendations for 2nd to 5th metacarpal fractures. Please indicate your agreement by answering Yes or No to the statements below. In the instance, you select No, provide your reasoning in the open box below the question.**			
Initiate immediate early motion after stable or rigid ORIF of metacarpal neck and shaft fractures to prevent adhesion formation.	X		78%
Immediate early active range of motion exercises after stable or rigid ORIF of metacarpal neck and shaft fractures starts 2-3 days post-surgery	X		89%
After metacarpal head fractures the MCPJ position depends on the fracture pattern and position of stability.	X		89%
After metacarpal head fractures the affected MCPJ and an adjacent finger's MCPJ is splinted/immobilised in flexion of 70°.		X	56%
Splint types should be clinically reasoned and individualised for each patient.	X		100%
The splint time period should be clinically reasoned according to the fracture pattern and individualised for each patient.	X		100%
Splinting types for second to fifth metacarpal fractures managed with percutaneous K-wires	X		100%

should consider and be moulded to respect the K-wire placement.			
Fractures managed with percutaneous K-wires should be splinted for the period when the K-wire is in situ.	X		100%
Grasp types exercises. **This section covers recommendations about including GRASP types, according to the Feix et al., 2016, into the rehabilitation of 2nd to 5th metacarpal fractures to improve hand function through a careful progression of the affected and unaffected MCPJ flexion. Please indicate your agreement by answering Yes or No to the statements below. In the instance, you select No, provide your reasoning in the open box below the question.**			
Incorporating grasp types of the hand is valuable in rehabilitation to promote hand function.	X		100%
Careful use of grasp types in the rehabilitation for 2nd to 5th metacarpal fractures after conservative management can improve hand function.	X		100%
Careful use of grasp types in the rehabilitation for 2nd to 5th metacarpal fractures after percutaneous K-wire management can improve hand function.	X		100%
Use of grasp types in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management can start at 2-3 days.	X		89%
Use of grasp types in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after K-wire management can start after K-wire removal.		X	56%
Incorporating the grasp types Phase 1 (Image provided above) in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after conservative management can start after 2-3 weeks of immobilisation. The splint is removed for exercises and reapplied afterwards.		X	56%
Incorporating the grasp types Phase 2 (Image provided) in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after conservative management can start after 4 weeks of immobilisation where the splint is removed for exercises.		X	56%

Incorporating the grasp types Phase 3 (Image provided) in the rehabilitation for the affected MCPJ 2nd to 5th metacarpal fractures after conservative management can start after 6 weeks of immobilisation.		X	44%
SHAFT 2nd to 5th metacarpal fractures management with stable ORIF **This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of 2nd to 5th SHAFT metacarpal fractures after stable surgical Open Reduction and Internal Fixation (ORIF). Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.**			
Shaft fractures managed surgically a stable ORIF fixation require a Futuro wrist extension brace without immobilisation of the MCPJ's.		X	11%
In Shaft fractures managed surgically with a stable ORIF fixation, a Futuro wrist extension brace without immobilisation of the MCPJ's is sufficient immobilisation.		X	18%
Shaft fracture managed surgically with a stable locking plate fixation wouldn't need a splint if the bone is in a good position and fracture configuration is simple.		X	18%
Shaft fracture managed surgically with a stable ORIF fixation wouldn't need a splint if bone good position and fracture configuration are simple.		X	18%
SHAFT 2nd to 5th metacarpal fractures managed with CONSERVATIVE or K-WIRES **This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of 2nd to 5th SHAFT metacarpal fractures after conservative and percutaneous K-wire management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.**			
Shaft fractures with no rotation and scissoring a commercially manufactured wrist extension brace for example Futuro with the affected finger buddy strapped to the unaffected neighbouring finger.		X	56%
Shaft metacarpal fractures managed with percutaneous K-wires requires a volar hand-based splint.		X	56%

BASE 2nd to 5th metacarpal fractures management with stable ORIF **This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of BASE of 2nd of 5th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.**			
Base of metacarpal fractures managed with percutaneous K-wires requires an immobilisation period of four weeks.		X	33%
Base of metacarpal fractures managed with stable ORIF fixation requires immobilisation for three days.		X	56%
Base of metacarpal fracture managed with stable ORIF fixation requires active mobilisation (including involved MCPJ) after 3 to 5 days after surgery.	X		78%
HEAD 2nd to 5th metacarpal fractures management with stable ORIF **This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of HEAD of 2nd of 5th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.**			
For head of metacarpal fractures managed surgically with an ORIF fixation a volar hand base splint is used.		X	56%
For head of metacarpal fractures managed surgically with an ORIF fixation a clam/sandwich hand-base splint (photo provided below this question) is used. 		X	56%
For head of metacarpal fractures managed surgically with an ORIF fixation a 4 week splinting time period is advised.		X	56%
For head of metacarpal fractures managed surgically with an ORIF fixation removal of splint for exercises and light function from 2 weeks is advised. (Midgley & Toemen 2011)		X	56%
HEAD 2nd to 5th metacarpal fractures management with percutaneous K-WIRES			

This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of HEAD of 2nd of 5th metacarpal fractures after percutaneous K-wires management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.			
For head of metacarpal fractures managed with percutaneous K-wires a volar hand-base splint is used.		X	44%
NECK of 5th (BOXERS) metacarpal fractures management with stable ORIF **This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of NECK of 5th (BOXERS) metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.**			
Neck of 5th (Boxers) metacarpal fractures with ≤ 70° angulation and no rotational deformity are to be treated with no reduction, a palm soft wrap and buddy strapping of fourth and fifth fingers for three weeks. (Level 1b, Van Aaken et el (2016))		X	56%
Neck of 5th (Boxers) metacarpal fractures with ≤ 70° angulation and no rotational deformity are to be treated with no reduction, a palm soft wrap and buddy strapping of fourth and fifth fingers for three weeks. (Level 1b, Van Aaken et el (2016))		X	44%
Neck of 5th (Boxers) fractures are generally impacted and therefore stable. Splinting is just for comfort as the fractures are unlikely to displace.	X		89%
NECK of 2nd to 4th metacarpal fractures management with stable ORIF **This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of NECK of 2nd to 4th metacarpal fractures after stable Open Reduction Internal Fixation (ORIF) management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.**			
Neck of 2nd to 4th fracture managed surgically with a stable ORIF fixation wouldn't need a splint.		X	11%

2nd to 4th Neck fracture managed surgically with a stable ORIF fixation requires a splinting time period of 2 weeks.		X	44%
Provided the fixation for 2nd to 4th Neck of metacarpal fractures are stable, early mobilisation should be commenced earlier than 2/52.	X		89%
2nd to 4th neck fracture managed surgically with a stable ORIF fixation requires active mobilization (including the involved MCPJ) earlier than 2 weeks.	X		89%
2nd to 4th neck fracture managed surgically with a stable ORIF fixation requires active mobilization (including the involved MCPJ) earlier from 3 to 5 days after surgery.		X	67%
NECK 2nd to 4th metacarpal fractures managed with CONSERVATIVE or K-WIRES **This section covers recommendations about splinting types, time period of splinting and other recommendations for the management of 2nd to 4th NECK metacarpal fractures after** **conservative and percutaneous K-wire management. Please indicate whether you agree with the statement by selecting Yes or No. In the instance, you selected No, provide your reasoning in the open comment box below the recommendation statement.**			
2nd to 4th Neck fractures managed surgically with percutaneous K-wires require a splinting time period of 4 weeks.	X		89%
2nd to 4th neck fracture managed conservatively requires a volar hand-based splint.		X	33
Is there anything else on your mind that you wish to share?			

16/40 = 36%

Open-ended responses:

I appreciate the feedback you have sent via email and adding your opinions to the available open-ended options.

Rehabilitation recommendations:

rehab_immed_act_mob_no:

Do you mean immediate, as in straight after the ORIF. Would usually suggest a day after surgery to elevate and gently mobilise, then start formal movement exercises after this. Stable fractures start mobilisation on day of assessment But both depend on how you define early motion - would suggest avoiding movement with the potential to displace the fracture. Is it immediate if 2-3 days after surgery? Agree with the sentiment **(rehab_immedtime)**.

Just give the wound some time to rest and don't stress the patient out. As long as they can wiggle a bit that's enough for first couple of days.

Need initial 2-3 days rest for inflammatory phase

Head_sp_degrees:

Often cant achieve 70 degrees due to pain and swelling so splint in as much MCP joint flexion as able

This seems to contradict the previous statement

Depends on which digit affected. if for E.g. LF wouldn't splint if less than 70 deg volar angulation.

Try not to immobilise intra-articular fractures unless very unstable.

Kwire_time:

ideally kwires out after 3 weeks and may need splinting for a further week for healing

Grasp types exercises.

Grasp_types_exorif:

We don't get them to function with the injured digit this early even if fixed. They function as able with the unaffected digits

grasp_type_exkwire:

Depending on position of k-wires and stability, some grasp postures may be possible before k-wire removal - for movement exercises, rather than function

A K-wire stabilizes the fracture while healing. So why should I wait 4-6 weeks until K-wire removal to start grasp type exercises? Especially Phase 1 and 2 grasp type exercises can be performed whith the K-wire still in situ. Depending on the stability of the fracture, phase 3 can also be started during the K-wire "wearing time". We again avoid extensor tendon adhesions with moving earlier and, thus, reduce extensor lags to a minimum.

It depends on the position of the k-wires and how restrictive they are, whether they are impinging on other structures, how efficiently they hold the fracture together, whether there is any rotation

it can be started prior to k-wire removal, depending on the stability of fixation, fracture pattern and wire placement

grasp_types_ex_cons1_no:

As discussed previously - depending on digit affected and amount of displacement - may not splint. If using wrist brace and Bedford splint - may start to phase 1 grasps immediately.

Do you mean the grasp postures or functional activities with the hand? Grasp postures earlier than 2-3 weeks. Timing sounds reasonable for light functional use, but would likely want to encourage more MCPJ flexion than afforded by these postures

Certainly not all, but definitvely most of the phase 1 grasp types can be exercised already earlier without removal of the splint. Especially ulnar MCP-fx (MCP 4 and 5), when the dig 1-3 are free to be used for light daily activities. Of course the power of the grasp types (in kg) has to be adjusted according to fracture healing and pain.

If its a stable fractur eit can start within the splint or with buddy taping

grp_types_ex_cons3_no

In some cases - immobilization can be stopped after 4 weeks

Would often start many of these earlier than 6 weeks.

Would suggest incorporating these postures much earlier in the rehab pathway. Thinking about the force applied when using for function.

In X, we have a different reasoning behind the progression of MCP flexion during the bone healing time: we do not think in grasp types, but rather in degrees of motion (as home exercises), and give our patients instructions how to best use their splinted hand for daily activities without overloading the fracture site. With this reasoning, we allow our patients all sorts of grasping types with adjusted strength / resistance. For example, the phase 3 grip "small diameter (No.2)" can be exercised with very little force applied, rather aiming for tendon gliding than muscle training.

It can start earlier if the patient is careful and the instructions are clear. Grasp intensity will need to be adjusted but position less so.

SHAFT 2nd to 5th metacarpal fractures management with stable ORIF

SHAFT 2nd to 5th metacarpal fractures managed with SURGICALLY, CONSERVATIVE or K-WIRES

shaft_splint_surgic_no

Often hand swollen so we make a more secure protective splint initially

I agree that the MCPJs don't have to be immobilized but don't agree with the recommendation for a specific brand of brace

Again depends on the patient - could use a book end type splint. May just use splint for night and vulnerable situations.

Might not need the wrist immobilising and could be managed with a hand-based cast/clam splint

can use a hand based splint, so wrist movement can be performed

I agree with the statement of not immobilising the MCPJ's, but do not agree with immobilizing the wrist in stable shaft fractures with a ORIF. We simpy prepare a handbased splint for this kind of fractures, to protect the hand from hitting hard objects during daily activities and to remind the patient to reduce his/her hand use during the fracture healing phase. For MCP 5 shaft fractures, we usually add a twin-tape to the dig 4 to avoid getting stuck somewhere with the 5th finger.

They need a hand based splint

Does not require, but I think it is better. It is sometimes of value, but I individualize. Sometimes after fixation I use a hand based splint to get MCPJ flexion in a patient who tends to keep MCPJ in extension

shaft_spl_surg_fut

needs to be clinically reasoned depending on extension of digit post surgery

This is the same recommendation as before. I agree with the recommendation in general but agree with the recommendation for a specific brand of brace

Why immobilise the wrist? protect the hand

shaft_spl_surg_no

Generally provide some splint to prevent patient returning to full ADL too quickly

They may need one for comfort and function

How are you defining a simple fracture configuration and good position? Would say that some protection should be offered for at risk environments/activities

only a hand based splint would be needed for first few weeks - for protection when out of the home. reminder to pt and for protection should someone hit them or they fall.

Actually I agree with the statement, but would nevertheless not completely forgo a splint for protective and patient education's reasons.

The splint is not really for the fracture - it is for patient comfort, analgesia, reminding the patient to not use their hand for heavy work and occasionally for positioning of a wrist or fingers which tends to be kept in a non-functional position

shaft_spl_surg_1_no

Generally provide some splint to prevent patient returning to full ADL too quickly

They may need one for comfort and function

for comfort. only a hand based splint would be needed for first few weeks - for protection when out of the home. reminder to pt and for protection should someone hit them or they fall.

Actually I agree with the statement, but would nevertheless not completely forgo a splint for protective and patient education's reasons.

Protection still important

shaft_splin_cons_no

Agree with recommendation but not the specific brand of a brace (also a custom wrist orthosis may fit better in some cases than a prefab)

hand based splint adequate

I don't believe that a soft futuro brace would sufficiently stabilize a conservatively treated MCP fracture. These splints usually only have a stabilizing part on the palmar side of the wrist, and end mid-palm, therefore only stabilizing half of the MCP bone. I'd prefer a custom-made thermoplastic hand-based splint plus buddy strap.

No need for wrist brace. Hand for protection +/- buddy tape

shaft_spl_kwire

I agree that they need a hand-based orthosis but whether it's volar, dorsal, ulnar gutter, or radial gutter may depend on involved digit, pin placement, functional needs, presence of wounds, etc. Also unclear whether the recommendation is to include MPJs or not.

Depends on which MC - radial or ulnar elements might offer more stability than volar splint, especially for boarder digits

sandwich splint / volar hand based splint

I'd still prepare a "circumferential" hand-based splint for percutaneous K-wires to increase protection of the wires. We usually cut a hole in the splint where the K-wire pops out of the skin, or press the splinting material away from the K-wire so that it is protected like under a little "dome-shaped" roof.

BASE 2nd to 5th metacarpal fractures management with stable ORIF

base_surg_kwire

Tendon gliding exercises are always completed when K wires insitu otherwise digit becomes very stiff

The length of immobilization will depend on length of K-wire fixation, which can be longer than 4 weeks

Depends which joints you're talking about. Would need wrist immobilised, but not necessarily the fingers.

The fingers do not need to be immobilised - movement from MCPJ distal is unlikely to disrupt fracture site

Here I am not sure to which joints you are referring to when talking about "immobilisation period of four weeks". The wrist? The MCPJ's? Both? For base MCP-fx, I would not immobilise the MCPJ's, but protect the K-wire area for the time the K-wire is in situ, usually 4-6 weeks.

I do 6 - no evidence, but makes me sleep better...

base_surg_immob_time

Always good to rest in initial 3-5 days post op

Perhaps 3-7 days? And may benefit from longer for comfort or function

Not sure why 3 days ??

Why be so prescriptive with 3 days?

Well yes. Three days are usually the time needed from surgery to the first hand therapy visit. Giving the hand a rest during this time is crucial to reduce pain and swelling to a minimum, while adhesion formation is not yet taking place during this early stage of wound healing.

Requires is a strong word - stable fixation should not require immobilization, but I often use it for the first week for pain relief and then start ROM

need inflammatory response to settle

base_splint_time

I think it's more about can initiate movement at 3-5 days, not required to initiate movement at 3-5 days

Again, this is very prescriptive. What about: ideally AROM should commence 2-5 days after surgery?

HEAD 2nd to 5th metacarpal fractures management with stable ORIF

HEAD 2nd to 5th metacarpal fractures management with percutaneous K-WIRES

head_splint_surg_no

Agree with hand-based orthosis but whether it's volar, dorsal, ulnar gutter, or radial gutter may depend on involved digit, pin placement, functional needs, presence of wounds, etc. And it's unclear if this recommendation includes MPJs or not. I assume yes.

If stable - may not require splint all the time.. May use just for night and vulnerable situations. More often would use dorsal ulnar gutter to allow free movement of PIPj/ DIPjs

Could just as well be dorsal with volar straps or ulnar/radial gutter type splint. Volar splint is an option, but not necessarily the option. Also, this says nothing about the joints included in the splint.

I would prepare a sandwich hand-based splint for this kind of fractures. In my experience, patients feel safer and better protected with a sandwich splint. If the MCPJ's are left free, they can be trained for active extension from the first week post-surgery onwards, also reducing extensor lags to a minimum.

head_splint_sur_clam

I think MPJ immobilization is advantageous in this population.

I would generally use a dorsal/ volar based ulnar gutter splint including the MCPj. Not sure if this is what the pic shows?

Might need a component extending to P1 region to promote MCPJ position.

Will need to go over MP jt for approx 1 - 2 weeks, then start mobilizing

head_spl_time_orif

unclear if this is 4 weeks full-time or if this recommendation includes removal for exercise/light function at 2 weeks

Depends on patient, surgeons and presentation of fracture and ORIF.

Splint, with regular AROM

The splint wearing time depends on the stability of the fracture. As head MCP fractures are usually stable + a ORIF fixation is also a very stable surgical solution, 2 weeks splinting time might suffice. We usually recommend to wear the splint for out of the house activities, but to remove it at home when being in a safe environment. At night, the splint can be worn for 4-6 weeks depending on the patient's needs.

If this is immobiisation -no. If splint comes off for exercises / light function -yes

head_spl_tim_orif

If stable would move much earlier.

Could also start gentle movement earlier, if no contra-indications for the individual?

Earlier. 2-3 days

Yes and no - if stable fixation, start with 3-5 days - if worried about stability, wait 2-4 weeks

head_splint_kwire_no

I agree that they need a hand-based orthosis but whether it's volar, dorsal, ulnar gutter, or radial gutter may depend on involved digit, pin placement, functional needs, presence of wounds, etc. Also unclear whether this recommendation includes MPJ immobilization.

Could be volar or dorsal.

As with my responses to the other questions: It could be. Often a dorsal component to protect the k-wire from being knocked is helpful for patients.

I'd recommend a sandwich-shaped hand-based splint with either a hole or "dome-shaped" roof where the K-wire perforates the skin.

This depends on stability of fixation. Generally I prefer o dorsal splint - I'm often not comfortable mobilising the MCPJ after K-wire fixation. I therefore use dorsal splint with MCPJ in 70 flexion, but it allows active ROM of PIPJ and DIPJ in splint

NECK of 5th (BOXERS) metacarpal fractures management with stable ORIF

box_splint_cons

Sometimes splint made if ext lag or lots of oedema. Clinical reasoning again

Yes, although a hand based splint that allowed hand function could also be used. And reduction may have been performed in ED

No would reduce and immobilise for 2 weeks and then limited active ex, back into splint

Splint for protection +/- buddy tape

box_spli_time_cons

would immobilise with rigid splint, and limited active ex

Yes sometimes but I prefer to provide a splint for protection. If they don't wear it, fine

depends on pain, swelling and ROM. Also patient factors. Will be between 2-4 weeks

NECK of 2nd to 4th metacarpal fractures management with stable ORIF

neck2_4_surg

splint if oedema or lag and for comfort if needed

May need one for comfort or function

Depends on patient, surgeon and presentation.

Depends on the type of post-operative dressings and when the patient is asked to remove them

may need a hand based splint for protection, especially if a sports person

For protective reasons, I would nevertheless prepare a splint for 2 weeks for this kind of fractures.

Protection

As mentioned previously - the fracture does need a splint, but the patient might

need splint for reducing loading in function reducing pain/swelling

neck2_4_surg_time

2-4 weeks (likely 2 weeks full-time)

Depends on patient, surgeon and presentation.

Would suggest that splint and early movement would be better than staying in post-operative bulky dressings for 2 weeks - in terms of patient comfort and ease of washing

Longer, protection only

neck2_4_mob_orif_2

I think earlier than 2 weeks is appropriate, not earlier than 3-5 days. I also don't think "requires" is the most appropriate word choice.

3-5 seems reasonable.

need time for oedema and inflammatory response to settle

NECK 2nd to 4th metacarpal fractures managed with CONSERVATIVE or K-WIRES

neck2_4_spl_cons_no

I agree that they need a hand-based orthosis but whether it's volar, dorsal, ulnar gutter, or radial gutter may depend on involved digit, pin placement, functional needs, presence of wounds, etc. Also unclear whether this recommendation includes MPJ immobilization.

Depends on patient, surgeon and presentation.

ulnar/radial gutter type splints which are semi-circumferential

can have a hand based sandwich splint, incorporating affected MP jt

I'd still prefer the sandwich-type of hand-based splint for the same reasons given above.

This is a difficult one - volar based splint will be better at maintaining a reduction, but makes it more difficult to get active PIPJ and DIPJ motion in the splint

may be dorsal to allow IPJ movement

Round Three: What to expect.

Many thanks for your time and commitment to this project!

Kind regards,

Monique

Addendum HII

Recommendations for the Conducting and REporting of Delphi Studies (CREDES) (Jünger et al., 2017)

Rationale for the choice of the Delhi technique			
1.	**Justification**	"The choice of the eDelphi technique as a method of systematically collating expert consultation and building consensus needs to be well justified. When selecting the method to answer a particular research question, it is important to keep in mind its constructivist nature."	**P183**
Planning and design			
2.	**Planning and process**	**"**The eDelphi technique is a flexible method and can be adjusted to the respective research aims and purposes. Any modifications should be justified by a rationale and be applied systematically and rigorously."	**P183-P188**
3.	**Definition of consensus**	**"** Unless not reasonable due to the explorative nature of the study, an a priori criterion for consensus should be defined. This includes a clear and transparent guide for action on (a) how to proceed with certain items or topics in the next survey round, (b) the required threshold to terminate the eDelphi process and (c) procedures to be followed when consensus is (not) reached after one or more iterations."	**P183**
Study conduct			
4.	**Informational imput**	**"**All material provided to the expert panel at the outset of the project and throughout the eDelphi process should be carefully reviewed and piloted in advance in order to examine the effect on experts' judgements and to prevent bias."	**Systematic review info provided from Phase II P71**
5.	**Prevention of bias**	**"** Researchers need to take measures to avoid directly or indirectly influencing the experts' judgements. If one or more members of the research team have a conflict of interest, entrusting an independent researcher with the main coordination of the eDelphi study is advisable."	**P195**
6.	**Interpretation and processing of results**	**"**Consensus does not necessarily imply the 'correct' answer or judgement; (non)consensus and stable disagreement provide informative insights and highlight differences in perspectives concerning the topic in question."	**Addendum DII, EII, FII**
7.	**External validation**	**"**It is recommended to have the final draft of the resulting guidance on best practice in palliative care reviewed and approved by an external board or authority before publication and dissemination."	**P190 Expert panel received final draft for review, but not external**

			board due to time restraints to submit. Recommendation
Reporting			
8.	**Purpose and rationale**	**"**The purpose of the study should be clearly defined and demonstrate the appropriateness of the use of the eDelphi technique as a method to achieve the research aim. A rationale for the choice of the eDelphi technique as the most suitable method needs to be provided."	**P182**
9.	**Expert panel**	**"**Criteria for the selection of experts and transparent information on recruitment of the expert panel, sociodemographic details including information on expertise regarding the topic in question, (non)response and response rates over the ongoing iterations should be reported."	**P185-P186**
10.	**Description of the methods**	**"**The methods employed need to be comprehensible; this includes information on preparatory steps (How was available evidence on the topic in question synthesised?), piloting of material and survey instruments, design of the survey instrument(s), the number and design of survey rounds, methods of data analysis, processing and synthesis of experts' responses to inform the subsequent survey round and methodological decisions taken by the research team throughout the process."	**P183-P188**
11.	**Procedure**	"Flow chart to illustrate the stages of the eDelphi process, including a preparatory phase, the actual 'eDelphi rounds', interim steps of data processing and analysis, and concluding steps."	**P187**
12.	**Definition and attainment of consensus**	"It needs to be comprehensible to the reader how consensus was achieved throughout the process, including strategies to deal with non-consensus."	**P188**
13.	**Results**	**"**Reporting of results for each round separately is highly advisable in order to make the evolving of consensus over the rounds transparent. This includes figures showing the average group response, changes between rounds, as well as any modifications of the survey instrument such as deletion, addition or modification of survey items based on previous rounds."	**P188-P190**
14.	**Discussion of limitations**	**"**Reporting should include a critical reflection of potential limitations and their impact of the resulting Guidance."	**P194-P195**
15.	**Adequancy of conclusions**	**"**The conclusions should adequately reflect the outcomes of the eDelphi study with a view to the scope and applicability of the resulting practice guidance."	**P194**

16.	**Publication and dissemination**	**“**The resulting guidance on good practice in palliative care should be clearly identifiable from the publication, including recommendations for transfer into practice and implementation. If the publication does not allow for a detailed presentation of either the resulting practice guidance or the methodological features of the applied eDelphi technique, or both, reference to a more detailed presentation elsewhere should be made (e.g. availability of the full guideline from the authors or online; publication of a separate paper reporting on methodological details and particularities of the process (e.g. persistent disagreement and controversy on certain issues)). A dissemination plan should include endorsement of the guidance by professional associations and health care authorities to facilitate implementation.”	**P180**

Addendum III

Author guidelines: Hand

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TABLE OF CONTENTS

HAND INSTRUCTIONS FOR AUTHORS 1

MANUSCRIPTS ACCEPTED TO HAND 3

WHAT TO EXPECT AFTER YOU SUBMIT A MANUSCRIPT TO HAND 3

ETHICAL RESPONSIBILITIES OF AUTHORS 4

COPYRIGHT 5

DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST AND FUNDING 6

STATEMENT OF HUMAN AND ANIMAL RIGHTS 7

STATEMENT OF INFORMED CONSENT 8

MANUSCRIPT SUBMISSION 9

AUTHORSHIP CRITERIA 9

MANUSCRIPT ORGANIZATION 10

ARTICLE TYPES – DESCRIPTIONS, LENGTH, FORMATTING 14

Original Manuscript 14

Comprehensive Critical Reviews 14

Case Reports – All accepted Case Reports are now being published online only 15

Letter to the Editor 16

MULTIMEDIA ARTICLE SUBMISSION REQUIREMENTS (I.E. STREAMING VIDEOS) 16

LANGUAGE EDITING SERVICE 17

REGISTERING CLINICAL TRIALS 17

WHAT TO EXPECT AFTER ACCEPTANCE TO HAND 17

AUTHOR PROOFS 17

SAGE CHOICE 18

REQUESTING PERMISSION TO RE-USE HAND CONTENT 18

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- Case reports
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Description	Report of research conducted to increase the body of knowledge of a particular area of concern in hand or upper extremity injuries.	
Number of words/tables/figures	1. Should not exceed 3500 word limit (excluding Abstract and References) 2. Submitted in an editable Word document 3. Contain continuous line numbering and page numbers, double-spaced 4. No more than 7 figures or tables. (Any figures beyond 7 should be designated as Supplemental Material)	
Title Page	1. Title of the article 2. Author list. Include first and last names for each contributing author [first name, middle initial(s), surname, degree(s)]. Please ensure the accuracy of the author order, spelling, and appearance of all author names. 3. For all contributing authors, indicate the departmental and institutional affiliation(s) for each author 4. Corresponding Author must provide up-to-date email address and the complete mailing address (including the city, state or province, and country) where the work was performed 5. At the bottom, indicate any Acknowledgments of Grant Support or other Acknowledgements	
Manuscript Format	1. Structured Abstract 2. Introduction 3. Methods 4. Results 5. Discussions	6. Conclusions 7. Statements 8. References (not to exceed 40) 9. Figure(s)
Peer Review	Initial review by the Editor-in-Chief or an Associate Editor. Some manuscripts that are deemed inappropriate for the journal or very low priority by the editorial staff may be returned without review. If eligible for publication, the manuscript will be reviewed by 2 or more external reviewers with the final decision made by the Editor-in-Chief.	

Comprehensive Critical Reviews

Description	A thorough review of the literature presenting new relevant information to the areas of hand and upper extremity injuries.	
Number of words/tables/figures	1. Should not exceed 3500 word limit (excluding Abstract and References) 2. Submitted in an editable Word document 3. Contain continuous line numbering and page numbers, double-spaced	
	4. No more than 5 figures or tables. (Any figures beyond 5 should be designated as Supplemental Material)	
Title Page	1. Title of the article 2. Author list. Include first and last names for each contributing author [first name, middle initial(s), surname, degree(s)]. Please ensure the accuracy of the author order, spelling, and appearance of all author names 3. For all contributing authors, indicate the departmental and institutional affiliation(s) for each author 4. Corresponding Author must provide up-to-date email address and the complete mailing address (including the city, state or province, and country) where the work was performed 5. At the bottom, indicate any Acknowledgments of Grant Support or other Acknowledgements	
Manuscript Format	1. Abstract 2. Introduction 3. Methods 4. Results 5. Discussions	6. Conclusions 7. Statements 8. References (not to exceed 40) 9. Figure(s)
Peer Review	Initial review by the Editor-in-Chief or an Associate Editor. Some manuscripts that are deemed inappropriate for the journal or very low priority by the editorial staff may be returned without review. If eligible for publication, the manuscript will be reviewed by 2 or more external reviewers with the final decision made by the Editor-in-Chief.	

Case Reports [Limited Acceptance] – All accepted Case Reports are now being published <u>online only.</u>

Description	The presentation of a case that describes the signs, symptoms, diagnosis, treatment and follow-up of a patient. Case reports should be unique in nature and provide readers with educational insights and value.	
Number of words/tables/figures	Should not exceed 2000 word limit (excluding Abstract and References) Submitted in an editable Word document Contain continuous line numbering and page numbers, double-spaced No more than 7 figures or tables	
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	5. At the bottom, indicate any Acknowledgments of Grant Support or other Acknowledgements	
Manuscript Format	1. Abstract 2. Introduction 3. Methods 4. Results 5. Discussions	6. Conclusions 7. Statements 8. References (not to exceed 20) 9. Figure(s)
Peer Review	Initial review by the Editor-in-Chief or an Associate Editor. Some manuscripts that are deemed inappropriate for the journal or very low priority by the editorial staff may be returned without review. If eligible for publication, the manuscript will be reviewed by 2 or more external reviewers with the final decision made by the Editor-in-Chief.	

Letter to the Editor

Description	Comments on a published manuscript to expand on or clarify a particular subject of interest.

Number of words/tables/figures	• Should not exceed 500 word limit (excluding References) • Submitted in an editable Word document • Contain continuous line numbering and page numbers, double-spaced • No more than 2 figures or tables.
Title Page	1. Title of the article 2. Author list. Include first and last names for each contributing author [first name, middle initial(s), surname, degree(s)]. Please ensure the accuracy of the author order, spelling, and appearance of all author names 3. For all contributing authors, indicate the departmental and institutional affiliation(s) for each author 4. Corresponding Author must provide up-to-date email address and the complete mailing address (including the city, state or province, and country) where the work was performed 5. At the bottom, indicate any Acknowledgments of Grant Support or other Acknowledgements
Manuscript Format	1. Unstructured format (no abstract required) 2. No more than 5 relevant references
Peer Review	Decision made at the discretion of the HAND Editor-in-Chief

MULTIMEDIA ARTICLE SUBMISSION REQUIREMENTS (I.E. STREAMING VIDEOS)

Multimedia articles are papers where the video is the heart of the article. The video should contain the original content of the article and the text should be used to supplement the video.

For multimedia articles, the text will be published in the print version of the Journal and both the text and video will be published in the electronic version of the Journal. The text of the multimedia article should contain a clear reference to the video available electronically and consist of the following:

- Abstract (please follow the instructions for abstract organization in the section above)

- A brief, bulleted list giving an overview of the main points contained within thevideo
- A reference list if needed (please follow the instructions for reference organization in the section above

The author(s) will be required to submit the video in the following format:

- Video clips should not exceed 9 minutes
- Multimedia file for review and submission: submit videos as either .mp4 or .mov
- All narration should be in English

Please follow the manuscript and title page formatting instructions found in the "Manuscript Organization" section above when submitting the manuscript.

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HAND requires all articles reporting results of clinical trials to be registered in a public trials registry that is in conformity with the International Committee of Medical Journal Editors (ICMJE). All clinical trials, regardless of when they were completed, and secondary analyses of original clinical trials must be registered before submission of a manuscript based on the trial. Phase I trials designed to study pharmacokinetics or major toxicity are exempt.

Manuscripts reporting on clinical trials (as defined above) should indicate that the trials are registered and include the registry information on a separate page, immediately following the authors' financial disclosure information. Required registry information includes trial registry name, registration identification number, and the URL for the registry.

WHAT TO EXPECT AFTER ACCEPTANCE TO HAND

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Addendum JII

AGREE II Reporting Checklist 2016

This checklist is intended to guide the reporting of clinical practice guidelines.

CHECKLIST ITEM AND DESCRIPTION	REPORTING CRITERIA	Page #
DOMAIN 1: SCOPE AND PURPOSE		
1. OBJECTIVES Report the overall objective(s) of the guideline. The expected health benefits from the guideline are to be specific to the clinical problem or health topic.	√☐ Health intent(s) (i.e., prevention, screening, diagnosis, treatment, etc.) √☐ Expected benefit(s) or outcome(s) √☐ Target(s) (e.g., patient population, society)	P5 P36P5 P5
2. QUESTIONS Report the health question(s) covered by the guideline, particularly for the key recommendations.	√☐ Target population √☐ Intervention(s) or exposure(s) ☐ Comparisons (if appropriate) √☐ Outcome(s) √☐ Health care setting or context	P31 P31 N/A P31 P31
3. POPULATION Describe the population (i.e., patients, public, etc.) to whom the guideline is meant to apply.	√☐ Target population, sex and age √☐ Clinical condition (if relevant) √☐ Severity/stage of disease (if relevant) ☐ Comorbidities (if relevant)	P36 P28 P31 N/A

	√☐ Excluded populations (if relevant)	P70
DOMAIN 2: STAKEHOLDER INVOLVEMENT		
4. GROUP MEMBERSHIP Report all individuals who were involved in the development process. This may include members of the steering group, the research team involved in selecting and reviewing/rating the evidence and individuals involved in formulating the final recommendations.	√☐ Name of participant √☐ Discipline/content expertise (e.g., neurosurgeon, methodologist) ☐ Institution (e.g., St. Peter's hospital) √☐ Geographical location (e.g., Seattle, WA) √☐ A description of the member's role in the guideline development group	Anon P88 Anon P209
5. TARGET POPULATION PREFERENCES AND VIEWS Report how the views and preferences of the target population were sought/considered and what the resulting outcomes were.	√☐ Statement of type of strategy used to capture patients'/publics' views and preferences (e.g., participation in the guideline development group, literature review of values and preferences) √☐ Methods by which preferences and views were sought (e.g., evidence from literature, surveys, focus groups) √☐ Outcomes/information gathered on patient/public information √☐ How the information gathered was used to inform the guideline development process and/or formation of the recommendations	P209 P209 P213 P214
6. TARGET USERS	√☐ The intended guideline audience (e.g. specialists, family physicians, patients,	*P256*

Report the target (or intended) users of the guideline.	clinical or institutional leaders/administrators) √☐ How the guideline may be used by its target audience (e.g., to inform clinical decisions, to inform policy, to inform standards of care)	P230
DOMAIN 3: RIGOUR OF DEVELOPMENT		
7. SEARCH METHODS Report details of the strategy used to search for evidence.	√☐ Named electronic database(s) or evidence source(s) where the search was performed (e.g., MEDLINE, EMBASE, PsychINFO, CINAHL) √☐ Time periods searched (e.g., January 1, 2004 to March 31, 2008) √☐ Search terms used (e.g., text words, indexing terms, subheadings) √☐ Full search strategy included (e.g., possibly located in appendix)	P44-47 P42
8. EVIDENCE SELECTION CRITERIA Report the criteria used to select (i.e., include and exclude) the evidence. Provide rationale, where appropriate.	√☐ Target population (patient, public, etc.) characteristics √☐ Study design √☐ Comparisons (if relevant) √☐ Outcomes √☐ Language (if relevant) √☐ Context (if relevant)	P42 P42 P43 P43 P42 P42

9. STRENGTHS & LIMITATIONS OF THE EVIDENCE Describe the strengths and limitations of the evidence. Consider from the perspective of the individual studies and the body of evidence aggregated across all Pthe studies. Tools exist that can facilitate the reporting of this concept.	√☐ Study design(s) included in body of evidence √☐ Study methodology limitations (sampling, blinding, allocation concealment, analytical methods) √☐ Appropriateness/relevance of primary and secondary outcomes considered √☐ Consistency of results across studies √☐ Direction of results across studies √☐ Magnitude of benefit versus magnitude of harm √☐ Applicability to practice context	P42 From P69 P46 P76 P80 P81 P81
10. FORMULATION OF RECOMMENDATIONS Describe the methods used to formulate the recommendations and how final decisions were reached. Specify any areas of disagreement and the methods used to resolve them.	√☐ Recommendation development process (e.g., steps used in modified Delphi technique, voting procedures that were considered) √☐ Outcomes of the recommendation development process (e.g., extent to which consensus was reached using modified Delphi technique, outcome of voting procedures) √☐ How the process influenced the recommendations (e.g., results of Delphi technique influence final recommendation, alignment with recommendations and the final vote)	P190 P190 P190

11. CONSIDERATION OF BENEFITS AND HARMS Report the health benefits, side effects, and risks that were considered when formulating the recommendations.	√☐ Supporting data and report of benefits X☐ Supporting data and report of harms/side effects/risks X☐ Reporting of the balance/trade-off between benefits and harms/side effects/risks X☐ Recommendations reflect considerations of both benefits and harms/side effects/risks	
12. LINK BETWEEN RECOMMENDATIONS AND EVIDENCE Describe the explicit link between the recommendations and the evidence on which they are based.	√☐ How the guideline development group linked and used the evidence to inform recommendations √☐ Link between each recommendation and key evidence (text description and/or reference list) √☐ Link between recommendations and evidence summaries and/or evidence tables in the results section of the guideline	P P205
13. EXTERNAL REVIEW Report the methodology used to conduct the external review.	√☐ Purpose and intent of the external review (e.g., to improve quality, gather feedback on draft recommendations, assess applicability and feasibility, disseminate evidence) √☐ Methods taken to undertake the external review (e.g., rating scale, open-ended questions)	P181 P185

	√☐ Description of the external reviewers (e.g., number, type of reviewers, affiliations) √☐ Outcomes/information gathered from the external review (e.g., summary of key findings) √☐ How the information gathered was used to inform the guideline development process and/or formation of the recommendations (e.g., guideline panel considered results of review in forming final recommendations)	P186 Added Added
14. UPDATING PROCEDURE Describe the procedure for updating the guideline.	√☐ A statement that the guideline will be updated √☐ Explicit time interval or explicit criteria to guide decisions about when an update will occur √☐ Methodology for the updating procedure	Added
DOMAIN 4: CLARITY OF PRESENTATION		
15. SPECIFIC AND UNAMBIGUOUS RECOMMENDATIONS Describe which options are appropriate in which situations and in which population groups, as informed by the body of evidence.	√☐ A statement of the recommended action √☐ Intent or purpose of the recommended action (e.g., to improve quality of life, to decrease side effects) √☐ Relevant population (e.g., patients, public)	P207 P200 P200 P204

	√☐ Caveats or qualifying statements, if relevant (e.g., patients or conditions for whom the recommendations would not apply) ☐ If there is uncertainty about the best care option(s), the uncertainty should be stated in the guideline	
16. MANAGEMENT OPTIONS Describe the different options for managing the condition or health issue.	√☐ Description of management options ☐ Population or clinical situation most appropriate to each option	P206
17. IDENTIFIABLE KEY RECOMMENDATIONS Present the key recommendations so that they are easy to identify.	√☐ Recommendations in a summarized box, typed in bold, underlined, or presented as flow charts or algorithms √☐ Specific recommendations grouped together in one section	P206 P206
DOMAIN 5: APPLICABILITY		
18. FACILITATORS AND BARRIERS TO APPLICATION Describe the facilitators and barriers to the guideline's application.	☐ Types of facilitators and barriers that were considered ☐ Methods by which information regarding the facilitators and barriers to implementing recommendations were sought (e.g., feedback from key stakeholders, pilot testing of guidelines before widespread implementation)	

	☐ Information/description of the types of facilitators and barriers that emerged from the inquiry (e.g., practitioners have the skills to deliver the recommended care, sufficient equipment is not available to ensure all eligible members of the population receive mammography) ☐ How the information influenced the guideline development process and/or formation of the recommendations	
19. IMPLEMENTATION ADVICE/TOOLS Provide advice and/or tools on how the recommendations can be applied in practice.	√☐ Additional materials to support the implementation of the guideline in practice. For example: o Guideline summary documents o Links to check lists, algorithms o Links to how-to manuals o Solutions linked to barrier analysis (see Item 18) o Tools to capitalize on guideline facilitators (see Item 18) o Outcome of pilot test and lessons learned	P232
20. RESOURCE IMPLICATIONS Describe any potential resource implications of applying the recommendations.	X☐ Types of cost information that were considered (e.g., economic evaluations, drug acquisition costs) X☐ Methods by which the cost information was sought (e.g., a health economist was	

	part of the guideline development panel, use of health technology assessments for specific drugs, etc.) X☐ Information/description of the cost information that emerged from the inquiry (e.g., specific drug acquisition costs per treatment course) X☐ How the information gathered was used to inform the guideline development process and/or formation of the recommendations	
21. MONITORING/ AUDITING CRITERIA Provide monitoring and/or auditing criteria to measure the application of guideline recommendations.	X☐ Criteria to assess guideline implementation or adherence to recommendations X☐ Criteria for assessing impact of implementing the recommendations X☐ Advice on the frequency and interval of measurement X☐ Operational definitions of how the criteria should be measured	
DOMAIN 6: EDITORIAL INDEPENDENCE		
22. FUNDING BODY Report the funding body's influence on the content of the guideline.	√☐ The name of the funding body or source of funding (or explicit statement of no funding) √☐ A statement that the funding body did not influence the content of the guideline	P219 P245

23. COMPETING INTERESTS Provide an explicit statement that all group members have declared whether they have any competing interests.	√☐ Types of competing interests considered √☐ Methods by which potential competing interests were sought √☐ A description of the competing interests √☐ How the competing interests influenced the guideline process and development of recommendations	P219 P219 P219 P219

From:

Brouwers MC, Kerkvliet K, Spithoff K, on behalf of the AGREE Next Steps Consortium. The AGREE Reporting Checklist: a tool to improve reporting of clinical practice guidelines. BMJ 2016;352:i1152. doi: 10.1136/bmj.i1152.

For more information about the AGREE Reporting Checklist, please visit the AGREE Enterprise website at http://www.agreetrust.org.

Addendum KII

American Society of Hand Therapy magazine article

VOLUME 27, ISSUE 3 • FALL 2020

ASHT TIMES

THE NEWSLETTER OF THE AMERICAN SOCIETY OF HAND THERAPISTS

CONTENTS

3 Editor's Letter
6 Regional Updates
7 President's Message
8 Viewpoint
9 Telehealth: What Have We Learned, and Where We Will Go?
10 Test Your Knowledge
11 AHTF Update
14 Diagnosis: Pandemic Tendonitis
17 Examining the Impacts of the Global Pandemic on Clinical Education Practices: A Faculty Perspective
19 Student Perspectives on COVID-19
20 Pivots, Policies and Procedures
21 Hand Assessment After Second to Fifth Metacarpal Fractures: ICF Framework and Taxonomy of Human Hand Grasps
24 Management of Lateral Epicondylitis Using the Mulligan Treatment Approach with an Occupation-Based Perspective
27 Clinical Corner
28 Ode to the Elbow
30 Welcome New Members
31 Division Updates

Feature

Special Considerations FOR HAND THERAPY AFTER COVID-19

By Hannah Gift, OTR/L, CHT, COMT, CEAS

While the clinical practice of hand therapists is always evolving, 2020 has presented us with unique challenges. An increasing number of individuals are now attending therapy while recovering from COVID-19. They may be experiencing upper extremity symptoms related to immobility and positioning while critically ill, or they may be seeking outpatient therapy for more general improvements in endurance and function. Each facility should have clear guidelines for returning to therapy after being sick with COVID-19; see also the Center for Disease Control Guidelines recommending that patients are cleared by a medical doctor or public health official prior to the evaluation, are no longer experiencing a fever or symptoms, and have quarantined more than 14 days after a positive test. This article focuses on the unique considerations for hand therapy evaluation and intervention of the post-COVID-19 patient.

Evaluation

A traditional hand therapy evaluation will identify patterns of weakness and/or range of motion limitations related to prolonged hospitalization or illness. Additional, easily-incorporated evaluation measures can promote safety in therapy and further demonstrate the impact of COVID-19 on health and function.

CONTINUED ON PAGE 4

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Feature

Hand Assessment After Second to Fifth Metacarpal Fractures:

ICF Framework and Taxonomy of Human Hand Grasps

By Monique M. Keller, MA Hand Rehabilitation (UKZN); Dr. Roline Y Barnes, PhD Physiotherapy (UCT); Dr. Corlia Brandt, PhD Physiotherapy (UFS)

Rationale

A fully-rehabilitated hand after conservative or post-surgical management of second to fifth metacarpal fractures should be the primary aim after hand rehabilitation. The International Classification of Functioning, Disability and Health (ICF) framework provides a valuable framework to describe function and disability, and to organize information during a hand assessment.[1] Attaining all three concepts of the ICF — body function and structure, activity and participation — allow for prevention of disability, optimize hand function and allow individuals to return to preinjury participation. A second to fifth metacarpal fracture may negatively impact the three ICF levels, as well as contextual factors such as the person, community and environment.

The relationship between hand fractures and epidemiology in a social-deprived population has been investigated.[2] Boxer's fractures (27% of all hand fractures) were significantly associated (p=0.017) with social deprivation in men. Social deprivation further influenced the pattern and management of the fractures, where affluent individuals received operative treatment more often.[2] Fifth metacarpal fractures have left individuals with functional deficits including weakened grip strength and a decrease in metacarpal joint range of motion, and the concern of the residual deficits is the young and working adult population who sustains metacarpal fractures most frequently.[3] With a decrease in hand function to earn a living and an increase in days off work, the concern is the economic consequences for both employees and employers.[4] To this end, human hand grasps offer a valuable observational assessment component that may prevent functional deficits.

The human hand grasps are static postures of the hand with which an object is securely held with one dominant or non-dominant hand, irrespective of the orientation of the hand.[5] The earliest studies on human grasp behavior allowed the description of grasps categories into cylindrical, lateral, tip, palmar, hook and spherical grasp.[6] These categories were defined by the object the hand had to manipulate and not the hand manipulation according to a task that had to be completed. Further research was conducted where a taxonomy of human grasp was developed.[7] The taxonomy divides the grasps into power and precision grasps, thereafter object shape and then function was included. Early studies on grasps also focused predominantly on the posture of the hand for prior selected objects but had not investigated hand manipulation during unstructured tasks and behaviors. This was addressed where grasp types and frequency of its use in manipulation tasks were investigated.[8] A literature study including the taxonomy of grasps was performed prior to conducting the research. The GRASP taxonomy that resulted includes the following categories: power grasps with palm or pad, intermediate grasp with the sides of the fingers and precision grasps with either the pad or sides of the fingers and opposition. For each of the three grasp categories, a distinction is made between thumb abduction and adduction during use.[5,8] Bullock et al[8] investigated two housekeepers and two mechanist. They were video recorded for a period of 7.45 hours each and the recordings analyzed for most frequent grasp types used.[8] The ten most frequently used grasps for the four participants presented under each grasp category were: medium wrap, power sphere, index finger extension, light tool, lateral pinch, lateral tripod, thumb-two finger, tripod, thumb-three finger and precision disk.[8]

The most extensive and complete grasp study had been conducted, with the result being the GRASP taxonomy (See Figure 1 on page 22).[5] Thirty-three different hand grasp types were identified and included into the GRASP taxonomy after a review of literature.[5] The GRASP taxonomy of human hand types included in Figure 1 falls under the activity and participation concepts of the ICF framework.

Conclusion

Incorporating the GRASP taxonomy of human grasp types as part of the observational assessment successfully incorporates the use of the ICF framework to assure multidimensional, interactive and comprehensive hand assessment and rehabilitation programs.

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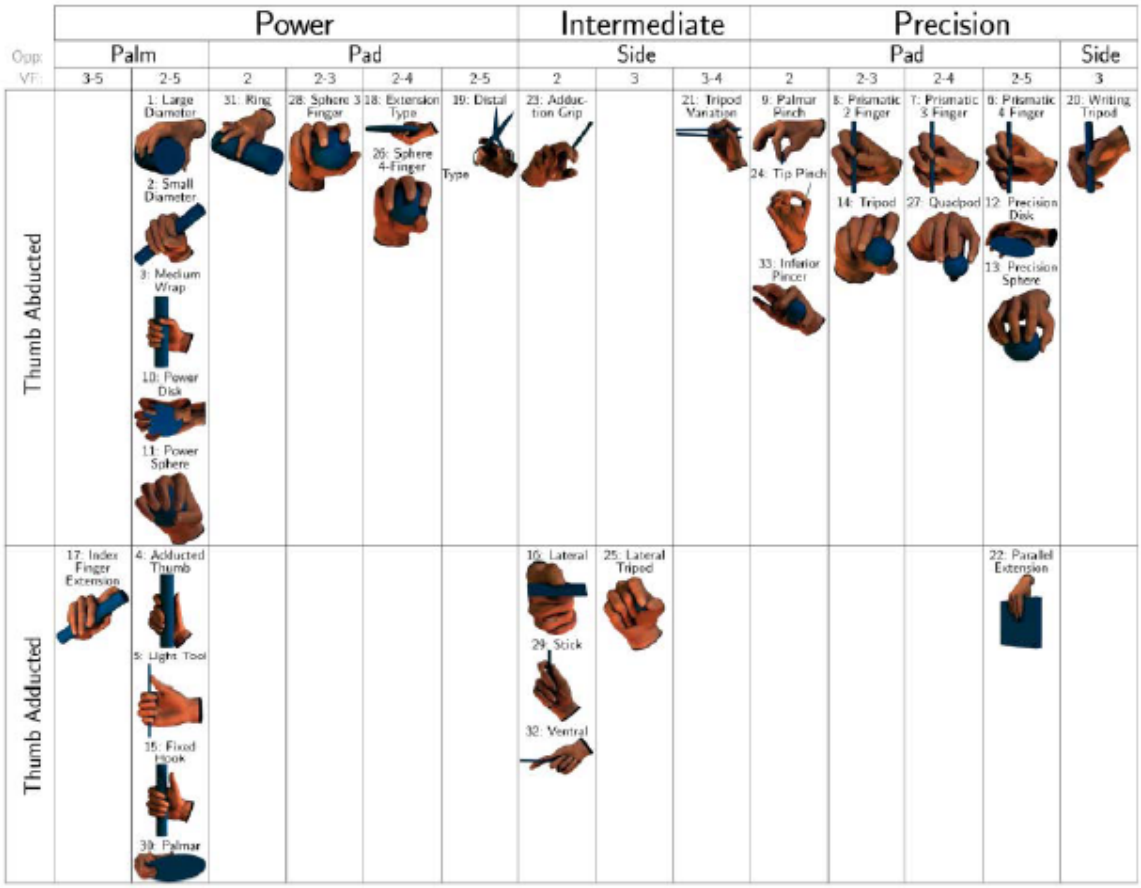

>> **Figure 1.** The GRASP taxonomy of human grasp types (Permission obtained for use by Thomas Feix[5])

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Addendum LII

Language editor declaration

VENESSA DE BOER:

TRANSLATION, LANGUAGE EDITING AND PROOF-READING SERVICES

TO WHOM IT MAY CONCERN

This to certify that I, Venessa de Boer, identity number 4607060025085, was responsible for the language editing and proof reading of the Ph.D. manuscript, entitled:

"Development of a Clinical Hand Rehabilitation Guideline for Second to Fifth Metacarpal Fractures in South Africa"

by

Ms Monique Marié Keller

Student number 2016391605

in fulfilment for the degree

Doctor of Physiotherapy

in the

Faculty of Science

Department of Physiotherapy

University of Free State

V de Boer (signed on computer)

Date: 2023:05:19