THE IMPAIRMENTS AND FUNCTIONAL OUTCOMES OF PATIENTS POST FLEXOR TENDON REPAIR OF THE HAND AT AN ACADEMIC HOSPITAL IN JOHANNESBURG, SOUTH AFRICA

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A dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, in fulfilment of the requirements for the degree of

Master of Science in Physiotherapy

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DECLARATION

I, Taryn Jane Spark, declare that this dissertation is my own work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

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Signature of Candidate

_____ day of ________________ 2016 in ________________________

DEDICATION

I would like to dedicate this work to my patients at Chris Hani Baragwanath Academic Hospital, who taught me to appreciate life's blessings and helped me grow into the physiotherapist I am today.

PRESENTATIONS ARISING FROM THIS STUDY

World Confederation for Physical Therapy Congress 2015, Singapore

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Dates: 1-4 May 2015

Title of Presentation: Functional Outcomes after Flexor Tendon Repair of the Hand: Preliminary Results of a Sowetan Population in South Africa (Poster).

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Title of Presentation: Impairments and Functional Outcomes after Flexor Tendon Repair at Chris Hani Baragwanath Academic Hospital (Platform). **(Winner of the Best Therapist Presentation prize).**

ABSTRACT

Background: Flexor tendon injuries (FTI) are common hand injuries for which optimal surgical and post-operative treatment has not yet been established. The variability in results is great, with good outcomes being achieved in specialised hands units in developed countries. Minimal research has been undertaken in developing countries, in particular South Africa, regarding flexor tendon repair (FTR) and the outcomes thereof.

Purpose: The purpose of this study was to describe the demographic details of patients who sustained FTI and underwent FTR, to establish the range of movement (ROM), grip strength and hand function at six months post FTR as well as to determine the factors that affect the impairments and functional outcomes at six months post FTR.

Method: The study was conducted at Chris Hani Baragwanath Academic Hospital (CHBAH), Soweto, South Africa between January 2013 and September 2015. One hundred and twenty six participants were recruited consecutively post FTR. Inclusion criteria: flexor tendon injury (in any zone, in any finger, with any associated injury), primary FTR performed at CHBAH and over the age of 14. Exclusion criteria: previous injury to the affected hand resulting in ROM or strength deficit, previous or current injury to the unaffected hand resulting in a ROM or strength deficit and tendon grafting or reconstruction (i.e. secondary repair) performed. At one, three and six months post FTR the ROM of the injured and contralateral finger(s) were measured. The Total Active Motion (TAM) classification system was applied to each affected digit and the average TAM determined for the participants' affected hand. At three and six months post FTR the participants' bilateral power and pinch grip strength were measured. The power and pinch grip strengths were calculated as a percentage of the unaffected hand. At three and six months post FTR participants performed the Jebsen Hand Function Test (JHFT) and a Quick Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire was administered in an interview format. All assessments were done by the first author. Data were analysed using Stata version 14.

Results: One hundred and twenty six participants (n=126) enrolled in the study. There was a drop out rate of 48%, leaving 65 participants that completed six months follow up, 41 males (63%) and 24 females (37%) aged 32 (SD±10, n=65). Out of 65 participants 2% (n=1) had an excellent outcome, 32% (n=21) had a good outcome, 32% (n=21) had a fair outcome and 34% (n=22) had a poor outcome with regards to TAM. At six months post FTR the average power grip was 60% (SD±25, n=65) of the unaffected hand while the average pinch grip was 52% (SD±42, n=65) of the unaffected hand. The average time taken for the JHFT at six months was 74 seconds (SD±33, n=65) for the non-dominant hand and 62 seconds (SD±54, n=65) for the dominant hand. The average score on the Quick DASH questionnaire was 19.34 (SD±16.89, n=65) at six months. Of the 41 participants who were employed prior to injury, 71% (n=29) had returned to work by six months post-surgery and scored an average of 15.89 (SD±23.74 n=24) on the Quick DASH work module. Sixty eight percent (n=44) of patients had post operative complications: the most common complication was tenodesis/adhesions (25%, n=16), followed by contracture (22%, n=14). There were only four patients who had ruptures (6%, n=4) in this sample. Eleven participants (17%) underwent further surgery. The factors found to significantly affect the impairments and functional outcome at six months post FTR include: age, zone of injury, associated injury, delay between injury and surgery, OT protocol used and language barrier.

Conclusion: Although there were some promising outcomes, during this period, participants did not consistently achieve the good or excellent functional outcomes that are achieved in developed countries. More research needs to be conducted regarding the outcome of FTR in South Africa.

Key Words: Flexor Tendon Repair; Outcomes; South Africa

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LIST OF ABBREVIATIONS

ADLs	Activities of daily living
ASSH	American Society for Surgery of the Hand
BBT	Box and Block Test
CHBAH	Chris Hani Baragwanath Academic Hospital
DASH	Disability of the arm, shoulder and hand
DIPJ	Distal interphalangeal joint
EAM	Early active motion
EPM	Early passive motion
FDP	Flexor digitorum profundus
FDS	Flexor digitorum superficialis
FDT	Functional Dexterity Test
FTI	Flexor tendon injury
FTR	Flexor tendon repair
JHFT	Jebsen Hand Function Test
JHTU	Johannesburg Hospital Trauma Unit
ICC	Intraclass correlation
ICF	International Classification of Functioning, Disability and Health
MCID	Minimal clinically important difference
MCPJ	Metacarpal phalangeal joint
MDC	Minimal detectable change
MDT	Multidisciplinary team
MHQ	Michigan Hand Questionnaire
NHPT	Nine-Hole Peg Test
OT	Occupational therapy/therapist
PIPJ	Proximal interphalangeal joint
PPT	Purdue Pegboard Test

PRWHE	Patient Rated Wrist and Hand Evaluation
ROM	Range of motion
RTW	Return to work
SHAP	South Hampton Assessment Procedure
SSI	Surgical site infection
TAM	Total active motion

CHAPTER 1

1. INTRODUCTION

1.1 Background

Flexor tendon injuries (FTI) are common hand injuries that pose a challenge to the multi-disciplinary team (Saini et al., 2010). Despite being the most researched topic in hand literature (Mass and Phillips, 2005), the optimal surgical and post-operative treatment of flexor tendon injuries remains unclear and results after flexor tendon repair (FTR) continue to be unpredictable (Kotwal and Ansari, 2012).

In studies of outcomes post FTR, the achievement of “good to excellent” results is highly variable. Hung et al. (2005) achieved 71% “good to excellent” results in zone II repairs and 77% in other zones, while Saini et al. (2010) achieved 82% “good to excellent results” in finger flexor tendon repairs and 87% in isolated flexor pollicis longus repairs. Chow et al. (1988) achieved an extraordinary outcome of 98% “good to excellent” results. In his review of reported clinical outcomes after FTR, Tang (2005) concluded that more than 75% of primary tendon repairs had good or excellent functional outcomes. However, most of the above-mentioned research was done at specialised hand surgery centres in developed countries.

There are several differences in post-surgical outcomes between developed and developing countries. In developing countries, outcomes may be influenced by: a lack of resources (both of the healthcare facilities and of the patients that utilise the services) (Dias, 2006; Schaub and Chung, 2006; Tang, 2006); a higher post-operative infection rate (Allegranzi and Pittet, 2007); language barriers (Schlemmer and Mash, 2006); lower education levels (Chung, Kotsis and Kim, 2007).

Other factors that are reported to affect functional outcome post FTR include age, smoking, mechanism of injury, zone and extent of injury, time lapsed from injury to surgery, surgical technique, post-operative rehabilitation and adherence to therapy (Kasashima, Kato and

Minami, 2002; Saini et al., 2010; Seiler, 2001; Silfverskiöld, May and Oden, 1993; Tang, 2005).

The International Classification of Functioning, Disability and Health (ICF) provides a framework for the description of all health conditions in terms of the following components: body functions and structure, activities and participation, as well as personal and environmental factors. Outcome post FTR is most frequently determined by measuring the impairments in body structure and functions, such as range of motion (ROM) and strength of the affected hand. Limitations in activities and participation restrictions are assumed, rather than measured (MacDermid, 2005), demonstrating neglect of the activity and participation domains of the ICF.

Thus, this study seeks to establish functional outcome at all levels of functioning post FTR of the hand. Although much research has been done in developed countries and many studies show good and excellent outcomes post FTR, minimal research has been done in developing countries.

1.2 Research Questions

1.2.1 What are the impairments and functional outcomes of patients post FTR at an academic hospital in Johannesburg, South Africa?

1.2.2 What are the factors which may influence impairments and functional outcome post FTR in this study population?

1.3 Aims of the study

- To determine the impairments and functional outcome of patients post FTR.
- To determine the factors that influence impairments and functional outcome post FTR.

1.4 Objectives of the study

1.4.1 To describe the profile of patients who underwent FTR in this study.

1.4.2 To establish the hand ROM of patients one, three and six months post FTR.

1.4.3 To establish the hand power and pinch grip strength of patients at three and six months post FTR.

1.4.4 To establish the hand function at activity and participation levels at three and six months post FTR.

1.4.5 To determine the factors that may affect hand ROM, power and pinch grip strength and functional outcome at six months post FTR.

1.5 Significance of the study

To the researcher's knowledge, minimal research regarding FTR has been undertaken in South Africa. If more is known about the functional outcomes after FTR, patients that ask "am I going to get better?" can be better informed about what to expect in their rehabilitation period. Knowing the outcomes post FTR can aid the multi-disciplinary team (MDT) that works in the "Hand Unit" in determining whether the management being provided to this patient population is effective or not. If outcomes are unsatisfactory, the MDT can scrutinise their interventions and change their protocols, where possible, in an attempt to improve the treatment being provided. Risk factors for poor outcome may be identified from this study which will allow interventions to be implemented in order to address those risk factors before complications occur. The results from this research may pave the way for further research, for example, determining outcomes post FTR after a certain intervention has been put into place.

1.6 General outline of thesis

The general outline of the thesis is as follows:

Chapter 2: Literature review

Chapter 3: Methodology

Chapter 4: Results

Chapter 5: Discussion

Chapter 6: Conclusion

CHAPTER 2

2. LITERATURE REVIEW

2.1 Introduction

Historically there has been an abundance of international literature published about flexor tendon injuries, their management and their outcomes in developed countries. There is, however, a scarcity of publications originating from developing countries, such as South Africa. The purpose of this literature review is to explore the impairments and functional outcome after FTR, and the factors that affect them, both globally and in South Africa. A brief background on historical and current surgical and rehabilitation concepts relating to flexor tendon repair (FTR) will also be provided.

2.2 Literature search strategy

The databases PubMed and PEDro were searched and a Google Scholar search was conducted. The reference lists of retrieved articles were also used to locate further articles relevant to each topic.

The search was limited to articles published in English and those that studied adult populations. There were no limits set with regards to date of publishing.

Search terms used:

- Flexor tendon injury and Flexor tendon repair
- Rehabilitation/Physiotherapy/Occupational Therapy/Exercise
- Epidemiology of hand injury/tendon injury
- Developed versus developing country surgical outcomes
- Level of education and its effect on rehabilitation
- Adherence/Compliance
- Language barrier
- Smoking and wound healing

- Tenolysis
- ICF
- FTR in South Africa

2.3 History of flexor tendon repair

Avicenna, a great Muslim philosopher is credited as the first surgeon to repair tendons, as early as the eleventh century (Manske, 2005). Avicenna's techniques were adopted by European surgeons in the fourteenth and sixteenth centuries. The first tendon healing experiment was performed by John Hunter in 1767 (Manske, 2005). In 1934, Bunnell coined the term "No Man's Land" to describe the region where the flexor tendons pass through the digital sheath, an area that was more prone to restrictive adhesions (Manske, 2005). In 1947 Boyes noted that primary repair in this region usually failed and, therefore, advocated the use of tendon grafting as the treatment of choice (Manske, 2005). From 1950 onwards several surgeons started to publish reports of successful primary repair in "No Man's Land". These included 62% excellent and good results achieved by Siler in 1950, 87% satisfactory results by Posch in 1956 and publications (Verdan, 1960; Lindsay and McDougall, 1960; Carter and Mersheimer, 1966) in the 1960s that also reported good results (cited in Manske, 2005). The turning point in flexor tendon surgery, which was the move from tendon grafting to primary repair, was a presentation, "Primary Repair of Flexor Tendons in No Man's Land" by Kleinert, Kutz et al. (1967) at the annual meeting of the American Society for Surgery of the Hand, held in San Francisco in 1967. This triggered a sudden surge in flexor tendon related research and clinicians and investigators of today are indebted to the twentieth century researchers who established that primary repair of the flexor tendons is the treatment of choice (Manske, 2005).

2.4 Anatomy of the flexor tendons and tendon healing

A tendon consists of fibroblasts, collagen, proteoglycans and elastin. These molecules are arranged in fibrils, which are arranged in parallel bundles called fascicles (Goodman and Choueka, 2005). These fascicles are bound together by endotenon and then the entire tendon is encased in a synovial membrane, the epitenon (Goodman and Choueka, 2005). Collagen is responsible for the tendon's ability to stretch and conduct tension, allowing it to perform its function of transmitting force from the muscle to the finger to produce motion (Goodman and Choueka, 2005).

The blood supply to the flexor tendons originates from the radial and ulnar digital arteries, which mostly supply the dorsal part of the tendon. The volar part of the tendon contains little or no direct blood supply (Griffin et al., 2012).

The flexor tendons of the hand arise from the forearm muscles. The flexor digitorum profundus (FDP) arises from the deeper layer of flexor muscles and the flexor digitorum superficialis (FDS) from the more superficial layer (Allan, 2005; Griffin et al., 2012). The tendons enter the hand through the carpal tunnel, along with the median nerve (Allan, 2005; Griffin et al., 2012). In the hand, a synovial sheath encloses the flexor tendons and the synovial fluid acts as both a source of nutrition for the tendons and a lubricant to minimise friction. The course of the flexor tendons is divided into five zones: I. the region distal to the synovial sheath and the FDS insertion, housing only the FDP; II. between the limits of the digital flexor sheath, from A1 pulley to FDS insertion; III. from the distal aspect of the transverse carpal ligament to the A1 pulley; IV. the carpal tunnel; V. the forearm proximal to the carpal tunnel. In zone II annular and cruciate pulleys prevent bowstringing of the tendons (Allan, 2005; Griffin et al., 2012). The anatomy of the flexor tendons at the wrist and the flexor tendon zones, as described above, are shown in figures 2.1 and 2.2.

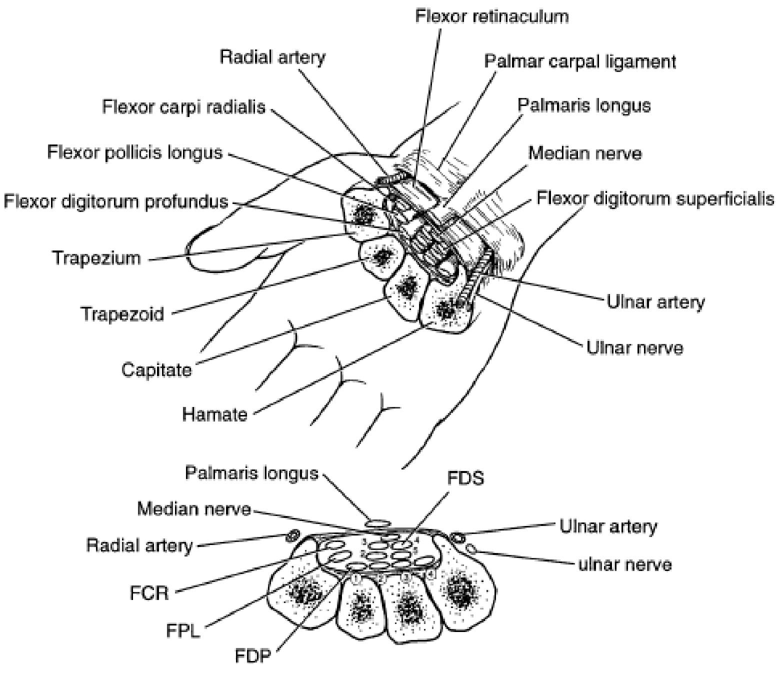

Figure 2.1: Flexor tendon anatomy at the wrist (Allan, 2005)

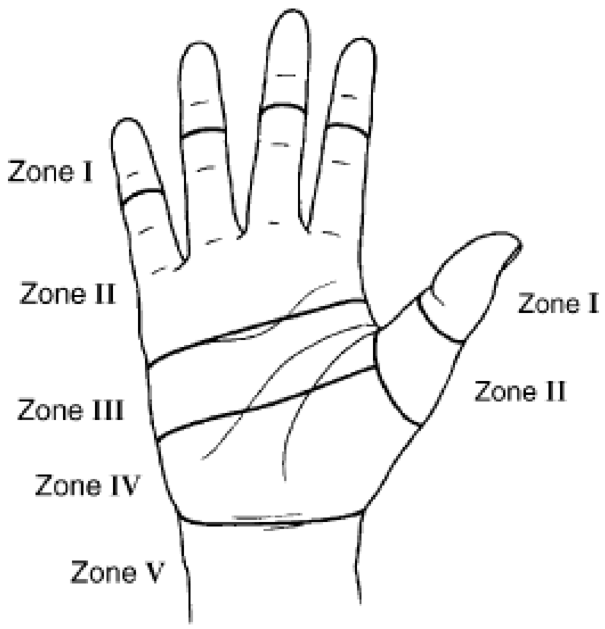

Figure 2.2: Flexor tendon zones (Allan, 2005)

Tendon healing occurs through intrinsic and extrinsic processes. In intrinsic healing, the tendon has inherent healing properties and the tendon fibroblasts contribute to repair by producing collagen. There is an exudative and formative phase, similar to that of wound healing. In extrinsic healing the synovial fluid supplies nutrients and there is proliferation of tenocytes, which migrate into the defect from the ends of the tendon sheath. Tendon healing takes place in three phases: inflammation (three to seven days post injury), proliferation/repair (five days to four weeks post injury) and remodelling (six weeks post injury). The weakest point during tendon healing is five to ten days post surgery. At this point fibroblasts are only beginning to synthesise collagen. This collagen is laid down in a random manner, and has not yet had sufficient time to mature in order to increase its tensile strength. (Griffin et al., 2012; Maffulli and Moller, 2005; Goodman and Choueka, 2005)

2.5 Epidemiology of flexor tendon injuries

Hand injuries are common, accounting for 21% and 28.6% of injuries assessed in Scottish and Danish emergency departments respectively (Clark, Scott and Anderson, 1985; Angermann and Lohmann, 1993). De Jong et al. (2014) found the rate of acute traumatic tendon (both flexor and extensor) injuries to be 33.2 injuries per 100,000 person-years over a ten year period in Minnesota, United States of America and Angermann and Lohmann (1993) found that tendon injuries were the second most common injury, making up 29% of the 50,272 hand injuries they assessed in Danish accident and emergency departments. The most frequently injured zone is zone II (Hung et al., 2005; De Jong et al., 2014), however the literature does not suggest any reasons as to why zone II is significantly more likely to be injured than other zones. With regards to likelihood of the dominant versus non-dominant hand being injured Hollis and Watson (1993), Beaton, Williams and Moseley (1994) and Kaisha and Khainga (2007) found no difference between the dominant and non-dominant hand's probability of getting injured.

Men are more likely than females to sustain hand injuries and the peak incidence of hand injury occurs between 20 and 29 years of age (Clark, Scott and Anderson, 1985; Angermann and Lohmann, 1993; O'Sullivan and Colville, 1993; De Jong et al., 2014). Young people and men, in particular, are more likely to be injured due to the increased level of risk-taking behaviours around this age (Kent, 2010; Sorenson, 2011). In addition, men are more likely to be exposed to occupations or activities where they may sustain injury (National Health and Medical Research Council, 1996; Sorenson, 2011) and men consume more alcohol (which is commonly related to injury) than women (Wilsnack et al., 2000; Sorenson, 2011). These statistics are in keeping with the global trend of young males experiencing high rates of injuries when compared with other age and gender groups (National Health and Medical Research Council, 1996; Kent, 2010; Sorenson, 2011).

There is a lack of reliable health statistics regarding hand injury in South Africa, making it difficult to compare epidemiology with that of other countries. One can assume, however, that the incidence of hand injury in South Africa, where there are high levels of trauma and interpersonal violence (Norman et al., 2007), would be greater than that of the above-mentioned countries. Asbury (2011) conducted an epidemiological study to examine the prevalence of injuries relating to interpersonal violence at Johannesburg Hospital Trauma Unit (JHTU) and found that in only forty days the number of cases seen at the JHTU was approximately six times the cases of a unit in the United Kingdom and twenty times more than a unit in Ireland, where similar studies were conducted. Pietrobon (1996) found that 57% of hand cases seen by Occupational Therapy (OT) at Johannesburg Hospital were due to assaults. Patterns of injury vary according to a country's socio-economic state and level of development (Kaisha and Khainga, 2008) meaning the proportions of accidental, violence-related and work-related injuries will differ from study to study and country to country (Beaton, Williams and Moseley, 1994; Kaisha and Khainga, 2008; De Jong et al., 2014).

2.6 Differences in surgical outcomes between developed and developing countries

Major parts of the world's population suffer from poverty, overcrowding, breakdown of medical infrastructure and poor access to healthcare (Raza et al., 2004). This leads to big differences in post-surgical outcomes between developed and developing countries, which can be influenced by: a lack of resources, lower levels of education and a higher post-operative infection rate in developing countries (Dias, 2006; Schaub and Chung, 2006; Tang, 2006; Allegranzi and Pittet, 2007; Chung, Kotsis and Kim, 2007). These factors will be discussed below.

2.6.1 Lack of resources

In developing countries, both the patients and the hospitals that service them suffer from a lack of resources. The infrastructure to care for hand injuries is still in the early phases of development and most countries cannot afford to set up the rehabilitation systems required to provide optimal care for patients post FTR (Dias, 2006). This results in a lack of adequate post-operative care. It has been found that hospitals in the developing world are grossly understaffed for hand injuries, where the healthcare manpower is needed most (Dias, 2006; Schaub and Chung, 2006; Tang, 2006).

2.6.2 Level of education

A Poverty Trends report released by Statistics South Africa in 2014 showed that in 2006 approximately half of adult South Africans were living in poverty and that the relationship between poverty and education is strong, with a significant increase in levels of poverty with lower levels of education (Stats SA, 2014). The link between education and poverty works both ways – people who are poor are unable to afford the cost of schooling so do not receive quality education – without this education they are unable to find jobs and therefore less likely to earn an income, continuing the cycle of poverty (Van Der Berg, 2008). Other factors that can be considered when looking at the relationship between education and poverty include: children who live in poverty may suffer from malnutrition which in turn physiologically affects their ability to learn (Van Der Berg, 2008); the home environment of those living in poverty may not be conducive to learning (e.g., poor lighting) (Van Der Berg, 2008); poor schools may lack educational resources (Van Der Berg, 2008).

It is well documented that there is a significant association between level of education and health outcomes, with those individuals with higher levels of education experiencing better health outcomes (Cutler and Lleras-Muney, 2007; Eide and Showalter, 2011). The reasons for this are complicated and despite being highly researched are not well understood, but may include: patients who are more educated may use health information provided to them in a better way than those who are less educated (Meara, 2001); the more educated are more likely to embrace advances in medical technology (Lleras-Muney and Lichtenberg, 2002); higher levels of education give access to better paying jobs enabling the more highly educated to afford better medical care (Lleras-Muney, 2005); the type of jobs held by lower and higher educated people also differ, with more highly educated people having better access to safer work environments i.e. the more highly educated will encounter fewer work-related injuries and diseases than their less educated counterparts (Cutler and Lleras-Muney, 2007); lack of education is associated with stress and depression, which in turn have a negative effect on health (Adler et al., 1994).

From the above it can be concluded that in South Africa, where there are high levels of poverty and lower levels of education, health outcomes are likely to be worse and recovery post FTR more challenging. The relationship between poverty, level of education and health is a complex, multifactorial one and it is difficult to form definite conclusions about their effects on each other. MacDermid et al. (2002) and Chung, Kotsis and Kim (2007) provide some suggestions as to why patients with lower levels of education may experience worse outcomes post injury when compared with patients with higher levels of education. They proposed that patients with lower levels of education are more likely to be employed in lower paying, manual labour jobs and therefore may not be able to rest their injured limb to adequately promote healing (MacDermid et al., 2002) or may not be able to attend therapy sessions due to lack of funds or access to transport or inability to take time off work (Chung, Kotsis and Kim, 2007). Both authors reported those with lower levels of education may be less compliant with home exercise programmes, but did not offer reasons as to why this may be so (MacDermid et al., 2002; Chung, Kotsis and Kim, 2007). Jin et al. (2008) performed a review of literature relating to compliance and found that there were contradictory findings – several studies indicated that more highly educated patients had higher rates of compliance, while some studies found no association between level of education and compliance. From this they concluded that the level of education may not be a useful tool in determining whether a patient was going to adhere to medical treatment or not.

2.6.3 Post-operative infection rate

Nosocomial infections, and in particular surgical site infections (SSI), add to the high burden of infection in sub-Saharan Africa (Rothe, Schlaich and Thompson, 2013). Brown et al. (2007) stated that SSI may be disproportionately high in countries with limited resources. Allegranzi and Pittet (2007) reported that the post-operative infection rate was much higher in developing countries than in developed countries with rates of 12-39% and 2-5% respectively. The conditions in theatre may contribute to higher infection rates – in developing countries, theatres are crowded by surgical staff, trainees and students, and the theatres may be overused and not adequately ventilated (Raza et al., 2004). Infection control measures can be costly to implement and lack of funding may lead to initiatives being discontinued due to a lack of resources (Raza et al., 2004).

2.7 Factors that affect outcome post flexor tendon repair

2.7.1 Age

The quality of the tendon is influenced by age: the elasticity of the tendon is highest at maturity and declines with advancing age – there is decreased tendon collagen, proteoglycan and water content and the tendon becomes smaller and weaker (Goodman and Choueka, 2005). These changes can be seen in patients as early as in their thirties, but the deterioration becomes more marked after the age of forty (Tuite, Renstrom and O'Brien, 1997). With advancing age the quality of tendon decreases which ultimately makes tendon repairs more prone to poor outcomes. This was confirmed by Stone, Spencer and Almquist (1989) and Freuh et al. (2014) who experienced greater problems with adhesions and decreased ROM following FTR in older patients.

2.7.2 Language barriers

Language barriers are often encountered in hospitals in South Africa, where the healthcare worker may only speak one or two of the eleven official languages of South Africa and there is a lack of availability of trained translators. These language barriers lead to a reduction in quality health care provision (Schlemmer and Mash, 2006).

The literature reviewed showed that non-English speakers were less satisfied with their health care (David and Rhee, 1998; Carasquillo et al., 1999), reported fewer visits to the physician (Derose and Baker, 2000) and were more likely to default medication (Manson, 1988; Orrell at el., 2003) than those that spoke English or those who could communicate in the same language as the medical staff. The reasons suggested for the above included the fact that patients who were unable to understand the medical staff would have difficulty understanding the reasoning behind their prescribed treatment and would be less likely to adhere as a result (Manson, 1988); medical staff unable to communicate with the patient may choose to omit explanations required for patient understanding and adherence (David and Rhee, 1998); patient frustration with being unable to communicate with the medical staff may lead to dissatisfaction with health care (Derose and Baker, 2000).

Most of the above-mentioned studies were conducted in the United States of America with Spanish-speaking patients; only one study (Orrell et al., 2004) was conducted in South Africa. The extent of the problem may be more far-reaching in South Africa due to the larger number of languages spoken by those that attend healthcare institutions.

Language barriers may prevent effective communication between the healthcare provider and the patient. This breakdown in communication may lead to misunderstanding of the post-FTR precautions (Torrie et al., 2010), which may result in the patient inadvertently engaging in non-adherent behaviour, such as removing their splint or using their hand when they should be resting it.

2.7.3 Smoking history

The effect of smoking on circulation in the hand has been well established. The toxic ingredients in cigarette smoke, nicotine, carbon monoxide and hydrogen cyanide, cause cutaneous vasoconstriction, decreased blood flow to the digits and delayed wound healing (Silverstein, 1992; Yaffe, Cushin and Strauch, 1984). Van Adrichem et al., (1992) used a laser Doppler flowmeter to determine the acute effect of smoking of patients who had undergone digital replantation. They established that there was a mean decrease in blood flow of 8% and 19% after the first and second cigarettes respectively, with no recovery ten minutes after the last cigarette, and concluded that smoking has a negative effect on the microcirculation of the digits. These negative effects were confirmed by Trumble et al. (2010), who found that patients who smoked had less mean combined flexion ROM, as well as larger mean flexion contractures, than the patients in their study that did not smoke. Trumble et al. (2010) also concluded that smoking had a significant negative effect on the rehabilitation post FTR.

Reddy et al. (2015) investigated the prevalence of smoking in South Africa and found an estimated prevalence of 17.6%. In addition, they found that males and those who live in urban areas with lower income and education levels (similar to the population in the current study) were more likely to smoke.

2.7.4 Mechanism of injury

When looking at the mechanism of injury, this can be broadly classified into whether it was a sharp or a crushing/tearing injury. Tearing types of injuries, such as those caused by grinders or saws, lead to worse outcomes than those injuries caused by sharp objects, for example knives or glass (Starnes, Saunders and Means, 2012). This is owing to the fact that adhesions form in proportion to the amount of tissue crushing that has occurred during the injury (Strickland, 1995a). Additionally, tearing type injuries may increase severity of injury when compared to an injury from a sharp object (Starnes, Saunders and Means, 2012). Therefore, digits that have sustained a crush injury are more likely to develop stiffness (Dy et al., 2012).

2.7.5 Zone of injury

The zone of injury influences the outcome after FTR in that different zones are more susceptible to adhesion formation than others (Torrie et al., 2010). Adhesions are more likely to form in zone II, than in other zones, because two tendons need to glide through limited space in the fibro-osseous tunnel (Braga Silva and Kuyven, 2005; Dy and Daluiski, 2014). Injuries in zone II are notorious for poorer outcomes when compared to injury in other zones (Starnes, Saunders and Means, 2012). As a result, most of the research focuses on treatment in this difficult area (Howell and Peck, 2013), rather than zones III, IV and V which are easier to treat (Tang, 2006). Hung et al. (2005) found that patients with zone II injuries took longer to achieve the same result. This could be due to the greater amount of adhesion and contracture formation that has to be overcome by the therapist in order to achieve adequate ROM.

2.7.6 Extent of injury: associated injury and number of digits injured

The extent of injury affects the rehabilitation and outcomes after FTR. The extent of injury can be broken down into a) injury of structures other than tendon, i.e. associated injury; b) the number of digits that were injured.

The more structures involved in the injury the more difficult it is to rehabilitate the patient and the poorer the outcome (Dy et al., 2012; Starnes, Saunders and Means, 2012; Trumble et al., 2010). Rehabilitation is more challenging as one must treat multiple injuries instead of focussing on an isolated area or aspect of the hand. This is supported by Strickland (1995a), who reported that the final outcome of patients who sustained combined tissue injuries were not as good as those patients who sustained isolated tendon injuries. Other studies confirm that in the presence of a concomitant bone or neurovascular injury, the rehabilitation process is slower, stiffness is more common and results are poorer (Dy et al., 2012; Starnes, Saunders and Means, 2012; Trumble et al., 2010). On the other hand, many FTR studies (Chow et al., 1988; Tottenham, Wilton-Bennett and Jeffery, 1995; Caulfield et al., 2008; Moriya et al., 2015) exclude patients with associated injuries, which means that the current study adds value in determining their influence on the outcome post FTR.

In a study of zone V FTI, a regression analysis showed that the extent of the tendons and nerves injured significantly predicted ROM, grip and pinch strength and functional outcome at both initial and final assessments – the greater the number of injured tendons and/or the presence of associated median and/or ulnar nerve injury, lead to poorer ROM and strength outcomes, contributing to limitation in hand function (Al-Shanawany et al., 2003). Injury to nerves not only affects ROM and strength, but also sensibility, which profoundly affects refined hand function (Lundborg and Rosen, 2007).

In addition to associated injuries, the number of digits involved also affects the outcome. Trumble et al. (2010) found that patients who had multiple digit injuries achieved overall less ROM, had larger contractures and lower satisfaction with their outcome when compared to patients who had sustained a single digit injury. The contractures are likely due to the difficulty with rehabilitation of more than one affected structure and the decreased satisfaction is likely due to the patient having a poorer functional outcome.

2.7.7 Time lapsed between injury and surgery

The timing of surgical repair after FTI is a topic of great debate with some authors claiming that tendon repair should be done as soon as possible (Lin, Cardenas and Soslowsky, 2004), others saying that they do not have to be treated as a surgical emergency but should be done within a few days of injury (Dy and Daluiski, 2014), and a more current belief that a delay of four to seven days post injury is advisable (Torrie et al., 2010). All of the above fall within primary repair time allowance, and time lapsed between injury and surgery comes down to surgeon preference and unit protocol. However, significant delay – more than three weeks between injury and surgery – may result in proximal tendon retraction (Elliot, 2005), ruling out the possibility of doing a primary repair (Griffin et al., 2012), which is preferred as it is a less complicated procedure and is more likely to have a successful outcome (Elliot, 2005). In contrast, McFarlane, Lamon and Jarvis (1968) state that direct repair may be possible up to several months post injury, depending on the amount of tendon retraction that has occurred.

In specialised hand centres in developed countries (Caulfield et al., 2008; Farzad et al., 2014; Moriya et al., 2015), patients are likely to undergo surgery sooner post injury than those in developing countries (Braga-Silva and Kuyven, 2005), where there may be difficulty with access to healthcare.

2.7.8 Surgical technique

There has been extensive research into the surgical technique that will optimise outcomes post FTR. The goal is to perform a repair that is strong enough to withstand the demands of an early active motion protocol and is not excessively bulky, which leads to increased work of flexion (Lee, 2012). The strength of the repair is influenced by the surgical technique, the number of strands crossing the repair site, epitendinous sutures and the calibre of the core suture (Taras et al., 2001). In addition, the experience and expertise of the hand surgeon plays an important role in the quality of the repair and poor technique and lack of knowledge can put the patient at risk for worse outcomes (Tang, 2006). However, most studies regarding FTR do not measure or mention the experience and expertise of the surgeon as a factor that affects outcome.

Conventionally flexor tendon repairs were done with two strands, however, today the most widely accepted technique is the four-strand core suture, which is the most favourable compromise between strength and bulk (Torrie et al., 2010). The cruciate repair method “appears to come closest to the ideal suture technique” according to Strickland (2000) (cited in Lee, 2012, p108). Repair strength is directly proportional to the number of suture strands crossing the repair site (Lin, Cardenas and Soslowsky, 2004) and, therefore, the rupture rate is lower with the use of multi-strand repairs (Starr et al., 2013; Tang. 2006). However, the surgeon has to exercise caution as with an increased number of strands there is an increase in the bulkiness of the repair and work of flexion, which may result in decreased ROM (Evans, 2012). The move towards more aggressive, earlier active mobilisation has meant a need for stronger repairs and most present-day studies (Trumble et al., 2010; Freuh et al., 2014; Moriya et al., 2015) would not accept less than a four-strand repair into their sample.

The core suture material and size can affect the strength of the repair (Lutsky, Giang and Matzon, 2015) and Taras et al. (2001) found that increasing suture calibre increased the strength of the repair without making the repair more difficult to perform. If the actual strength of the suture material provides resilience to the repair, the surgeon may not need to perform as strong a repair, which in turn makes the surgical technique easier.

An additional point of contention when it comes to the surgical technique is whether to repair both the FDS and FDP or to repair the FDP alone (with or without FDS excision). Strickland (1995a) reported that it had been shown that it was better to repair both tendons, however, more recent research has shown that repairing both tendons increases the work of flexion (Starnes, Saunders and Means, 2012). Khanna et al. (2009) suggested that it was better to repair FDP only and excise the FDS when both tendons were injured in zone II, as suture of both tendons leads to a higher re-operation rate due to rupture or adhesions.

2.7.9 Post-operative rehabilitation protocol

Post-operative rehabilitation is vital to the outcomes after FTR. Without adequate rehabilitation it is near-impossible to achieve optimal functional outcomes. The hand therapist is tasked with implementing a programme that aims to restore ROM and strength comparable to the uninjured side, while avoiding the complications of rupture and adhesion and contracture formation (Lin, Cardenas and Soslowsky, 2004; Torrie et al., 2010).

Exact protocols vary greatly from country to country and from centre to centre (Tang, 2006). Options for post-operative treatment include: immobilisation, early passive motion (EPM) and early active motion (EAM) (Starr et al., 2013) – these will be discussed individually below.

The immobilisation protocol involves three to four weeks of immobilisation in a splint that is worn for 24 hours a day and is only removed by a therapist for supervised passive motion exercises. This protocol is currently only used for children, non-compliant patients and patients with cognitive impairment (Baskies, Tuckman and Paksima, 2008).

EPM protocols include the Duran and Hauser protocol and the Kleinert protocol. In both protocols a dorsal blocking splint is applied to the patient's hand and passive motion exercises are performed – in the Duran protocol the patient passively flexes their fingers using their unaffected hand, whereas in the Kleinert protocol passive flexion is achieved through use of rubber bands attached to the fingers. Passive motion protocols are still used in some hand units owing to the fact that they provide a balance between adhesion formation and rupture rate when compared to immobilisation and EAM protocols respectively (Baskies, Tuckman and Paksima, 2008).

EAM protocols require active flexion of the affected digit(s) within the confines of a splint. EAM is becoming more widely used, but requires complete cooperation and understanding of a compliant patient in order to be beneficial (Baskies, Tuckman and Paksima, 2008).

Traditional practice was conservative, with post-operative immobilisation for three to four weeks, but this has almost universally been abandoned owing to the high levels of adhesions that formed (Braga-Silva and Kuyven, 2005; Torrie et al., 2010). Over the years, results after FTR have improved and this has been credited to the move toward early mobilisation after surgery (Braga-Silva and Kuyven, 2005). Early post-operative motion stimulates tendon healing, improves the strength of the repair site, decreases adhesion and contracture formation and enhances gliding function (Braga-Silva and Kuyven, 2005; Hung et al., 2005; Lin, Cardenas and Soslowsky, 2004) and is now seen as the gold standard of care in FTR rehabilitation (Dy and Daluiski, 2014; Howell and Peck, 2013; Torrie et al., 2010). There is still insufficient evidence, however, to identify the best early mobilisation strategy (Khanna et al., 2009; Torrie et al., 2010). Studies that compare the different protocols are discussed below.

There is much research that compares active and passive motion protocols. In passive protocols there is a higher risk of decreased ROM, while in EAM protocols there is higher risk of repair rupture as the digits are free to move (as opposed to being restricted by an orthosis with an elastic band) which may lead to the patient using the hand inappropriately (Starr et al., 2013). Bal et al. (2010) and Freuh et al. (2014) investigated outcomes after use of passive motion protocols and found that only 52% (Bal et al., 2010) and 53% (Freuh et al., 2014) of digits achieved good or excellent Total Active Motion (TAM). Most studies favour the EAM protocol and report that patients who followed the EAM protocol achieved better outcomes – significantly greater ROM, fewer flexion contractures and higher satisfaction – than those who followed a passive protocol (Dy et al., 2012; Lutsky, Giang and Matzon, 2015; Trumble et al., 2010). A possible explanation for improved outcomes with the EAM protocol is that there is superior tendon gliding in EAM protocols (Trumble et al., 2010), which results in decreased tendon adhesion and improved excursion.

Gratton (1993) was part of a team that developed an EAM treatment regimen that came to be known as "the Belfast regimen" and was implemented in Ulster Hospital in Belfast, Ireland, and Northern General Hospital in Sheffield, England. Three studies were done in these two hospitals from 1985 to 1990 with varying results. The Belfast study in 1989 had 46% excellent results, 31% good, 14% fair and 9% poor with a 9.4% rupture rate. The Sheffield study in 1989 produced 71% excellent results, 6.5% good, 3.5% fair and 19% poor with a 6% rupture rate. Finally, the Sheffield study in 1990 had 49% excellent results, 36% good, 11% fair and 4% good with a 7% rupture rate. This is evidence that even if an identical protocol is carried out, it can have different results in different centres, at different times. Dy et al. (2012) report on other studies that used EAM and achieved 57-92% good to excellent results with rupture rates of 5-46%. Braga-Silva and Kuyven (2005) implemented an EAM protocol after FTR in zone II and results were excellent (72.2%), good (26.0%) and fair (1.9%) according to Strickland's standards. Braga-Silva and Kuyven's (2005) study was conducted in Brazil where patient access to post-operative rehabilitation is difficult, but they still managed to achieve good functional results, with a diminished number of cases requiring tenolysis. Although Braga-Silva and Kuyven (2005) had a rupture rate of 7.4%, the patients still achieved at least good outcomes once the ruptured tendon was repaired. Variations in results between centres and times can be attributed to differences in surgeon and therapist skill and experience, and patient socio-economic status.

In South Africa, therapists use all of the above-mentioned protocols (including immobilisation) with therapists favouring passive motion protocols (Duran, modified Duran, Kleinert, modified Kleinert) over EAM and immobilisation protocols (Venter, 2012; Mncube and Puckree, 2014). These South African studies were both conducted in government settings where access to regular, supervised therapy and adherence to home exercise programmes is often limited. This may be why the therapists in these two studies preferred to implement passive motion protocols, which are favoured when patients struggle to attend therapy sessions regularly (Elliot, 2005, cited in Venter, 2012). Practice at the research site, Chris Hani Baragwanath Academic Hospital (CHBAH) Hands Unit, is similar to that in Venter (2012) and Mncube and Puckree's (2014) studies, however the immobilisation protocol is not used. There is no available research regarding protocol use by therapists working in private practice in South Africa.

2.7.10 Patient adherence to therapy

Compliance or adherence has been described as the “most unpredictable, least controllable variable in a medical intervention” (Sanford, Barlow and Lewis, 2008, p44). Patient compliance with an exercise programme is a critical component of the rehabilitation process and a vital part of final recovery (Dobbe, van Trommel and Ritt, 2002; Kirwan, Tooth and Harkin, 2002), especially post FTR where non-compliance with protective precautions has been associated with poor function and tendon rupture (Kaskutas and Powell, 2013). Tendon ruptures in the early stages of rehabilitation were associated with inappropriate use of the injured hand in functional activities (Kaskutas and Powell, 2013; Strickland, 1995b). In general, non-compliance has been shown to contribute to ongoing disability with a decreased ability to work and associated loss of income (Kirwan, Tooth and Harkin, 2002; Sanford, Barlow and Lewis, 2008).

Patient adherence is a complicated and much-researched topic. More than 200 factors have been found to be related to compliance (Kirwan, Tooth and Harkin, 2002). Sanford, Barlow and Lewis (2008) reported that patient level of education, the patient-therapist relationship (i.e., seeing different therapists at different visits, long waiting times at appointments and long distances to travel) and the demands of the treatment programme were a few factors that influenced the likelihood of patient compliance with rehabilitation.

In Sanford, Barlow and Lewis’ (2008) study of adherence to 24 hour splint wear, it was found that 67.1% of patients removed their splints in the first four weeks of treatment. They found that there was no significant correlation between hand dominance, type of injury (i.e., flexor or extensor) or age, and the likelihood of a patient removing their splint. In their study (Sanford, Barlow and Lewis, 2008), three patients had ruptured repairs, two of whom removed their splint themselves. The rehabilitation after FTR is very demanding, and requires patients to function with one-hand for three to four weeks. Kaskutas and Powell (2013) investigated the impact of FTR rehabilitation on patients’ activities of daily living (ADLs) and discovered that 59% of patients were unable to adhere to the prescribed splint wear and FTR precautions because they had no choice but to perform tasks for which they were responsible at home. Their suggestion was that hand therapists should incorporate more one-handed training and ADLs assistance during treatment sessions, in order to help the patient comply with the necessary precautions.

Peck et al. (1996) revealed that those patients who attended therapy according to their unit protocol were 11.8 times more likely to achieve a good or excellent result in single injury and 13.9 times more likely to achieve a good or excellent result in multiple digit injury. This is logical, as patients who attend regular therapy sessions will receive more therapist input and progression of exercise, and any complications that may arise can be dealt with more promptly than if the patient attends therapy sporadically. Appointment attendance was measured by Asvat (2011) at the research site, CHBAH, in the out-patient physiotherapy department and determined that there was a non-attendance rate of 33%, over a two month period in 2009.

2.8 Complications post flexor tendon repair

Despite extensive research into their prevention, complications continue to occur after FTR, with rates of rupture, adhesion formation and re-operation sitting steadily at 4%, 4% and 6% respectively. These rates, estimated by Dy et al. (2012), are in line with previous research (Tang, 2005; Chesney et al., 2011). The different complications that can occur post FTR are discussed below.

Tendon adhesion is the most frequent complication (Braga-Silva and Kuyven, 2005). The adhesive response is more evident in patients treated with post-operative immobilisation (Khanna et al., 2009), while early post-operative motion has been found to prevent tendon adhesions (Dy et al., 2012).

The second most common complication encountered in the rehabilitation post FTR is that of joint contracture. It has been reported that even with adherence to post-operative exercise protocols, the rate of interphalangeal joint contracture is 17% (Dy et al., 2012).

Tendon rupture can be caused by overload of the tendons, bulky tendons, triggering in the pulleys and misuse of the hand (Tang, 2006). Harris et al. (1999, p277) concluded that the most common cause of rupture was due to “acts of stupidity” by the patient. The incidence of rupture is consistently quoted at 4-6%, regardless of the post-operative mobilisation protocol followed (Torrie et al., 2010), and Chesney et al. (2011) found no statistical difference in rupture rate between the protocols used. These studies did not account for patients treated with immobilisation. One would expect less ruptures with an immobilisation protocol, but the risk of poor outcomes associated with the use of this protocol (Braga-Silva and Kuyven, 2005; Torrie et al., 2010) outweigh the benefits of a lower rupture rate.

Even under the care of the most experienced multidisciplinary team these complications may occur; the aim is to minimise complications through meticulous surgical technique and comprehensive rehabilitation. It is hoped that further research and future medical developments will greatly decrease the incidence of complications post FTR (Lilly and Messer, 2006).

2.9 Reoperation after flexor tendon repair

Two commonly performed operations after FTR include tenolysis and re-repair of a ruptured tendon. Tenolysis is the surgical release of tendon adhesions (Breton et al., 2005) which is required when tendon adhesions occur after surgery (Tang, 2006) and the active ROM movements do not improve over several months, despite strict adherence to a rehabilitation protocol (Dy et al., 2012). May and Silfverskiöld (1993) suggest that it may be worth be waiting six to twelve months post FTR before performing tenolysis, as ROM only reaches a steady-state at one year post FTR. If ruptures occur soon after primary repair, the surgeon may be able to directly re-suture at the rupture site, however, if the rupture occurs at a later post-operative stage, a tendon graft may need to utilised (Tang, 2006).

2.10 International Classification of Functioning, Disability and Health in flexor tendon repair

The International Classification of Functioning, Disability and Health (ICF) provides a framework for the description of all health conditions in terms of the components body functions and structure, activities and participation, as well as personal and environmental factors. Individuals who have sustained an FTI and undergone FTR experience limitations in all domains of the ICF (Kaskutas and Powell, 2013).

When investigating functional outcomes, most FTR research is focussed on outcomes related to impairments in body function and structure, with the activity limitations and participation restrictions being assumed, rather than measured (MacDermid, 2005; Fitinghoff et al., 2011; Winthrop Rose et al., 2011; Kaskutas and Powell, 2013). Winthrop Rose et al. (2011) found that publications in The Journal of Hand Therapy (between 1987 and 2010) addressed body structures and functions in 99% of the articles reviewed, while activities were addressed in only 41% and participation in only 37% of the articles reviewed. This neglect of the activity and participation dimensions of the ICF is in opposition to the global change in perspective of health conditions (Oltman et al., 2008). It is important to focus not only on the diagnosis and impairments, but also on the injury's effect on activity and participation, as even a minor injury to the hand may have far reaching effects on the patient within his/her specific context (Oltman et al., 2008). The assessment and treatment of patients with FTR need to be holistic in order to determine the full extent of the injury on the patient.

Functional outcome can be defined as a measure of health status that goes beyond traditional physiological assessments (American Academy of Physical Medicine and Rehabilitation, 2013), and is, therefore, more adequately described by the activity and participation components of the ICF, rather than the impairment component. Activity is defined as "the execution of a task or action by an individual," and participation is defined as "the person's involvement in a life situation (van de Ven-Stevens et al., 2009, p151)." Activities include writing, eating, washing, picking up objects and manipulating objects, and injury to the hand may affect a person's ability to carry out such activities. Participation restrictions that may be caused by a hand injury include an inability to go to work or school or participate in recreational activities or hobbies. Return to work (RTW) post injury is an important measure of participation and is a highly-researched area in hand injured patients (Bruyns et al., 2003; Gustafsson and Ahlstrom, 2004; Wong, 2008; Opsteegh et al., 2009).

It is important to measure the effect a hand injury has on activity and participation components as they are an important part of gauging functional outcome after hand surgery (Oltman et al., 2008). Oltman et al. (2008) and Fitinghoff et al. (2011) suggest that it will benefit hand therapy if future FTR research includes outcome measures that address limitations in activity and participation restrictions more comprehensively. Additionally Oltman et al. (2008) say there is a need for an ICF Core Set to be developed for FTR and rehabilitation.

2.11 Outcome Measures used post flexor tendon repair

To assess the body function and structure domain (of the ICF) post FTR ROM and grip and pinch strength are assessed. Other possible impairments post FTR include pain and alterations in sensation, however these are rarely included in FTR literature. ROM is considered the primary impairment post FTR (MacDermid, 2005) and is the most investigated outcome in FTR literature (Yuste et al., 2015). Libberecht et al. (2006) state that measurement of strength (especially pinch grip strength) should be included in assessment of results post FTR. Gault (1987), Deniz et al. (2000), Kitis, Buker and Kara (2009) and Bal et al. (2010) all included assessment of power and pinch grip strength in their studies. Although ROM and strength are usually affected post FTR, the extent to which they affect function is unknown. Hume et al. (1990) found that only a small percentage of the active ROM of the hand joints is required for functional activity. Tyler, Adams and Ellis (2005) found a wide range of correlations between grip strength and functional outcome.

O'Neill (1995, p477) describes hand function as "the ability of the individual to use the hand in everyday activities" and states that in order to assess hand function, one must measure the patient's performance in tasks that simulate activities of daily living (ADLs). Currently there is no gold standard for assessment of hand function, and there are numerous tools that are used to evaluate changes after hand surgery (van de Ven-Stevens et al., 2009). Schoneveld, Wittink and Takken (2009) state that both performance tests and self-reported measures in the form of questionnaires should be used to assess activity and participation after hand injury, as they assess different aspects of hand function. The Jebsen Hand Function Test (JHFT), a performance test, measures activity limitations, by simulating ADLs, and the Disabilities of the Arm, Shoulder and Hand (DASH) Questionnaire measures both activity limitations and participation restrictions. Van de Ven-Stevens et al. (2009) suggest including JHFT and DASH as part of a preliminary core-set of instruments to use in measurement of activity limitations in those with hand disorders.

Other outcome measures that assess self-reported function, like the DASH, are the Michigan Hand Questionnaire (MHQ) and the Patient Rated Wrist and Hand Evaluation (PRWHE). Both the MHQ and PRWHE are valid and reliable instruments that are widely used, however, the DASH questionnaire is the most extensively studied (Schoneveld, Wittink and Takken, 2009), and norms are available (Hunsaker et al., 2002; Aasheim and Finsen, 2014). There are more studies which use the DASH (Baer et al., 2003; Klein, 2003; Libberecht et al., 2006), rather than the Quick DASH (Bal et al., 2010), however Gummeson, Ward and Atroshi (2006) found that the DASH can be substituted with the Quick DASH and still maintain a high level of reliability.

In addition to reported measures, there are other performance tests (like the JHFT), such as the Purdue Pegboard Test (PPT), Nine-Hole Peg Test (NHPT), the Box and Block Test (BBT), the South Hampton Assessment Procedure (SHAP) and the Functional Dexterity Test (FDT), that are used to assess activities in patients with hand injury (Schoneveld, Wittink and Takken, 2009; van de Ven-Stevens et al., 2009). All of these tests have been studied and found to have their own advantages and disadvantages (Schoneveld, Wittink and Takken, 2009; van de Ven-Stevens et al., 2009). The choice of which test to use usually comes down to availability in clinical practice (de Klerk, Buchanan and Pretorius, 2015).

2.12 Flexor tendon repair in South Africa

Research has been conducted in South Africa on the subject of FTR, however, it has not focused on functional outcomes. Instead the literature reviewed has focussed on treatment (Kaplan, 1964), FTI in children (Grobbelaar and Hudson, 1994), epidemiology (Asbury, 2011), occupational therapists' use of protocols (Venter, 2012), severity of panga/machete injuries (Howard et al., 2014) and therapists' perspectives on rehabilitation (Mncube and Puckree, 2014). These publications may have alluded to outcomes post FTR however they were not the main focus of the results presented.

2.13 Summary of literature review

Flexor tendon repair has a long history and there have been major developments over the years. Tendon injuries are common hand injuries, with young males being the most likely to sustain them. The epidemiology of tendon injury in South Africa has not been established. The worse post-surgical outcomes in developing countries, when compared to developed countries, may be influenced by a lack of resources, decreased level of education and increased post-operative infection rate. The factors that affect the outcome post FTR include: age, language barrier, smoking history, mechanism of injury, zone of injury, extent of injury (associated injury and number of digits injured), time lapsed between injury and surgery, surgical technique, post-operative rehabilitation protocol and patient adherence to therapy. Complications post FTR include adhesion, contracture and rupture and despite developments in the care of FTR, these complications continue to occur at steady rates. Tenolysis and re-repair are commonly performed surgeries to deal with complications post FTR. The research regarding the factors affecting outcome post FTR, complications post FTR and reoperation has mostly been conducted in developed countries, in specialised hand units. Assessment of outcome post FTR has mostly focused on the body function and structure aspect of the ICF, and there is a need to include outcome measures that address activity limitations and participation restrictions. Range of movement, power grip and pinch grip strength are the most commonly used outcome measures used to assess function post FTR. There is no gold standard for the assessment of hand function, however, the JHFT and DASH outcome measures have been suggested as useful tools to measure activity levels in patients with hand injuries. There has been research conducted in South Africa, but the main focus has not been the outcome post FTR.

After a thorough evaluation of the literature it is evident that further research needs to be conducted in developing countries, specifically South Africa, to determine the outcomes after FTR and to identify which factors influence those outcomes. If more is known about this subject the care of these patients can be improved and the burden of morbidity post FTR reduced.

CHAPTER 3

3. METHODOLOGY

This chapter provides an outline of the research method and outcome measures used to determine the impairments and functional outcomes after flexor tendon repair (FTR). In addition, this chapter describes the population and sample used as well as the data analysis.

3.1 Study design

A longitudinal observational descriptive research design was used.

3.2 Study setting

The study was conducted at the Hands Unit at Chris Hani Baragwanath Academic Hospital (CHBAH), from January 2013 to September 2015. CHBAH is located in the township of Soweto, South Africa. It is a teaching hospital for the University of the Witwatersrand, and has approximately 3200 beds. (Chris Hani Baragwanth Hospital, 2016) The Hands Unit was established by Professor John Fleming and Dr Walter Stuart, on 4 February 2005. It is the result of a joint private-government venture, and it is Africa’s first self-contained hand surgery unit (Minors, 2012). Approximately 150 surgeries are performed in the hand unit every month, about 15% of which are flexor tendon repairs.

3.3 Study population

3.3.1 Sample selection

Participants were recruited consecutively: Participants were identified from CHBAH theatre lists once they had been booked for FTR by the CHBAH Hands Unit doctors, and every subject that met the inclusion criteria was selected until the sample size was reached.

3.3.1.1 Inclusion criteria

- Patients who had sustained a flexor tendon injury (in any zone, in any finger, with any associated neurovascular and/or bony injury).
- Primary FTR performed at CHBAH.
- Over the age of 14 years.

3.3.1.2 Exclusion criteria

- Previous injury to the affected hand that had resulted in a ROM and/or strength deficit.
- Previous or current injury to the unaffected hand that had resulted in a ROM and/or strength deficit, making it impossible to compare the affected hand to the unaffected hand as it does not have "normal" ROM and/or strength.
- Tendon grafting or reconstruction to the affected hand.

3.3.2 Sample size

From literature, the factors found to affect functional outcome post FTR are: 1) age, 2) language barriers, 3) smoking, 4) mechanism of injury, 5) zone of injury, extent of injury including 6) number of digits injured and 7) associated injury, 8) time lapsed from injury to surgery, 9) surgical technique, 10) post-operative rehabilitation protocol and 11) adherence to therapy. For every factor that is considered to have a possibility of influencing the results of the study, at least ten participants were required (Nunnaly, 1978). This would mean a minimum of 110 participants for the current study. Adjusting for a 15% loss to follow-up, 126 patients were required, thus n= 126 were recruited for the current study.

3.4 Ethical considerations

Permission to conduct research was obtained from CHBAH (Appendix 1) and ethical clearance granted by the University of the Witwatersrand Human Research Ethics

Committee (Medical): Clearance Certificate Number M130748 (Appendix 2). An information sheet (Appendix 3) and a consent letter (Appendix 4) were given to each subject. For participants under the age of 18 years, the caregiver received a parental information sheet (Appendix 5) and signed a parental consent form (Appendix 6) and the participant received an information sheet for participants aged 14-17 years (Appendix 7) and signed an assent form (Appendix 8).The participants were informed that participation was completely voluntary and that they could withdraw at any time, without penalty.

3.5 Instrumentation and outcome measures

3.5.1 Universal metal finger goniometer

Range of movement was measured with a universal metal finger goniometer. Bear-Lehman and Abreu (1989, p1026) consider goniometry an "accurate, reproducible means of evaluation." Georgeu, Mayfield and Logan. (2002) and Chiu et al. (1998) found conventional goniometry to be comparable with computer-aided goniometry and motion analysis. Goniometers are generally "accepted as valid clinical tools" (Gajdosik and Bohannon, 1987, p1870).

A finger goniometer is a stainless steel instrument used for measuring the angles of the finger joints. There are two 180° scales going in opposite directions marked in 5° increments.

Figure 3.1: Universal Metal Finger Goniometer (Fabrication Enterprises, 2015)

The finger goniometer has excellent inter-rater (ICC=0.998) and intra-rater reliability (ICC=0.985) (De Carvalho, Mazzer and Barbieri, 2012). Any change in ROM ≤5° is considered clinically non-meaningful (Macionis, 2013).

3.5.2 Jamar dynamometer

Grip strength was measured with a Jamar dynamometer in the position described by the American Society of Hand Therapists (elbow flexed 90 degrees, forearm in neutral and patient gripping the dynamometer at the second handle position) (Fess, 1992, cited in El-Sais and Mohammad, 2014). The Jamar dynamometer is a handheld, hydraulic dynamometer, with adjustable grip positions and measurements in pounds and kilograms.

Figure 3.2: Jamar Hand Dynamometer (Therapy Specialities, 2015)

“The reliability of grip strength testing has been well-established” (MacDermid, 2005, p299), which includes both inter-rater (ICC>0.87, MacDermid et al., 1994; ICC=0.98, Peolsson, Hedlund and Oberg, 2001) and intra-rater reliability (ICC=0.87-0.97, Peolsson, Hedlund and Oberg, 2001). The minimal detectable change (MDC) has not been established (Lamb, 2014). Lang et al., 2008 found the minimal clinically important difference (MCID) to be 5.0kg and 6.2kg for affected dominant and non-dominant sides respectively, however, this study (Lang et al., 2008) was conducted in stroke patients so the values may not be applicable to patients post FTR.

The Jamar dynamometer is easy to use and there are readily available age and gender specific norms (Lamb, 2014) (Appendix 9). The Jamar dynamometer is the most widely used dynamometer in research (Roberts et al., 2011), which enables comparisons to be made between the current study and others. The Jamar dynamometer is considered the gold standard (Roberts et al., 2011).

3.5.3 Pinch meter

Pinch strength was measured using a pinch meter. The pinch meter measures thumb-finger prehension in pounds and/or kilograms.

Figure 3.3: Pinch Meter (3B Scientific, 2015)

Pinch strength measurement using a pinch meter is “valid and reliable across different conditions and using different test instruments” (MacDermid, 2005, p302). MacDermid, Evenhuis and Louzon (2001) assessed the inter-instrument reliability of three different devices for measuring pinch grip and found ICC>0.90 in patients and ICC>0.80 in healthy subjects. The inter-rater reliability was found to be 0.991 and 0.996 (Pearson’s *r*) for right and left hands respectively, and test-retest reliability was found to be 0.818 and 0.820 (Pearson’s *r*) for right and left hands respectively (Mathiowetz et al., 1984).

The pinch meter is easy to use and norms are available (Mathiowetz et al., 1985) (Appendix 9).

3.5.4 Jebsen Hand Function Test (JHFT)

Hand function at body function/structure and activity levels was measured using the JHFT. The JHFT (Appendix 10) was developed by Jebsen et al. in 1969. It measures the time it takes to complete seven functional tasks, with both dominant and non-dominant hands. These tasks include: writing, turning over cards, picking up small common objects, simulated feeding, stacking checkers, picking up large light objects and picking up large heavy objects. The JHFT tests the speed of unilateral hand function, not the quality (Raad, 2012). The longer the time taken to complete the task(s), the higher the level of disability (Poole, 2011).

Figure 3.4: Jebson Hand Function Test (Euro Medical, 2015)

Ferreiro, dos Santos and Conforto (2010) reported excellent internal consistency (Cronbach's α=0.924) and inter-rater (ICC=1.0) and intra-rater (ICC=0.997) reliability of the JHFT. This research, however, was conducted using the Portuguese version of the JHFT, making it difficult to compare to the current study. One similarity is that the study (Ferreiro, dos Santos and Conforto, 2010) was done in Brazil, which, like South Africa, is a developing country. Beebe and Lang (2009) found excellent correlation between the JHFT and grip (r=0.79-0.81) and pinch (r=0.60-0.79) strength when examining concurrent validity. Both of the above mentioned studies were done with patients post stroke.

The JHFT is a standardised test of hand function, which is widely used and can be used for a wide variety of diagnoses, from neurological conditions, to arthritis, to post hand surgery (Poole, 2011; Raad, 2012). It is easy to administer and score, with no formal training required (Poole, 2011) and there are norms available, including South African norms (Govender, 2008). An additional advantage of this test is the fact that it is a performance test, which acts as a counterpart to the self-reported measure, the Quick DASH, described below. Lastly, it is a measure which can be demonstrated to the participant, rather than relying on the use of language, which can assist in eliminating some of the difficulties associated with translation.

3.5.5 Quick Disabilities of the Arm, Shoulder and Hand outcome measure

Hand function at activity and participation levels was measured using the Quick DASH outcome measure. The Quick DASH (Appendix 11) was developed by Beaton, Wright and Katz in 2005. It is a shortened version of the DASH outcome measure, using 11 items (as opposed to 30 DASH items) to measure physical function and symptoms in people with upper limb disorders. There are optional work and sport modules, which are scored separately. The higher the score, the higher the level of disability present (Institute for Work & Health, 2006).

Reliability, validity and responsiveness of the DASH have been well established (Beaton et al., 2001) and Gummeson, Ward and Atroshi (2006) found that the DASH can be substituted with the Quick DASH and still maintain a high level of reliability: DASH internal consistency Cronbach's α=0.97, Quick DASH Cronbach's α=0.94; DASH test-retest ICC=0.96, Quick DASH ICC=0.94 (Institute for Work and Health, 2006). The psychometric properties of the Quick DASH include: excellent test-retest reliability (ICC=0.90), the minimal detectable change (MDC) is 11.2 percentage points and the Minimal Clinical Important Difference (MCID) is 8 percentage points (Mintken, Glynn and Cleland, 2009). This study (Mintken, Glynn and Cleland, 2009) was conducted using patients with shoulder pain, but is the only study to establish the MDC and MCID.

The Quick DASH is free and easy to administer, with no formal training required and has been shown to work well in research (Institute for Work & Health, 2006). The Quick DASH was chosen over the DASH as it minimises the time taken to complete the test, while still maintaining a high level of reliability (Mintken, Glynn and Cleland, 2009).

3.6 Pilot Study

A pilot study was conducted with fourteen (n=14) patients who had undergone FTR.

3.6.1 Purpose

- To determine the length of time it would take the researcher to complete a full assessment.
- To familiarise the researcher with the instruments to be used in the study.
- To check if all data could be captured on the data capturing spreadsheet developed for this study.

3.6.2 Procedure

Each participant in the pilot study signed a consent form and understood that they were participating in a pilot study, not the main study. The participants were patients who had undergone an FTR and were over three months post-surgery to ensure that there were no contra-indications to any of the testing procedures. The researcher performed a full assessment, including ROM and strength measurement and administration of the Quick DASH and JHFT. Each participant went through the exact procedure that was used in the main study, however, testing was done only once.

3.6.3 Findings and implications

A full assessment was found to take 20 – 30 minutes, which was dependent on the extent of the injury and whether the participant could speak and understand English. The services of a nurse were used for translation if necessary.

The researcher became acquainted with the instruments that were to be used, in particular the JHFT, which requires the procedure to be followed identically each time the test is administered. This process included the making of markings on the table where the JHFT was to be conducted in order to correctly identify where each object should be placed in order to have standardised administration of the test. No changes were made to the procedure following the pilot.

All data could be captured on the data capturing sheet developed for this study.

3.7 Main study

Each week day the researcher obtained theatre lists from the CHBAH Hands Unit doctors and identified the patients that had been booked for FTR. Each patient then underwent surgery and was treated by an Occupational Therapist (OT) for four weeks post-surgery (i.e., no physiotherapy treatment was received in the first four weeks post-surgery). The OT protocols used included passive motion, controlled active motion and early active motion protocols (Appendix 12).

The patients were recruited and invited to participate in the study by the researcher when the patient attended their first physiotherapy appointment at one month post-surgery. Each patient was given a copy of the information sheet (Appendix 3) and consent form (Appendix 4) and was informed that they had the right to refuse to participate in the study. For participants under the age of 18 years, the caregivers received a parental information sheet (Appendix 5) and signed a parental consent form (Appendix 6) and the participant received an information sheet for participants aged 14-17 years (Appendix 7) and signed an assent form (Appendix 8). Each participant received occupational and physiotherapy at the treating therapists' discretion (Appendix 12).

At the first assessment, one month post-surgery, a data collection form (Appendix 13) that covered details about demographics, injury, surgery, rehabilitation and post-operative complications was completed. The sections regarding rehabilitation and post-operative complications were supplemented at the three and six month assessment sessions where applicable.

At one month post-surgery, the participant's bilateral hand ROM was measured using a standard metal finger goniometer. For measurement of the finger joints the participant's wrist was in neutral, and the participant was asked to form a composite fist to measure flexion ROM (i.e., joints were not measured in isolation). The participant was then asked to open their hand as much as possible in order to measure extension ROM. For the thumb flexion and extension ROM measurement, the participant was asked to flex and extend their thumb as fully as possible (with wrist in neutral). Bilateral hand ROM was documented in a table on the data collection sheet (Appendix 13). ROM of the affected hand was measured in an identical manner at three and six months post-surgery.

At three and six months post-surgery, the participant's bilateral grip strength and pinch strength were measured. Grip and pinch strength were measured in the position described by the American Society of Hand Therapists, with the elbow flexed 90 degrees and forearm in neutral (Fess, 1992, cited in El-Sais and Mohammad, 2014). Three measurements were taken for both affected and unaffected hands and an average of the three readings was calculated (Innes, 1999).

The JHFT (Appendix 10) was administered at the three and six month assessment sessions. JHFT times were recorded on the data collection sheet (Appendix 13). The Quick DASH (Appendix 11) was administered in interview format at the three and six month assessment sessions. If the participant was unable to understand English, translation was done by a nurse. The optional work module of the Quick DASH was completed if the participant was employed prior to sustaining their injury. The Quick DASH questionnaire was attached to the back of the data collection sheet (Appendix 13) once completed, and the total(s) tallied and recorded on the data collection sheet.

All efforts were made to ensure the assessment session coincided with the participant's regular doctor and/or therapy appointment. If the assessment session did not coincide the participant was given money to reimburse them for transport costs. Patients were provided with an appointment card for their follow-up assessments and were reminded of their follow-up assessments via text messages. If a patient missed an assessment session they were contacted telephonically and rebooked. Participants who repeatedly missed assessments were repeatedly contacted and rebooked until they had exceeded their follow up date by a month, i.e., when they had reached seven months post-surgery for their six month assessment. Every effort was made to ensure each participant attended their follow up assessments in order to prevent loss to follow up. All data from the data collection sheet were captured in Excel.

3.8 Data handling and statistical analysis

The Total Active Movement (TAM) classification system, as described by the American Society for Surgery of the Hand (ASSH) (ASSH, 1990, cited in Libberecht, 2006), was applied to the ROM measurements. TAM was calculated by subtracting the sum of the extension deficit present at each joint [metacarpal-phalangeal joint (MCPJ), proximal interphalangeal joint (PIPJ) and distal interphalangeal joint (DIPJ)] from the sum of the degrees of flexion at each joint:

TAM = total active flexion (MCPJ, PIPJ, DIPJ) – total extension deficit (MCPJ, PIPJ, DIPJ) (ASSH, 1990, cited in Libberecht, 2006).

A percentage was then calculated by dividing the TAM of the injured finger by the TAM of the contralateral finger:

% = TAM of injured finger/TAM of contralateral finger x 100 (ASSH, 1990, cited in Libberecht, 2006).

The average TAM for the affected hand was then calculated and classified according to the TAM classification system. See Table 3.1.

Table 3.1: TAM Classification System*

PERCENTAGE	SCORE
100%	Excellent
>75%	Good
>50%	Fair
<50%	Poor

*(ASSH, 1990, cited in Libberecht, 2006)

For power and pinch grip strength measurements, three measurements were taken bilaterally and an average determined. The average of the affected hand was then divided by the average of the unaffected hand to determine the percentage of unaffected grip strength.

The Quick DASH was scored according to the scoring guidelines. The formula used is ([sum of n responses/n] – 1) x 25 for both the main disability and work components of the tool. This calculation was inserted into the Excel spreadsheet and the calculation was done automatically.

The JHFT times were recorded in the format of min:sec:millisec. An Excel formula was devised to calculate the sum of the times for each task. The final value was then converted into seconds for ease of analysis (e.g., 00:43.26 = 43 seconds; 1:05.98 = 66 seconds) and the difference between the three and six month values calculated.

Stata statistical software (version 14) was used for statistical analysis. Significance was set at $p \leq 0.05$. Descriptive statistics were used to analyse demographic information, ROM, pinch and grip strength and functional ability (from the Quick DASH and JHFT). Continuous data were presented in the form of medians and percentiles.

Friedman's test was used to compare median scores of ROM over the study period (one, three and six months). A Wilcoxon Signed Rank Test was used to compare median scores of grip and pinch strength and functional ability (the Quick DASH scores and JHFT times) over the study period (three and six months). A one-sample t-test was used to compare JHFT times to established norms.

The relationships between the predictor variables and the outcome variables ROM, power grip, pinch grip and Quick DASH score were investigated using correlations, one-way/t-tests and regression analysis. The predictor variables were: age category, smoking history, mechanism of injury (sharp or tearing), zone of injury, number of digits injured, associated injury, number of weeks between injury and surgery, suture technique, OT protocol, adherence to therapy and presence of language barrier. JHFT time was excluded from this analysis due to difficulty with knowing whether to use the time taken for the non-dominant hand or for the dominant hand or whether an average of the two should be taken. Quick DASH covers both activity and participation aspects of the ICF, therefore one of these is not eliminated by the exclusion of JHFT from the analysis.

Pearson's correlation was used for ROM, power grip and Quick DASH score, while Spearman's correlation was used for pinch grip, due to the skewness of its distribution. To test association, T-test, one-way ANOVA and Kruskal-Wallis tests were used. The t-test was used to determine if the outcome variables varied across two different categories of the specific independent (predictor) variable. A one-way ANOVA was used in the same fashion as the t-test, however, it was used when there were more than two categories. The Kruskal-Wallis test was used for the tests regarding the outcome variable, pinch grip, due to the skewness of its distribution. For all of the above, the null hypothesis of no change was rejected if $p \leq 0.05$. The Bonferroni test was used to determine which groups differ, when there are differences between the groups. It compares the pairs of categories, and for each pair it gives a p-value. If $p<0.05$ the null hypothesis that the two categories were the same was rejected. Regression analysis was done using multiple linear regression. The factors found to be significantly correlated to and/or associated with each outcome variable were used in the regression analysis.

3.9 Conclusion

This chapter dealt with the research methodology used to determine the impairments and functional outcomes of patients post FTR. The sample population, instrumentation, outcome measures, procedure followed and statistical analysis were described.

CHAPTER 4

4. RESULTS

In this chapter the results will be presented according to the objectives of the study which were to: a) describe the profile of patients who underwent FTR in the current study, b) establish the ROM at one, three and six months post FTR, c) establish the power and pinch grip strength at three and six months post FTR, d) establish hand function at activity and participation levels at three and six months post FTR and e) determine the factors that may affect functional outcome at six months post FTR.

4.1 Study participants' profile

4.1.1 Demographic information

One hundred and twenty six participants (n=126) enrolled in the study, and of these participants 75% (n=94) completed their three month assessment and 56% (n=72) completed their six month assessment. Seven participants attended their six month assessment, but not their three month assessment, leaving 51.5% (n=65) of participants (141 fingers) with complete data and eligible for analysis, thus results have been presented using n=65. For results from participants with incomplete data refer to Appendix 14.

The demographics of the study sample are summarised in Table 4.1.

Table 4.1: Demographics of study sample (n=65)

Descriptor		n (%)
Gender	Male	41 (63%)
	Female	24 (37%)
Age*	< 20 years old	5 (7.5%)
	20 – 30 years old	24 (37%)
	31 – 40 years old	20 (31%)
	41 – 50 years old	11 (17%)
	> 50 years old	5 (7.5%)
Occupation	Employed	41 (63%)
	Unemployed	17 (26%)
	Other**	7 (11%)
Type of Work * **	Sedentary	4 (10%)
(n= 41)	Light	15 (36.5%)
	Medium	15 (36.5%)
	Heavy	7 (17%)
Hand Dominance	Right	59 (91%)
	Left	6 (9%)
Smoker	Yes	19 (29%)
	No	46 (71%)
Language Barrier	Yes ****	8 (12.5%)
	No	51 (78.5%)
	Slight ****	6 (9%)

* *Mean age of the participants was 32 years (SD±10, n=65). The youngest participant was 15 and the oldest 62*

** *Includes scholars, students, pensioners and prisoners*

*** *See Appendix 15 for description of classification*

**** *"Yes" required a translator, "Slight" meant participant was not fluent in English, but a translator was not required*

Table 4.1 shows that most (63%) of the participants were male and between the ages of twenty and thirty (37%). Sixty three percent (n=41) of the participants were employed, with most being employed in light (36.5%) and medium (36.5%) level work. Ninety one percent of the sample was right hand dominant, 71% were non-smokers and 78.5% could understand and speak English fluently.

4.1.2 Characteristics of the injuries

The characteristics of injuries sustained by participants are summarised in Table 4.2.

Table 4.2: Characteristics of the injuries (n=65)

Descriptor		**n (%)**
Hand Injured	Dominant	40 (61.5%)
	Non-dominant	25 (39.5%)
Cause of Injury	Accidental*	28 (43%)
	Violence-related	24 (37%)
	Motor/Pedestrian vehicle accident	2 (3%)
	Occupational	5 (8%)
	Self-inflicted**	6 (9%)
Sharp/Tearing* **	Sharp	60 (92%)
	Tearing	5 (8%)
Zone	I	1 (1.5%)
	II	19 (29%)
	III	9 (14%)
	IV	3(4.5%)
	V	26 (40%)
	Thumb (zones I-III)	7 (11%)
Number of digits injured	1	25 (38.5%)
	2	18 (28%)
	3	11 (17%)
	4	8 (12%)
	5	3 (4.5%)
Associated Injury******	Isolated median nerve laceration	10 (15%)
	Isolated ulnar nerve laceration	14 (21.5%)
	Combined median and ulnar nerve laceration	4 (6%)
	Digital nerve laceration	11 (17%)
	Fracture/dislocation	5 (7%)
	Vascular Injury	9 (14%)
	Extensor tendon/thenar muscle laceration	5 (7%)
	A2/A4 pulley injury	2 (3%)
	None	21 (32%)

* *Injuries caused by accidents (outside of work) such as falling onto glass or cutting oneself accidentally*

** *Injuries sustained by punching windows and in one case a parasuicide*

*** *Sharp: knives, broken bottles, glass, blade and windows; tearing: grinders/saws and a spanner in one case*

**** *Accounts for combined injuries, i.e., more than one associated injury*

Table 4.2 shows that most (61.5%) participants injured their dominant hand, with the main causes of injury being accidental (43%) and violence-related (37%). The mechanism of injury was most commonly sharp (92%). The most commonly injured zone was zone V (40%) followed by zone II (29%). Most participants only injured a single digit (38.5%). The most common associated injuries were nerve injuries: ulnar nerve (21.5%) and digital nerve (17%) and the median nerve (15%). Thirty two percent of participants did not have an associated injury.

4.1.3 Details of surgery undergone by participants

Details of the surgery undergone by participants are summarised in Table 4.3.

Table 4.3: Details of surgery undergone by participants (n=65)

Descriptor		n (%)
Delay between injury and surgery*	< 1 week	37 (57%)
	1 – 2 weeks	18 (28%)
	>2 – 3 weeks	3 (4.5%)
	>3 – 4 weeks	3 (4.5%)
	> 1 month, < 2 months	1 (1.5%)
	> 2 month, < 3 months	2 (3%)
	> 3 months	1 (1.5%)
Suture	4 strand	31 (48%)
	2 strand	2 (3%)
	4 strand FDP**, 2 strand FDS**	1 (1.5%)
	4 strand FDP only	3 (4.5%)
	Not recorded***	28 (43%)

* *The mean delay between injury and surgery was 11 days (SD±15, n=65) with a minimum wait of 0 days (i.e., the participant was operated on the day of injury) and a maximum delay of over three months*

** *FDP: flexor digitorum profundus; FDS: flexor digitorum superficialis*

*** *Surgeon did not record the surgical technique used in the surgery notes*

With regard to the time elapsed between injury and surgery, there was a mean delay of 11 days (SD±15, n=65), with most of the participants (57%) undergoing FTR within a week of sustaining their FTI. Almost half of the patients (48%) had four-strand repair of both FDP and FDS. There was a high rate (43%) at which the surgeon did not specify which suture was used, in the surgery notes.

4.1.4 Rehabilitation and adherence to therapy

Details of the rehabilitation protocol used and adherence to therapy are summarised in Table 4.4.

Table 4.4: Rehabilitation and adherence details (n=65)

Descriptor		n (%)
Occupational Therapy protocol	Passive motion	57 (88%)
	Controlled active motion	4 (6%)
	Early active motion	2 (3%)
	No OT received	2 (3%)
Self-removal of splint	Yes*	14 (22%)
	No	49 (75%)
	Did not receive splint	2 (3%)
Adherence to therapy attendance**	40-49%	1 (1.5%)
	50-59%	2 (3%)
	60-69%	3 (4.5%)
	70-79%	6 (9%)
	80-89%	10 (15%)
	90-99%	5 (8%)
	100%	38 (59%)

* *Removed splint during first four weeks post-surgery. (If the splint was easily removed and/or the participant's hand was very clean on splint removal at four weeks, the participant was marked as having removed their splint themselves, even if they did not admit to it)*

** *Calculated by dividing the number of appointments the participant attended by the number of appointments the participant should have attended in the first twelve weeks post surgery*

The mean adherence to therapy attendance was 91% (SD±13, n=65).

The most commonly used protocol for post-operative rehabilitation was a passive motion protocol, which 88% of patients received. The majority (75%) of participants were compliant with splint wear. The mean adherence to therapy attendance was 91% (SD±13, n=65), with 59% of participants having 100% attendance in the first twelve weeks post FTR.

4.1.5 Completion of therapy

With regards to the completion of therapy, 52% (n=34) of participants completed treatment (i.e., they were discharged by the treating therapist/s). These participants attended a mean of 7 (SD±2, n=34) physiotherapy treatments before being discharged and were discharged at a mean of 8 (SD±2, n=34) months post FTR. Seventeen percent (n=11) of participants defaulted treatment, and all of them defaulted after six months of therapy.

Twelve percent (n=8) of participants were transferred to other healthcare facilities at a mean of 9 (SD±2, n=8) months post FTR and after attending a mean of 8 (SD±2, n=8) physiotherapy treatments. Seventeen percent (n=11) of participants were still receiving hand therapy at CHBAH at the time of completion of data collection. This number of patients was a mean of 10 (SD±4, n=11) months post FTR at the time of completion of data collection.

4.1.6 Post-operative complications and reoperation

Sixty eight percent of participants (n=44) experienced one or more complications post FTR. The complications are summarised in Figure 4.1.

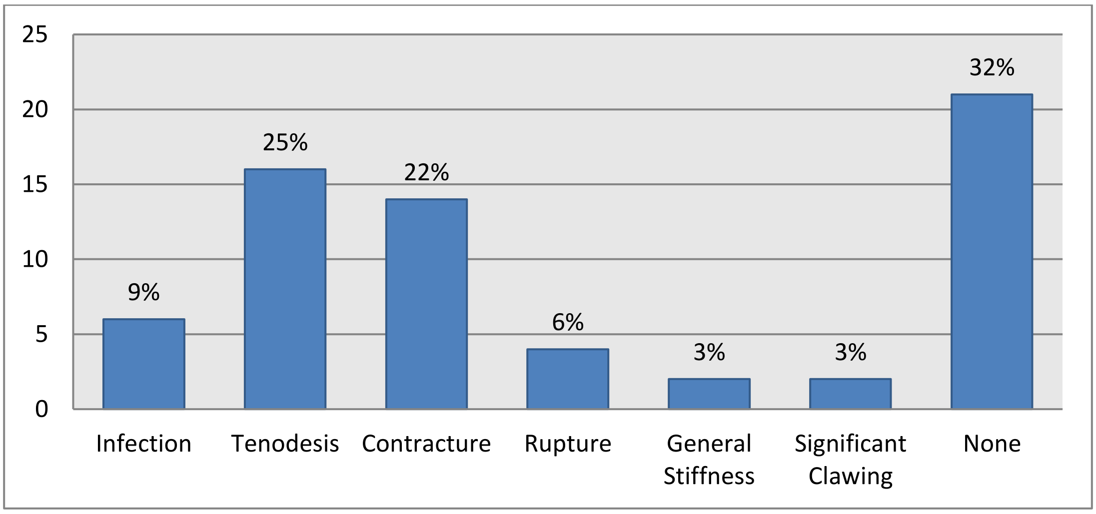

Figure 4.1: Post-operative complications (n=65)

A high number (68%, n=44) of participants experienced complications post FTR. The most common complication was tenodesis/adhesions (25%, n=16), followed by contracture (22%, n=14). There were only four patients (6%) who had ruptures in this sample.

While two-thirds of participants experienced complications, only 11 (17%) underwent further surgery. The further surgeries included: three debridements, three tenolysis, one contracture release, three secondary tendon repairs and one Riordan tendon transfer. Six participants were booked for further surgeries (including tenolysis, contracture release and bone grafting), however, they defaulted, so the researcher was unable to ascertain whether the participant actually underwent the surgery they were booked for.

4.2 Range of motion

The range of motion (ROM) of participants at one, three and six months post FTR is shown in Table 4.5.

Table 4.5: Range of Motion (ROM) in terms of Total Active Movement (TAM) (n=65)

	One Month	Three Months	Six Months
Median	21%	57%	65%
25th percentile	9%	28%	43%
75th percentile	29%	65%	80%
Mean (SD)	21% (±14)	50% (±23)	61% (±25)
Minimum	0%	9%	9%
Maximum	56%	92%	100%

The improvement in median TAM was 36% from one to three months ($p<0.001$) and 8% from three to six months ($p<0.001$), using Friedman's Test.

The ROM was further classified according to the TAM system, as seen in Table 4.6.

Table 4.6: TAM Classification of ROM at one, three and six months post FTR (n=65)

Score	Percentage	n (%)		
		1 month	3 months	6 months
Excellent	**100%**	0	0	1 (2%)
Good	**75-100%**	0	8 (12%)	21 (32%)
Fair	**50-75%**	4 (6%)	29 (45%)	21 (32%)
Poor	**< 50%**	61 (94%)	28 (43%)	22 (34%)

At one month post FTR, the majority (94%, n=61) of participants had ROM classified as poor. At three months post FTR, the ROM classification was divided almost equally between fair (45%, n=29) and poor (43%, n=28). Finally, at six months post FTR the participants' ROM was split almost equally into thirds of good and excellent (34%, n=22), fair (32%, n=21) and poor (34%, n=22) results.

4.3 Power and pinch grip strength

The power and pinch grip strength of participants at three and six months post FTR is shown in Table 4.7.

Table 4.7: Power and pinch grip strength at three and six months post FTR (percentage of unaffected hand) (n=65)

	Power Grip 3 Months	Power Grip 6 Months	Pinch Grip 3 Months	Pinch grip 6 Months
Median	41%	62%	29%	54%
25th percentile	17%	42%	0%	21%
75th percentile	54%	78%	60%	71%
Minimum	0	3%	0	0
Maximum	85%	105%	135%	176%
Mean (SD)	40% (±23)	60% (±25)	34% (±34)	52% (±42)
RHD Mean	42%	62%	36%	54%
LHD Mean	28%	44%	17%	33%

The improvement in power grip was 21% ($p<0.001$) and in pinch grip was 25% ($p<0.001$) from three to six months, using a Wilcoxon Signed Rank test.

4.4 Hand function at activity and participation levels

Activity was measured using the JHFT and the Quick DASH. The JHFT is measured according to dominant and non-dominant hands, rather than affected and unaffected hands. The times taken for the JHFT at three and six months are summarised in Table 4.8.

Table 4.8: Time taken (in seconds) for JHFT at three and six months post FTR (n=65)

	Non-dominant 3 months	Non-dominant 6 months	Dominant 3 months	Dominant 6 months
Median	69	61	54	47
25th percentile	57	51	44	39
75th percentile	93	82	78	62
Mean Time (SD)	82 (±38)	74 (±33)	74 (±60)	62 (±54)
Minimum Time	36	32	33	29
Maximum Time	220	169	385	371

The overall change in median time from three to six months was significant with an improvement of eight seconds ($p<0.001$) and seven seconds ($p<0.001$) in the non-dominant and dominant hand respectively, using a Wilcoxon Signed Rank test.

Times for individual domains of the JHFT, and a comparison with the norms established by Jebsen et al. (1969) and Govender (2008), are shown in Table 4.9 for female participants and in Table 4.10 for male participants. The mean times (as opposed to the median times) were used because the established norms, with which these times were compared, are presented as means, not medians. The times of all participants who completed the six month assessment were used (n=72), as there was no comparison being drawn between these times and the times achieved at three months post FTR. For the Jebsen et al. (1969) norms the 20-59 age category was used as the majority (97%, n=63) of participants in the current study fell within this age range. The two (3%) participants who did not fall within the category were 60 and 62 years of age.

Table 4.9: Mean JHFT times (in seconds) for each domain at six months post FTR with comparisons with established norms (females)

	Dominant Hand					Non-Dominant Hand				
	Current Study	SA Norms	P-value	JHFT Norms	P-value	Current Study	SA Norms	P-value	JHFT Norms	P-value
Hand writing	23.36 ±24.39	12.7 ±4.41	0.03*	11.7 ±2.1	0.02*	35.97 ±25.05	28.6 ±9.07	0.13	30.2±8.6	0.22
Page turning	5.14 ±5.30	4.94 ±1.19	0.08	4.3 ±1.4	0.41	5.43 ±3.42	5.59 ±1.31	0.81	4.8±1.1	0.33
Small objects	10.57 ±14.38	5.59 ±1.16	0.08	5.5 ±0.8	0.07	8.49 ±5.96	6.12 ±1.52	0.04*	6.0±1.0	0.04*
Feeding	6.59 ±2.32	6.28 ±1.13	0.49	6.7 ±1.1	0.80	7.66 ±2.05	7.56 ±1.44	0.79	8.0±1.6	0.39
Checkers	4.73 ±2.09	2.38 ±0.49	0.00*	3.3 ±0.6	0.00*	5.22 ±1.56	2.72 ±0.6	0.00*	3.8±0.7	0.00*
Light objects	3.44 ±1.98	3.65 ±0.72	0.58	3.1 ±0.5	0.37	3.26 ±0.79	4.02 ±0.81	0.00*	3.3±0.6	0.81
Heavy objects	4.00 ±3.58	3.8 ±0.65	0.77	3.2 ±0.5	0.24	3.72 ±1.15	4.11 ±0.9	0.08	3.3±0.5	0.06

**indicates a significant difference between the means of this sample and the norms*

*** SA norms: Govender (2008); JHFT norms: Jebsen et al. (1969)*

Table 4.10: Mean JHFT times (in seconds) for each domain at six months post FTR with comparisons with established norms (males)

	Dominant Hand					Non-Dominant Hand				
	Current Study	SA Norms	P-value	JHFT Norms	P-value	Current Study	SA Norms	P-value	JHFT Norms	P-value
Hand writing	23.81 ±14.78	13.89 ±5.58	0.00*	12.2±3.5	0.00*	39.79 ±21.28	32.24 ±10.46	0.02*	32.3±11.8	0.02*
Page turning	5.23 ±3.21	4.73 ±1.21	0.31	4.0±0.9	0.01*	5.14 ±2.00	5.76 ±1.4	0.04*	4.5±0.9	0.04*
Small objects	11.74 ±12.08	5.53 ±0.93	0.00*	5.9±1.0	0.00*	9.18 ±6.59	6.2 ±1.18	0.00*	6.2±0.9	0.00*
Feeding	6.97 ±4.08	6.11 ±1.02	0.17	6.4±0.9	0.36	7.76 ±3.05	7.39 ±1.42	0.43	7.9±1.3	0.76
Checkers	7.10 ±17.52	2.37 ±0.6	0.08	3.3±0.7	0.16	4.77 ±2.10	2.72 ±0.68	0.00*	3.8±0.6	0.00*
Light objects	3.33 ±1.06	3.54 ±0.62	0.20	3.0±0.4	0.04*	3.30 ±0.67	3.7 ±0.67	0.00*	3.2±0.6	0.32
Heavy objects	4.91 ±10.65	3.63 ±0.6	0.43	3.0±0.5	0.24	3.58 ±1.36	3.91 ±0.77	0.12	3.1±0.4	0.02*

**indicates a significant difference between the means of this sample and the norms*

*** SA norms: Govender (2008); JHFT norms: Jebsen et al. (1969)*

Female participants were significantly slower stacking checkers with both dominant (p=0.00) and non-dominant (p=0.00) hands, picking up small objects with the non-dominant hand (p=0.04) and writing with the dominant hand (p=0.03), but significantly faster at picking up light objects with the non-dominant hand (p=0.00) than Govender's (2008) South African norms. When compared with the original norms that Jebsen et al. (1969) established during development of the JHFT, it was found that female participants in the current study were significantly slower in writing with the dominant hand (p=0.02), picking up small objects with the non-dominant hand (p=0.04) and stacking checkers with both the dominant (p=0.00) and non-dominant hand (p=0.00).

When compared with Govender's (2008) South African norms, male participants were significantly slower at writing (dominant hand p=0.00, non-dominant hand p=0.02) and picking up small objects (dominant hand p=0.00, non-dominant hand p=0.00) with both dominant and non-dominant hands and at stacking checkers with the non-dominant hand (p=0.00), but significantly faster at page turning (p=0.04) and picking up light objects (p=0.00) with the non-dominant hand. Male participants were significantly slower at writing (dominant hand p=0.00, non-dominant hand p=0.02), page turning (dominant hand p=0.01, non-dominant hand p=0.04) and picking up small objects (dominant hand p=0.00, non-dominant hand p=0.00) with both dominant and non-dominant hands, stacking checkers (p=0.00) and picking up heavy objects (p=0.02) with the non-dominant hand and picking up light objects (p=0.04) with the dominant hand when compared with the Jebsen et al. (1969) norms.

Participation was measured using the Quick DASH questionnaire and return to work status. At three and six months post FTR participants completed the Quick DASH questionnaire. The Quick DASH score can range from 0 to 100 with 0 indicating least disability and 100 indicating most disability. There are currently no divisions to categorise Quick DASH scores into mild, moderate and severe levels of disability. The participants' scores at three and six months are shown in Table 4.11.

Table 4.11: Quick DASH scores at three and six months post FTR (n=65)

	Quick DASH 3 months	Quick DASH 6 months
Median	22.72%	15.91%
25th percentile	12.5%	9.09%
75th percentile	40.00%	22.50%
Mean (SD)	26.16% (±16.78)	19.34% (±16.89)
Minimum	0.00	0.00
Maximum	70.45%	77.27%

The improvement in Quick DASH scores from three to six months was 6.81%, which was found to be significant ($p<0.001$) using a Wilcoxon Signed Rank test.

At three months post FTR, 28 participants (68%) who were employed prior to their injury were back at work. The 13 participants (32%) that had not returned to work were previously employed in the following types of jobs: 3 (23%) light work, 9 (69%) medium work and 1 (8%) heavy work.

At six months post FTR, 29 participants (71%) who were employed prior to their injury were back at work. The 12 participants (29%) that had not returned to work were previously employed in the following types of labour: 3 (25%) light work, 7 (58%) medium work and 2 (17%) heavy work.

Of the above mentioned participants, 24 had scores for both three and six month Quick DASH work module assessments and therefore comparison between three and six month Quick DASH work module scores were calculated using n=24. Table 4.12 summarises the scores achieved on the work module of the Quick DASH by those participants who had returned to work at three and six months post FTR.

Table 4.12: Quick DASH Work Module scores at three and six months post FTR (n=24)

	Quick DASH Work Module 3 months	Quick DASH Work Module 6 months
Median	18.75%	12.50%
25th percentile	12.50%	0.00%
75th percentile	45.31%	12.50%
Mean (SD)	27.86% (±28.31)	15.89% (±23.74)
Minimum	0.00	0.00
Maximum	100.00%	100.00%

The improvement in Quick DASH work module scores of 6.25% from three to six months was found to be significant ($p<0.001$) using a Wilcoxon Signed Rank test.

4.5 Factors affecting the impairments and functional outcome at six months post FTR

The relationships between the predictor variables and the outcome variables ROM, power grip, pinch grip and Quick DASH score were investigated using correlations, t-tests and regression analysis. The results are presented below.

The results of correlation tests are shown in table 4.13.

Table 4.13: Correlation of outcome variables

	ROM		Power Grip		Pinch Grip		Quick DASH	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**
ROM**	-							
Power Grip**	0.31	0.01*	-					
Pinch Grip**	0.28	0.02*	0.65	0.00*	-		-0.48	0.00*
Quick DASH**	-0.44	0.00*	-0.55	0.00*			-	1.00

*significant

** test used: Pearson's Correlation for ROM, Power Grip and Quick DASH; Spearman's Correlation for Pinch Grip

Table 4.13 shows that all the outcome variables are significantly correlated, however the strength of the correlations are moderate to weak. The correlation between power and pinch grip is the strongest (r=0.65 denoting a good correlation) in this sample, while the correlation between ROM and pinch grip is the weakest. ROM, power grip and pinch grip are all positively correlated, therefore, as ROM improves, strength improves and vice versa. The Quick DASH score is negatively correlated with all the other outcome variables, meaning that as ROM and strength increase, the Quick DASH score decreases, i.e., indicating a lower level of disability.

After testing for correlation, tests for association were done, using t-test, one-way ANOVA and the Kruskal-Wallis test. For the factors found to be associated with the outcome variables, Bonferroni was used to determine which group (in each factor) was most likely to be different. The summary is presented in Table 4.14, with only the factors that were significantly associated with at least one outcome variable being included. A table with the non-significant factors can be found in Appendix 16.

Table 4.14: Summary of associations of factors with outcome variables (significant factors)

	ROM		Power Grip		Pinch Grip		Quick DASH	
	Mean (SD)	p	Mean (SD)	p	Mean (SD)	p	Mean (SD)	p
Age Category								
< 20	75.05 (±19.74)		56.80 (±24.00)				17.18 (±5.35)	
20 – 30	63.87 (±23.14)	0.01 √	66.08 (±23.68)	0.15	NA	0.12**	17.01 (±17.80)	0.42
31 – 40	59.94 (±25.55)		62.10 (±21.64)				16.85 (±13.33)	
41 – 50	63.71 (±25.40)		56.82 (±25.80)				26.38 (±22.88)	
> 50	32.43 (±13.73)		36.00 (±31.56)				27.18 (±16.74)	
Zone of Injury								
I	63.46 (±0.00)		73.00 (±0.00)				54.55 (±0.00)	
II	60.54 (±15.52)		74.37 (±16.99)				15.05 (±18.97)	
III	62.95 (±26.42)	0.01 √	57.11 (±26.36)	0.00 √	NA	0.00** √	17.83 (±16.82)	0.01 √
IV	23.64 (±11.13)		17.33 (±12.66)				45.23 (±17.21)	
V	69.90 (±23.31)		48.81 (±19.76)				20.24 (±13.95)	
Thumb	43.03 (±33.04)		85.14 (±10.16)				13.47 (5.50)	
Number of Digits Injured								
1	52.33 (±24.53)		76.44 (±18.86)				16.96 (±14.03)	
2	69.55 (±22.32)	0.11	57.56 (±21.31)	0.00 √	NA	0.11**	15.59 (±19.45)	0.11
3	62.75 (±29.39)		45.36 (±26.27)				26.05 (±19.29)	
4	60.84 (±21.43)		40.75 (±18.44)				28.69 (±14.57)	
5	77.59 (±4.40)		48.33 (17.67)				12.12 (±8.60)	
Associated Injury								
Ulnar nerve	75.55 (±29.28)		54.10 (±20.46)				19.34 (±15.85)	
Median nerve	61.85 (±22.06)		44.43 (±19.92)				21.25 (±12.09)	
Combined median and ulnar nerve	59.63 (±19.04)	0.13	29.25 (±12.18)	0.00 √	NA	0.00** √	35.28 (±21.61)	0.08
Digital nerve	66.78 (±21.85)		74.09 (±21.69)				23.08 (±23.24)	
Fracture/ dislocation	53.64 (±8.63)		69.00 (±30.64)				13.56 (±9.62)	
Pulley	71.89 (±0.66)		88.00 (±1.41)				0.00 (±0.00)	
Nil	50.98 (±26.26)		68.52 (±24.90)				15.75 (±15.45)	
Language Barrier								
Yes	52.28 (±22.60)	0.57	39.13 (±17.27)	0.03 √	NA	0.27**	39.91 (±24.21)	0.00 √
No	62.17 (±24.87)		63.55 (±23.68)				16.38 (±13.38)	
Slight	63.49 (±26.99)		60.50 (±30.01)				17.08 (±16.40)	

Test used: No star – ANOVA; ** Kruskal-Wallis test (no Bonferroni calculation done)

√ Significant

Table 4.14 shows that ROM at six months is significantly associated with age and zone of injury. Participants aged 50 and older or who had an injury in zone IV of their hand were more likely to have decreased ROM when compared to other age categories and zones. Power grip is significantly associated with zone of injury, number of digits injured, associated injury and presence of a language barrier. Participants who had an injury in zone IV, a combined median and ulnar nerve injury or were unable to speak English were more likely to have decreased power grip, while those with injury to the thumb or a single digit injury were more likely to have increased power grip. Pinch grip is significantly associated with zone of injury and associated injury. No Bonferroni calculation was done for pinch grip, therefore the group most likely to be different cannot be determined. Quick DASH score is significantly associated with zone of injury and presence of a language barrier. Participants who had an injury in zone IV or who were unable to speak English were more likely to score higher on the Quick DASH, indicating higher levels of disability. Although the zone I category has the highest Quick DASH score, there was only one participant in this category, and when one takes into consideration the standard deviation and the fact that there were three participants in the zone IV category, it can be concluded that participants with zone IV injury averaged higher scores on Quick DASH.

The factors found to be significantly correlated to and/or associated with each outcome variable were used in the regression analysis. Regression analysis was done using multiple linear regression, shown in Tables 4.15 – 4.18.

Table 4.15: Multiple Regression – ROM

ROM	Coefficient	Standard Error	t	P > I t I	95% Confidence Interval	
Age	-0.70	0.27	-2.61	0.01*	-1.25	-0.16
Zone of Injury (Base category: Zone I)						
II	-0.93	21.83	-0.04	0.97	-44.73	42.88
III	6.65	22.84	0.29	0.77	-39.19	52.48
IV	-35.92	25.25	-1.42	0.16	-86.58	14.75
V	4.96	22.47	0.22	0.83	-40.14	50.05
Thumb	-14.86	23.03	-0.65	0.52	-61.08	3136
Delay between Injury and Surgery (in days)	-4.83	2.06	-2.34	0.02*	-8.97	-0.70
Number of Digits	1.40	3.17	0.44	0.66	-4.96	7.76
Suture (Base category: 2-strand)						
4-strand	0.66	16.03	0.04	0.97	-31.51	32.84
FDP** 4 strand, FDS** 2 strand	19.44	2725	0.71	0.48	-35.24	74.13
FDP** only	-15.09	19.69	-0.77	0.45	-54.60	24.41
Not recorded	9.96	15.87	0.63	0.53	-21.88	41.81

R-squared = 0.41; Adjusted R-squared = 0.28

* - significant

** - FDP: flexor digitorum profundus; FDS: flexor digitorum superficialis

Table 4.15 shows that for each year decrease in age there is a 0.7° increase in ROM (p=0.01). For every day earlier that the participant was operated on post-injury, there is a 4.83° increase in ROM (p=0.02).

Table 4.16: Multiple Regression – Power Grip

Power Grip	Coefficient	Standard Error	t	P > I t I	95% Confidence Interval	
Age	-0.62	0.23	-2.64	0.01*	-1.09	-0.15
Zone of Injury (Base category: Zone I)						
II	4.62	19.04	0.24	0.81	-33.58	42.81
III	-7.27	19.56	-0.37	0.71	-46.52	31.99
IV	-30.20	23.22	-1.30	0.20	-76.80	16.41
V	2.88	22.28	0.13	0.90	-41.83	47.60
Thumb	21.14	19.82	1.07	0.29	-18.64	60.92
Associated Injury (Base category: Nil injury)						
Median nerve	-8.01	11.82	-0.68	0.50	-31.72	15.70
Ulnar nerve	-23.91	12.78	-1.87	0.07	-49.56	1.75
Combined median and ulnar nerve	-33.86	14.44	-2.34	0.02*	-62.85	-4.89
Digital nerve	5.74	7.00	0.82	0.42	-8.31	19.79
Fracture/ dislocation	6.55	11.92	0.55	0.59	-17.37	30.46
Pulley injury	14.58	13.54	1.08	0.29	-12.59	41.74

R-squared = 0.57; Adjusted R-squared = 0.47
* - significant

Table 4.16 shows that for each year decrease in age there is a 0.62kg increase in power grip (p=0.01). A participant with a combined median and ulnar nerve injury is 34 times more likely to have decreased power grip strength when compared to those with no associated injury (p=0.02).

Table 4.17: Multiple Regression – Pinch Grip

Pinch Grip	Coefficient	Standard Error	t	P > I t I	95% Confidence Interval	
Age	-0.73	0.45	-1.64	0.11	-1.63	0.16
Zone of Injury (Base category: Zone I)						
II	12.10	36.09	0.34	0.74	-60.47	84.67
III	-1.24	36.73	-0.03	0.97	-75.09	72.60
IV	2.85	43.55	0.07	0.95	-84.72	90.42
V	42.70	41.92	1.02	0.31	-41.59	126.99
Thumb	33.06	37.27	0.89	0.38	-41.87	108.00
Associated Injury (Base category: Nil injury)						
Median nerve	-32.83	22.10	-1.49	0.14	-77.27	11.61
Ulnar nerve	-57.94	24.13	-2.40	0.02*	-106.46	-9.42
Combined median and ulnar nerve	-75.84	27.53	-2.75	0.01*	-131.21	-20.48
Digital nerve	21.80	13.67	1.60	0.12	-5.68	49.27
Fracture/ dislocation	26.43	24.45	1.08	0.29	-22.73	75.59
Pulley injury	17.87	25.74	0.69	0.49	-33.90	69.63
Mechanism of Injury (Base category: Sharp injury)						
Tearing	-41.86	24.68	-1.70	0.10	-91.48	7.77
OT Protocol** (Base category: Passive motion protocol)						
CAM**	48.63	22.95	2.12	0.04*	2.49	94.77
EAM**	14.95	25.78	0.58	0.57	-36.89	66.79
Did not receive OT	-18.75	36.10	-0.52	0.61	-91.33	53.83

R-squared = 0.52; Adjusted R-squared = 0.36
* - significant
** - OT: occupational therapy; CAM : controlled active motion; EAM: early active motion

Table 4.17 indicates that participants with an ulnar nerve injury or with combined median and ulnar nerve injury were 58 times (p=0.02) and 76 times (p=0.01) more likely to have decreased pinch grip strength respectively. Participants who were treated using a CAM protocol were 49 times more likely to have increased pinch grip strength when compared to those treated with a passive motion protocol (p=0.04).

Table 4.18: Multiple Regression – Quick DASH

Quick DASH	Coefficient	Standard Error	t	P > I t I	95% Confidence Interval	
Zone of Injury (Base category: Zone I)						
II	-41.70	14.90	-2.80	0.01*	-71.54	-11.86
III	-36.86	15.31	-2.41	0.02*	-67.51	-6.21
IV	-22.85	17.23	-1.33	0.19	-57.34	11.65
V	-37.57	14.63	-2.53	0.01*	-67.28	-7.87
Thumb	-41.26	15.53	-2.66	0.01*	-72.36	-10.15
Language Barrier (Base category: Yes)						
No	-20.29	6.03	-3.36	0.00*	-32.37	-8.21
Slight	-19.00	8.27	-2.30	0.03*	-35.57	-2.42

R-squared = 0.34; Adjusted R-squared = 0.26
* - significant

Table 4.18 demonstrates that participants with injuries in all zones, except zone IV, scored lower on the Quick DASH outcome when compared to zone I. Participants who were fluent in English or only encountered a slight language barrier scored 20 times (p=0.00) and 19 times (p=0.03) lower on the Quick DASH respectively when compared to those who could not speak or understand English.

After comparison of the multiple regression results with associations and correlations found previously, the factors found to affect the impairments and functional outcome at six months post FTR are: age, zone of injury, associated injury, delay between injury and surgery, OT protocol used and language barrier.

4.6 Conclusion

From these results it was identified that out of 65 participants, 2% (n=1) had an excellent outcome, 32% (n=21) had a good outcome, 32% (n=21) had a fair outcome and 34% (n=22) had a poor outcome with regards to TAM. At six months post FTR the average power grip was 60% (SD±25, n=65) of the unaffected hand while the average pinch grip was 52% (SD±42, n=65) of the unaffected hand. The average time taken for the JHFT at six months was 74 seconds (SD±33, n=65) for the non-dominant hand and 62 seconds (SD±54, n=65) for the dominant hand. The average score on the Quick DASH questionnaire was 19.34

(SD±16.89) at six months. Of the 41 participants who were employed prior to injury, 71% (n=29) had returned to work by six months post surgery and scored an average of 15.89 (SD±23.74) on the Quick DASH work module. The factors found to significantly affect the impairments and functional outcome at six months post FTR include: age, zone of injury, associated injury, delay between injury and surgery, OT protocol and language barrier. Older age and increased time lapsed between injury and surgery results in decreased ROM. Older age and the presence of a combined median and ulnar nerve injury results in decreased power grip strength. The presence of an ulnar nerve injury or a combined median and ulnar nerve injury results in decreased pinch grip strength, while the use of CAM protocol (as opposed to passive motion protocol) results in increased pinch grip strength. Lastly, the presence of injury in all zones, except zone IV, and the ability to understand English results in lower levels of disability, as measured by Quick DASH scores.

CHAPTER 5

5. DISCUSSION

The aims of this study were to determine the impairments and functional outcomes post FTR and to determine the factors that influence the impairments and functional outcome. In this chapter the participant profile is discussed and results are analysed and discussed under headings that correspond to the objectives of the study.

5.1 Study participants' profile

5.1.1 Demographic information

The majority of the participants were male between the ages of twenty and thirty, which is similar to previous research (Clark, Scott and Anderson, 1985; Angermann and Lohmann, 1993; O'Sullivan and Colville, 1993; De Jong et al., 2014) and is in keeping with the global trend of young males experiencing high rates of injury when compared with other age and gender groups (National Health and Medical Research Council, 1996; Kent, 2010; Sorenson, 2011). This is due to the increased level of risk-taking behaviours (Kent, 2010; Sorenson, 2011), increased exposure to occupations or activities where they may sustain injury (National Health and Medical Research Council, 1996; Sorenson, 2011) and increased alcohol consumption when compared to women (Wilsnack et al., 2000; Sorenson, 2011).

Almost two-thirds of the participants were employed (63%), with the majority of those employed in light (37.5%) and medium level work (37.5%). Twenty six percent were unemployed, which is similar to South Africa's unemployment rate of 25% (Stats SA, 2015). It is difficult to compare these figures with other flexor tendon research as employment is rarely considered in the assessment of outcomes post FTR.

Twenty nine percent of the participants were smokers. This is the same percentage as Trumble et al.'s (2010) study, and a lot higher than the estimated smoking prevalence in South Africa of 17.6% (Reddy et al., 2015). A possible reason why this study (Reddy et al., 2015) showed an increased prevalence of smoking is that the participants in this sample come from Soweto - an urban population with relatively lower levels of education and income (Mears, 1997), which are risk factors for increased tobacco use (Reddy et al., 2015). Additionally, this sample is mostly made up of males, who are significantly more likely to use tobacco than females (Reddy et al., 2015).

The majority of the participants were able to speak English fluently. The impact of language barriers on functional outcome in the current study is discussed later in the chapter.

5.1.2 Characteristics of the injuries

The injuries sustained by the participants were mostly accidental (43%) or violence-related (37%). The high incidence of violence-related injury may be because South Africa has high levels of interpersonal violence and trauma (Norman et al., 2007). Kaisha and Khainga (2008) determined that 30.3% of injuries seen at Kenyatta National Hospital in Nairobi, Kenya, were due to assaults. Pietrobon (1996) reported that 57% of cases seen by OT at Johannesburg Hospital between 1992 and 1994 were due to assaults, leading to 202 injuries involving the flexor tendons (28% of all injuries treated). Both of these studies can be compared to the current study as they were both conducted in facilities similar to this study's research site. A large difference between this study and Pietrobon's (1996) study is that her study was conducted between 1992 and 1994, a time of major unrest in South Africa, due to political transition, which may account for the higher incidence of violence-related injuries.

There were relatively few work-related injuries (8% of the total sample; 8% of those employed), which is very low compared to De Jong et al. (2014), Kaisha and Khainga (2008) and Beaton, Williams and Moseley (1994) who found occupational injuries accounted for 24.9%, 31.3% and 52.8% of hand injuries seen respectively. Kaisha and Khainga (2008) state that the patterns of injury may reflect the country's socio-economic state and level of development. South Africa and Kenya are similar in their socio-economic state and level of development, therefore one would expect the current study to have a similar rate of occupational injury when comparing to the study by Kaisha and Khainga (2008). A possible reason why this sample has such a low incidence of work-related injuries compared to the previously mentioned studies could be due to potential differences in employment rates between the current study and the others. The previously mentioned studies do not specify the employment rate of their samples, however if the participants were employed at higher rates in De Jong et al. (2014), Kaisha and Khainga (2008) and Beaton, Williams and Moseley's (1994) studies there would be a higher likelihood of their participants sustaining work-related injuries. The current study can, however, be compared to Pietrobon's (1996) study which had a similar unemployment rate (32%) to the current study (26%) and found that injury on duty only accounted for 6% of all hand injuries seen.

Ninety two percent of the participants were injured by sharp objects, such as knives, bottles, window panes and blades. Only 8% of injuries were caused by objects that caused tearing or crushing, such as grinders, saws and a spanner. Starnes, Saunders and Means (2012), De Jong et al. (2014) and Hung et al. (2005) found that sharp injuries accounted for 73%, 68% and 78% of tendon injuries respectively in their studies. All of these are relatively lower percentages than that of the current study. A reason for this could be the high level of violence-related injury in the current study, where the injuring object is most often a knife or a broken bottle, and the low level of work-related injury, where the injuring object is often a saw/grinder or a machine.

The majority of the participants' dominant hand was injured. This is contrary to several studies (Hollis and Watson, 1993; Beaton, Williams and Moseley, 1994; Kaisha and Khainga, 2007) that concluded that there was no difference in likelihood of injury to dominant or non-dominant hands. In a study of 99 patients with varied hand injuries, Kaisha and Khainga (2007) found that tendon injury specifically was sustained in 10 dominant hands and 11 non-dominant hands. Pietrobon's (1996) study was in agreement with the current study, with the dominant hand injured in 65% of cases seen. Beaton, Williams and Moseley (1994) found that the likelihood of the dominant hand being injured increased when the cause of injury was non-accidental (mostly due to fights or intentionally punching a wall or window). A possible reason for an increased likelihood of injury to the dominant hand with non-accidental injuries is that during a fight, or when being attacked, it is more likely that an individual will use their dominant hand with which to fight and/or defend themselves. With the high representation of right-handed participants, as well as increased percentage of violence-related (i.e., non-accidental) injuries in the current study, it, therefore, makes sense that there would be a higher representation of dominant hand injury.

The most commonly injured zones were zones II (29%) and zone V (40%). Studies by De Jong et al. (2014) and Hung et al. (2005) found that zone II was the commonly injured flexor tendon zone, injured in 19.1% and 52% of cases respectively. These studies found that zone V was injured in 6.7% and 17% of cases, which is much lower than that of the current study. Often FTR research does not include injuries in zone V due to the higher likelihood of an associated peripheral nerve injury, which is often an exclusion criterion (Braga-Silva and Kuyven, 2005; Chesney et al., 2011). The lack of associated nerve injury as part of the exclusion criteria in the current study may account for the higher representation of zone V injuries in this sample. It is also more difficult to find information in the literature regarding incidence of injury in zones other than zone II, which is the zone most FTR research focuses on (Howell and Peck, 2013). The fact that the current study did not exclude zone V injuries is a strength of the study, as it aids in broadening the literature regarding zone V injuries.

The number of multiple digit injuries in the current study was much higher at 61.5% than the 25% reported by De Jong et al. (2014) or the 13% reported by Trumble et al. (2010). This may be due to differing causes of injury, with intentional/violence-related injury possibly being more severe (i.e., more digits injured) than accidental/unintentional injury; for example an individual is more likely to sustain a serious injury when defending themselves from being stabbed than when accidentally cutting themselves with a knife. De Jong et al. (2014) reported only 6.4% violence-related cases compared with the 37% in the current study, therefore the injuries in De Jong et al.'s (2014) study may not have been as severe as those in the current study. Another reason could be the exclusion criteria of the Trumble et al. (2010) study, where patients with concomitant fractures, vascular injury or crush injury were excluded. If the patient had the previously-mentioned associated injuries, it can be assumed that the injury was more severe, and therefore more likely to affect more than one digit. By excluding such patients, Trumble et al. (2010) are likely to have a higher percentage of patients with single-digit injury than the current study, where no associated injuries were excluded.

Nerve lacerations were the most commonly associated injury: 17% had a digital nerve laceration, 15% had a median nerve laceration and 21.5% had an ulnar nerve laceration. Vascular injury was the most common secondary associated injury (n=9). Trumble et al. (2010) had a 36% incidence of digital nerve injuries in their sample and Hung et al. (2005) had a 67% incidence. These higher numbers are to be expected as both studies focussed on zone II FTI, where injury to digital nerves occurs. The higher incidence of associated peripheral nerve injuries than other associated injuries in the current study is more than likely due to the high number of zone V injuries sustained by this sample. However, the figures from the current study are not as high as those found by Al-Shanawany et al. (2003) where there was involvement of the median nerve in 25% of cases, the ulnar nerve in 30% of cases and combined median and ulnar nerve injury in 45% (only 6% in the current study) of cases. Most FTR studies over the years (Chow et al., 1988; Tottenham, Wilton-Bennett and Jeffery, 1995; Caulfield et al., 2008; Moriya et al., 2015) have excluded patients with associated injuries making it difficult to compare this research with other flexor tendon research.

5.1.3 Details of surgery undergone by participants

With regard to the time elapsed between injury and surgery, there was a mean delay of 11 days (SD±15, n=65), with most of the participants (57%) undergoing FTR within a week of sustaining their FTI. This compares favourably with Braga-Silva and Kuyven's (2005) study in Brazil, where all of the participants had surgery between day seven and twenty-one post injury. This was due to difficulties with access to specialist hand surgery, which is a factor in the South African healthcare system too. In the developed countries of England (Caulfield et al., 2008), Japan (Moriya et al., 2015) and Iran (Farzad et al., 2014), in specialised hand centres, the majority of patients underwent surgery much sooner. All patients in the study by Caulfield et al. (2008) had surgery on day two post injury. Farzad et al. (2014) only included patients who had undergone surgery within two weeks after sustaining the injury in their study, with 78% of their participants having undergone surgery within 48 hours post injury. In Moriya et al.'s (2015) study, 58% of patients underwent surgery within 24 hours, 48.5% between day two and day twenty-six post injury, and only 4.5% more than 28 days after injury.

Both Tang (2007) and Dy and Daluiski (2014) state that there is no solid evidence regarding the best time to perform tendon repair. Tang (2007) refers to McFarlane, Lamon and Jarvis' (1968) study that stated that direct repair may be possible up to several months post injury, depending on the amount of tendon retraction that has occurred. This is confirmed by the five patients in the current study who had a primary FTR performed despite delays of over one month post injury.

Almost half of the patients (48%) had four-strand repair of both FDP and FDS. Four-strand repairs were done on another 6% of participants, but only the FDP was repaired with four strands. Only 3% of the sample had two-strand repairs. This is in keeping with the move away from the conventional two-strand method toward the most widely accepted four-strand technique (Torrie et al., 2010). There are no present day studies (Trumble et al., 2010; Freuh et al., 2014; Moriya et al., 2015) that would accept less than a four-strand repair into their sample due to the move towards more aggressive, earlier active mobilisation, which requires the strength of more than a two-strand repair.

A concern was the high rate (43%) at which the surgeon did not specify which suture was used in the surgery notes. This hinders rehabilitation – if the therapist does not know which suture was used he/she does not have the option of choosing an active motion protocol for fear of rupturing a weaker repair. In addition, it compromises the current study, and any future research on this sample, as one cannot analyse this aspect of a large proportion of the sample.

5.1.4 Rehabilitation and adherence to therapy

The most commonly used protocol for post-operative rehabilitation was a passive motion protocol, which 88% of patients received. This is consistent with Venter (2012) and Mncube and Puckree (2014) who concluded that therapists working in government settings in South Africa prefer passive motion protocols. A reason for this is that passive motion protocols are favoured when patients are unable to attend therapy sessions regularly (Elliot, 2005, cited in Venter, 2012, p68), as is the case in the current study. In addition, the use of active motion protocols requires a four-strand repair and a patient who is fully able to understand the precautions and is motivated and compliant (Baskies, Tuckman and Paksima, 2008). In the current study the four-strand repair was not always done and/or documented, and there was the presence of language barriers, which would lead therapists to lean toward a more conservative passive motion protocol. This is not in keeping with the rest of the world's move towards more active protocols, which are seen as the gold standard of FTR rehabilitation (Dy and Daluiski, 2014; Howell and Peck, 2013; Torrie et al., 2010), however, this sample still had improvements in impairments and function, as described below. During the study period the OT working in the CHBAH Hands Unit began a trial comparing the conventional passive motion protocol used at CHBAH with an early active motion protocol. Data collection is still ongoing, but the results from her study could change the way patients with FTR are treated at CHBAH. The influence of the OT protocol on functional outcome in the current study is discussed later in the chapter.

The mean adherence to therapy attendance was 91% (SD±13, n=65), with 59% of participants having 100% attendance in the first twelve weeks post FTR. When examining adherence post FTR, most studies (Sanford, Barlow and Lewis, 2008; Kaskutas and Powell, 2013) examine adherence to splint wear, rather than adherence to appointment attendance, making it difficult to compare attendance rate from the current study with other research. Peck et al. (1996) alluded to appointment attendance improving outcomes, but did not present results on the actual percentage of appointments attended by their sample.

A limitation of the results regarding adherence is that only those participants who completed all three assessments were included. These participants can be assumed to be more adherent than those that did not attend all the assessments, which skews the results in favour of increased adherence percentage. The adherence when using n=126 was 81% (SD±20), which is significantly lower than the n=65 adherence of 91%.

The majority (75%) of participants were compliant with splint wear and did not remove their splints by themselves at home within the first four weeks post FTR. These adherence levels are much higher than those by Sanford, Barlow and Lewis. (2008) and Kaskutas and Powell (2013) who found that patients removed their splints by themselves in 67.1% and 59% of cases respectively. One would assume that a possible reason for the higher adherence in the current study is the above-mentioned, inherent adherence of the n=65 sample, however the n=126 sample had a splint-wear compliance of 74.5%. In the Sanford, Barlow and Lewis (2008) study, adherence was examined using an anonymous questionnaire, rather than by asking the patient directly whether they had removed their splint at home, as in the current study. It is possible that participants are more likely to be truthful about their adherence to splint wear when answering questions anonymously rather than face-to-face with a therapist, who they may not want to disappoint, so the slightly lower adherence in Sanford, Barlow and Lewis' (2008) study may be more accurate than the current study. A difference between the current study and the Kaskutas and Powell (2013) study, that may explain the large difference in adherence levels, is the length of time of immobilisation in the splint – in Kaskutas and Powell (2013) the average length of time was 7.2 weeks, with 38% immobilised for longer than six weeks, whereas in the current study it was only four weeks. Kaskutas and Powell (2013) found high levels of adherence in the first two weeks, which decreased over time as participants became more frustrated with being unable to perform ADLs. If adherence decreased over time, the extra 3.2 weeks of immobilisation could account for the lower levels of adherence in Kaskutas and Powell's (2013) sample when compared to this sample.

5.1.5 Completion of therapy

There was a high loss to follow up in the current study, with 53% of total participants defaulting therapy, in spite of every effort to ensure participants returned for therapy and assessments. This is much higher than the non-attendance rate of 33% found by Asvat (2011) at CHBAH out-patient physiotherapy department. This may be due to the fact that Asvat's (2011) study was conducted on new patients, whereas the current study had a longer follow-up period. The main reasons for non-attendance in the study by Asvat (2011) were transport problems (14%) and forgetting about the appointment (13%). In the current study forgetting about the appointment should not have been a factor as the participants were reminded about their appointments via text messages and phoned to reschedule if they missed appointments. Many participants were phoned multiple times in vain. It can be assumed then that the main reason for non-attendance in the current study was due to transport and financial issues, as many participants complained of this when asked to return for an assessment. Transport costs were covered for assessments which were scheduled outside of the participants' usual appointments at the hospital and when a participant complained about being unable to attend an assessment due to financial problems. However, there were still participants who did not attend the appointment, despite being told that their transport costs would be covered.

When looking at outcome of treatment for n=65, only 17% defaulted treatment, again demonstrating the bias created by inherently more adherent participants that was mentioned above. All the participants defaulted therapy after six months (or more) post-surgery.

For those participants that were discharged (n=34; 52%), the mean number of physiotherapy treatments received was 7 (SD±2; n=34). At discharge, the mean number of months post surgery was 8 (SD±2, n=34). One would expect a higher number of mean treatments given the long mean post surgery period in this sample, however, due to difficulties with transport and finances, patients cannot be booked for therapy as often as one might be able to in developed countries. For example, Peck et al (1996), in Manchester, United Kingdom, booked patients twice weekly for 1-4 weeks post surgery and once weekly for 5-12 weeks. At CHBAH patients are booked every two weeks from weeks 5-12. The long period post surgery for which participants were seen is also a concern. The aim in FTR rehabilitation is to have patients return to normal activity by twelve weeks post surgery.

5.1.6 Post-operative complications and reoperation

A high number (68%) of participants experienced complications post FTR. This is much higher than the rate quoted by Dy et al. (2012) of 4% rupture and 4% adhesions, and the rate quoted by Tang (2005) of 4-10% rupture and 10% adhesions. The rupture rate of 6% in the current study is equivalent to the rate of 4-

6% consistently quoted in the literature (Torrie et al., 2010), however, the adhesion rate of 25% is much higher than that found in other literature (Tang, 2005). The higher adhesion rate is likely due to the passive motion protocol currently used at CHBAH, owing to the fact that in passive motion protocols there is a higher risk of decreased ROM and adhesions (Dy et al., 2012; Lutsky, Giang and Matzon, 2015; Trumble et al., 2010; Starr et al., 2013).

Despite the high number of complications in this sample, only 17% (n=11) of participants underwent further surgery. This is higher than the reoperation rate quoted by Dy et al. (2012) of 6%, but is low compared to the number of participants who experienced complications. This could be due to patient factors (not wanting to undergo further surgery, for example) or hospital/surgeon factors (due to the high number of emergency cases at CHBAH there may have been limited time for what would be seen as an elective surgery), however the exact reasons for this were not established in the current study.

5.2 Range of motion

The median Range of Motion (ROM) (n=65) in terms of Total Active Movement (TAM) was 21% at one month, 57% at three months and 65% at six months. There was a significant improvement in ROM from one to three months ($p<0.001$) and from three to six months ($p<0.001$). May and Silfverskiöld (1993, as cited in Libberecht et al., 2006 and Hung et al., 2005) found that, with rehabilitation, post-FTR ROM improves for the first six months, as is shown in this sample, and only reaches a plateau at around one year post repair. This is a limitation of the current study as the follow up period was only six months, so participants had not reached a steady state and could still have improved after their final assessment.

At six months post FTR the results according to TAM classification are a far cry from the 75% good or excellent outcomes reported by Tang (2005) and the over 80% good or excellent outcomes stated by Strickland (2000), with only a third (34%) of this sample achieving good or excellent TAM. However, the results that Tang (2005) and Strickland (2000) are referring to come out of specialised hand centres in developed countries, which implement the latest surgical techniques and practice early active motion protocols. Bal et al. (2010) and Freuh et al. (2014) investigated outcomes after use of passive motion protocols and found that only 52% (Bal et al., 2010) and 53% (Freuh et al., 2014) of digits achieved good or excellent TAM respectively. These results are less than those cited by Tang (2005) and Strickland (2000), but are still much higher than the TAM achieved by this sample. Both these studies (Bal et al., 2010 and Freuh et al., 2014) followed a very similar rehabilitation protocol to the one used in the current study – a dorsal blocking splint was applied post-operatively, a home exercise programme of passive motion exercises to be done ten times hourly was given and the patients were followed up weekly in the first month and every two weeks from the second month. There are many possible reasons for the differences in TAM despite following similar rehabilitation protocols including: differing follow-up periods – Bal et al. (2010) followed up at a mean of 72 months post-FTR which could account for the higher TAM as their participants had a much longer period in which to recover; differing complication rates – in the current study the adhesion rate was 25%, much higher than the rate of 15% in Freuh et al. (2014), meaning participants in this sample are more likely to have reduced ROM secondary to the presence of adhesions; differing ways of calculating TAM – in Bal et al. (2010) and Freuh et al. (2014) they assumed TAM to be equal to 260° and 270° respectively, instead of comparing the TAM with the contralateral hand which could influence the results; and differing zones of injury – Bal et al. (2010) only looked at zones II and V, while Freuh et al. (2014) only looked at zones I and II.

5.3 Power and pinch grip strength

The median power and pinch grip percentage of the unaffected hand were 41% and 29% at three months and 62% and 54% at six months respectively. There was a significant improvement in strength for power grip and pinch grip from three to six months. Like ROM, grip strength also improves for the first six months and reaches a steady state at one year post FTR, as described by May and Sifverskiöld (1993, cited in Hung, 2005 and Libberecht et al., 2006).

For power grip strength, Kitis, Buker and Kara's (2009) findings were a mean of 85% of the unaffected hand at twelve weeks post FTR, much higher than this sample's 62% at six months post FTR, but their study (Kitis, Buker and Kara, 2009) only looked at zone II injuries, where median or ulnar nerve injuries were not a factor that could affect the grip strength. Bal et al. (2010) found a mean of 62% (71% in zone II and 53% in zone V) of the unaffected hand with a median follow-up period of 72 weeks, an identical result to the current study, and they included patients with peripheral nerve injury.

The pinch grip result of 54% is relatively lower than the average of 76% found in Gault (1987), Deniz et al. (2000) and Libberecht et al.'s (2006) studies. All three studies did not exclude nerve injuries, so can be compared to the current study, however the average follow-up period in these three studies was 30 weeks, slightly longer than the current study, which could account for the greater improvement in pinch grip in their studies.

There was a variation in strength according to hand dominance, with the right hand dominant participants averaging 18% higher in power grip and 11% higher in pinch grip than the left hand dominant participants at six months post FTR. When one considers the 10% rule, (where strength of the dominant hand is 10% more than that of the non-dominant hand, especially for right hand dominant people) (Libberecht et al., 2006), this variation is lessened.

5.4 Hand function at activity and participation levels

The JHFT and Quick DASH were the measures chosen to assess hand function in the current study. The JHFT measures activity, while the Quick DASH measures activity and participation.

Trumble et al. (2010) used the JHFT as one of their outcome measures post FTR in a study comparing active and passive motion and found that the JHFT did not show a significant difference between the two groups despite there being a significant difference in ROM and patient satisfaction. They did not report the actual times taken by the participants to perform the JHFT, making it impossible to compare the current study's results with theirs. Other ways to interpret the results, besides comparing the current study to other literature, are by comparing the results of the current study with established norms and by establishing the significance of the improvement in time taken to perform the JHFT.

Female participants were significantly slower stacking checkers with both dominant and non-dominant hands, picking up small objects with the non-dominant hand and writing with the dominant hand, but significantly faster at picking up light objects with the non-dominant hand than the population studied by Govender (2008). On the other hand, male participants were significantly slower at writing and picking up small objects with both dominant and non-dominant hands and at stacking checkers with the non-dominant hand, but significantly faster at turning cards and picking up light objects with the non-dominant hand.

When compared with the original norms that Jebsen et al. (1969) established during development of the JHFT, it was found that female participants in the current study were significantly slower in writing with the dominant hand, picking up small objects with the non-dominant hand and stacking checkers with both the dominant and non-dominant hand. Male participants were significantly slower at writing, turning cards and picking up small objects with both dominant and non-dominant hands, stacking checkers and picking up heavy objects with the non-dominant hand and picking up light objects with the dominant hand.

Writing and stacking checkers showed the most significant differences from the norms, across both dominant and non-dominant hands and male and female participants. A reason for this could be that, like many South Africans, hand writing may not be a commonly performed activity by the participants from this sample (Govender, 2008). For the stacking of checkers subtest, it has been acknowledged that this does not replicate any activity of daily living (ADL) and was considered by Jebsen et al. (1969) to be the least functional of all the subtests (Govender, 2008).

Female participants' times deviated from the South African norms in 5/14 subtests and from the JHFT norms in 4/14 subtests. Male participants deviated from the South African norms in 7/14 subtests and from the JHFT norms in 9/14 subtests. From the above one can deduce that the majority of female participants and just under half of male participants in this sample fell within the times achieved by healthy subjects for the JHFT.

Govender (2008) found that the norms established by Jebsen et al. (1969) were significantly different from the ones determined in her sample and suggests that rather than comparing JHFT scores with norm references one should compare the JHFT times achieved by the patient over time. Statistically there was a significant improvement ($p<0.001$) in JHFT times from three to six months, however, the minimal clinically important difference (MCID) for the JHFT is yet to be established and, therefore, there is no value with which to compare this improvement to ascertain whether this was a clinically important change.

With the Quick DASH scores, the improvement was also statistically significant ($p<0.001$) however, the change of 6.81% is less than the MCID of eight percentage points, meaning that the change is unlikely to be of clinical importance to the participant(s). Normative values have been established for the DASH questionnaire, but not for the Quick DASH. Hunsaker et al. (2002), in a large survey of the general American population, determined that the general population would score 10.1 (SD±14.68) on the DASH. Aasheim and Finsen (2014) found the mean DASH score for the Norwegian population they studied to be 13 and found that the mean Quick DASH scores were similar to the DASH scores. If we assume, based on Aasheim and Finsen's (2014) statement that one can compare DASH and Quick DASH scores, the mean Quick DASH score of 19.34 (SD±16.89) in this sample is much higher than the previously mentioned norms indicating a higher level of disability in this sample when compared to the general population.

Many FTR studies use the DASH rather than the Quick DASH as an outcome measure (Baer et al., 2003; Klein, 2003; Libberecht et al., 2006) and found much lower mean scores than this sample with DASH scores of 5.4, 7.82 and 8.5 respectively. Bal et al. (2010) used the Quick DASH and found a mean score of 24.2 (SD±20.1) in zone V and 21.4 (SD±18) in zone II at a median of 72 weeks post FTR. These scores are slightly higher than the mean of 19.34 (SD±16.89) in this sample, indicating that the participants in the current study experienced lower levels of disability, with a shorter follow-up period, than those in Bal et al.'s (2010) study. The current study and Bal et al.'s (2010) study were similar in the rehabilitation protocol used and the fact that peripheral nerve injuries were not considered an exclusion criterion. It is difficult to identify why there is a difference in Quick DASH score between the two studies especially when considering that the participants in the Bal et al. (2010) study achieved greater ROM and the same grip strength as those in the current study, but still experienced higher levels of disability. What this discrepancy does demonstrate is that an improvement in impairments, such as ROM and strength, does not necessarily translate into an improvement in functional ability.

Return to work (RTW) is another measure of participation, and is an important measure of participation in the current study. Sixty eight percent of participants who were employed prior to their injury returned to work by three months post-surgery. An additional five participants (12% of the employed participants) returned to work by six months post-surgery. There were, however, four participants (10% of the employed participants) who RTW by three months, but were no longer working at six months. Reasons for this included: unable to perform the job due to hand injury (n=2) (both reported high rates of disability at three month Quick DASH work module assessment), terminated due to hand condition (n=1) and resigned from her job voluntarily (n=1) in order to further her studies.

There has been much research in RTW and the factors that affect RTW in hand injured patients (Bruyns et al., 2003; Gustafsson and Ahlstrom, 2004; Wong, 2008; Opsteegh et al., 2009), however, one has to look at these studies individually due to inconsistent methods of investigating RTW. These methods include: purely looking at whether the patient returned to work within a year post injury (Bruyns et al., 2003), analysing actual time off work in weeks (Wong, 2008), as well as the use of subjective questionnaires (Gustafsson and Ahlstrom, 2004). Bruyns et al. (2003) looked at patients with median and ulnar nerve injuries and found that 59% had RTW within one year, with an average time off work of 31.3 weeks. The RTW in this sample is higher at six months (71%) than Bruyns et al. (2003), even though this sample contains a fair number of participants with median and/or ulnar nerve injuries. Gustaffson and Ahlstrom (2004) had 27 out of 91 participants with injuries to the flexor tendons and found that 59% had RTW within three months, 25% returned from three months to one year post injury and 16% were still off work at one year post injury. This sample shows a higher rate of RTW at three months (68%), however, it was stated by Gustaffson and Ahlstrom (2004) that the patients with FTI experienced shorter time off work than other injuries, e.g., amputation, so the RTW rate for patients with FTI may be greater than the average of 59% for all patients. Wong (2008) found a high rate of RTW, with 88% having RTW at follow-up, however, it is stated that almost half of the sample had sedentary or light jobs and the severity of injury in their sample was relatively mild. Patients with FTI in this sample spent an average of 6.8 weeks off work, longer than soft tissue injury (2.1 weeks) simple lacerations (4.5 weeks) and finger fractures (6.3 weeks), but longer than distal radius fractures (12.4 weeks) and severe crush injury/amputation (16.2 weeks). The current study did not assess exact amount of time off work, which is a limitation when trying to compare the current study to other research, where time off work is the primary outcome measure. Opsteegh et al. (2009) found that 48% of participants returned to work by ten weeks post injury, and considered this early RTW. The rest of the participants were considered late RTW, and eight patients only returned after a year and four had not resumed work within two years. This sample, again, has a higher rate of RTW.

A couple of factors that have been found to affect RTW after hand injury include severity of injury (Wong, 2008; Opsteegh, 2009) and job demands (Bruyns et al., 2003; Wong, 2008). The relationship between severity of injury and RTW was not established in the current study, however, the job demands of those who did not RTW were considered. Most participants who did not RTW were previously employed in medium level work (67% at three months; 50% at six months). There were a low number of employed participants who were employed in sedentary (10%) and heavy (17%) work to begin with, therefore one wouldn't expect high numbers of these in the sample of those who had not returned to work. On the other hand, there were an equal number of light (36.5%) and medium (36.5%) level workers to begin with, indicating that RTW is favoured by those with light jobs, as one would expect.

5.5 Factors affecting the impairments and functional outcome at six months post FTR

The factors that significantly affect the impairments and functional outcome at six months post FTR include: age, zone of injury, associated injury, delay between injury and surgery, OT protocol used and language barrier.

In the current study, increasing age lead to decreasing ROM and power grip strength. In particular, participants aged fifty and over were more likely to have decreased ROM when compared to other age groups. These findings are similar to those of Stone, Spencer and Almquist (1989) and Freuh et al. (2014), both of which found that older age is associated with decreased ROM post FTR. This is explained by the deterioration of tendon quality with advancing age (Goodman and Choueka, 2005), which makes tendon repairs more prone to poor outcomes.

The zone of injury was significantly associated with ROM, strength and functional outcome at six months post FTR – injury in zone IV was associated with worse ROM and power grip and worse scores on the Quick DASH, indicating higher levels of disability, while injury to the thumb alone was associated with higher power grip strength than injuries to zone I-V. Although zone IV injuries can be complicated due to their proximity to the carpal tunnel (Griffin et al., 2012), the fact that zone IV injuries had the worst outcome in the current study was unexpected. One would assume that either zone II injuries, which are notorious for poor results (Starnes, Saunders and Means, 2012; Hung et al., 2005), or zone V injuries, in which there are more likely to be multiple digit injuries and associated peripheral nerve injury, would have the worst results. In this sample, two out of the three participants who were injured in zone IV had associated peripheral nerve injury – one had a median nerve injury and the other had a combined median and ulnar nerve injury – injury to nerves affects ROM, strength, sensibility and hand function (Al-Shanaway et al., 2003; Lundborg and Rosen, 2007), which could be a possible reason for the worse outcomes. All three of the participants had complications relating to decreased ROM – one had contracture, the other two had tenodesis/adhesions – which may have affected the strength and functional outcome. Higher power grip strength in isolated thumb injury was to be expected as the testing procedure with the Jamar dynamometer involves squeezing mostly with the fingers, with minimal involvement of the thumb. Additionally, isolated thumb injury is less likely to be associated with multiple tendon involvement and peripheral nerve injury, which significantly affects the final outcome of grip strength (Al-Shanaway et al., 2003).

In the multiple regression, participants with zone II, III, V and thumb injuries scored lower on the Quick DASH. This was unexpected as one would expect that a participant with only one tendon injury (as is usually the case in zone I injury) would experience lower levels of disability than those with multiple tendon injuries (as is usually the case in the other zones). An explanation for this is that there was only one participant with a zone I injury who scored very highly on the Quick DASH outcome measure, therefore comparing the other zones to this zone may be unreliable. The participant who had high scores on the Quick DASH at six months sustained a fracture of his “unaffected” upper limb (i.e., the hand without the FTR) during the study period, which may have contributed to higher levels of disability.

Associated injury was found to affect both the power and pinch grip strength at six months post FTR, a similar finding to Trumble et al. (2010), Dy et al. (2012) and Starnes, Saunders and Means (2012), who found that in the presence of an associated bony or neurovascular injury, results are poorer. A combined median and ulnar nerve injury was the associated injury to cause the greatest loss of power and pinch grip strength, while ulnar nerve injury also resulted in decreased pinch grip strength. This makes sense as the median and ulnar nerves innervate all the flexors in the forearm and hand, so laceration of both nerves would greatly affect grip strength in the hand. The ulnar nerve supplies the adductor pollicis muscle which is essential for pinch grip strength (Warwick et al., 2009). Another reason associated injury could affect the outcome of grip strength is that more severe injuries, involving multiple structures, could require a period of immobilisation before active rehabilitation can commence (Freuh et al., 2014). This delay in active mobilisation could lead to development of adhesions and stiffness which may be difficult to overcome once active ROM starts.

The delay between injury and surgery had a significant effect on ROM. None of the specific categories stood out from the others as being different, but an increased delay resulted in decreased ROM. This makes sense in that the sooner the patient is operated on the better the outcomes, due to the fact that as time progresses the proximal tendon retracts (Elliot, 2005), making primary repair more complicated or even impossible (Griffin et al., 2012).

Torrie et al. (2010) found that outcomes were improved if patients underwent surgery within seven days of sustaining a FTI. Additionally, unless patients receive pre-operative hand therapy, the lack of movement of the affected digit(s) could lead to stiffness pre-operatively, which could affect the ROM at a later stage.

The OT protocol used affects the pinch grip strength at six months post FTR – the use of the CAM protocol resulted in a higher pinch grip than the use of the passive motion protocol. This is similar to most studies which favour active motion over passive motion protocols (Dy et al., 2012; Lutsky, Giang and Matzon, 2015; Trumble et al., 2010). It is, however, unclear why only pinch grip is affected by OT protocol and not the other outcome variables, and also why only CAM, and not EAM, lead to improved pinch grip.

The final factor that was found to affect the outcome post FTR is the presence of a language barrier. A possible reason why a language barrier affects the outcome is if the participants are able to communicate effectively with the health professionals treating them, they should be able to understand the strict instructions and the importance of rehabilitation post FTR. If the participant understands both of these they would be less likely to unintentionally be non-adherent (Torrie et al., 2010) with splint wear and the home exercise programme, and hopefully more likely to attend therapy sessions, all of which are important to the functional outcome post FTR. Participant inability to understand English was associated with decreased power grip strength and predictive of higher Quick DASH scores than those who could speak English fluently or where there was only a slight language barrier. It is unclear why power grip, and not ROM and pinch grip, was affected by the presence of a language barrier. With regards to the Quick DASH score, it makes sense that a language barrier may have had an influence as the instrument was administered in an interview format, with untrained translators. Owing to this, the participants who could not speak English may have understood the questions differently from those who had a grasp of the English language. It is difficult to compare this result with other studies due to a lack of research regarding language barriers in FTR. This lack of research is likely due to the fact that most FTR research is done in developed countries where the medical staff speaks the same language as the patients, so language barriers are not generally an issue that is considered post FTR.

CHAPTER 6

6. CONCLUSION

6.1 Conclusion

Demographically, the majority of participants in the current study participants were young males, were employed, were non-smokers and were able to speak English fluently. The injuries sustained by participants were mostly accidental or violence-related, caused by a sharp object, and affecting the dominant hand. The most commonly injured zones were zone II and V, with nerve lacerations being the most common associated injury and a relatively high number of multiple digit injuries. Most participants underwent FTR within a week of sustaining their FTI and had a four-strand repair performed. Post-operatively, the passive motion protocol was the most commonly used OT protocol and the majority of participants in this sample were compliant with therapy attendance and splint wear. A high number of participants experienced post-operative complications, however, only 17% underwent further surgery.

At six months post FTR the participants in this sample did not consistently achieve the good or excellent ROM outcomes achieved by patients in developed countries with approximately one-third having good or excellent results, one-third fair results and one-third poor results. In addition, these participants experienced high levels of post-operative complications, especially adhesions.

The participants regained a fair amount of power grip strength relative to their unaffected hand, but their pinch grip did not recover as well, only regaining just over half their pinch grip strength relative to the unaffected hand.

In spite of the impairments in ROM and strength still present at six months post FTR, the results of assessment of hand function at activity and participation levels (JHFT and Quick DASH) were promising, with participants in the current study showing only slightly higher levels of disability than those in healthy individuals. A further positive result was that there was a good rate of return to work amongst those employed prior to their injury. Participants improved significantly from baseline to six months post FTR in all aspects – impairment, activity and participation.

The factors found to significantly affect the impairments and functional outcome at six months post FTR include: age, zone of injury, associated injury, delay between injury and surgery, OT protocol used and language barrier.

6.2 Limitations of the study

The primary limitation of the study is the small size of the sample and high dropout rate, both of which affect the reliability of the analyses and make it difficult to generalise the results.

Secondly, the follow-up period of six months may have meant that participants had not achieved their final functional outcome, which may have been more accurately assessed if the follow up had been one year.

Lastly, the high rate at which the surgeon did not specify which suture was used is a limitation. This is due to the fact that the researcher was unable to analyse this aspect of a large proportion of the sample.

6.3 Recommendations

6.3.1 Research

More research needs to be conducted regarding the outcome of FTR in South Africa. Further research should preferably have a larger sample size and a follow-up period of at least one year.

In addition, translation of the Quick DASH into commonly spoken languages in South Africa, such as Sotho and Zulu, would also be a worthwhile undertaking.

6.3.2 Interventions

Using the information from the current study patients could be informed on their prognosis based on age, zone of injury, associated injury, delay between injury and surgery, OT protocol used and language barrier. The age, zone of injury and associated injury factors are out of the control of the MDT, however the MDT can have an influence on the delay between injury and surgery, OT protocol used and presence of a language barrier factors. With regards to delay between injury and surgery, members of the MDT could advocate for patients being operated on sooner rather than later post FTI. A move towards a more active post-operative rehabilitation protocol, particularly the EAM protocol, would be of benefit for patients. Related to this is the need to emphasise accurate documentation of surgery notes by hand surgeons, so therapists have information about the suture used in order to adhere to the necessary precautions and contraindications. As for the language barrier, the current study indicates the need for a translator to be present for patients who are unable to speak and/or understand the language used by their health care professional.

CHAPTER 7

7. REFERENCES

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CHAPTER 8

8. APPENDICES

Appendix 1

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE
CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 26 September 2013

TITLE OF PROJECT: The functional outcomes of patients post flexor tendon repair of the hand

UNIVERSITY: Witwatersrand

Principal Investigator: Taryn Spark

Department: Physiotherapy

Supervisor (If relevant): V Ntsiea

Permission Head Department (where research conducted): Yes

Date of start of proposed study: September 2013
Date of completion of data collection: December 2016

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Hospital. The CEO /management of Chris Hani Baragwanath Hospital is accordingly informed and the study is subject to:-

- Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.
- the Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- the MAC will be informed of any serious adverse events as soon as they occur
- permission is granted for the duration of the Ethics Committee approval.

Recommended
(On behalf of the MAC)
Date: 26 September 2013

Approved/Not Approved
Hospital Management
Date: 01/10/13

Appendix 2

R14/49 Ms Taryn Jane Spark

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M130748

NAME: (Principal Investigator)	Ms Taryn Jane Spark
DEPARTMENT:	Physiotherapy Faculty of Health Sciences Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	The Functional Outcomes of Patients Post Flexor Tendon Repair of the Hand
DATE CONSIDERED:	26/07/2013
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	V Ntsiea/L Godlwana
APPROVED BY:	Cleatonjones Professor PE Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	04/09/2013

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

Principal Investigator Signature ______________ Date ______________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 3

Research Information Sheet

Title of Study: The Impairments and Functional Outcomes of Patients Post Flexor Tendon Repair of the Hand

Principal Investigator (PI):

Taryn Spark

Chris Hani Baragwanath Academic Hospital Physiotherapy

0825439781

Purpose:

You are being asked to be in a research study of the outcomes after repair of the flexor tendons in the hand because you have undergone a flexor tendon repair surgery. This study is being conducted at Chris Hani Baragwanath Academic Hospital.

Study Procedures:

If you take part in the study, you will be asked to attend assessment sessions at one, three, six and twelve months after your operation. At these assessment sessions you will be asked questions about your injury, your work and how well you can use your hand and the movement and power in your hand will be measured. Each session will take 45 minutes to an hour. All efforts will be made to ensure your assessment session is on the same day as your regular doctor or therapy appointment.

Benefits

As a participant in this research study, there may be no direct benefit for you; however, information from this study may benefit other people now or in the future.

Risks

There are no known risks at this time to participation in this study. You may, however, experience the normal discomfort associated with your injury during the measurement of the movement and power of your hand.

Costs

The study sponsor will pay for all transport costs for assessment sessions attended on days other than your regular doctor or therapy appointment day.

Compensation

- You will receive compensation for your transport costs for any assessments attended out of your regular treatment time.
- You will not have to pay any money towards the study

Confidentiality:

- All information collected about you during the course of this study will be kept without any identifiers.
- You will be identified in the research records by a code name or number.
- Only the researcher, research supervisors and research assistants may see the information collected about you during the course of the study.

Voluntary Participation/Withdrawal:

Taking part in this study is voluntary. You may choose not to take part in this study, or if you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will involve no penalty or loss of benefits.

Questions:

If you have any questions about this study now or in the future, you may contact Taryn Spark at the following phone number 0825439781 or 0119339953.

Alternatively you can contact:

- Veronica Ntsiea on 011 717 3702 or veronica.ntsiea@wits.ac.za
- Lonwabo Godlwana on 011 717 3707 or lonwabo.godlwana@wits.ac.za
- Prof Cleaton Jones (chairman of Wits HREC) on 011 717 2301

Participation:

By completing the consent form you are agreeing to participate in this study.

Appendix 4

Consent to Participate in a Research Study

Title of study: The Impairments and Functional Outcomes of Patients Post Flexor Tendon Repair of the Hand

I ………………………………… (full name and surname) voluntarily agree to take part in this study. I choose to take part in this study knowing that I am at liberty to withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicates that I have read and understood the information sheet or the researcher has explained the entire research information sheet, including the risks and benefits, and have had all of my questions answered.

______________________________ ________________________

Signature of Participant Date

______________________________ ________________________

Printed Name of Participant Time

______________________________ ________________________

Signature of witness (if the participant used X or can't sign)

______________________________ ________________________

Name of witness Date

Appendix 5

Research Information Sheet for Caregivers/Parents

Title of Study: The Impairments and Functional Outcomes of Patients Post Flexor Tendon Repair of the Hand

Principal Investigator (PI):

Taryn Spark

Chris Hani Baragwanath Academic Hospital Physiotherapy

0825439781

Purpose:

I would like to invite your child to participate in a research study of the outcomes after repair of the flexor tendons in the hand because they have undergone a flexor tendon repair surgery. This study is being conducted at Chris Hani Baragwanath Academic Hospital.

Study Procedures:

If your child takes part in the study, they will be asked to attend assessment sessions at one, three, six and twelve months after their operation. At these assessment sessions they will be asked questions about their injury, their school/work and how well they can use their hand. The movement in their hand will be measured using a goniometer, which is an instrument that measures angles, and the strength in their hand will be measured using a dynamometer, which is an instrument that they squeeze that measures the power they can produce. They will also be asked to do a test that measures the time it takes for them to finish doing seven activities, including writing, turning over cards, eating and picking up different objects. Finally they will be asked questions about how well they can use their hand at home and at school/work. Each session will take 45 minutes to an hour. All efforts will be made to ensure their assessment session is on the same day as their regular doctor or therapy appointment.

Benefits

As a participant in this research study, there may be no direct benefit for your child; however, information from this study may benefit other people now or in the future.

Risks

There are no known risks at this time to participation in this study. Your child may, however, experience the normal discomfort associated with their injury during the measurement of the movement and power of your hand.

Costs

The study sponsor will pay for all transport costs for assessment sessions attended on days other than your child's regular doctor or therapy appointment day.

Compensation

- You will receive compensation for your child's transport costs for any assessments attended out of their regular treatment time.
- You or your child will not have to pay any money towards the study

Confidentiality:

- All information collected about your child during the course of this study will be kept without any identifiers.
- Your child will be identified in the research records by a code name or number.
- Only the researcher, research supervisors and research assistants may see the information collected about your child during the course of the study.

Voluntary Participation/Withdrawal:

Taking part in this study is voluntary. You or your child may choose not to take part in this study, or if you, or your child, decide to take part, you can change your mind later and withdraw from the study. You and your child are free to not answer any questions or withdraw at any time. Your decision will involve no penalty or loss of benefits.

Questions:

If you, or your child, have any questions about this study now or in the future, you may contact Taryn Spark at the following phone number 0825439781 or 0119339953.

Alternatively you can contact:

- Veronica Ntsiea on 011 717 3702 or veronica.ntsiea@wits.ac.za
- Lonwabo Godlwana on 011 717 3707 or lonwabo.godlwana@wits.ac.za
- Prof Cleaton Jones (chairman of Wits HREC) on 011 717 2301

Participation:

By completing the consent form you are agreeing to participate in this study.

Appendix 6

Parental Consent for Child to Participate in a Research Study

Title of study: The Impairments and Functional Outcomes of Patients Post Flexor Tendon Repair of the Hand

I ………………………………… (full name and surname), parent of.. (full name and surname), voluntarily agree to allow my child to take part in this study. I choose to allow my child to take part in this study knowing that we are at liberty to withdraw at any time. I am not giving up any of my or my child's legal rights by signing this form. My signature below indicates that my child and I have read and understood the information sheet or the researcher has explained the entire research information sheet, including the risks and benefits, and have had all of our questions answered.

______________________________ ________________________

Signature of Parent Date

______________________________ ________________________

Printed Name of Parent Time

______________________________ ________________________

Signature of witness (if the parent used X or can't sign)

______________________________ ________________________

Name of witness Date

Appendix 7

Research Information Sheet for Participants Aged 14-17

Title of Study: The Impairments and Functional Outcomes of Patients Post Flexor Tendon Repair of the Hand

Principal Investigator (PI):

Taryn Spark

Chris Hani Baragwanath Academic Hospital Physiotherapy

0825439781

Purpose:

I would like to invite you to participate in a research study of the outcomes after repair of the flexor tendons in the hand because you have undergone a flexor tendon repair surgery. This study is being conducted at Chris Hani Baragwanath Academic Hospital.

Study Procedures:

If you take part in the study, you will be asked to attend assessment sessions at one, three, six and twelve months after your operation. At these assessment sessions you will be asked questions about your injury, your work and how well you can use your hand. The movement in your hand will be measured using a goniometer, which is an instrument that measures angles, and the strength in your hand will be measured using a dynamometer, which is an instrument that you squeeze that measures the power you can produce. You will also be asked to do a test that measures the time it takes for you to finish doing seven activities, including writing, turning over cards, eating and picking up different objects. Finally you will be asked questions about how well you can use your hand at home and at work. Each session will take 45 minutes to an hour. All efforts will be made to ensure your assessment session is on the same day as your regular doctor or therapy appointment.

Benefits

As a participant in this research study, there may be no direct benefit for you; however, information from this study may benefit other people now or in the future.

Risks

There are no known risks at this time to participation in this study. You may, however, experience the normal discomfort associated with your injury during the measurement of the movement and power of your hand.

Costs

The study sponsor will pay for all transport costs for assessment sessions attended on days other than your regular doctor or therapy appointment day.

Compensation

- You will receive compensation for your transport costs for any assessments attended out of your regular treatment time.
- You will not have to pay any money towards the study

Confidentiality:

- All information collected about you during the course of this study will be kept without any identifiers.
- You will be identified in the research records by a code name or number.
- Only the researcher, research supervisors and research assistants may see the information collected about you during the course of the study.

Voluntary Participation/Withdrawal:

Taking part in this study is voluntary. You may choose not to take part in this study, or if you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will involve no penalty or loss of benefits.

Questions:

If you have any questions about this study now or in the future, you may contact Taryn Spark at the following phone number 0825439781 or 0119339953.

Alternatively you can contact:

- Veronica Ntsiea on 011 717 3702 or veronica.ntsiea@wits.ac.za
- Lonwabo Godlwana on 011 717 3707 or lonwabo.godlwana@wits.ac.za
- Prof Cleaton Jones (chairman of Wits HREC) on 011 717 2301

Participation:

By completing the assent form you are agreeing to participate in this study.

Appendix 8

Assent to Participate in a Research Study

Title of study: The Impairments and Functional Outcomes of Patients Post Flexor Tendon Repair of the Hand

I ………………………………… (full name and surname) voluntarily agree to take part in this study. I choose to take part in this study knowing that I can withdraw at any time. I am not giving up any of my rights by signing this form. My signature below indicates that I have read and understood the information sheet or the researcher has explained the entire research information sheet, including the risks and benefits, and have had all of my questions answered.

________________________________ ________________________________

Signature of Participant Date

________________________________ ________________________________

Printed Name of Participant Time

________________________________ ________________________________

Signature of witness (if the participant used X or can't sign)

________________________________ ________________________________

Name of witness Date

Appendix 9

Power and Pinch Grip Strength Norms

(Massy-Westropp et al., 2011; n=1366 males/1312 females)

Table 1 Mean and Standard Deviation and Hand Grip Strength in kilograms, for men and women, presented in ascending age groups

Men				Women			
Age	right	left	BMI	Age	right	left	BMI
20 to 29	47(9.5)	45(8.8)	26.4(5.1)	20 to 29	30(7)	28(6.1)	25.1(5.8)
30 to 39	47(9.7)	47(9.8)	28.3(5.2)	30 to 39	31(6.4)	29(6)	27.3(6.8)
40 to 49	47(9.5)	45(9.3)	28.4(4.6)	40 to 49	29(5.7)	28(5.7)	27.7(7.7)
50 to 59	45(8.4)	43(8.3)	28.7(4.3)	50 to 59	28(6.3)	26(5.7)	29.1(6.4)
60 to 69	40(8.3)	38(8)	28.6(4.4)	60 to 69	24(5.3)	23(5)	28.1(5.1)
70 +	33(7.8)	32(7.5)	27.2(3.9)	70 +	20(5.8)	19(5.5)	27(4.7)

ADULT PINCH AND GRIP STRENGTH
(Mathiowitz, USA, 1985)

WOMEN

AGE	HAND	MEAN (KG)
20-24	Right	32.00
	Left	27.70
25-29	Right	33.86
	Left	28.86
30-34	Right	35.77
	Left	30.90
35-39	Right	33.68
	Left	30.13
40-44	Right	32.00
	Left	28.31
45-49	Right	28.27
	Left	25.45
50-54	Right	29.90
	Left	26.04
55-59	Right	26.04
	Left	21.50
60-64	Right	25.04
	Left	20.77

Gripstr(enght)/doc

ADULT PINCH AND GRIP STRENGTH
(Mathiowitz, USA, 1985)

MEN

AGE	HAND	MEAN (KG)
20-24	Right	55.00
	Left	47.50
25-29	Right	54.90
	Left	50.22
30-34	Right	55.36
	Left	50.18
35-39	Right	54.40
	Left	51.31
40-44	Right	53.09
	Left	51.27
45-49	Right	49.95
	Left	45.81
50-54	Right	51.63
	Left	46.31
55-59	Right	45.95
	Left	37.81
60-64	Right	40.77
	Left	34.90

Gripstr(enght)/doc

Appendix 10

Jebsen Test of Hand Function

Developers: The Jebsen Test of Hand Function was developed by Jebsen, Taylor, Treischmann, Trotter and Howard (1969). The test had 7 items. A modified version was recently evaluated by Bovend'Erdt et al., (2004), and included 3 test items (turning over cards, stacking four cones, and spooning 5 kidney beans into a bowl). An Australian version has also been developed and includes the original test items plus a grip strength measurement using the Jamar dynamometer, (8 items in total), (Agnew & Maas, 1982).

Access: Details of the test materials, test procedure, mean times and standard deviations (United States population) are provided in the original publication by the developers (Jebsen, et al., 1969). There is also a detailed description of the construction of the original test and the Australian version (see Agnew and Maas, 1982).

Cost: The test items can be easily compiled by the therapist, based on measurements and descriptions provided in the original publications. It can also be purchased "ready made" through *Westons Home and Medical Equipment Internet Catalogue* at http://www.westons.com/acatalog/index.html
or from Psychtest at http://www.psychtest.com/curr02/CATLG007.HTM. The cost is over AUS$500 plus post and handling from the United States.

Copyright: Jebsen, Taylor, Treischmann, Trotter, & Howard, (1969).

Description: The Jebsen was designed to provide a short, objective test of hand functions commonly used in activities of daily living. The test was developed for health professionals working in restoration of hand function. The test items include a range of fine motor, weighted and non-weighted hand function activities which are timed: (1) writing (copying) a 24-letter sentence, (2) turning over 3 x 5" cards, (3) picking up small common objects such as a paper clip, bottle cap and coin (4) simulated feeding using a teaspoon and five kidney beans, (5) stacking checkers, (6) picking up large light objects (empty tin can) and (7) picking up large heavy objects (full tin can x 1 lb). There is a choice of 4 pre-written sentences for the writing subtest so that a different sentence can be selected for each re-test with the same client.

Administration: The test is conducted according to the instructions published in Jebsen et al. (1969). This original paper includes specific instructions for test construction and administration as well as operational definitions for all items used. The test is therapist administered and timed. No training is required. The non-dominant hand is tested first, then the dominant hand, providing a score for each hand.

Research by Rider et al., (1988) confirmed the need to use the Jebsen strictly as prescribed by the authors, as variation in administration may bias the test results and reduce test validity. That research confirmed a significant difference in performance if plastic checkers (which are more readily available) were used instead of wooden checkers. The Australian norms provided by Agnew and Maas (1982), were based on testing using wooden checkers, as originally intended by Jebsen et al. (1969).

Administration time: The test takes approximately 15 minutes to complete, but can take up to 45 minutes with slower clients.

Scoring and Interpretation:
The time taken to complete each of the tasks is recorded during test administration, thus no separate scoring time is required. Comparison with normative data can take up to 15 minutes.

Normative data are available for males and females in the 20-60 year age range, for both the dominant and non-dominant hand (Jebsen et al., 1969). Hackel and colleagues (1992) provide normative values for people aged 60-90. Percentile norms for the Australian population are provided by Agnew and Maas (1982). Less stable test-retest results have been reported for the subtests of writing and simulated feeding; these subtest results should be interpreted more cautiously (Stern, 1992).

Population Groups: Adults with neurological or musculo-skeletal conditions involving hand disabilities. There is research published for clients with spinal cord injury, mild to moderate stroke, arthritis, acquired neurological disorders. The test has been used with children from 8 years (Mazur, Menelaus, Hudson, & Stillwell, 1986; Noronha, Bundy, & Groll, 1989).

Languages: Available in English only. The Jebsen may be inappropriate for people with speech/language disorders or those from culturally and linguistically diverse communities (CALD), due to the dependency on language for instruction (Hill et al. 2005).

Appendix 11

*Quick*DASH

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Do heavy household chores (e.g., wash walls, floors).	1	2	3	4	5
3. Carry a shopping bag or briefcase.	1	2	3	4	5
4. Wash your back.	1	2	3	4	5
5. Use a knife to cut food.	1	2	3	4	5
6. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
7. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
8. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	1	2	3	4	5

Please rate the severity of the following symptoms in the last week. *(circle number)*	NONE	MILD	MODERATE	SEVERE	EXTREME
9. Arm, shoulder or hand pain.	1	2	3	4	5
10. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
11. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)*	1	2	3	4	5

***Quick*DASH DISABILITY/SYMPTOM SCORE** = $\left(\left[\frac{\text{sum of n responses}}{n}\right] - 1\right) \times 25$, where n is equal to the number of completed responses.

A *Quick*DASH score may not be calculated if there is greater than 1 missing item.

*Quick*DASH

WORK MODULE (OPTIONAL)

The following questions ask about the impact of your arm, shoulder or hand problem on your ability to work (including homemaking if that is your main work role).

Please indicate what your job/work is:________________________________

❐ I do not work. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week.

Did you have any difficulty:	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. using your usual technique for your work?	1	2	3	4	5
2. doing your usual work because of arm, shoulder or hand pain?	1	2	3	4	5
3. doing your work as well as you would like?	1	2	3	4	5
4. spending your usual amount of time doing your work?	1	2	3	4	5

SPORTS/PERFORMING ARTS MODULE (OPTIONAL)

The following questions relate to the impact of your arm, shoulder or hand problem on playing *your musical instrument or sport or both*. If you play more than one sport or instrument (or play both), please answer with respect to that activity which is most important to you.

Please indicate the sport or instrument which is most important to you:________________________________

❐ I do not play a sport or an instrument. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week.

Did you have any difficulty:	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. using your usual technique for playing your instrument or sport?	1	2	3	4	5
2. playing your musical instrument or sport because of arm, shoulder or hand pain?	1	2	3	4	5
3. playing your musical instrument or sport as well as you would like?	1	2	3	4	5
4. spending your usual amount of time practising or playing your instrument or sport?	1	2	3	4	5

SCORING THE OPTIONAL MODULES: Add up assigned values for each response; divide by 4 (number of items); subtract 1; multiply by 25.
An optional module score may <u>not</u> be calculated if there are any missing items.

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Appendix 12

CHBAH Occupational Therapy and Physiotherapy FTR protocols

OT:

Early active mobilisation protocol:

Period post-surgery	Splint	Splint Wearing Schedule	Exercise
Day 1	Dorsal blocking splint Wrist: neutral (0°) MCP joints: 60° flexion IP joints: full extension	Full time wear	Passive PIP and DIP joint flexion, active PIP and DIP joint extension within splint.
Week 1	As above	As above	Active PIP joint flexion to 30°, active PIP joint extension within splint. Synergistic wrist and finger motion during therapy sessions.
Week 2-3	As above	As above	Active PIP joint flexion and extension within splint. Synergistic movement within splint, removing palmar block.
Week 4-6	As above	Night time wear and for protection in busy places	Protected active motion out of splint.
Week 6-8	As above		Isometric strengthening
Week 8-12	N/A	Remove splint	Concentric strengthening

Early passive mobilisation protocol:

Period post-surgery	Splint	Splint Regimen	Exercise
Day 1	Dorsal blocking splint Wrist: 0-10° flexion MCP joints: 60° flexion IP joints: full extension A rubber band traction will be attached to the fingernails.	All time wear	Passive PIP and DIP joint flexion by means of the rubber band traction, active PIP and DIP joint extension. All exercise within splint.
Week 1	As above	As above	
Week 2-3	As above	As above	Passive PIP and DIP joint flexion by means of the rubber band traction, active PIP and DIP joint extension. All exercise within splint. Synergistic wrist and finger mobilisation during therapy sessions.
Week 4-6	As above	Night time wear and for protection in busy places	Protected active mobilisation out of splint.
Week 6-8	As above	As above	Isometric strengthening
Week 8-12	N/A	Remove splint	Concentric strengthening

Physiotherapy:

FLEXOR TENDON INJURY

WEEK 4-6

- Wear your splint at night and in crowded areas
- Continue scar management
- Exercises

  Place and hold exercises – 10 times every hour

Gently move wrist down and up with the fingers in relaxed position. – 10 times every hour

Isolated joint movements – 10 times every hour

Tendon gliding exercises – 10 times every hour

DO……

- Your exercises regularly
- Continue with scar massage

DON'T………

- Do any passive movement/Push fingers backwards. Injury is still prone to rupture.
- Grip anything hard e.g. tap, opening of fridge door.
- Do any resisted activities
- Lift anything heavier than ½ kg (half a pack of sugar)
- You may use your hand for very light activities only.

EXAMPLES OF ACTIVITIES

- Dressing, not zips/shoelaces
- Use cutlery, don't use knife in affected hand
- Folding clothes
- Playing cards
- Writing for short periods
- Marbles
- Board games involving gentle pinch e.g. draughts
- Turning pages of newspaper or magazine
- Holding small glass of colddrink/teacup
- Jigsaw puzzles

Appendix 13

The impairments and functional outcomes of patients post flexor tendon repair of the hand

<u>Subjective Assessment</u>

Participant Number _____

Section A: Demographic Information

Age ______

Gender

☐ Male ☐ Female

Employment Status

☐ Unemployed ☐ Employed _______________________

Hand Dominance

☐ Right ☐ Left ☐ Ambidextrous

Smoker

☐ Yes ☐ No

Section B: Injury

Date of Injury ___________

Mechanism of Injury _______________________

Flexor Zone

☐ I ☐ II ☐ III ☐ IV ☐ V

Tendons Injured

☐ Index Finger FDS ☐ Middle Finger FDS ☐ Ring Finger FDS ☐ Little Finger FDS

☐ Index Finger FDP ☐ Middle Finger FDP ☐ Ring Finger FDP ☐ Little Finger FDP

☐ Flexor Carpi Ulnaris ☐ Flexor Carpi Radialis

☐ Flexor Pollicis Longus ☐ Palmaris Longus

Associated Injury

☐ Median Nerve ☐ Ulnar Nerve ☐ Digital Nerve

☐ Fracture ______________________ ☐ Vascular ______________________

Section C: Surgery

Date of Surgery ___________

Number of Days between Injury and Surgery _____

Suture Done

☐ Modified Kessler ☐ Four Strand Cruciate

Section D: Rehabilitation

Occupational Therapy Protocol

☐ Passive Motion ☐ Controlled Active Motion

Self-Removal of Splint (before 4 weeks)

☐ Yes ☐ No

Adherence to Appointments

☐ Week 1 ☐ Week 2 ☐ Week 3 ☐ Week4 ☐ Week 5 ☐ Week 6

☐ Week 7 ☐ Week8 ☐ Week 9 ☐ Week10 ☐ Week 11 ☐ Week 12

Number of Therapy Sessions Received Before Discharge _____

Section E: Post-Operative Complications

☐ Rupture ☐ Infection ☐Tenodesis ☐ Contracture

☐ Re-Operation ______________________

Objective Assessment

Range of Movement

One Month

Affected	MCP		PIP		DIP	
	Active	Passive	Active	Passive	Active	Passive
IF						
MF						
RF						
LF						
Thumb						

Unaffected	MCP		PIP		DIP	
	Active	Passive	Active	Passive	Active	Passive
IF						
MF						
RF						
LF						
Thumb						

Three Months

Affected	MCP		PIP		DIP	
	Active	**Passive**	**Active**	**Passive**	**Active**	**Passive**
IF						
MF						
RF						
LF						
Thumb						

Six Months

Affected	MCP		PIP		DIP	
	Active	**Passive**	**Active**	**Passive**	**Active**	**Passive**
IF						
MF						
RF						
LF						
Thumb						

Strength

Three Months

Affected	**Attempt 1**	**Attempt 2**	**Attempt 3**	**Average**
Power Grip				
Pinch Grip				

Unaffected	**Attempt 1**	**Attempt 2**	**Attempt 3**	**Average**
Power Grip				
Pinch Grip				

Six Months

Affected	**Attempt 1**	**Attempt 2**	**Attempt 3**	**Average**
Power Grip				
Pinch Grip				

JHFT Score

Three Months ____________

Six Months ____________

Quick DASH Score/Quick DASH Work Module Score

Three Months _____/_____

Six Months _____/_____

Appendix 14

Results for n=126

Demographics of Study Sample (n=126)

Descriptor		n (%)
Gender	Male	84 (67%)
	Female	42 (33%)
Age*	< 20 years old	11 (9%)
	20 – 30 years old	55 (44%)
	31 – 40 years old	37 (29%)
	41 – 50 years old	17 (13%)
	> 50 years old	6 (5%)
Occupation	Employed	68 (54%)
	Unemployed	40 (32%)
	Other**	18 (14%)
Type of Work * (n= 68)**	Sedentary	7 (10%)
	Light	23 (34%)
	Medium	29 (43%)
	Heavy	9 (13%)
Hand Dominance	Right	113 (90%)
	Left	13 (10%)
Smoker	Yes	51 (40%)
	No	75 (60%)
Language Barrier	Yes ****	19 (15%)
	No	97 (77%)
	Slight ****	10 (8%)

* *Mean age of the participants was 31 years (SD±10, n=126). The youngest participant was 15 and the oldest 62*

** *Includes scholars, students, pensioners and prisoners*

*** *See Appendix 15 for description of classification*

**** *"Yes" required a translator, "Slight" meant participant was not fluent in English, but a translator was not required*

.

Characteristics of the injuries (n=126)

Descriptor		n (%)
Hand Injured	Dominant	77 (61%)
	Non-dominant	49 (39%)
Cause of Injury	Accidental*	54 (43%)
	Violence-related	50 (40%)
	Motor/Pedestrian vehicle accident	3 (2%)
	Occupational	9 (7%)
	Self-inflicted**	10 (8%)
Sharp/Tearing* **	Sharp	117 (93%)
	Tearing	9 (7%)
Zone	I	3 (2.5%)
	II	43 (34%)
	III	22 (17.5%)
	IV	4 (3%)
	V	46 (37%)
	Thumb (zones I-III)	8 (6%)
Number of digits injured	1	55 (44%)
	2	32 (25%)
	3	22 (17%)
	4	10 (8%)
	5	7 (6%)
Associated Injury****	Isolated median nerve laceration	21 (17%)
	Isolated ulnar nerve laceration	20 (16%)
	Combined median and ulnar nerve laceration	7 (5.5%)
	Digital nerve laceration	25 (20%)
	Fracture/dislocation	10 (8%)
	Vascular Injury	16 (13%)
	Extensor tendon/thenar muscle laceration	11 (9%)
	A2/A4 pulley injury	2 (1.5%)
	Radial nerve laceration	1 (1%)
	Amputation at proximal interphalangeal join	1 (1%)
	None	41 (32.5%)

* *Injuries caused by accidents (outside of work) such as falling onto glass or cutting oneself accidentally*

** *Injuries sustained by punching windows and in one case a parasuicide*

*** *Sharp: knives, broken bottles, glass, blade and windows; tearing: grinders/saws and a spanner in one case*

**** *Accounts for combined injuries, i.e., more than one associated injury*

Surgery Details (n=126)

Descriptor		n (%)
Delay between injury and surgery*	< 1 week	75 (60%)
	1 – 2 weeks	33 (26%)
	>2 – 3 weeks	9 (7%)
	>3 – 4 weeks	4 (3%)
	> 1 month, < 2 months	1 (1%)
	> 2 month, < 3 months	3 (2%)
	> 3 months	1 (1%)
Suture	4 strand	62 (49%)
	2 strand	3 (2%)
	4 strand FDP, 2 strand FDS	7 (6%)
	4 strand FDP only	6 (5%)
	Not recorded**	48 (38%)

* *The mean delay between injury and surgery was 11 days (SD±15, n=65) with a minimum wait of 0 days (i.e., the participant was operated on the day of injury) and a maximum delay of over three months*

** *FDP: flexor digitorum profundus; FDS: flexor digitorum superficialis*

*** *Surgeon did not record the surgical technique used in the surgery notes*

Rehabilitation and Adherence Details (n=126)

Descriptor		n (%)
OT protocol	Passive motion	106 (84%)
	Controlled active motion	11 (9%)
	Early active motion	7 (5.5%)
	No OT received	2 (1.5%)
Self-removal of splint	Yes	30 (24%)
	No	94 (74.5%)
	Did not receive splint	2 (1.5%)
Adherence to therapy attendance*	20-29%	1 (1%)
	30-39%	3 (2%)
	40-49%	4 (3%)
	50-59%	15 (12%)
	60-69%	10 (8%)
	70-79%	21 (16.5%)
	80-89%	16 (13%)
	90-99%	7 (5.5%)
	100%	49 (39%)

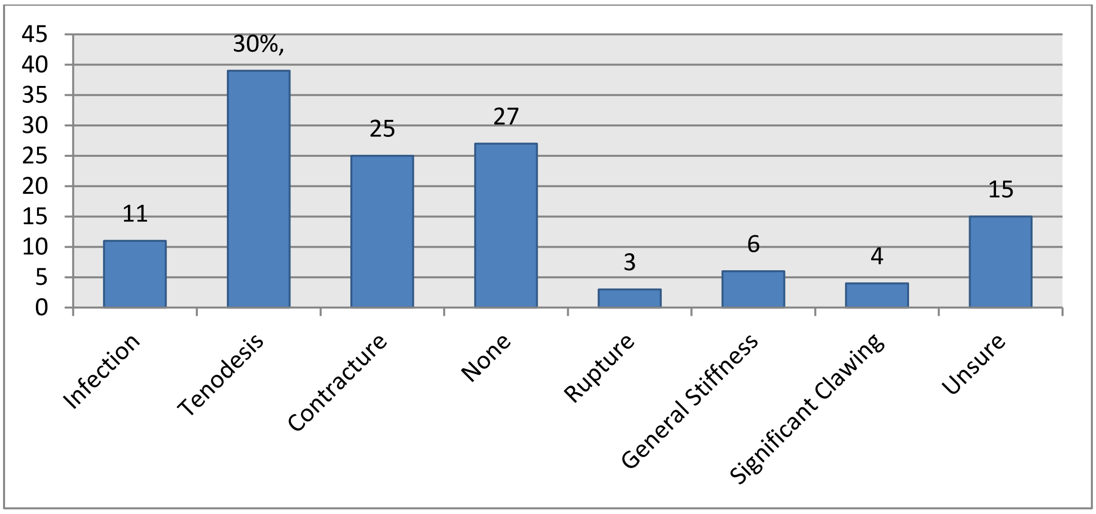
* *The mean adherence to therapy attendance was 81% (SD±20 ,n=126).*

Completion of therapy

- 30% (n=38) of participants completed treatment (i.e. they were discharged by the treating therapist(s))
- 53% (n=67) of participants defaulted treatment
- 7% (n=9) of participants were transferred to other healthcare facilities
- 10% (n=12) of participants were still receiving hand therapy at the time of completion of data collection.

67% (n=84) experienced one or more complications post FTR.

Figure 4.2: Post Operative Complications



While two-thirds of participants experienced complications, only 14 (21%) underwent further surgery. The further surgeries included: 4 debridements, 5 tenolysis, 1 contracture release and 1 Riordan tendon transfer. 10 participants were booked for further surgeries (including tenolysis, contracture release and bone grafting), however it was unsure whether they underwent surgery as they were never treated post-surgery because they defaulted).

Range of motion

The average Range of Motion (ROM) for all participants (n=126) in terms of Total Active Movement (TAM) was 22% (SD±14) at one month, 52% (SD±22) at three months and 60% (SD±24) at six months.

The improvement in ROM was significant both from one to three months ($p<0.001$) and from three to six months ($p<0.001$).

The ROM was further classified according to the TAM classification system, as seen in Table 4.6 below.

Table 4.6: TAM Classification of ROM

Score	Percentage	n (%)		
		1 month (n=126)	3 months (n= 94)	6 months (n=72)
Excellent	**100%**	0	0	1 (1%)
Good	**75-100%**	1 (1%)	15 (16%)	22 (31%)
Fair	**50-75%**	7 (5.5%)	39 (41%)	25 (35%)
Poor	**< 50%**	118 (93.5%)	40 (43%)	24 (33%)

Power and Pinch Grip Strength

Table 4.7: Power and Pinch Grip Strength at Three and Six Months (Percentage of Unaffected Hand)

	Power Grip 3 Months	Power Grip 6 Months	Pinch Grip 3 Months	Pinch grip 6 Months
Mean (SD)	41 (±23)	61 (±23)	33 (±34)	54 (±40)
RHD Mean	42	63	34	54
LHD Mean	28	45	26	42

Hand function at activity and participation levels

Table 4.8: Time Taken (in seconds) for JHFT at Three and Six Months post FTR

	Non-dominant 3 months	Dominant 3 months	Non-dominant 6 months	Dominant 6 months
Mean Time (SD)	82 (±35)	77 (±63)	73 (±32)	61 (±51)
Minimum Time	36	33	32	29
Maximum Time	220	414	169	371

Table 4.9: Difference in Time Taken (in seconds) for JHFT between Three and Six months post FTR

	Non-dominant	Dominant
Mean Improvement	14	17
Mean Deterioration	10	18
Minimum Change	0	0
Maximum Improvement	76	139
Maximum Deterioration	49	104

Table 4.11: Quick DASH scores at Three and Six Months post FTR

	Quick DASH 3 months (n=94)	Quick DASH 6 months (n=72)
Mean (SD)	25.57 (±17.02)	19.81 (±16.76)
Minimum	0.00	0.00
Maximum	77.50	77.27

At three months post FTR, 39 participants (72%) who were employed prior to their injury were back at work. The 15 participants (28%) that had not returned to work were previously employed in the following types of labour: 4 (27%) light work, 10 (67%) medium work and 1 (6%) heavy work.

At six months post FTR, 30 participants (68%) who were employed prior to their injury were back at work. The 14 participants (32%) that had not returned to work were previously employed in the following types of labour: 5 (36%) light work, 7 (50%) medium work and 2 (14%) heavy work.

Table 4.12: Quick DASH Work Module Scores at Three and Six Months post FTR

	Quick DASH Work Module 3 months (n=39)	Quick DASH Work Module 6 months (n=30)
Mean (SD)	31.57 (±29.17)	14.58 (±21.92)
Minimum	0.00	0.00
Maximum	100.00	100.00

Appendix 15

Type of Work Classification

Classification	Physical Demands	Examples of Jobs
Sedentary	• Limited lifting and carrying • Limited standing and walking	Receptionist, call centre
Light	• Frequent light lifting • Standing/walking most of the day	Cashier, merchandising, security
Medium	• Constant standing/ walking/ kneeling/ bending • Frequent heavier lifting	Domestic worker, plumber, electrician
Heavy	• Heavy lifting most of the day	Construction worker, manual labourer

(Stasiuk, 2009)

Appendix 16

Summary of associations of factors with outcome variables (non-significant factors)

	ROM		Power Grip		Pinch Grip		Quick DASH	
	Mean (SD)	p	Mean (SD)	p	Mean (SD)	p	Mean (SD)	p
Smoking history								
Yes	55.92 (±6.18)	0.31*	61.53 (±6.79)	0.81*	NA	0.57**	23.50 (±4.33)	0.24*
No	63.20 (±3.48)		59.74 (±3.33)				17.62 (±2.34)	
Mechanism of injury								
Sharp	62.12 (±3.19)	0.26	60.33 (±3.09)	0.96*	NA	0.08**	18.83 (±2.24)	0.14*
Tearing	48.58 (±10.07)		59.40 (±15.63)				25.50 (±3.36)	
Delay between injury and surgery								
< 1 week	66.54 (±21.69)		62.03 (±24.36)				18.93 (±16.80)	
1 - 2 weeks	54.46 (±27.35)		55.39 (±24.73)				22.32 (±17.47)	
2 - 3 weeks	54.77 (±2.96)	0.10	56.33 (±30.24)	0.21	NA	0.21**	14.92 (±21.72)	0.43
3 – 4 weeks	64.84 (±27.58)		71.67 (±5.51)				10.30 (±4.22)	
1 - 2 months	12.59 (±0.00)		101.00 (±0.00)				4.55 (±0.00)	
2 – 3 months	69.19 (±35.76)		64.50 (±0.71)				12.39 (±14.30	
> 3 months	18.00 (±0.00)		11.00 (±0.00)				50.00 (±0.00)	
Suture used								
2-strand	52.13 (±41.58)		80.00 (±11.31)				10.00 (±10.61)	
4-strand	58.35 (±26.47)	0.51	53.45 (±23.08)	0.19	NA	0.46**	23.78 (±18.04)	0.33
FDP 4, FDS 2 strand	77.00 (±0.00)		42.00 (±0.00)				18.18 (±0.00)	
FDP only 4 strand	45.30 (±9.42)		66.33 (±32.87)				20.83 (±8.04)	
Not recorded	65.85 (±22.68)		66.39 (±24.93				14.98 (±16.02)	
OT protocol								
Passive motion	61.44 (±25.11)	0.60	60.00 (±24.35)	0.99	NA	0.09**	19.17 (±17.75)	0.85
CAM	65.28 (±19.01)		63.75 (±33.09)				21.25 (±8.29)	
EAM	65.29 (±12.91)		61.50 (±14.85)				12.50 (±3.54)	
Did not receive OT	38.17 (±33.56)		59.50 (±44.55)				27.27 (±12.86)	
Adherence Category								
100%	65.09 (±27.23)		60.13 (±25.71)				17.45 (±14.33)	
90-99%	60.07 (±17.56)		61.40 (±26.01)	0.92	NA	0.46**	21.00 (±12.94)	
80-89%	47.74 (±18.48)	0.34	55.10 (±23.37				30.98 (±23.12)	
70-79%	64.88 (±16.39)		60.50 (±27.73)				14.85 (±24.80)	0.37
60-69%	56.09 (±10.16)		60.00 (±27.22)				18.94 (±10.25)	
50-59%	69.13 (±37.54)		71.50 (±7.78)				7.95 (±1.61)	
40-49%	22.73 (±0.00)		88.00 (±0.00)				17.50 (±0.00)	

Test used: No star – ANOVA; * T-test; ** Kruskal-Wallis test (no Bonferroni calculation done)

Appendix 17

Turnitin Report

turnitinversion.docx

ORIGINALITY REPORT

10%	6%	5%	5%
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