Determinants of positive functional outcomes at 16 weeks after flexor tendon repair at a tertiary hospital in the Eastern Cape of South Africa. A descriptive, analytical study.

Dissertation for MSc Occupational Therapy

University of Cape Town

HREC REF 713/2016

Amy Menegaldo

MNGAMY001

Supervisor: A/Prof. Helen Buchanan

February 2019

Plagiarism Declaration

Name: Amy Peta Menegaldo
Student Number: MNGAMY001
Course: MSc Occupational Therapy (diss)

Declaration

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Abstract

Title: Determinants of positive functional outcomes at 16 weeks after flexor tendon repair at a tertiary hospital in the Eastern Cape of South Africa: A descriptive, analytical study.

Introduction: Flexor tendon injuries account for a substantial number of hand injuries presenting to health care facilities, yet rehabilitation following flexor tendon repair remains a challenge. There is limited research pertaining to flexor tendon rehabilitation in middle economic income countries like South Africa.

Objectives: The aim was to identify determinants of positive functional outcomes sixteen weeks after flexor tendon repair at a tertiary hospital in South Africa. The objectives were: 1) to describe the functional outcomes at four, eight, twelve and sixteen weeks post flexor tendon repair using total active motion (TAM), muscle strength and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, 2) to ascertain the demographic profile for patients presenting to the hospital with a flexor tendon injury, 3) to describe the rate of recovery between the four assessment intervals, and 4) to cross-culturally translate the DASH questionnaire into isiXhosa.

Method: Ethical approval was obtained through the University of Cape Town's Human Research Ethics Committee. A quantitative, descriptive, analytical design was used. The DASH was translated as per the guidelines for cross-cultural translation by the Institute for Work and Health. All patients presenting to the target institution with a flexor tendon injury between February and August 2017 formed the sample. Twenty-two participants were recruited. Participants were assessed at four, eight, twelve and sixteen weeks post operatively using TAM, muscle strength and the DASH questionnaire. Demographic and treatment factors for each participant were compared to 16-week DASH scores using Mann-Whitney U and Kruskal-Wallis ANOVA tests. The rate of recovery was analysed using Spearman's Rank Correlation Coefficient, Friedman's ANOVA and Wilcoxon Matched Pairs for TAM, DASH score and muscle strength respectively.

Results: Time to repair was the only factor to have statistical significance at 16-weeks post operatively ($H(df=9)=15.3$; $p=0.05$). Rate of recovery when compared to DASH ($F(df=3)=12.98$; $p=0.005$) and muscle strength ($Z=3.076$; $p=0.002$) scores showed statistical significance, though TAM did not ($r_s(df=2)=0.06$; $p=0.78$). The epidemiological profile was similar to those documented elsewhere in South Africa and globally.

Conclusion: The outcomes achieved in the present study were poorer than those described in the vast body of literature in the field, but similar to those described in a similar cohort elsewhere in the country. The demographic profile was similar to those previously documented in South Africa and across the globe, but with different environmental and institutional barriers. Rate of recovery appears greatest between four and eight weeks, as well as between weeks twelve and sixteen. Time to repair showed that it is not harmful to delay primary flexor tendon repair up to six days post injury. Recommendations for future policy, education, practice and research were made.

Acknowledgements

It is amazing to sit at the end of a three year journey and think about the various people who have helped me to realise this dream. Each person or entity mentioned here, in their own way, helped me navigate this very long, difficult and often lonely road.

Firstly, I would like to thank the University of Cape Town's (UCT) Division of Health and Rehabilitation Sciences. Despite being a distance learner, I have never felt disadvantaged. I would especially like to mention the staff of the Health Sciences Library, the postgraduate administration team and A/Prof. Romy Parker for helping me at different stages of the journey.

I would also like to thank my funders for seeing the value in my research. To the American Hand Therapy Foundation for awarding the Burkhalter New Investigator Award to fund the translation of the Disabilities of the Arm Shoulder and Hand into isiXhosa. Also to the UCT Faculty Research Committee for the Postgraduate Publication Incentive Award to aid in the dissemination of these findings in the months to come.

To my work supervisor, management and all my colleagues at the tertiary hospital ("he who shall not be named"), thank you for supporting the research and assisting in the data collection. I would not have obtained the rich and valuable data that I have here without your help and support.

To my supervisor, Helen. Your consistent support and guidance has been the staff that I could lean upon when the road got tough. I am so grateful to have had a supervisor with the wealth of experience and knowledge that you have.

Finally, I would like to thank family. To my parents who always put their children's welfare and education first, and their needs last. To my brother for checking in from time to time and making me laugh at myself. To my sister, thank you for agreeing to read and help me to edit this monster toward the end, without hesitation. Lastly, to my husband… thank you for putting up with me for the past three years. Thank you for all the cups of tea, home cooked dinners, hugs, foot rubs and critiques that got me through. I would not have stuck it out if it wasn't for all the love and laughter that fills our home, everyday.

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Definition of terms

- *FLEXOR TENDON INJURY:*

A laceration (partial or complete) or rupture of the flexor tendons in the forearm and hand of the upper limb (Taras, Martyak, Steelman, Pettengill, & Van Strien, 2011).

- *FUNCTIONAL OUTCOME:*

The extent to which a person is able to participate in their activities of daily living within the limitations of body functions, body structures as well as contextual barriers or aids (WHO, 2013). This is quantified according to the person's own assessment of their capacity or impairment as well as objective measures of the capabilities of their body structures and context (WHO, 2013).

- *COMPLEX INJURY:*

This term will be used in this dissertation to describe a flexor tendon injury that has an additional complex injury to other structures in the hand (i.e. peripheral nerve laceration, fractured bone, extensor tendon injury etc.) (Germann, Karle, Brüner, & Menke, 2000).

- *PRE-OPERATIVE REHABILITATION:*

Any rehabilitative intervention afforded a patient whilst awaiting surgical intervention.

- *POST-OPERATIVE REHABILITATION:*

All rehabilitative intervention that occurs after surgical intervention, whether as an in- or out-patient.

- *TERTIARY HOSPITAL:*

Refers to the site where the study was conducted. The name of the hospital was withheld in accordance with University of Cape Town's Human Research Ethics Committee's recommendation to protect the identity of the hospital and its staff.

Abbreviations

The following abbreviations will be used in the dissertation.

	Chosen abbreviation	Description
	ADL/ADLs	Activity of Daily Living / Activities of Daily Living
	DASH	Disabilities of the Arm, Shoulder and Hand
	EAM	Early Active Mobilisation
	FDP	Flexor Digitorum Profundus
	FDS	Flexor Digitorum Superficialis
	PFAE	Passive Flexion Active Extension
	POP	Plaster of Paris
	PROM	Patient Rated Outcome Measure
	ROM	Range of Movement
	TAM	Total Active Motion
Joints	DIP	Distal interphalangeal
	MCP	Metacarpal phalangeal
	PIP	Proximal interphalangeal
Statistical	df	Degrees of Freedom
	F	Friedman’s ANOVA
	H	Kruskal-Wallis H
	No	Number
	rs	Spearman’s Rho
	U	Mann-Whitney U
	Z	Wilcoxon Matched Pairs
	%	Percentage

Chapter 1: Background

1.1.1. Introduction

The following chapter will frame the context for the dissertation. The frame of reference for the study will be outlined and context of South Africa's history and its influence on health and wellbeing will be unpacked. Thereafter, the context of the tertiary hospital and an overview of the current flow of care will be described. Finally, the purpose and rationale of the study as well as the research question, aims, objectives and hypotheses will be presented.

1.1.2. Context and its impact on health

Over the past ten years, the amount of research pertaining to the surgical management and rehabilitation of flexor tendon injuries has increased dramatically. New findings and techniques have been described and published worldwide, mainly in upper income[1], well resourced countries (Dy, Hernandez-Soria, Ma, Roberts, & Daluiski, 2012; Singh, Rymer, Theobald, & Thomas, 2015; Tang, Amadio, Guimberteau, & Chang, 2012; Wong & Peck, 2014). There are few articles from middle or low income countries in the field of flexor tendon repair and rehabilitation (Kitis, Buker, & Kara, 2009; Sanmartin-Fernandez, Fernandez-Bran, & Couceiro-Otero, 2017) and fewer still from middle income countries of Sub-Saharan Africa (Makobore, Galukande, Kalanzi, & Kijjambu, 2015). Furthermore, information pertaining to the outcomes after flexor tendon surgery and rehabilitation in the South African context is limited, especially in areas of the country that are historically under-resourced. This study therefore set out to contribute to the existing body of knowledge in this field.

According to the International Classification of Functioning, Disability and Health (WHO, 2013), the complex interaction between a person, their context and health influences a person's level of participation, functioning and possible disability. In this framework, health and wellbeing cannot be considered in a vacuum (Dunn, Brown, & McGuigan, 1994; WHO, 2013). Context plays a major role in shaping a person's opportunities, experiences and barriers to engaging in occupations that will positively or negatively impact on their health (Dunn et al., 1994; Townsend & Wilcock, 2004; WHO, 2013). South Africa's critical history and disparate contexts has resulted in many different challenges impacting on the health and wellbeing of the population today. Eide and Ingstad (2011) argue that the person is not the source of ill-health and disability but rather that disability is the result of the intersection of the barriers created by

[1] As described by the World Bank.

the cultural, political and economic environment and that these barriers can perpetuate the person's disability. The social, environmental, political and economic context shapes the occupational choices afforded people, resulting in well-being or ill-health (Townsend & Wilcock, 2004). In South Africa, poverty, lack of education and limited opportunities for employment have resulted in very few and desperate occupational choices for its people. In 2010, Southern Africa had the highest incidence of interpersonal violence in the world (Harrendorf, Heiskanen, & Malby, 2010). Unintentional (e.g. road traffic accidents) and intentional injuries (e.g. interpersonal violence) were the third and fourth highest contributors respectively to Disability Adjusted Life Years in South Africa (Bradshaw et al., 2000). At the time, Pietrobon (1996) reported that over half of hand injuries presenting to a casualty unit in Johannesburg, South Africa were the result of an assault while 13% were secondary to a motor vehicle accident and only 3% were as a result of an injury on duty. These articles were the latest sources for this information at the time of the dissertation. The high incidence of intentional and unintentional injuries may be as a result of socioeconomic disparities that currently exist in the country. All of these factors pose significant barriers to prosperity and health.

1.1.3 The study context

From 1948 until 1990, South Africans were segregated into different racial groups by the laws of Apartheid (Dockrat et al., 2011). These racial groupings were determined by the colour of a persons skin and family background (Wiley & Kornbluh, 2007). Each racial group was given specific areas where they could live or work and government services were segregated for each racial group, giving privilege to white people (Dockrat et al., 2011). When considering the political, economic and cultural background of South Africa, most of the Eastern Cape was demarcated in the Group Areas Act of 1950 as a homeland for black, native South Africans (Dockrat et al., 2011). The cabinet and laws of the land were governed by the various chiefs of the native isiXhosa tribes but were overseen by the South African Apartheid Government at the time (Dockrat et al., 2011). Due to infighting and corruption between the governing chiefs, state funds for the province were depleted, resulting in problems with service delivery and resource management (Dockrat et al., 2011). Despite numerous attempts, the leaders of the Easter Cape Province and adjacent homeland of the Transkei were denied an autonomous economy and relied on the South African Government for support (Dockrat et al., 2011). Most people who were employed in the province were on the payroll of the government itself. Very few private enterprises thrived in the Eastern Cape leading to widespread unemployment and poverty (Dockrat et al., 2011).

In 1994, the Transkei and all other homelands were reintegrated into the territory of South Africa (Dockrat et al., 2011). The legacy of the Apartheid regime and the Group Areas Act of 1950 is still seen today. Based on statistics from the 2011 Census, 17 years after the first democratic elections, the dominant languages spoken in the Eastern Cape were isiXhosa (77% of the population), Afrikaans (10.4%) and English (5.5%) (Lehohla, 2014). Strikingly, 10.5% of the population above the age of 20 in the Eastern Cape received no formal education and only 28.5% completed Grade 12 or attained higher education (Lehohla, 2014). Furthermore, 20.2% of the population in the Eastern Cape of South Africa were living in poverty and only 24% of the population were registered as employed (Lehohla, 2014). As a result, a great number of the population rely social grants from the South African Social Security Agency (SASSA) as a source of income. Twelve percent of the population in the Eastern Cape can afford to pay for medical aid to fund privatised medical care (August, Mbengashe, Matiwane, Kaye, & Mavuso, 2019). The remainder population rely on the health care services provided by the state (August et al., 2019).

The Eastern Cape Department of Health's structure is based on a Primary Health Care System which aims at strengthening health promotion and disease prevention, as opposed to a purely curative model (August et al., 2019; Maillacheruvu & McDuff, 2014). The mission of the Eastern Cape Department of Health is: "To provide and ensure accessible comprehensive integrated services in the Eastern Cape, emphasising the primary health care approach, optimally utilising all resources to enable all its present and future generations to enjoy health and quality of life" (August et al., 2019, p. Vision and Mission). The Eastern Cape Department of Health's services are divided into three regions, namely the western, central and eastern regions (August et al., 2019). On average, for every 13 000 people there is one community health clinic to provide primary health care services in the community (August et al., 2019). These community health clinics fall under a district hospital that provides 24 hour care with medical staff consisting of general practitioners and nurses. These district hospitals provide emergency care services as well as family medicine, paediatric health, obstetrics and gynaecology, internal medicine and general surgery with a bed capacity that can range between 50 to 300 beds (Matsoaledi, 2012). Each district hospital falls under the umbrella of a regional hospital that provides more specialised services in the domains of internal medicine, paediatrics, obstetrics and gynaecology and general surgery (Matsoaledi, 2012). Regional hospitals must provide the aforementioned services as well as at least one specialist service in either orthopaedic surgery, psychiatry, aesthetics or diagnostic radiology with a bed capacity of 200 to 800 beds (Matsoaledi, 2012). Within each of the three regions of the Eastern Cape there is one tertiary hospital that provides specialist services for the population of that area (August et al., 2019). The tertiary hospital provides specialist services in the same domains as a regional hospital, in addition to sub-specialist services within these domains including an intensive care unit (Matsoaledi, 2012). A tertiary hospital has a bed capacity of 400 to 800 beds (Matsoaledi, 2012). Of the 6.5 million people living in the Eastern Cape, 22% fall within the western region's catchment area for the tertiary hospital of this study. The population the hospital serves live in urban, peri-urban and rural settings with a large proportion living without in-house access to water or sanitation (Lehohla, 2014). One of the sub-specialist services provided at the hospital is hand surgery.

In 2006 Dias and Garcia-Elias (2006) reported that 20% of all admissions to accident and emergency units around the world were related to hand injuries. This is consistent with the statistics of the occupational therapy department at the tertiary hospital which reflects that over a third of the total case load in 2015, 2016 and 2017 were patients with hand injuries as reported by M. Jacobs[2] (personal communication, January 2018). Dr. B. Smith[3] (personal communication, June 2016) reported that the Orthopaedic Surgery Department of the tertiary hospital employs seven Orthopaedic Surgeons, one of which is a sub-specialist in hand surgery. The orthopaedic department at the tertiary hospital is the only orthopaedic service that caters to 1.4 million people that fall within the western region of the Eastern Cape (Lehohla, 2014). Dr. B. Smith (personal communication, June 2016) also stated that hand injuries are a common presentation to the Orthopaedic Surgery Department. Consultants, Registrars and Medical Officers operate on these patients and, as a result, the amount of expertise and years of experience can vary from one to 30 years (B. Smith, personal communication, June 2016). However, due to the high number of patients presenting to the tertiary hospital with trauma and often poly-trauma, prioritisation of limited theatre time and resources is assigned to those with life threatening injuries (personal communication with B. Smith, June 2016). As a result, primary repair of hand injuries can be delayed by one to three weeks (B. Smith, personal communication, June 2016). Pietrobon (1996) argued that if no intervention is instituted to accommodate the high incidence of hand trauma patients in South Africa, a detrimental impact on the national health care system will be seen in the future. It was predicted that the increased incidence of hand injuries presenting to tertiary hospitals would result in limited theatre time and pressure for hospital beds (Pietrobon, 1996) and this prediction has come to fruition at this tertiary hospital.

In South Africa, 33% of trauma of the hand presenting to a casualty unit at a tertiary hospital involve flexor tendons (Pietrobon, 1996). This means that the burden of flexor tendon injuries on a tertiary hospital are high considering that a patient with clinical signs of a flexor tendon

[2] Pseudonym used to protect the source's identity as well as the identity of the tertiary hospital.

[3] Pseudonym used to protect the source's identity as well as the identity of the tertiary hospital.

injury requires surgical intervention to ensure return of function. Despite the high incidence of flexor tendon injuries in South Africa, only two articles related to flexor tendon repair have been published to date. The first study, a clinical trial from over 30 years ago conducted in Gauteng Province, studied the outcomes of patients two to eight months after flexor tendon repair. (Edinburg, Widgerow, & Biddulph, 1987). The second study was a descriptive, analytical study that assessed the outcomes of patients with flexor tendon injuries in the Gauteng province (Spark, Godlwana, & Ntsiea, 2018). These studies will be discussed in more detail in chapter 2. Although these articles shed light on the state of flexor tendon repair and rehabilitation in South Africa, the paucity of literature is concerning, particularly when considering the high incidence of hand injuries presenting to tertiary hospitals in South Africa (Pietrobon, 1996).

Most patients in the Eastern Cape with flexor tendon injuries present to their district hospital within 48 hours of the initial injury before being transferred to the tertiary hospital for specialist care. Due to structural and staffing limitations, patients can wait for up to three weeks from date of admission until a primary flexor tendon repair is performed. Dr. B. Smith (personal communication, June 2016) reported that on admission to the tertiary hospital, patients who present with flexor tendon injuries are assessed, their wounds are washed out, sutured closed and the hand placed in a dorsal Plaster of Paris (POP) back-slab (i.e. wrist 0-20° flexion, metacarpal-phalangeal (MCP) joints in 60-70° flexion and distal inter-phalangeal (DIP) and proximal inter-phalangeal (PIP) joints in full extension or slight flexion) and immobilised. Patients are then referred to an occupational therapist, pre- or post-operatively, to initiate the rehabilitation process and build a rapport. Post-operatively, the patients remain in hospital for a period of one to three days for pain management and rehabilitation. Depending on the strength of the tendon repair (two strand versus four or six strand) and the patients cognitive capacity to adhere to and understand strict protocols (determined by age or a pre-existing diagnosed cognitive impairment), one of three protocols are followed: Immobilisation, Passive Flexion, Active Extension (PFAE) or Early Active Mobilisation (EAM) (Asmus et al., 2015). The patient is then discharged home where they continue with a generic home programme. They are followed up at the orthopaedic clinic at the tertiary hospital at two, four and eight weeks post-operatively. The patient is also seen by an occupational therapist at two, four, eight, twelve and fourteen weeks post-operatively, on the same day as the orthopaedic surgeon review, after which the patient is either discharged or continues therapy every two weeks depending on the improvement in hand function.

1.2. Problem statement

On a global level, numerous studies related to flexor tendon repair and rehabilitation are available and aim to improve the outcomes for these patients. The outcomes documented in the literature at the time of the study proposal were incongruent with those noted clinically at the tertiary hospital. Contextual barriers at the hospital, as mentioned above, meant that patients confronted many challenges to their recovery including delayed time to operation and subsequent prolonged immobilisation. At times, patients waited longer than three days for primary repair of a flexor tendon injury. According to Wong (2002) stiffness is a common problem in injuries to the hand and stems from prolonged immobilisation, persistent oedema, scar formation and shortening of soft tissue structures. If left untreated, these factors can protract healing and rehabilitation (Wong, 2002). The researcher noticed that despite the use of strong repairs and rigorous protocols at the tertiary hospital, the rehabilitation period for patients with flexor tendon injuries was uncharacteristically longer than that described in literature. This resulted in prolonged impairment in hand function, and in some more serious cases, the awarding of social grants for patients deemed unfit to return to work. The long term impact of impaired hand function and eventual disability for these patients may have cumulative consequences. The loss of employment and income could result in a downward spiral into poverty. This is a problem considering that men between the ages of 20 to 35, whose principle occupation is work (Cronin, 2016), are more likely to sustain a flexor tendon injury than any other age group (Spark et al., 2018; Trumble et al., 2010). Literature pertaining to delayed flexor tendon repair and rehabilitation following hand injury is limited worldwide. In the local context of South Africa, and more specifically the Eastern Cape, literature on hand injuries in general, and more particularly to flexor tendon injuries, is scarce.

1.3 Purpose for the study

Currently there is no published literature that describes the functional outcomes of flexor tendon injuries or the factors that may influence them, for the Eastern Cape. There is also no evidence on the rate of recovery for the initial stages of flexor tendon rehabilitation. This information is necessary in order to understand the extent of the problem with regards to rehabilitation of flexor tendon injuries at the tertiary hospital. By doing this study, factors that determine functional outcomes can be identified to inform what changes are necessary to improve current institutional policy and occupational therapy practice at the hospital. Understanding the rate of recovery will further our comprehension of the impact of tissue healing on hand function as well as identify time frames where recovery stagnates. A descriptive analytical study was undertaken to research the factors affecting functional outcomes following flexor tendon repair at the tertiary hospital.

1.4. Research question, aim, objectives and hypotheses

1.4.1. Research question

What are the determinants of positive functional outcomes at 16 weeks post flexor tendon repair at a tertiary hospital in the Eastern Cape of South Africa?

1.4.2. Study Aim

The aim of the study was to identify the determinants of positive functional outcomes in patients with flexor tendon injuries presenting to a tertiary hospital in the Eastern Cape of South Africa.

1.4.3. Study Objectives

1. To translate the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire into isiXhosa (please see chapter 4).
2. To establish the demographic profile of patients presenting to the tertiary hospital with flexor tendon injuries.
3. To describe outcomes at four, eight, twelve and sixteen weeks after flexor tendon repair using total active motion (TAM), muscle strength and the DASH questionnaire.
4. To determine whether the rate of recovery differs between the four measurement points (four, eight, twelve and sixteen-weeks) post flexor tendon repair.

1.4.4. Hypotheses

1. Participants undergoing surgery by more experienced surgeons will have better functional outcomes than those whose surgery was done by registrars or medical officers.
2. Patients treated using a more active protocol will achieve better functional outcomes than those treated with a more passive protocol.
3. Patients who smoke will have poorer functional outcomes than non-smokers.
4. Patients with complex injuries (involving multiple structures of the hand) will have poorer functional outcomes than those with a pure flexor tendon injury.
5. Patients with a shorter waiting period to time of surgery will have better functional outcomes than those who wait longer.

1.4.5. Chapter Summary

This chapter noted the contexts where literature pertaining to flexor tendon injuries and rehabilitation predominantly originates and the paucity of literature in this field from the Southern African region. It describes the conceptual frameworks of the ICF as well as those of Occupational Science with regards to health and wellbeing. The South African historical, political and socioeconomic contexts and their influences on the occupational participation of the population were described in relation to population statistics. The historical context for the Eastern Cape was reported before exploring the cumulative effects on current service delivery and health of the population. Issues regarding lack of research in the field of hand therapy in South Africa and more specifically from the Eastern Cape was highlighted. The problem statement and purpose for the study was outlined. The research question, study aim, objectives and hypotheses were described. The next chapter presents a brief history of the origins of flexor tendon repair and rehabilitation and reviews the current body of knowledge in the field.

Chapter 2: Literature review

2.1. Introduction

There is a wealth of knowledge and literature available in the field of flexor tendon repair and rehabilitation (Wong & Peck, 2014). Over 200 articles were published every year regarding flexor tendon repair from 2011 to 2014 and appeared to have an upward trend (Wong & Peck, 2014). This chapter reviews and highlights the most important concepts in the field of flexor tendon repair and rehabilitation, specifically: the history of flexor tendon repair, tendon anatomy and biomechanical properties, surgical technique, complications and factors affecting outcome, rehabilitation protocols, assessment of outcomes and the experience of living with a flexor tendon injury. Literature was sourced from multiple databases during the period March 2016 to July 2018 namely: Pubmed, ClinicalKey and Science Direct. The following databases were access using EBSCOHost over the same time period: Academic Search Primer, CINAHL, Health Source-Consumer Edition, Health Source-Nursing/Academic Edition and Medline. Key search phrases included: activities of daily living, anatomy, assessment, cerebral reorganisation, complications, flexor tendon, forces, healing, injury, outcome measures, rate of recovery, rehabilitation and repair. Articles and books that were not available using online databases were sourced from the University of Cape Town's Faculty of Health Sciences Library. In addition, alerts were created to pick up any recent and relevant publications on Pubmed. This was done to ensure a comprehensive search base.

2.2. The history of flexor tendon repair

In 1918, Bunnell described for the first time that a flexor tendon injury could be repaired utilising a two strand core suture, which was later given with the eponym, a Bunnell suture (Manske, 2005). For many years, subsequent repairs utilised this technique whilst immobilising the hand for four weeks post operatively as any movement was considered to pose too high a risk of rupturing the repair (Manske, 2005). It was only much later, in 1980, when Strickland changed how flexor tendon repair was performed, particularly in the infamous zone II. Commonly referred to as “no man’s-land” due to the poor outcomes achieved with flexor tendon repair in zone II, Strickland and Glogovac (1980) suggested that controlled passive assisted rehabilitation following flexor tendon repair had significantly better results than those of the immobilisation protocol. The concept of an EAM protocol, as opposed to a PFAE protocol (i.e. Kleinert or Duran-Houser), was introduced as early as 1987 in The Belfast Experiment (Tang, Amadio, Guimberteau, Chang, et al., 2012). The premise of the study was that patients were in fact noted to be actively flexing their fingers before the tension of the elastic bands were adjusted for a Kleinert splint for the purpose of passive flexion (Tang, Amadio, Guimberteau, Chang, et al., 2012). In The Belfast Experiment, which was later replicated by Dr. Elliot in the United Kingdom in the early twentieth century, it was found that EAM resulted in better total active motion (TAM) and the same rupture rate (5%) as the Kleinert protocol (Tang, Amadio, Guimberteau, Chang, et al., 2012). Although this concept of EAM was described this early on, it was only in later years that EAM was considered the better standard of care in institutions around the world (Tang, Amadio, Guimberteau, Chang, et al., 2012). In a review of concepts at the time, Strickland (1995) highlighted the importance of understanding the relevant anatomy, tendon healing and nutrition as well as adhesion formation and control for flexor tendon repairs. This was in order to advocate for strong, 4-strand core and epitendinous sutures and a controlled active rehabilitation protocol to achieve the best results (Strickland, 1995). Since then, there has been a vast increase in the amount of literature in an attempt to better understand tendon healing and excursion. This understanding has aided in improving surgical techniques in order to adopt more aggressive rehabilitation protocols with the overall goal of improving functional outcomes following flexor tendon injury. It appears that many of the major institutions in the world have their own unique protocol for surgical technique and rehabilitation and each argues that their technique is superior (Tang, Amadio, Guimberteau, Chang, et al., 2012). Different outcome measures have been used to determine the efficacy of each protocol, making comparison in systematic reviews a challenge (Chesney, Chauhan, Kattan, Farrokhyar, & Thoma, 2011; Dy et al., 2012; Sameem, Wood, Ignacy, Thoma, & Strumas, 2011). Some surgeons and institutions advocate for stronger repairs describing 6-strand repairs with a circumferential suture (Tang, 2012; Tang, Wang, Chen, Pan, & Xie, 2001), while others prefer a less bulky 4-strand repair (Singh et al., 2015; Taras et al., 2011; Trumble et al., 2010; Wong & Peck, 2014). This is all in an effort to improve tensile strength of the repair and to allow for more active rehabilitation protocols. More aggressive protocols have been proposed most recently and are showing promising results (Tang, 2018). One protocol named the Manchester Protocol, advocates for shorter splints to allow for active flexion of the wrist, out-of-splint active and passive movements for more 'compliant' patients with strong 6-strand repairs (Tang, 2018; Wong & Peck, 2014). To date, evidence supporting this more active protocol is limited (Tang, 2018; Wong & Peck, 2014). To better understand how these developments came about, it is important to understand current theories regarding tendon anatomy and biomechanics.

2.3. Flexor tendon anatomy and bio-mechanical properties

The flexor muscles of the hand originate from the medial epicondyle of the humerus in the forearm (Gray, 1980). As the muscle belly ends, the muscle continues via tendons that extend into the hand through the carpal tunnel, distally forming part of the palmer aponeurosis before entering the fibrous sheath that forms a tunnel that the flexor tendons glide through (Gray, 1980). The flexor digitorum profundus (FDP) lies deep to the flexor digitorum superficialis (FDS) in the forearm. In order for the FDP to insert distal to the FDS, the FDS bifurcates at the level of the proximal phalanx. The FDS then inserts onto the proximal end of the middle phalanx, allowing the FDP to pass through Camper's chiasma to insert into the distal phalanx of the finger (Gray, 1980; Strickland, 1995). The different zones of injury are divided according to the anatomical structures that are involved in each area (see Table 1 and Figure 1).

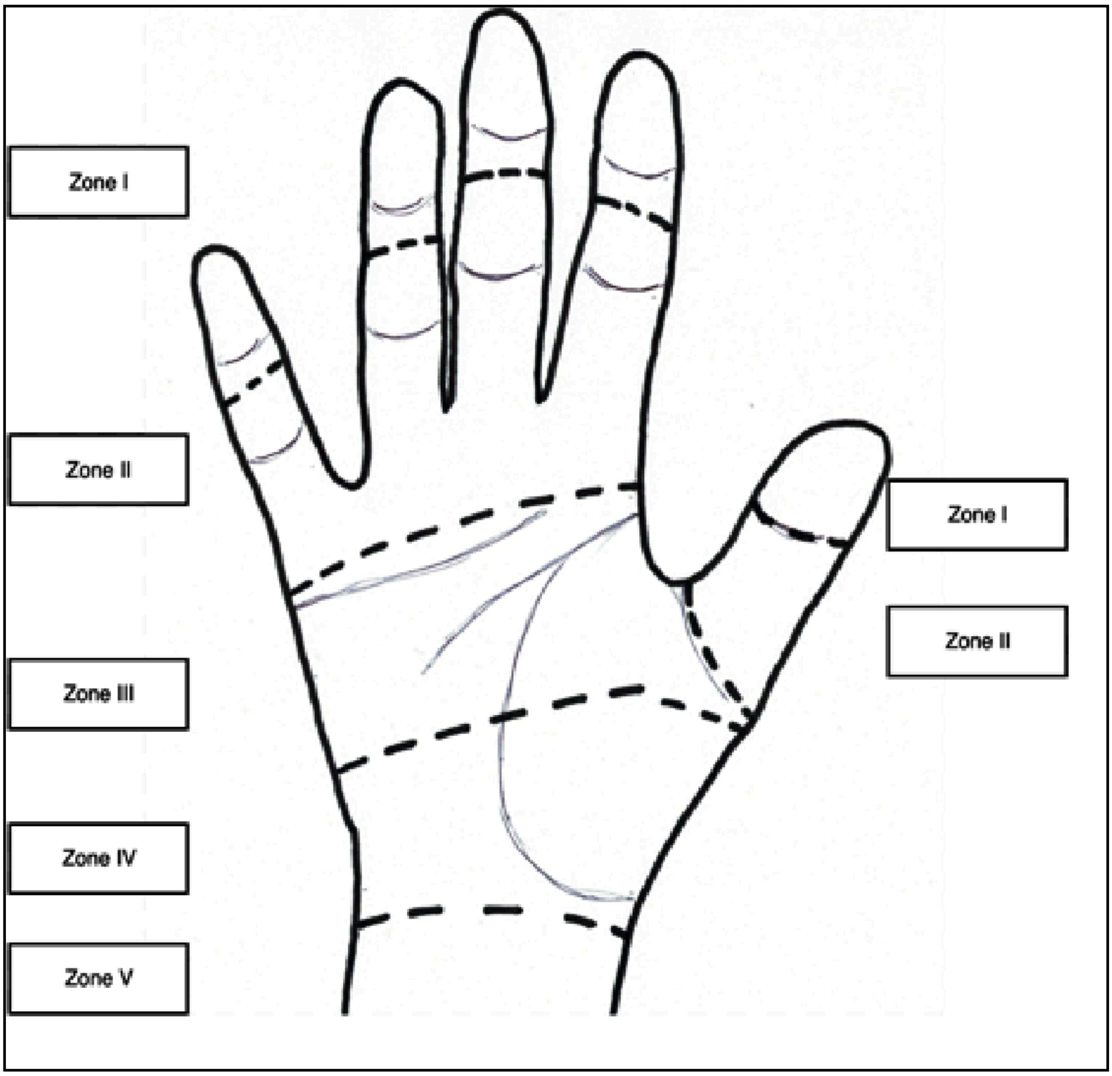

Figure 1: Zones of injury for flexor tendon repairs (illustrated by the author).

Table 1: Anatomical structures for zone of injury.

	Anatomical Structure
Zone I	FDP insertion
Zone II	FDS insertion Flexor tendon sheath and pulley system
Zone III	Lumbricals Palmer aponeurosis
Zone IV	Carpal tunnel Median nerve
Zone V	Median and ulnar nerves Wrist flexors

These zones have aided surgeons and therapists alike in identifying which areas of flexor tendon repair are more complex and have a poorer prognosis, and thus influence the interventional approach used (Strickland, 1995). Studies in the field of flexor tendon repair have focused on zone II injuries, infamously given the name 'no man's land', as they are known to have the poorest outcome (Strickland, 1995) A recent study in South Africa has shown that patients with zone IV injuries had the worst outcome (Spark et al., 2018). Spark et al. (2018) attributed these findings to the increased likelihood of sustaining an additional peripheral nerve injury in this zone, complicating rehabilitation and prolonging healing times.

Understanding tendon healing has been one of the main areas of research in the field of flexor tendon repair. Tendon healing begins with the inflammatory phase, spanning from the time of injury or repair until three to five days post surgery, during which time there is an increase of cellular activity both within and around the tendon (Goggins, Syme, & Murali, 2014). During the fibroblastic phase, which begins from five days until four weeks after injury or repair, collagen fibres begin to form around the tendon and surrounding tissues. Tensile strength increases gradually up until the beginning of the remodelling phase. This phase is thought to last up to three months (Goggins et al., 2014; Thomopoulos, Parks, Rifkin, & Derwin, 2015), although Wong and Peck (2014) proposed that tendon maturation only occurs 1 year post injury. This process has been found to be slower in patients that smoke as opposed to non-smokers (Trumble et al., 2010). Tendon healing can occur intrinsically or extrinsically. Intrinsic healing occurs within the tendon. It is reliant on nutrition within the tendon itself to formulate new collagen fibrils, bridging the gap between the two severed ends of the tendon (Moriya et al., 2015; Singh et al., 2015; Strickland, 1995). Intrinsic healing is encouraged when greater tendon excursion and tension is applied upon the tendon during the fibroblastic phase as elicited with active rehabilitation protocols. Tensile motion has been found to increase the up regulation of collagen synthesis, decrease inflammation and encourage better collagen alignment (Wong &

Peck, 2014). In contrast, extrinsic healing relies on nutrition supplied by surrounding tissues (i.e. tendon sheath) and is promoted when there is little or no tension on, or excursion of the tendon. Collagen formation with extrinsic healing is disorganised and adheres the tendon to the surrounding tissues (Moriya et al., 2015; Singh et al., 2015). Adhesion formation, decreased tendon glide and excursion is a consequence of extrinsic healing (Moriya et al., 2015; Singh et al., 2015). It is therefore argued that intrinsic healing is considered superior to extrinsic healing for the purpose of achieving better functional outcomes (Moriya et al., 2015; Singh et al., 2015). Although much has been discovered regarding tendon anatomy and healing, flexor tendon repair still poses a challenge to surgeons who aim to optimise functional outcomes for these patients.

2.4. Surgical technique

Surgical technique has developed significantly since Bunnell's (1918) article describing new instruments that could be used in flexor tendon repair at the time (Pulos & Bozentka, 2015). Much of the focus in research since 1980 pertains to developing a surgical technique that is strong and prevents adhesions, gapping and rupture (Pulos & Bozentka, 2015; Tang, 2012).

Two strand core sutures were considered better in the twentieth century as they were viewed as less bulky and therefore decreased the likelihood of adhesions by 57% (Dy et al., 2012). In a study on rabbit tendons, a single suture in the tendon was found to result in an acellular area around the suture within the first day which continued until the fourteenth day (Wong, Cerovac, Ferguson, & McGrouther, 2006). This suggests that utilising fewer strands through the tendon may be preferable for tendon healing (Wong et al., 2006). However, there has been stronger advocacy for four and six strand repairs (Lalonde, 2011; Pulos & Bozentka, 2015; Singh et al., 2015; Starr, Snoddy, Hammond, & Seiler, 2013; Tang, Amadio, Guimberteau, & Chang, 2012; Tang, Amadio, Guimberteau, Chang, et al., 2012; Trumble et al., 2010; Wong & Peck, 2014) as the greater number of strands results in a stronger repair and lessens the chance of gapping or rupture at the repair site when rehabilitation is initiated (Dy et al., 2012; Lalonde, 2011; Singh et al., 2015). The estimated repair strength of a two-strand repair at two weeks is roughly half that of a four-strand repair and a third of that of a six-strand repair (Strickland, 1995). Early active finger flexion to 25% of composite movement can produce 12-29 Newtons[4] (N) of force as opposed to 2-4N produced with PFAE (Groth, 2004). It is therefore considered better to utilise a four- or six-strand core suture that can withstand the forces that are needed to encourage greater intrinsic healing of the tendon (Groth, 2004; Strickland, 1995). Dy et al. (2012) found in a systematic review, that an epitendinous suture[5] in addition to the core suture, decreased the re-operation rate by 84% due to increased tensile strength, decreased incidence of gapping post-operatively and an overall neater repair. A further development in surgical technique was the use of a 3-0 suture material because it is two to three times stronger than a 4-0 suture and 66% stronger than 5-0 suture material (Lalonde, 2011; Pulos & Bozentka, 2015).

The most difficult area to repair the flexor tendon is within the notorious “no man’s-land”. Not only are both the FDS and FDP tendons required to glide seamlessly through this area, they also need to glide past each other within the confines of the flexor sheath and the pulley system therein (Tang, Amadio, Guimberteau, Chang, et al., 2012). Of all the pulleys that form

[4] A Newton is a measurement of force.

[5] An epitendinous suture is a running suture around the tendon (Taras et al., 2011).

part of the flexor sheath, it is considered important to preserve the integrity of the A2 and A4 pulley's in particular, as they are the most important in maximising the strength of the grasp, as well as preventing bowstringing[6] of the tendon (Tang, Amadio, Guimberteau, Chang, et al., 2012; Taras et al., 2011). With zone II flexor tendon repairs, there are circumstances where the repair of the tendons is so bulky that they struggle to glide through the pulleys effectively, resulting in adhesions or gapping of the repair (Pulos & Bozentka, 2015; Tang, Amadio, Guimberteau, Chang, et al., 2012; Taras et al., 2011). To try and rectify this problem, some surgeons advocate repairing the FDP and sacrificing the FDS tendon, which results in better glide through the pulley system, at the cost of a reduction in grip strength. (Pulos & Bozentka, 2015; Tang, Amadio, Guimberteau, Chang, et al., 2012). Another more controversial option, is the idea of venting (i.e. cutting open) the pulley up to 50% to allow for more space for the tendon to glide (Kannas, Jeardeau, & Bishop, 2015; Pulos & Bozentka, 2015; Tang, Amadio, Guimberteau, Chang, et al., 2012). Although it has been viewed with skepticism because of the possibility of bowstringing, it has been found to be useful in improving tendon glide for zone II repairs when performed by an experienced surgeon (Kannas et al., 2015; Tang, Amadio, Guimberteau, Chang, et al., 2012; Taras et al., 2011).

In more recent times, the idea of wide awake local anaesthesia no tourniquet (WALANT) surgery has been promoted (Higgins & Lalonde, 2016; Wong & Peck, 2014). This is where a mixture of lignocaine and adrenaline are injected into the tissues providing anaesthesia and a bloodless field without the need for a tourniquet (Higgins & Lalonde, 2016; Wong & Peck, 2014). This then allows the surgeon to ask the patient to move intra-operatively to test the tensile strength of the repair and fix any gapping or rupture that may occur before closure (Higgins & Lalonde, 2016; Wong & Peck, 2014). Though the potential benefits of using this method for decreasing waiting time for theatre and staff requirements as well as ensuring the integrity of the repair, WALANT has not been integrated at the tertiary hospital.

The 'ideal repair' is one that is of sufficient strength to withstand active movement with minimal gapping, minimal interference with surrounding structures and vascular supply and allows for smooth gliding within the flexor tendon sheath (Strickland, 1995). To date, these factors remain the ideals for flexor tendon repair in an attempt at promoting more aggressive rehabilitation protocols and subsequently better functional outcomes (Tang, 2018). Despite this, complications still arise.

[6] When the tendon doesn't follow the normal line of movement and arcs against the skin.

2.5. Complications and factors affecting outcome

A recent study found that 41 per 100,000 people sustain a flexor tendon injury every year in the United Kingdom and, of those who receive primary flexor tendon repair, 11% require repeat surgery as a result of complications (Wong & Peck, 2014). Complications may include bowstringing, rupture, swan necking, adhesions and scarring, stiffness, joint contractures, oedema, pulley disruption and triggering resulting in unsatisfactory outcomes, pain and dysfunction (Elliot, Moiemen, Flemming, Harris, & Foster, 1994; Pulos & Bozentka, 2015; Starr et al., 2013; Taras et al., 2011; Thomopoulos et al., 2015). Factors affecting outcomes have been published in order to understand how flexor tendon repair and rehabilitation may be improved. A randomised control trial found that patients who were known smokers, had an associated nerve injury, had injury to multiple digits and were not treated by a trained hand therapist were more likely to have decreased range of movement (ROM), worse adhesions and decreased level of satisfaction with the outcome (Trumble et al., 2010). Adhesion formation plays a major role in affecting tendon glide and function. Without sufficient glide and strength, the finger will not be able to move and will need to be considered for repeat surgical intervention (Pulos & Bozentka, 2015; Wong & Peck, 2014). Spark, Godlwana and Ntsiea (2018) studied factors affecting outcome in a South African Hospital in Pretoria. The results indicate that factors that predicted positive functional outcomes in patients with flexor tendon injuries were younger age, absence of complex injury, no language barriers (i.e. spoke the language of the health professional) and time to surgery of less than one week from time of admission (Spark et al., 2018). In addition, patients who followed the EAM protocol had better functional outcomes than those following a PFAE protocol (Spark et al., 2018). These findings are in keeping with findings of similar studies abroad.

According to Von Der Heyde (2015), delayed repair in children also has a devastating impact on the recovery of the tendon and results in the worst outcomes. This, according to Tang et al. (2001) is attributed to the tendon becoming covered with granulation tissue and collagen fibres that need to be removed before primary flexor tendon repair can occur causing further damage to surrounding tissues. The greater the delay, the more that needs to be removed (Tang et al., 2001). The extent of surface injury and tissue damage is directly proportional to the amount of adhesion formation resulting in poorer functional outcomes (Griffin, Hindocha, Jordan, Saleh, & Khan, 2012). There are currently no guidelines available to assist with pre-operative rehabilitation in the case of delayed repair of flexor tendon injuries. Flexor tendon injuries are traditionally repaired within 24 - 72 hours after presentation to a medical facility (Tang, Amadio, et al., 2012). This is often not possible in South Africa due to the contextual barriers in state hospitals. The resultant delays may in some cases span weeks (Edinburg et al., 1987; Spark et al., 2018).

One of the challenges to successful rehabilitation of flexor tendon injuries as described by Sanmartin-Fernandez, Fernandez-Bran and Couceiro-Otero (2017), was a lack of specialised hand therapists. In Spain, there was a four week waiting period for a patient to see a specialised hand therapist (Sanmartin-Fernandez et al., 2017). In an attempt to improve outcomes, home-based rehabilitation programs were given to patients by an occupational therapist and followed up once a week while awaiting their appointment with the specialised hand therapist (Sanmartin-Fernandez et al., 2017). Results showed a 5% rupture rate in patients given the home program, similar to results in other studies (Sanmartin-Fernandez et al., 2017). This shows that with home based rehabilitation even when done by non-specialised therapists, outcomes can be acceptable (Sanmartin-Fernandez et al., 2017). There are many rehabilitation protocols that aim to prevent these complications and loss of function which will be discussed in the section below.

2.6. Rehabilitation protocols

Advances in surgical techniques have resulted in different rehabilitation protocols for flexor tendon repair being developed over the years in an attempt to achieve better functional outcomes (Tang, 2012). Rehabilitation has increased in force from immobilisation to PFAE to more recently place-and-hold or EAM protocols. According to Wong (2002) stiffness is a common problem in any hand injury and stems from prolonged immobilisation, persistent oedema, scar formation and shortening of soft tissue structures. If left untreated, these factors can be prolonged into later stages of healing (Wong, 2002). Furthermore, any restriction of active or passive ROM can result in loss of motion in the hand and predisposes the hand to contracture formation and stiffness (Glasgow, Tooth, & Fleming, 2010). In contrast, encouraging normal movement of a joint induces stress upon the newly deposited collagen fibres (Glasgow et al., 2010). This promotes healing and fibre realignment that follows the desired direction of movement of the joint (Glasgow et al., 2010). The best treatment for stiffness in the hand is prevention (Glasgow et al., 2010).

In addition to the concern regarding stiffness in the hand, there is concern over the loss of motor and sensory discrimination as a result of cerebral reorganisation. A study conducted by Coert et al. (2009) found that immobilisation of the hand following a flexor tendon injury had a significant impact on the brain. Imaging of the brain showed that after a period of immobilisation after a flexor tendon injury, there was reduced blood flow in certain areas of the motor cortex which is similar to that seen in loss of orderly motor control (Coert et al., 2009). This change was reversed once active movement was reinitiated (Coert et al., 2009). The change in cerebral activity implies that the representation on the motor homunculus is negatively impacted by immobilisation and may further impede on progress in rehabilitation (Lundborg, 2003; Navarro, Vivó, & Valero-Cabré, 2007). Early passive or active protocols help to address the challenges related to stiffness, collagen realignment and neuro-plastic changes.

Duran and Houser first developed the PFAE protocol in 1975 (Tang, Amadio, Guimberteau, Chang, et al., 2012). This protocol suggests passive flexion and active extension of the affected and unaffected digits within the confines of a dorsal thermoplastic or POP splint with the wrist in 0-20° flexion, MCP joints in 60-70° flexion and the IP joints in neutral (Tang, Amadio, Guimberteau, Chang, et al., 2012). It was developed in order to allow for some tendon excursion, preventing adhesion formation, whilst avoiding placing too much tension on the repair site which could result in rupture and gapping in a weaker repair (Tang, 2012). The force exerted by this movement on the tendon is equal to 2-4 N, a fairly low level of force (Groth, 2004; Strickland, 1995). However, it is possible to achieve 8 mm of tendon excursion with this movement, 6.3mm in excess of the required 1.7mm to prevent unbreakable and possibly disabling adhesions within the flexor sheath (Groth, 2004). After immobilisation, this protocol is generally accepted as the safest to follow if the strength of the repair and the patient's adherence to therapy is questionable (Tang, 2012).

Another early passive protocol, the Kleinert protocol, involved using rubber band traction attached to the nail of the affected fingers to passively pull the fingers into flexion whilst allowing the fingers to extend actively within the confines of the thermoplastic splint (similar to the ones used in the PFAE protocol) (Chow et al., 1988). Hundozi, Murtezani, Hysenaj and Mustafa (2013) found this technique to be effectual in achieving 96% good to excellent results in TAM at the end of the study period. However, there have been criticisms of this method. Problems such as rubber band traction failures, incorrect tension and unappealing aesthetics resulted in decreased adherence and PIPJ joint contractures (Moriya et al., 2015). Although some authors have argued that the Kleinert protocol can be used in conjunction with EAM (Rigo, Haugstvedt, & Rokkum, 2017), there is greater evidence that shows that EAM protocols remain superior in achieving earlier return to work and better TAM (Asmus et al., 2015; Frueh et al., 2014).

Gray and Amadio (2012) suggested the use of place-and-hold exercises in addition to passive flexion and active extension. This allows for greater force (3-9 N) and excursion (10mm) to be achieved with the tendon passively placed in composite flexion and actively held in place for ten seconds before actively pulled into full extension (Groth, 2004; Tang, Amadio, Guimberteau, Chang, et al., 2012). This addition to the PFAE protocol can only be considered with a stronger, four strand repair (Groth, 2004). However, Higgins and Lalonde (2016) found during WALANT surgery that place and hold exercises elicit what they named a "buckle and jerk" phenomenon. During place and hold exercises, the tendon buckles in the flexor sheath and when the muscle is activated causes the tendon to jerk. This can result in gapping or rupture of the tendon if the one end of the repair is caught onto the edge of a pulley (Higgins & Lalonde, 2016). For this reason, some institutions have stopped using place and hold exercises until four weeks post operatively (Higgins & Lalonde, 2016).

The latest rehabilitation protocol for flexor tendon injury is EAM. This involves active flexion (up to 25% of composite flexion or within pain limits) and full active extension of the affected and unaffected digits (within the same dorsal POP described above) from day three until week three post operatively (Chesney et al., 2011; Starr et al., 2013; Tang, Amadio, Guimberteau, Chang, et al., 2012; Trumble et al., 2010). The Belfast experiment conducted in 1986 and 1987 found that EAM was superior to the Kleinert protocol (Riaz, Hill, Khan, & Small, 1999). However, this protocol was only widely used in the late 1990s due to the higher risk of rupture and tendon gapping compared to passive-assisted protocols. In a randomised control trial, Tumble et al. (2010) found that EAM increased IP joint ROM, decreased the likelihood of flexion contractures and improved tendon gliding, which resulted in fewer adhesions and improved tendon excursion. This finding was supported by Wong and Peck (2014) who found that active movement encourages gliding of soft tissue, which is important in maintaining muscle strength and preventing adhesion formation. The theory of tendon healing reinforces these findings. Taras et al. (2011) argued that EAM encourages greater intrinsic healing of the tendon as opposed to extrinsic healing. Extrinsic healing is known to result in adhesion formation within the flexor sheath which limits tendon glide and results in loss of ROM (Goggins et al., 2014; Singh et al., 2015). Conversely, intrinsic healing occurs within the flexor tendon itself in the absence of venous supply, decreasing adhesion formation (Goggins et al., 2014; Singh et al., 2015). The force exerted by composite active flexion of the digits ranges within 12-29 N with up to 17mm of tendon excursion, considerably larger than in the PFAE protocol (Groth, 2004). For this reason, it is imperative that the chosen rehabilitation protocol is carefully matched to the strength of the surgical repair for each patient. Vögelin et al. (2012) suggested a “stop and go” approach to choosing the appropriate protocol for each patient. This approach considers factors such as adherence of the patient to the home programme, strength of repair, severity of injury, persistence of oedema and progress in therapy to determine which protocol will be used: PFAE, place and hold or EAM. A similar approach was used at the tertiary hospital of the present study. Comparison between rehabilitation protocols has been a challenge due to the numerous ways that the outcomes for each study was reported.

2.7. Assessment of outcomes

Literature pertaining to flexor tendon repair, predominantly used TAM or muscle strength to measure outcomes (Chesney et al., 2011; Dy et al., 2012). However, the specific tools used to measure these components differ from study to study. This accounts for difficulty in comparing research findings (Dy et al., 2012). In the field of flexor tendon repair and rehabilitation, ROM is interpreted into a percentage utilising a scoring system commonly known as TAM. There are many different ways to calculate TAM with different criteria and norms, namely: The Strickland and Glogovac criteria, The Modified Strickland Score, Buck-Gramcko Score and American Society for Surgery of the Hand scoring system (Cooper, Khor, Burr, & Sivakumar, 2015; Moriya et al., 2015; Quadlbauer et al., 2015; Trumble et al., 2010). In contrast, for the assessment of muscle strength, a Jamar Dynamometer was the most widely described and used (Guzelkucuk, Duman, Taskaynatan, & Dincer, 2007).

Guzelkucuk et al (2007) argued that the use of TAM and muscle strength in isolation is not enough when considering the complexity of hand function. As the hand needs to perform complex, coordinated combinations of movements to achieve functional goals, each part plays a role in achieving the desired movement and grasp (Guzelkucuk et al., 2007). Furthermore, hand therapy should consider not only the body but the spirit and mind as well. The psychological effects related to the traumatic event, the subsequent loss of function and influence on life roles can not be separated when dealing with a patient who has sustained a hand injury (Fitzpatrick & Finlay, 2008). In accordance with the International Classification of Functioning (ICF) (2013) outcome measures that aim to understand functional deficits related to participation and activity must be used in conjunction with those used to measure physical performance in order to measure health and ability holistically (Oltman, Neises, Scheible, Mehrtens, & Gruneberg, 2008). Oltman et al. (2008) conducted a systematic review of literature with regards to flexor tendon injury to ascertain whether the factors of activity and participation were included as an outcome measure in flexor tendon repair and rehabilitation. Results showed that outcome measures that aimed to assess body function and structure outweigh those that measure participation and activity (Oltman et al., 2008). For assessment of hand function, there are many different options available. Standardised tests used in international literature include: the Jebsen hand function test, Smith hand function test and the Disability of the Arm, Shoulder and Hand (DASH) questionnaire (Guzelkucuk et al., 2007; Moriya et al., 2015; Trumble et al., 2010). In order to fulfil the assessment framework of the ICF, a holistic understanding of what it is to live with a flexor tendon injury and an appropriate approach to assessment and treatment is needed to consider all the possible contributing factors.

2.8. Living with a flexor tendon injury

Fitzpatrick and Finlay (2008) found that the lived experience of those in the early stages of flexor tendon rehabilitation was one of ambivalence and ambiguity. Participants described the experience as a source of stress and disruption in their lives, with a sense of loss of life roles, routines and independence resulting in frustration and depression (Fitzpatrick & Finlay, 2008). Participants described having to live with changes in their body. Pain, the restricting nature of the splint and having to cope with everyday tasks with the unaffected hand become part of their lives and body function (Fitzpatrick & Finlay, 2008). Their time was structured according to their home programme or progress in rehabilitation whilst ADLs took longer to perform making participants feel like the process would be endless and out of their control (Fitzpatrick & Finlay, 2008). Furthermore, participants had to cope with the restricting nature of the protocols often resulting in limited occupational choice, decreased participation in meaningful occupations and, in totality, a shift in relationships and life roles (Fitzpatrick & Finlay, 2008). Participants experience was described using thematic analysis into three main themes: “struggling-adapting”, “retreating-battling” and “denying-accepting” (Fitzpatrick & Finlay, 2008).

In the first theme, “struggling-adapting”, the authors noted that participants struggled with many challenges as a result of the flexor tendon injury such as pain, decreased function and independence and time constraints, yet still managed to find a way to adapt and continue (Fitzpatrick & Finlay, 2008). It shows that even though patients with flexor tendon injuries do encounter many challenges and changes in their life as a result of the hand injury, they have the capacity to thrive. The second theme, “retreating-battling”, called attention to the sense of loss, disability and alienation from others as well as occupations that were previously meaningful to them (Fitzpatrick & Finlay, 2008). For rehabilitation to be successful, the patient needed to find their strengths in order to stand, fight and continue on the recovery journey (Fitzpatrick & Finlay, 2008). The final theme, “denying-accepting”, underlined the shame, resistance, denial and disablement that participants felt as a result of having to ask others for help and become a different, ‘disabled’ person (Fitzpatrick & Finlay, 2008). However, patients seemed to eventually come to terms with the injury and a place of acceptance (Fitzpatrick & Finlay, 2008). These qualitative data helps therapists begin to understand the challenges that patients who sustain flexor tendon injuries face in order to be able to cope with the demands of rehabilitation and personal loss (Fitzpatrick & Finlay, 2008). To become more responsive and therefore, more capable to treat not only the physical but psychological, spiritual and social deficits requires individual attention and continuous dialogue between the patient and the therapist (Fitzpatrick & Finlay, 2008).

To perform tasks that help a person to perform meaningful occupations that fulfil their life roles, the hand must be able to have balanced movement in all planes and of all tissues (Guzelkucuk et al., 2007). However, none of previously mentioned protocols place emphasis on the importance of the use of meaningful occupations in treatment plans (Powell & von der Heyde, 2014). Furthermore, hand therapists do not incorporate ADLs into their treatments because of time constraints and a lack of knowledge (Powell & von der Heyde, 2014). Hand therapists also assume that their patients know how to perform their ADLs with the unaffected hand (Powell & von der Heyde, 2014). Considering that patients are more likely to adhere to rehabilitation protocols and regain their independence if they can see what they can achieve functionally with the help of a therapist, this is a lost opportunity to increase hand function post-trauma (Guzelkucuk et al., 2007). Lack of education about how to perform ADLs during the two months post operatively, has been shown to lead to a loss of independence which increases stress levels and may result in non-adherence in up to 67% of patients (Powell & von der Heyde, 2014). When considering the challenges related to the lived experiences of those with a flexor tendon injury, the functional limitations and sense of loss, there is a strong argument for a holistic approach to flexor tendon rehabilitation.

2.9. Chapter Summary

Flexor tendon repair has been and continues to be a richly researched topic across the globe due to the many complications that arise secondary to injury and repair (Tang, 2012). Repercussions of these complications pose many challenges for patients, surgeons and hand therapists in achieving an acceptable functional outcome. An extensive literature search was conducted over multiple databases to ensure rich and varied literature was obtained. The current body of knowledge focuses on different types of surgical repair and their strengths, rehabilitation protocols, physiology of tendon healing, type of complications and anatomy (Tang, 2012). While the effects of factors such as zone, number of tendons injured and smoking status have been studied in the past, the impact of personal or contextual factors influencing functional outcome as well as the rate of recovery is not as richly described in the literature.

Chapter 3: Methodology

3.1. Introduction

This chapter will outline the methodology for the dissertation. Included in this chapter are the description of the research design, population and participants, recruitment methodology, instrumentation, procedure for the study, data collection, data management, data analysis and ethical considerations.

3.2. Research Design

A quantitative paradigm was adopted for this study. A descriptive, analytical study design was used as this method was most appropriate in allowing the researcher to describe and explore many different factors that could influence or determine a positive functional outcome in this population group (Salkink, 2014).

3.3. Population and Participants

The population for the study included all patients admitted to the research facility with a flexor tendon injury of the hand or forearm within the recruitment period: 01 February 2017 to 11 August 2017. It was expected that numerous variables would exist within this population that could impact their functional outcome, namely: age, gender, smoking status, employment status, participant's proximity to the research facility, severity of injury, level or zone of injury, expertise of surgeon, expertise of occupational therapist, initiation and type of rehabilitation (pre- or post-operatively) and volition. In order to maximise the data on this relatively unique population, the entire population formed the sample. This allowed the sample to be as representative of the population as possible. In addition, the sample size could be maximised as data were only collected from one site.

3.3.1. Sample Size

As flexor tendon injuries occur less frequently than other injuries to the hand (e.g. fractures), all patients who presented to the tertiary hospital with a flexor tendon injury within the 6 month recruitment period served as the sample. Sample size was calculated using the following formula:

$$\text{Sample size} = \frac{Z_{1-\alpha/2}{}^{2}\,p(1-p)}{d^{2}}$$

$Z1\text{-}\alpha/2$ = standard normal variate

p = predicted proportion of the population

d = absolute error

Image copied from Charan and Biswas (2013) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3775042/ on 21/07/2016.

The standard normal variate for this study (P=<0.05) was 1.96. For the p-variable, the statistic from Pietrobon (1996) was used to estimate the proportion of hand injuries presenting to a trauma unit in South Africa (33%). Finally, the absolute error for the Jamar Dynamometer, the primary outcome measure, according to Härkönen, Harju and Alaranta (1993) was estimated to be 1.2kg, therefore (d=1.2).

Thus the required sample size was 59 participants.

3.3.2. Inclusion and Exclusion Criteria

INCLUSION CRITERIA:

1. All patients admitted to the tertiary hospital with a flexor tendon injury within the 6-month recruitment period: February 2017 until August 2017.

EXCLUSION CRITERIA:

1. Patients below the age of 18. This was due to the ethical consideration of non-maleficence and beneficence. The patient may have been required to be absent from school for the researcher to assess them at the tertiary hospital which may not have been their closest clinic or hospital. This would require extra time away from school to travel to and from the hospital from their local community. This would have a negative impact on their school performance and therefore these patients were excluded from the study. It should be noted however that on completion of this study, the findings will inform treatment protocols for the hospital as well as the local district areas in order to benefit this group of patients in the future.
2. Patients who did not speak English, Afrikaans or isiXhosa as a first language.
3. Patients with injuries to both hands.
4. Patients who lived outside of the metropolitan area of the tertiary hospital as travel and time costs incurred for the participant would have been too great.

3.4. Recruitment

After ethical clearance was received from the University of Cape Town Human Research Ethics Committee (HREC REF: 713/2016; 18 November 2016; Appendix Q), permission from the Eastern Cape Department of Health to approach the tertiary hospital was obtained (NHRD REF: EC_2016RP53_44; 12 January 2017; Appendix R). Permission from the Senior Manager of Medical Services of the tertiary hospital was obtained on 31 January 2017 (Appendix S). Recruitment commenced on 6 February 2018. An amendment to the recruitment procedure was approved by the University of Cape Town Human Research Ethics Committee (Appendix T) on the 06 April 2018. This was due to possible participants being lost to the study secondary to inconsistent referral of the patients to occupational therapy before discharge from the tertiary hospital. The initial recruitment process and amended recruitment process are outlined in Table 2.

Table 2: Recruitment process Initial and Amended

Initial recruitment process (06 February-06 April 2017)	Amended recruitment process (06 April - 11 August 2017)
The referral for the patient was received and the initial assessment (See Appendix O) was completed by the treating occupational therapist.	The patient's name was obtained from the hands theatre list on each day. Patients who were documented for flexor tendon repair on the day were approached to participate in the study the next day.
The patient was approached by the researcher (who was not the treating occupational therapist) in person after initial assessment. This was done one to three days post-operatively to ensure that a follow up date could be set before discharge (once the person agreed to participate). It was noted that the patient may have been in pain at this time and, in turn, be vulnerable to agreeing to participate under duress. The researcher combatted this by allowing the patient a day to consider their participation and by doing so the patient would have had enough time to consider their choice.	The patient was approached by the researcher (who was not the treating occupational therapist) in person. This was done one day post-operatively to ensure that a follow up date could be set before discharge (once the person agreed to participate). It was noted that the patient may have had pain at this time and, in turn, be vulnerable to agreeing to participate under duress. The researcher combatted this by allowing the patient 2-3 hours to consider their participation and by doing so the patient was allowed enough time to consider their choice.
The researcher explained the purpose of the study and went through the information sheet with the patient. The benefits and risks of the research were explained to the patient at this time. The patient was given the opportunity to think about their decision.	The researcher explained the purpose of the study and went through the information sheet with the patient. The benefits and risks of the research were explained to the patient at this time. The patient was given the opportunity to think about their decision.
If the need for a translator arose, an isiXhosa speaking colleague was asked to translate for the researcher. Before the translation process, the colleague was educated on the importance of translating only what the researcher or the patient said/asked.	If the need for a translator arose, an isiXhosa speaking colleague was asked to translate for the researcher. Before the translation process, the colleague was educated on the importance of translating only what the researcher or the patient said/asked.
If the patient agreed to participate, he/she signed the consent form with the researcher and was assigned a research number. If the patient refused to participate in the study, they were not included in the research group.	If the patient agreed to participate, he/she signed the consent form with the researcher and was assigned a research number. If the patient refused to participate in the study, they were not included in the research group.

3.5. Instrumentation

This section describes the outcome measures used, the reasons they were chosen as well as the recommended assessment procedure for each. The validity and reliability for each outcome measure is then summarised.

3.5.1. Range of Movement (ROM)

INSTRUMENT:

In order to adhere to current norms for research, TAM was used for assessing, measuring and interpreting ROM. The Strickland and Glogovac scoring system was used as it included the measurement of the PIP and DIP joints and was the most commonly utilised and described in literature as a stricter scoring system (Chesney et al., 2011). TAM is described by Strickland and Glogovac as the sum of the degrees of active PIP and DIP joint flexion minus the sum of degrees of extensor lag of these joints (Chesney et al., 2011). i.e: [Flexion of PIP + DIP] - [Extension of PIP + DIP] = TAM.

The TAM scores were compared to the 'gold standard' of 175° as dictated by Strickland and Glogovac (Chesney et al., 2011). The formula, TAM divided by 175 times by 100 was used to calculate the percentage of TAM return (Chesney et al., 2011): i.e. [[TAM/175]x100]. The percentages were then categorised as shown in Table 3 (Chesney et al., 2011).

Table 3: Total Active Motion (TAM) Categories

Description	**Percentage range**
Excellent	85%-100%
Good	70%-84%
Fair	50%-69%
Poor	0%-49%

ASSESSMENT PROCEDURE:

ROM was assessed utilising a metal finger goniometer to the nearest degree. In cases where the goniometer reading was between degrees, the next highest degree was used. In order to ensure consistency of measurement, one goniometer was used and one assessor conducted the assessments for the ROM of all participants. Assessment was done with the elbow resting on a flat surface placed below chest height, forearm upright in mid-position and the wrist in neutral. Each participant was requested to actively bend the joint as far as they could whilst the researcher blocked the joint proximal to the joint being assessed. This assessment took approximately five to ten minutes for each participant.

VALIDITY AND RELIABILITY:

The goniometer is widely used by clinicians as a tool for the measurement of ROM (Roach, San Juan, Suprak, & Lyda, 2013). It is widely utilised as it is cheap and easy to use (Roach et al., 2013). In a study conducted by Ellis and Bruton (2002) the inter-rater reliability of the use of a finger goniometer was between 7-9 degrees whilst the intra-rater reliability was 2-5 degrees (Ellis & Bruton, 2002). In order to decrease the effect of inter-rater error, only the researcher conducted the assessment for all the participants. In a systematic review, ROM assessment of the wrist and fingers had an Intraclass Correlation Coefficient of 0.99 and a confidence interval 0.98-0.1, an almost perfect score (van de Pol, van Trijffel, & Lucas, 2010). This means that when ROM is repeat tested, the same score or very close to it is reached each time.

3.5.2. Muscle Strength

INSTRUMENT:

This outcome was assessed using a Jamar Dynamometer gauge. Muscle strength refers to the strength of a mass cylindrical grasp of the hand. The Jamar Dynamometer is the most well documented instrument for the assessment of muscle strength in flexor tendon injuries (Guzelkucuk et al., 2007) and was therefore chosen to be most consistent with current literature.

ASSESSMENT PROCEDURE:

The assessment was done with the participant seated in a chair with the shoulder adducted, neutral rotation and flexed to 0 degrees, the elbow flexed at 90 degrees and the forearm held in the mid position with the wrist in neutral (Fess & Moran, 1981). The participant was requested to squeeze the dynamometer gauge as hard as they could. The mean of three attempts was used as the final score. This assessment took approximately two minutes to complete. The scores were compared to and analysed utilising South African power grip strength norms (Pretorius, Drennan, Saunders, & Vermeulen, 2005) as well as to the scores of the contralateral hand as conducted by Spark et al. (2018).

VALIDITY AND RELIABILITY:

The Jamar Dynamometer is a tool to assess cylindrical grip strength in adults. It has a high construct validity and was therefore justified for its use in the assessment of cylindrical grasp strength in this study (Mühldorfer-Fodor et al., 2014). The readings are valid as long as the goniometer is calibrated and stored correctly and used in the correct manner. The American Society of Hand Therapists found that the use of a Jamar Dynamometer with the upper limb positioned as described above is highly reliable for the assessment of grip strength (Fess & Moran, 1981). In addition, it has a high test-retest reliability (Mühldorfer-Fodor et al., 2014). The intraclass correlation coefficient was found to be 0.996-0.998 for test-retest reliability (Lindstrom-Hazel, Kratt, & Bix, 2009).

3.5.3. Disabilities of the Arm Shoulder and Hand (DASH) questionnaire

INSTRUMENT:

The DASH is a 30 item self-report questionnaire with a Likert scale that asks questions pertaining to specific tasks that require the use of the upper limb. It takes an average of six to ten minutes to complete (Dowrick, Gabbe, Williamson, & Cameron, 2005).The questionnaire is free from the DASH website (http://www.dash.iwh.on.ca/) on condition that it is not used for commercial purposes. This assessment has been translated into “South African English” and “Afrikaans” but, at the time of the study, not into “isiXhosa”. Therefore, the DASH was translated into isiXhosa and validated. See chapter 4 for the translation and validation methodology.

ASSESSMENT PROCEDURE:

The participant scored their current difficulty in each specified task within the past week on a five point Likert scale. At least 27 of the 30 questions have to be answered for the score to be valid. The sum of the scores was then calculated using the formula: [(sum of n responses)/30 - 1] x 25 = DASH disability score (where n = to the number of completed responses). The higher the score, the greater the disability relating to ADL performance on a scale of zero (no disability) to 100 (severe disability).

VALIDITY AND RELIABILITY:

Construct validity of the DASH was found to have moderate to high correlations (over 0.70 for Pearsons correlation co-efficient) with other indicators of impairment including: overall rating of the problem, pain severity, ability to function, ability to work, SPADI pain, SPADI function, Brigham symptoms and Brigham function (Beaton et al., 2001). According to Beaton et al. (2001) the DASH has a high test-retest reliability with a correlation of 0.96.

3.6. Procedure for Study

This section outlines the steps taken at each point of the study and divided into five parts: negotiating access, recruitment, data collection, data management and data analysis.

3.6.1. Negotiating access

1. Ethical clearance was obtained through the Faculty of Health Sciences Human Research Ethics Committee at the University of Cape Town on 18 November 2016 (HREC REF. 713/2016; see appendix Q).
2. The study proposal was then submitted to the National Health Research Database for permission to conduct the study with patients using the services of the Eastern Cape Department of Health and approved on 12 January 2017 (Reference number: EC_2016RP53_47; see appendix R).
3. Final permission from the Senior Manager of Medical Services of the tertiary hospital was obtained on 31 January 2017 (see appendix, S).
4. Only after ethical approval had been obtained from the Human Research Ethics Committee were the Information sheet and Consent forms forward translated into isiXhosa and Afrikaans by a translation service and first language speaking colleagues respectively. These forms were then backward translated into English by a different first language isiXhosa and Afrikaans speaking persons to ensure veracity of the translated forms.
5. Once permission had been obtained by the Eastern Cape Department of Health and the study site, the researcher provided an information session to the medical staff of the Orthopaedics department of the tertiary hospital regarding the purpose, length and possible outcome of the study (see appendix L for outline). The intention was to make the staff aware of the study as well as to outline the information needed in the operation notes for the purpose of the study.
6. The occupational therapists of the tertiary hospital were provided with a separate training session on the purpose of the study, data collection requirements as well as a recap on rehabilitation protocols (see appendix L). This was to ensure that the staff followed the same procedure for each of the protocols and understood how to complete the General information form and file appropriately to ensure participant confidentiality was maintained.

3.6.2. Recruitment

7. Recruitment began on 06 February 2017 and ended 05 August 2017.
8. All participants signed informed consent (see appendix B) and were assigned a research number. The therapist treating the participant during their admission then obtained the necessary general information (see appendix F for general information sheet). This was done to ensure that confirmation bias was avoided. Single blinding of the data collector (i.e. the researcher) was used in this study. The researcher was blinded to information regarding the injury, surgical technique used, protocol used, treating surgeon or occupational therapist, distance to the hospital, dominance, employment status, highest level of education, smoking status, number of tendons involved and time to repair. This was achieved by the researcher refraining from treating patients with flexor tendon injuries during the recruitment and data collection period, not having access to participants folders, treatment notes or general information sheets until the end of the data collection period in December 2017.
9. Any one of the eight occupational therapists employed at the tertiary hospital who assessed the participant completed the general information form (see appendix F) using the information gained from the assessment form (see appendix O) and filed it away. Any one of the eight occupational therapists who treated the participant followed the relevant guideline (see appendix N) chosen by the assessing occupational therapist to guide their choice of the most appropriate treatment protocol and follow the protocol correctly. The researcher issued each participant a log book to record their adherence to the home programme given, any pain experienced as well as their activity level during the first four weeks post-operatively (see appendix P). The participant was shown how to use the log book by the researcher and practiced using the log book for the researcher to review whilst still in hospital to ensure they understood how to make use of it.
10. During the first two months of recruitment, it was noted that the initially proposed recruitment process was not yielding enough patients to participate in the study as the interns of the orthopaedic department were either referring patients to the occupational therapy department too late or not at all. On 27 March 2017 an amendment to the recruitment process was requested from the Human Research Ethics Committee of the Faculty of Health Sciences at the University of Cape Town. Approval was given on 06 April 2017 (see appendix S). From this point, possible participants were identified from the theatre list and approached before referral to the occupational therapy department.

3.6.3. Data Collection

1. As many patients receiving treatment resided in areas that involved transport costs to access the hospital, monetary compensation for transport (R50.00 per assessment) was provided. This was given to the participant each time they were assessed by the researcher at the beginning of each assessment.
2. Participants were booked to attend occupational therapy sessions at two, four, eight, ten, twelve and fourteen weeks post operatively as well as to see the surgeon at two, six and twelve weeks. At four, eight, twelve and sixteen weeks the study participants were assessed by the researcher, before their therapy session, in a separate room (see instrumentation on page 29). The data was recorded on specially designed assessment sheets identified by the participations research number (see appendix H, I, J, K). To improve the likelihood of attendance, patients were contacted via a short message service (SMS) the day before their appointment on the telephone number documented at the time of recruitment. If participants were unable to attend, they were contacted with a new date.
3. At the end of the sixteen weeks, each participant was thanked for their participation and debriefed to address any discomforting feelings, such as the time it was taking to recover, pain still experienced and loss of income due to the loss of employment.
4. The participant's occupational therapy treatment notes were accessed in December 2017 to extract the following information and record it on the last section of the sixteen week assessment form for each participant (see appendix K):
    a. Number of treatment sessions post-operatively until sixteen weeks.
    b. Complications: mild, moderate or severe adhesions, ruptures, sepsis, need for tenolysis, need for physiotherapy intervention etc. This was informed by whether any of the occupational therapists who treated the participant documented any of these complications. If no mention was made then it was assumed that the outcome was positive.
    c. Adherence to rehabilitation. This was informed by whether any of the occupational therapists who treated the participant noted problems in adherence as moderate or severe. If no mention was made then it was assumed that the outcome was positive.

3.6.4. Data Management

1. Data were collected from 06 February 2017 until the 01 December 2017. This occurred on five different occasions for each participant. Table 4 outlines the details for each form that was completed and where it was stored in the occupational therapy department:
2.

Table 4: Forms completed during recruitment and data collection.

Stage of completion	**Name of form (where available)**	**Completed by**	**Received by**	**Management**
Recruitment	Study Information Sheet (appendix A)	Researcher, participant	Participant	Participants record
Recruitment	Informed consent (appendix B)	Researcher, participant, witness	Researcher Participant	Locked in drawer 1 of filing cabinet. Participants record
Recruitment	Participant list (appendix G)	Researcher, participant	Researcher	Locked in drawer 2 of filing cabinet
Data Collection	General information form (appendix F)	Treating OT, participant	Treating OT	Locked in drawer 3 of filing cabinet
Data Collection (week 4)	Assessment sheet week 4 (appendix H)	Researcher, participant	Researcher	Locked in drawer 4 of filing cabinet
Data Collection (week 8)	Assessment sheet week 4 (appendix I)	Researcher, participant	Researcher	Locked in drawer 4 of filing cabinet
Data Collection (week 12)	Assessment sheet week 4 (appendix J)	Researcher, participant	Researcher	Locked in drawer 4 of filing cabinet
Data Collection (week 16)	Assessment sheet week 4 (appendix K)	Researcher, participant	Researcher	Locked in drawer 4 of filing cabinet

3. On completion of the data collection phase of the study, these assessment sheets were filed with the corresponding general information sheet within a locked drawer to which only the researcher had access to.
4. The raw data was entered into an Excel spread sheet on a password protected computer.

3.6.5. Data Analysis

The data analysis process began once the data collection period was completed in December 2017. Data were analysed with Statistica for Windows. A p-value of 0.05 or less was considered statistically significant for all statistical tests.

OUTCOMES

Two of the three outcome measures were analysed for each of the four time points and the third at the last two only due to tendon healing considerations. Due to the small sample size, mean and standard deviation could not be meaningfully analysed. Instead, median and range were described for all data. In order for the results to be easily understood and accessible to clinicians, the results for TAM and muscle strength were categorised as poor, fair, good or excellent. For TAM the Strickland and Glogovac (1980) scoring system was used (see instrumentation). For muscle strength, the mean of three scores was used to compare to South African normative scores for grip strength (Pretorius et al., 2005). The percentage return was documented using the categories described by Riaz, Khan and Small (1999) (see instrumentation). The median and range for the DASH scores were documented for each of the four time points.

RATE OF RECOVERY

The rate of recovery for TAM was analysed utilising Spearman's Rank Correlation Co-efficient. This was found to be the most appropriate statistical test for assessing the rate of recovery for TAM as TAM is considered a categorical data type and thus requires the use of a non-parametric test. The data derived from the DASH questionnaire are considered non-parametric, ordinal data as the DASH utilises a Likert scale and so the Friedman ANOVA test was used to test for differences between the four, eight, twelve and sixteen week DASH scores. Due to tissue healing considerations, muscle strength was only assessed at the twelve- and sixteen-week time frames. The Wilcoxon Matched Pairs Test was used to analyse these data. Data were considered statistically significant if the p-value should be less than or equal to 0.05 and the z-value (test of significance for standard normal distribution) greater than 1.96.

FACTORS THAT AFFECT OUTCOME

As TAM was calculated per finger and not per participant, it could not be used as an outcome measure. Instead, the DASH scores for each participant at the sixteen-week time frame was used to compare the factors that may have influenced the outcome. There were missing data for two participants at the sixteen-week assessment so the data from the twelve-week assessment were carried forward for this test. This practice is used when there are data points missing but can introduce bias as any change that may have occurred over time can't be accounted for (Kang, 2013). Smoking status and pre-operative occupational therapy treatment were analysed against the sixteen-week DASH scores utilising the Mann Whitney U test as there were only two categories for each (i.e. yes/no). Expertise of surgeon, time to repair, rehabilitation protocol used, zone of injury, number of days with pain and adherence were analysed against the sixteen-week DASH scores utilising the Kruskal-Wallis test due to the multiple variants for each category. As there were fewer than ten data points in each category for these data, it could introduce bias in the data analysis.

3.7. Ethical considerations

Ethical clearance was obtained through the University of Cape Town's Human Research Ethic Committee (HREC REF: 713/2016; 18 November 2016). In accordance with the Declaration of Helsinki (2013) the following ethical philosophy was observed during the course of the research:

3.7.1. Autonomy

Throughout the research process, the participant was respected as an autonomous individual with the freedom to choose which action they took. This was upheld in the informed consent (see appendix B) and information sheet (see appendix A) which stated any and all positive and possible negative effects if they chose to participate. Each participant had the freedom to withdraw from the study at any time without need for explanation or fear of negative consequences.

3.7.2. Beneficence

The researcher understood the importance of respecting the welfare of each participant. The possible risks to the participants were:

1. Physical discomfort during the ROM and muscle strength tests as they were requested to exert as much movement/force as possible;
2. Emotional discomfort when answering the questions in the DASH as this may have elicited feelings of helplessness or frustration at their difficulty in performing certain tasks;
3. Financial strain secondary to transport costs to attend occupational therapy and assessment at the tertiary hospital.

However, these risks were considered reasonable by the researcher as the benefits included:

1. Improved motivation with regular monitoring of ROM, muscle strength and hand function;
2. The knowledge gained from the research will aid in improving rehabilitation and surgical services at the tertiary hospital for future patients;
3. The participants were compensated for their transport fee.

3.7.3. Non-Maleficence

The researcher observed the ideology "first, do no harm" by taking every precaution to ensure that each participant's confidentiality and autonomy was respected. In addition, the researcher ensured that the research process did not place any undue physical, emotional, social or financial harm on the participant. Precautions included:

1. Making use of assessment tools that would cause no physical harm in accordance with soft tissue healing times (i.e. muscle strength assessed from twelve weeks when resisted movement is allowed). Physical discomfort experienced during the ROM and muscle strength tests were similar to those experienced during a participant's home programme.
2. Containment of any uncomfortable feelings of the participant was provided by the researcher when required.
3. Each participant was compensated financially for the cost of transport to and from the hospital (R50 per visit paid on the day of assessment).

3.7.4. Confidentiality

Confidentiality is important in order to uphold the principles of beneficence and non-maleficence. This was ensured by separating the participant's details in the informed consent forms to the assessment forms and general information forms. The participant list was stored in a locked drawer in the researcher's office and will be destroyed as soon as the dissertation is complete. The participant list was necessary in order to track the participants name to their research number during the data collection period only. Once destroyed, there will be no manner to match the participants name to their research number. In addition, it is understood that the identity of the institution as well as the orthopaedic surgeons and occupational therapists who work at the institution are protected and has been done to the best of the researchers ability. It is possible however for a reader to deduce the identity of the tertiary hospital as there are only three in the province and one in the study region. On completion of the data analysis and dissertation, the participant information will be kept for a period of a year and then destroyed. The general information sheet and assessment sheets were kept for a period of 6 months in a locked drawer in case of need for future reference and then destroyed. The informed consent sheets will be kept locked in a drawer in the occupational therapy department at the study site for a period of a year and destroyed thereafter.

3.7.5. Justice

Fair selection of research participants was ensured by recruiting all patients with a flexor tendon injury that matched the inclusion and exclusion criteria. Participation in the study was voluntary. This ensured that the risks and benefits were evenly distributed within this population group.

3.7.6. Veracity

The researcher understands that there is an obligation to tell each participant the truth about every known risk and benefit in consenting to participate in the research. This was clearly stated in the information sheet (see appendix A) in the participants home language at an acceptable level. This ensured that the participant fully understood what was stated. The researcher clearly stated that the participant could withdraw from the study at any time without need of an explanation or risk of persecution.

3.8. Chapter Summary

This chapter outlined the rigorous process followed for the present study. The descriptive analytical research design was described before the population and participants chosen for the study, instrumentation, procedure for the study and the ethical considerations were outlined.

Chapter 4: Cross Cultural Translation of the Disabilities of the Arm Shoulder and Hand Questionnaire into isiXhosa

4.1. Introduction

This chapter outlines the processes of the cross-cultural translation of the DASH questionnaire from English into isiXhosa. In order to understand the outcome measure and the relevance for a rigorous translation method, a background of the DASH and cross-cultural translation will be examined. The methodology section outlines the seven steps followed for the cross-cultural translation. The results for the process of forward and backward translation as well as the field testing are documented. Following the results, the discussion unpacks the challenges faced during the process and the reasoning for the changes that were made. Finally the conclusion summarises the findings for the chapter.

4.2. Background

The DASH questionnaire is a patient rated outcome measure (PROM) that was developed by the Institute for Work and Health, a company based in Toronto, Canada (Beaton & Kennedy, 2013). This 30-item outcome measure contains questions that are function based as opposed to movement or exercise based. This has made the DASH a popular tool in research for measuring participation and activity deficits resulting from upper limb injuries and pathologies (Oltman et al., 2008). Over 2092 articles have reported using the DASH as an outcome measure and it has been translated into more than 50 languages (Kennedy & Beaton, 2017).

The DASH allows the researcher, clinician and the patient to consider more than just body function and structure. Instead, it measures to what extent their upper limb injury is affecting their ability to perform the tasks in their day-to-day life (Beaton & Kennedy, 2013). This is in line with the International Classification of Functioning Disability and Health (ICF) framework. In an editorial for the Journal of Hand Therapy, MacDermid (2017) highlighted the importance of accurate measurement with the use of PROM's to improve clinical reasoning and have a better understanding of patient perspectives so that rehabilitation is more patient-directed. As most assessment tools are initially generated in English, cross-cultural translation is needed to broaden the use of the assessment for different languages and cultures whilst still maintaining their validity, clarity and relevance (MacDermid, 2017). However, items that are not culturally appropriate may need to be changed to suit the target populations' beliefs and values (MacDermid, 2017). Beaton et al (2007) developed a guideline for cross-cultural translation of the DASH to address the increasing need for direction when translating the DASH and quickDASH questionnaires. Over the years, the process of cross-cultural translation has improved ensuring that quality assessment tools can not only be read in different languages, but are also contextually and culturally sensitive to the differences in each culture (Beaton, Bombardier, Guillemin, & Ferraz, 2007; MacDermid, 2017). Several studies have shown that following the process of cross-cultural translation guidelines by Beaton et al. (2007) resulted in high test-retest reliability, inter-rater reliability and psychometric testing showing a strong correlation to the original English version of the DASH (Golicki, Krzysiak, & Strzelczyk, 2014; Ibikunle, Odole, Akosile, & Ezeakunne, 2017; Mousavi et al., 2008; Orfale, Araújo, Ferraz, & Natour, 2005; Themistocleous et al., 2006). With rigorous adherence to the guidelines as outlined by Beaton et al (2007), cross-cultural translation can be successful and beneficial to the communities of the subsequent translations.

As of the January 2017, there were only two South African language translations of the DASH and QuickDASH, namely: 'South African English' and 'Afrikaans' (Health, 2018). This was troubling considering that there are nine official languages of South Africa that were not represented, which limited its use in South African studies. Deumert's (2010) study on the effect of multilingualism on patient-provider interactions in health facilities in the Western Cape of South Africa showed the invisibility of indigenous South African languages within a predominantly mono-lingual English health system (Deumert, 2010). Findings revealed that if patients do not speak the language of the health care provider, there is a breakdown in communication (Deumert, 2010). Furthermore, key information is lost or overlooked, confidentiality is infringed upon with the use of support staff as translators, and both parties become frustrated (Deumert, 2010). This has a strong impact on accessing quality care as patients tend to avoid visiting these health care facilities and, even if they do attend, there are often errors in diagnosis and treatment (Deumert, 2010). Furthermore, the health care professional cannot be truly client centred or educate the patient properly on their health condition due to the language barrier (Deumert, 2010). As a result, there is a greater chance of non-adherence with treatment (Deumert, 2010). Considering the Batho Pele[7] principles of South African public service standards, which calls for inclusiveness in consultation and information giving, equal access to services, efficiency and accountability by public servants (Moeti, 2014), as well as the ethical principle of justice in the context of the present study, the outcome measures needed to be accessible to each participant in their home language (i.e. English, Afrikaans and isiXhosa). In this way the sample could be more representative of the population who are treated at the tertiary hospital. Translating the DASH into isiXhosa will also make it possible for patients and health care providers to engage in conversation regarding their functional deficits in order to bridge the language barrier gap.

[7] Meaning "people first".

4.3. Methodology

The Institute for Work and Health guidelines for the cross-cultural translation of the DASH were followed to produce the isiXhosa version of the DASH (Beaton et al., 2007). The process laid out in the guideline document was followed rigorously and is described in this section. The steps as described below are summarised in Figure 2.

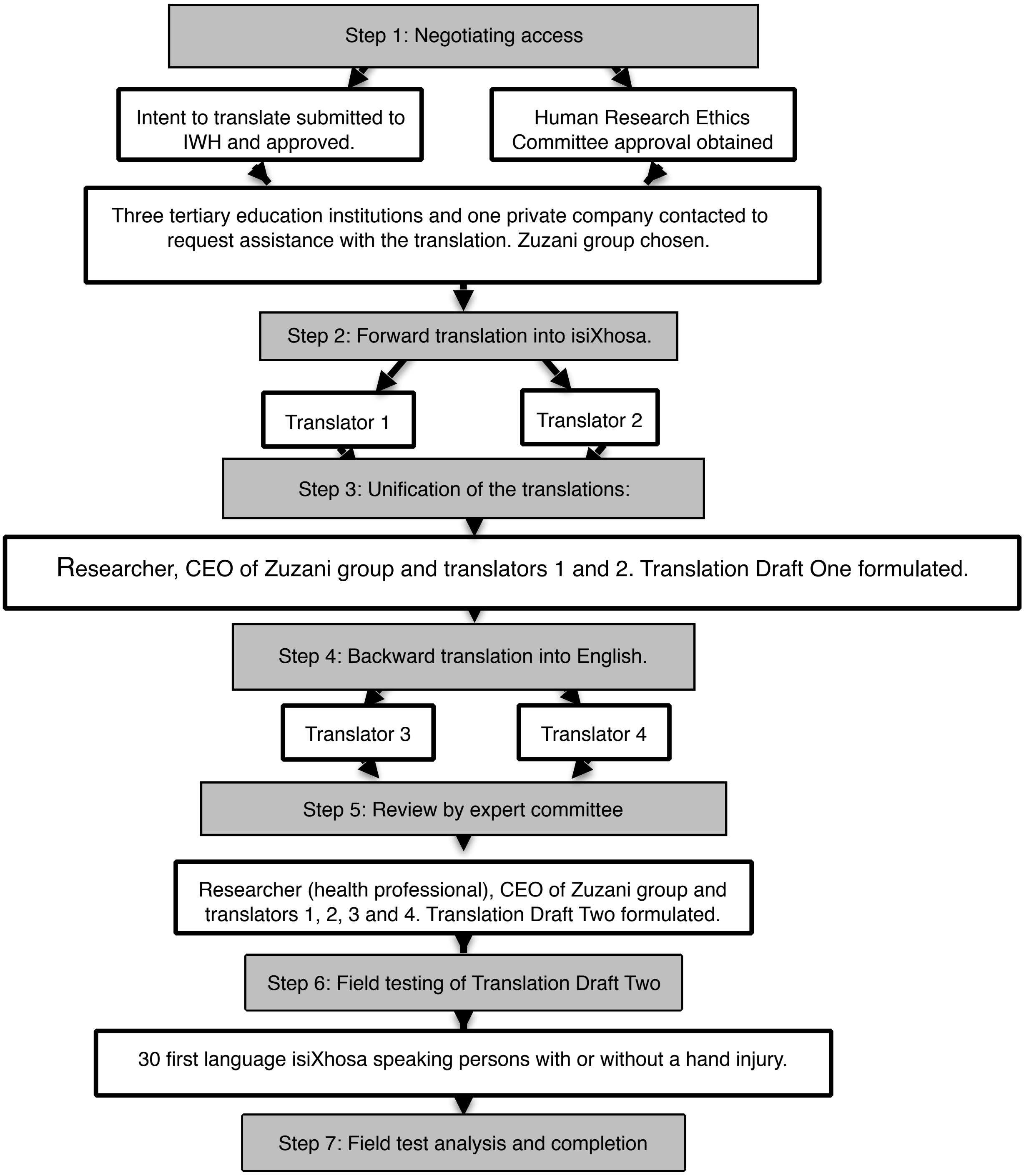

Figure 2: Process of Cross-Cultural Translation of the DASH into isiXhosa.

4.3.1. Step one: Negotiating access

An "Intent to translate" form was completed and sent to the Institute for Work and Health for approval to translate the DASH into isiXhosa. Written approval was received on 19 October 2016. The recommended process of cross-cultural translation for the DASH starts with an expert committee made up of a health professional, researcher, language professional and the translators (Beaton et al., 2007). This is to ensure that the use of the outcome measure and each of the question items is well understood as well as the use of language in the process of translation. Four institutions (three tertiary education institutions and one private translation company) were contacted telephonically and via email to request assistance with the translating the DASH into isiXhosa by first language speakers. Two institutions returned correspondence indicating they were willing to assist: a tertiary education institution and a private translation company. The private translation company was chosen due to their experience with translating legal documents and medical assessment tools. An initial meeting with the Chief Executive Officer (CEO) of The Zuzani Group was organised in order to clarify the process and the reasoning for the rigorous and specific protocols with the translation of the DASH. Four translators were identified for the task by the CEO. The CEO assisted the researcher in ensuring that the process was rigorous and followed the stipulated guidelines.

4.3.2. Step two: Forward translation into isiXhosa

The forward translation of the DASH from English into isiXhosa was conducted by two bilingual, first language isiXhosa-speaking persons who were experienced in translation. Both of the translators had not seen the outcome measure before. The translators were not allowed to have contact with one another during the translation process to ensure that it resulted in two isiXhosa versions of the DASH questionnaire.

4.3.3. Step three: Unification of the translations

A second telephonic meeting with the CEO, the researcher and the two translators was conducted. The discrepancies between the two forward-translations were discussed and analysed. Once consensus was reached for each of the discrepancies (see table 5), one document was made: "Translation Draft One".

4.3.4. Step four: Backward translation into English

Translation Draft One was then backward translated from isiXhosa into English by two additional, bilingual translators from Zuzani Group who were not involved in step two and had not seen the original English version of the DASH. This was done to ensure veracity. The translators were instructed not to be in contact with one another during the backward translation process.

4.3.5. Step five: Review by expert committee

The two backward-translations were analysed by the translation team made up of the four experienced translators who assisted in the processes of forward and backward translation, the CEO of Zuzani group and the researcher who is a health professional familiar with the DASH. This was done to ensure that the meaning of the questions remained the same (see Table 5). Once consensus had been reached by the team, “Translation Draft Two” was compiled in preparation for field testing.

4.3.6. Step six: Field testing of Translation Draft Two

The field test requires 30 people who are first language isiXhosa speaking persons to complete the DASH as if for themselves (Beaton, Bombardier, Guillemin, & Ferraz, 2007). They are then asked probing questions to ensure that the meaning of the questions remained true to the original version and whether any changes for cultural relevance or better understanding is needed (Beaton, Bombardier, Guillemin, & Ferraz, 2007). Participants for the field test were recruited from the tertiary hospital for the present study and came from different parts of the Western Region of the Eastern Cape

INCLUSION CRITERIA:

- Any person who is home language isiXhosa speaking was invited to participate.

EXCLUSION CRITERIA:

- Any person who could not read or write in isiXhosa at a grade nine (i.e. United Kingdom year ten) level or had a mental illness that would affect their ability to understand the implications of participating in the study.

Translation Draft Two of the DASH in isiXhosa was field tested on 30 persons with and without hand function deficits who were first language isiXhosa speakers. An information sheet (see appendix E) was given to each participant to read and given the opportunity to ask questions regarding their participation after which informed consent (see appendix E) was obtained from those who agreed to participate. The participants were then asked questions pertaining to the cultural relevance of the questions, the ease of answering the questions and the veracity of the questions.

4.3.7. Step seven: Field test analysis and completion

For this step, the expert committee gathers to review the findings of the field test and make changes to the preliminary translation as needed (Beaton, Bombardier, Guillemin, & Ferraz, 2007). A final version of the DASH is then compiled before being submitted to the Institute for Work and Health with all supporting documentation for review and approval (Beaton, Bombardier, Guillemin, & Ferraz, 2007). Participants' comments about Translation Draft Two of the isiXhosa version of the DASH were collated into a table and frequencies were determined for each comment by the researcher (See Table 6). These points were discussed with the expert committee. Each comment was discussed and relevant changes were made only when there was consensus by the expert committee. The Final Translation Draft of the isiXhosa version of the DASH and quick DASH was formulated. The final drafts and all supporting documents were sent onto the Institute for Work and Health for review.

4.4. Results

The results from the forward translation, backward translation and field testing are presented in this section. Section 4.3.1 present the results from the forward and backward translations and expert committee actions with reasoning. Section 4.3.2 presents the findings from the field testing, actions taken by the expert committee in response and reasoning.

4.4.1. Forward and backward translation changes

Table 5 charts the results from the forward and backward translations of the DASH from English into IsiXhosa by the translation team, the actions taken and the reasoning behind the chosen action.

Table 5: Forward and backward translation changes.

Page:	Comment by expert committee (paraphrased):	Action/Note:	Reasoning:
	Forward translation:		
1, 2, 3 & 4.	Two different words were used for arm: “ingalo” and “utekele"	The word “ingalo” was chosen.	“Ingalo” is the most colloquial and widely used term from arm.
	Backward translation:		
1	Meaning for “It doesn’t matter…” changed to “It’s not important…”	No change made.	The difference in wording doesn’t change the meaning of the sentence.
1	“every question” was translated as “all questions”	No change made.	The difference in wording doesn’t change the meaning of the sentence.
1	“This questionnaire asks about your symptoms as well as your ability to perform certain activities.” was translated as “The objective of this questionnaire is to ask you about your symptoms and your ability to do some activities”.	No change made.	The difference in wording doesn’t change the meaning of the sentence.

4.4.2. Field Testing

Of the 30 participants recruited for the field test, half were males and half females. Only question item 21 was not completed by three participants regarding “sexual activity”. Participants identified 31 problems with Translation Draft Two. The comments by participants were summarised and categorised in relation to four sections: general comments and layout, spelling errors and corrections, word or phrasing errors and cultural considerations for Translation Draft Two. These are collated according to problem type in Table 6.

Table 6: Field testing results, actions made and reasoning:				
General comments and layout:				
Page (Question)	Comment by participants (paraphrased):	No. of participants	Action to be taken/ note:	Reasoning:
All	Text can be too small to read	**1**	Make text larger by one font size	To make reading the text easier and more user friendly.
Page 3	Some questions are very long and can be difficult to read	**3**	No changes made.	Original English sentences were long. Shortening them may result in change in validity
All	The register of the language may be too high a level for the average isiXhosa speaking person.	**1**	No changes made.	One person mentioned this problem. 29 other participants were satisfied with the register of the language.
4 (5)	Question 5 needs numbers	**6**	To add scoring numbers.	For correct scoring to be done.
All	Spelling mistakes sometimes made it difficult to read.	**1**	To correct spelling mistakes.	See section below.
Spelling differences and corrections:				
Page (Question)	Comment by participants (paraphrased):	No. of participants	Change approved or declined:	Reasoning for change:
Pg-1	Iwembuzo should be spelled Iwemibuzo	**2**	Approved	Spelling more well known.
Pg-2	“ichanekileyo” should be spelled “**e**chanekileyo”	**2**	Approved	Spelling more well known.

Pg-2	"khange ukwazi" should be "ndikwazi"	1	Declined	Spelling not considered correct in formal or colloquial registers.
Pg-2 Q-18	"isandla should change to "nesandla"	1	Declined	Grammar not considered correct in the context of the sentence.
Pg-3 Q-23	"Bekungekho to" should change to "Bekungekho nto" "Okuncinane" should change to "Kancinane" "Okuphakati" should change to "Phakati" "Okukhulu" should change to "kakhulu" "Bendingakwzi" should be "Bendingakwazi"	1	No change made.	Spelling not considered correct in formal or colloquial registers.
Pg-3 Q-23	"Okwenzeni" should be "ekwenzeni"	1	No change made.	Spelling not considered correct in formal or colloquial registers.
Pg-3 Q-23	"ngemihl" should be "ngemihla"	**10**	Approved	Spelling more well known.
Pg-3 Q-23	"idlulileyo" should be "edlulileyo"	1	No change made.	Spelling not considered correct in formal or colloquial registers.
Pg-3 Q-25	"nxa" should be "xa"	**3**	Approved	Grammar considered more correct in the context of the sentence.
Pg-3 Q-26	"isandla" should be "esandleni"	2	No change made.	"Isandla" means "hand" whilst "esandleni" means "the hand of".
Pg-3 Q-29	"bebubungakanani" should be "bebungakanani"	**3**	Approved	Spelling more well known.
Pg-4	"bunzima" should be "ubunzima"	1	No change made.	Spelling not considered correct in formal or colloquial registers.
Pg-4 Part 1 Q-2	"sibuhlunguo" should be spelled "sibuhlungu"	**6**	Approved	Spelling more well known.
Pg-4 Part 2 Q-2	"ukudlaleni" should be "ekudlaleni"	1	No change made.	Spelling not considered correct in formal or colloquial registers.
Pg-4 Part 2 Q-4	"ekuthatheni" should be "ukuthatha"	1	No change made.	Spelling not considered correct in formal or colloquial registers.

Pg-4 Part 2 Q-5	"ezimidlalo should be "ezemidlado"	1	No change made.	Spelling not considered correct in formal or colloquial registers.
Word and Phrasing Errors:				
Page (Question)	Comment by participants (paraphrased):	No. of participants	Proposed change:	Change made: Reasoning for change:
Pg-2 Q-4	"Prepare a meal". The word "isidlo" for "meal" is not normally used.	1	For this item, it was suggested by one participant that the word used "isidlo" be changed to the word "ukutya".	No change made. This would change the meaning of the sentence to "prepare food" rather than "prepare a meal". Therefore, the word "isidlo" was kept as it was more true to the original translation even though it was suggested that it is not as commonly used in everyday conversations.
Pg-2 Q-6	"Place an object on a shelf above your head". According to two participants, the word used for shelf in the first draft "kwishelf" is a borrowed word from the English word "shelf"	**2**	It was suggested that a more culturally appropriate isiXhosa term "kwithala" should be used as opposed to "kwishelf".	No change made. "Kwithala" when translated means "library", not "shelf". It may, therefore affect the veracity of the item. According to Moropa and Kruger (2000), translation from one language to another can be difficult especially when translating culturally specific terms. One of the five strategies suggested is translation using a loan word if a word from the target language can't be found (Moropa & Kruger, 2000). In this case, the term "kwishelf" was kept.
Pg-3 Q-22	"Quite a bit". One participant noted that the term used for this measure, "Ibinkulu" did not fit the meaning.	1	It was suggested that it should be replaced with "Ibinkulwana".	No change made. The team decided against this change as "ibinkulwana" means "the larger" whilst "Ibinkulu" means "quite a lot" which is closer to the original version.

Pg-3 Q-30	"I feel less capable, less confident or less useful because of my arm, shoulder or hand problem". Two participants found this sentence confusing.	**2**	It was suggested that the wording of the sentence be changed to add more meaning to the sentence.	Suggested change approved. On inspection, it was found that this addition would help make the sentence easier to understand.
Pg-2 Q-20	"Manage transportation needs (getting from one place to another)". This item was originally translated as "Ukukhwela izithuthi (ujikeleza usiya kwiindawo ngeendawo)." which means "Transportation (going around from place to place)" but this was unclear for one participant.		Being more specific: i.e. riding in public transport or driving in a car.	It was changed to " Ukukhwela izithuthi zikawonke-wonke okanye ukuqhuba isithuthu (ujikeleza usiya kwiindawo ngeendawo)" which means "riding in public transport or driving a car (to go around from place to place)". This was to ensure that the meaning was clearer and more relevant to the South African commuting population who commonly use public transport in the form of mini-bus taxi's, buses or their own cars.
Cultural Considerations:				
Page (Question)	Comment (paraphrased):	No. of participants	Proposed change:	Change made: Reasoning for change:
Pg-2 Q-13	"Wash or blow dry your hair". Six participants noted that this activity is not relevant to them as they do not use a hair dryer on their hair.	**6**	It was suggested that "using a hair dryer" be changed to "wash or comb" your hair" "Wasa okanye komisa inwele"	This item was changed to "ukuhlamba inwele" which means to "wash your hair". This change was suggested as the activity of washing hair requires the same amount of shoulder flexion and abduction and elbow flexion as blow drying the hair does. It also requires the same prolonged isometric contraction to maintain this position during the activity.

Pg-2 Q-19	"Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.)". Eleven participants noted that the recreational activity examples mentioned in this question are not commonly played by South Africans let alone in isiXhosa speaking communities.	**11**	It was suggested that this be changed to "throwing a ball" (phosa ibhola) or "play netball".	Example changed to "phosa ibhola" meaning "throwing a ball" According to the South African Government Department of Sport and Recreation, common sporting activities in the country include cricket, rugby, soccer, tennis and netball amongst others (Tibane, 2018). In all of these sports it is at one time or another required to throw or pass a ball. The suggested change was "phosa ibhola" which means pass or throw a ball. This change was seen as relevant as the task of throwing or passing a ball is found in most of the above mentioned sporting activities and requires free movement and control of the whole upper limb including shoulder, elbow, wrist and hand as would be needed in frisbee or badminton..
Pg-2 Q-21	4 people were not comfortable with answering this question.	**4**	No change made.	The dash score is still valid if one question is not answered.
Pg-2 Q-21	"Sexual activities". Four participants found the term used in the translation "Ukwabelana ngesondo" to have two meanings. The one meaning is "to have sex" while the second meaning is "to thread a needle".	**4**	It was suggested that the phrase be changed to ukwabelana ngesondo" which means "to have sex"	No change made: the original translation used was appropriate. It is commonly used on radio, television, in clinics and communication about sex. It is even used mostly in HIV/AIDS campaigns.

4.5. Discussion

The process of cross-cultural translation of the DASH from the original version into isiXhosa will be discussed below. Firstly, the results from the forward and backward translations will be explored before reviewing the results from the field testing and expert committee review.

4.5.1. Forward and Backward translation

The double forward-backward translation process is essential in the translation of an assessment tool (Beaton, Bombardier, Guillemin, & Ferraz, 2007). In this study, there were four points in this process that needed discussion by the translation team, one with the double forward translation and three with the double backward translation.

Double forward translation allows for comparison in differences in diction and phrasing that one translator may use to another (Beaton, Bombardier, Guillemin, & Ferraz, 2007). The translation team can then debate and decide the diction or grammar that is most widely used or more correct in the context of the sentence (Beaton et al., 2007). With the double forward translation of the English version of the DASH into isiXhosa, only one discrepancy emerged. The word for arm was translated as "ingalo" by one translator and "utekele" by the other. Differences in diction are common with double forward translation processes (Golicki et al., 2014; Ibikunle et al., 2017; Mousavi et al., 2008; Orfale et al., 2005; Themistocleous et al., 2006). A word in one language could have many different words in another that could mean the same thing. For example, whilst English only has one word for love, there are nine different words in Hebrew for love, and each word is used in a different context (Translate, 2018). It is therefore important to review differences in diction to choose the one that is most true to the meaning of the original text. In this instance, the word for arm, "ingalo" was chosen as it is the most widely used across the isiXhosa language.

When translating any document from one language into another, differences in diction and phrasing that may not be true to the original text may emerge. Phrases or diction that may make sense in one language could mean something completely different or make no sense at all in another (Maclean, 2007). Double backward translation allows the translation team to ensure that the meaning of the work is still true to the original text and whether any troublesome differences warrant a review of the translated text (Cha, Kim, & Erlen, 2007). In this translation process, three differences in the phrasing was noted. Firstly the original sentence for "It doesn't matter…" was changed to "It's not important…" on backward translation. Also, "every question" was translated as "all questions" from the original to the backward translation and finally, "This questionnaire asks about your symptoms as well as your ability to perform certain activities." was translated as "The objective of this questionnaire is to ask you about your symptoms and your ability to do some activities". Though the differences in phrasing and wording was apparent, the changes did not influence the meaning of the instruction and therefore was not troublesome enough to warrant a review of Translation Draft One.

4.5.2. Field testing

Cross-cultural translation does not only involve the double forward-backward translation of words and phrases into the target language but ensures that the questions and activities mentioned are relevant to the target population (MacDermid, 2017). The role of field testing is to ensure that members from the target community engage in the activities mentioned, that the register of language used was appropriate and that the diction and phrasing was easily understood by the general population (Beaton et al., 2007). After which, it is the job of the translation team to address each comment and find solutions that will be culturally relevant in the community whilst still maintaining the veracity and validity of the original assessment tool (Beaton et al., 2007). Some of the problems that were identified by participants in the field test were similar to those found elsewhere, whilst others were unique to the cross-cultural translation of the DASH into isiXhosa. These similarities and differences will be discussed below.

The only question item that participants did not answer (n=3) was item 21 regarding "sexual activity". These participants expressed that they did not feel comfortable with answering the question. Similarly, in the Polish translation of the DASH questionnaire, this issue also arose during field testing, with 60% of participants leaving the question unanswered (Golicki et al., 2014). Due to the personal nature of question item 21, people may choose not to answer the question (Golicki et al., 2014). Despite this, the score can still be interpreted if more than 90% of the DASH is completed (Beaton et al., 2001).

The first issue arose from problems related to user-friendliness and the register[8] of the language used as tabulated in Table 6 under "General comments". These issues do not directly relate to diction or cultural relevance but are still important factors to consider in order for the final translated outcome measure to be user-friendly and time-efficient. Problems that were reported included the size of the text, length of sentences and overall register of the language used. The size of the text was easily rectified but the issue of the length of the sentences used and register were more difficult to address. The translation team decided that it was not possible to make the sentences shorter without possibly changing its meaning. Only one participant commented that the register was too difficult whilst the rest of the participants found the questionnaire easy to read and

[8] Refers to how formal the language that is used is.

understand. Previous literature showed similar results. In the translations for the DASH questionnaire into Polish (Golicki et al., 2014), Persian (Mousavi et al., 2008) and Canadian French (Durand, Vachon, Hong, & Loisel, 2005), the participants found that the language and instructions were easy to understand. The translation team agreed that the register for the isiXhosa translation was not too formal for a person with a grade nine level of education.

One of the categories of concern raised by participants were issues with regards to word and phrasing. Word and phrasing difficulties occur when the local population find that the diction and phrasing used in the translated questionnaire are not appropriate in the target language. Ibikunle et al. (2017) found that the manner in which the original tool was phrased did not fit into the Igbo lexis[9]. In order for the question items to be relevant to the target population, the way in which the sentences were structured needed to be adapted whilst still maintaining the original meaning of the PROM. Some participants found the wording for item 20 and 30 were confusing. In the Greek (Themistocleous et al., 2006) and Canadian French translations (Durand et al., 2005), participants noted that the wording for “managing transportation needs” (item 20) was misinterpreted for each of these two translations. In each case, the wording for item 20 needed changing in order for the meaning to be clearer (Durand et al., 2005; Themistocleous et al., 2006). For the isiXhosa translation, a similar change needed to be made to item 20 and 30. For item 20 in Translation Draft Two, the translated question did not make accommodation for those who use public transport. It was then decided by the translation team to add some more explanation to the item by adding examples of different transportation methods in brackets, including using a taxi, bus or car. For item 30, the wording of the question was changed to make the meaning of the question clearer. Three of the suggested changes would have changed or altered the meaning of the item and were therefore voted against by the translation team. For example, in item 4 where the word for “meal” was disputed. The word suggested to replace this word would have changed the sentence from “preparing a meal” to “preparing food” which have different meanings and task demands. In this way, the translation team decided that, in order to maintain the meaning of the sentence, the word for “meal” should remain.

As with many other cross-cultural translations of the DASH, not all activities mentioned in the assessment tool were applicable to the target population (Orfale, Araújo, Ferraz, & Natour, 2005; Themistocleous et al., 2006; Mousavi et al., 2008; Golicki, Krzysiak, & Strzelczyk, 2014; Ibikunle, Odole, Akosile, & Ezeakunne, 2017). Though changing an item may impact on the validity of the PROM, it is more important to ensure that the activities described are relevant to the target population (Beaton et al., 2007). Four items in the DASH were identified by field test participants as not being culturally relevant. Each of these were considered for discussion by the translation

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[9] Lexis: the level of vocabulary used.

team in order to find alternative activities and occupations that are more culturally relevant but will elicit the same or similar movement of the original item. For example, for item 19 regarding "Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.)", the examples given are not well known by the target population. This is similar to the translations of the DASH questionnaire into Canadian French (Durand et al., 2005), Greek (Themistocleous et al., 2006) and Nigerian Yoruba (Odole et al., 2016). For each of these translations, the examples for recreational activities needed to be changed for it to be more relevant to the target population. This process is accepted in the field of cross-cultural translation and is the reason for the name. When an activity is not performed within the context of the target population's everyday comings and goings, the item is then null and void. This results in question items being left blank or incorrectly scored as they are misunderstood (MacDermid, 2017). In addition, the replacement activity must mimic or incur similar movement patterns and demands as those of the original PROM to ensure validity (Beaton, Bombardier, Guillemin, & Ferraz, 2007). The activities chosen to replace those of the original outcome were discussed carefully by the translation team to be relevant to the target population whilst still utilising the same movement demands as the original text.

Differences in spelling is an uncommon issue with regards to translation of tools from one language into another. None of the articles reviewed regarding previous translations of the DASH into a new language noted problems with differences in spelling. This unique challenge was encountered when translating the DASH into isiXhosa. Due to the history of the development of an isiXhosa alphabet and subsequent isiXhosa-English dictionaries, differences in orthography for the language have developed. Moropa and Kruger (2000) outline the history and development of the isiXhosa orthography[10]. With the arrival of Western White Colonialists to South Africa, foreign missionaries were sent to the region to learn the native African languages and teach them Christianity (Jones, Podile, & Puttkammer, 2005). There were numerous attempts by multiple foreign missionaries to create an alphabet and dictionary (Moropa & Kruger, 2000). In addition to this, the changing nature of language has resulted in modern day difficulties in deciding on new versus old orthography when creating a spell checker for the isiXhosa language (Jones et al., 2005). Since no other translation for the DASH questionnaire experienced this issue, it was difficult to model reviewing the issue on previous literature. The translation team decided that all differences in spelling should be documented and tabulated. When more than one person suggested a change, this suggestion was considered by the translation team. Only when the spelling was considered more commonly used in day-to-day communications was the spelling changed in the final version.

[10] Orthography: the agreed conventional written version of the language.

The challenges that arose during the translation of the DASH questionnaire into isiXhosa were similar to those described in other translations. These challenges pertained to diction and phrasing, user-friendliness, cultural considerations and unanswered items. The one challenge that was unique to this translation was that of differences in spelling due to the complex history of the development of the isiXhosa orthography.

4.6. Chapter summary

The cross-cultural translation of the DASH and QuickDASH into isiXhosa was accepted by the Institute for Work and Health. The process for translation was followed as per the guidelines outlined by the Institute for Work and Health (Beaton et al., 2007) to ensure that the translation maintained veracity. Thirty participants were involved in the field test which revealed 31 incongruences relating to cultural norms and values (n=4), wording or phrasing difficulties (n=6), spelling discrepancies (n=16) and general layout (n=5). These were attributed to the historical development of the isiXhosa orthography by foreign missionaries and the constant changing nature of language as well as cultural differences in activity participation. Thirteen changes were made by the translation team after the field test. The isiXhosa version of the DASH and QuickDASH are available for free download from the Institute for Work and Health's Website (http://www.dash.iwh.on.ca/available-translations). In future, additional testing will be needed to validate the preservation of the psychometric properties of the isiXhosa version of the DASH.

Chapter 5: Results

5.1. Introduction

This chapter reports the results of the study. The chapter begins by outlining the study flow with regards to recruitment and assessment at the four time points. This is followed by the results from the data obtained for the demographic profile. The three outcome measures are then reported for each of the four time points and categorised as mentioned in the data analysis section. The rate of recovery is then examined for each of the three outcome measures before the determinants of positive functional outcomes is reported.

5.2. Study flow

Thirty-two patients were assessed for eligibility of which 22 were eligible, gave informed consent and were recruited into the study. Of the 19 data sets, one did not have data for the eight week assessment, another at twelve weeks and two at the final assessment. Figure 3 illustrates the study flow diagram showing the recruitment and assessment process during the data collection period.

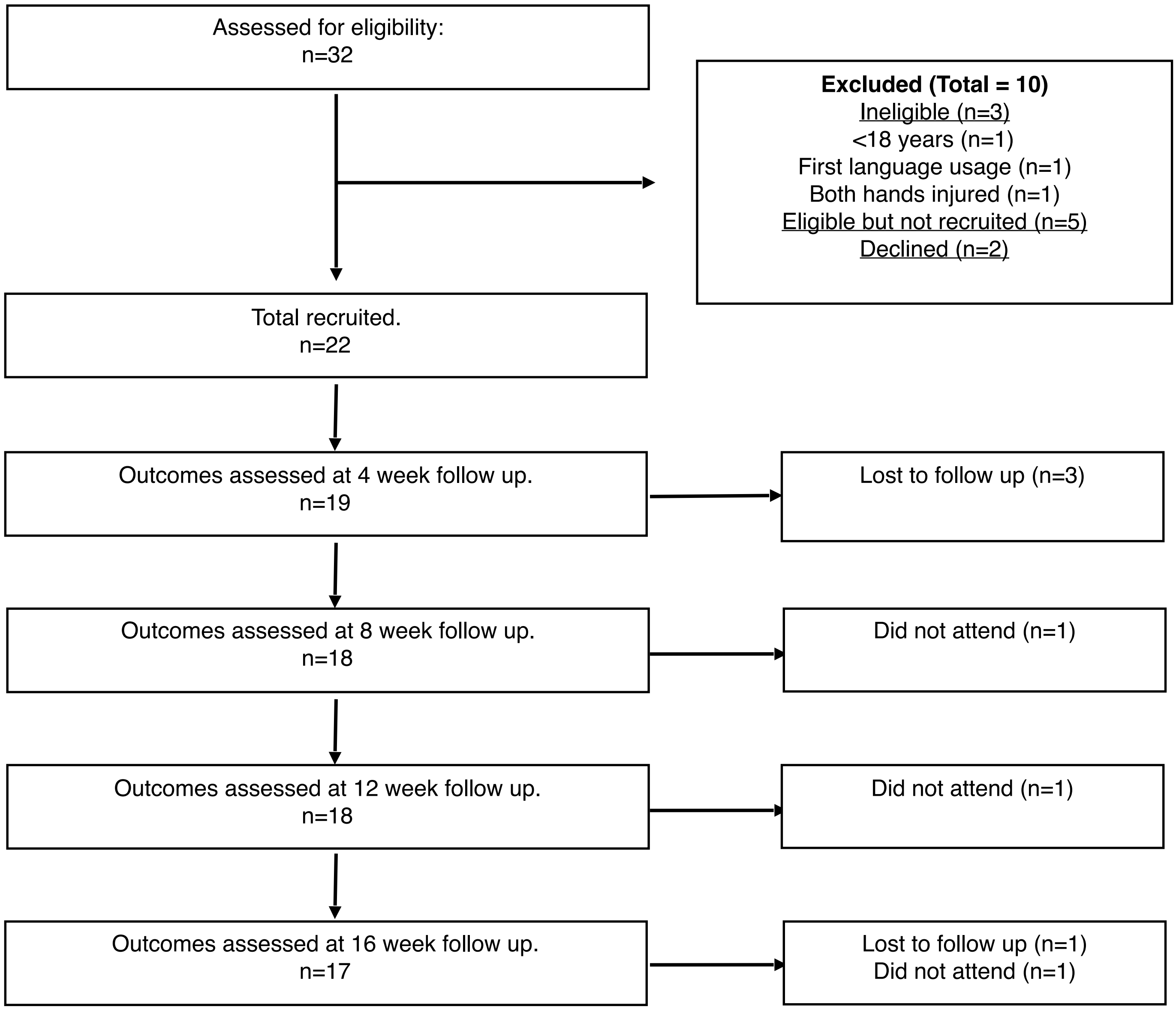


Figure 3: Flow chart of participants:

5.3. Demographic and Treatment Profile of participants

Reported in this section are the results pertaining to the first objective of the study, to describe the demographic profile for the study population. Table 7 outlines the demographic and injury profile for the participant group. Number and percentage are reported where applicable. The median age of participants was 30 years (range: 21-52 years). Participants travelled a median distance of 9 kilometres to reach the tertiary hospital (range: 3-33 kilometres). In total, 36 fingers were injured, with the index finger most commonly involved (n=12). Participants waited a median of six days for surgery (range: 1-11 days).

Table 7: Demographic and injury profile (n=19)

		Number (Percentage)
Gender		
	Male	14 (73.7)
	Female	5 (26.3)
Employment status		
	Permanent	8 (42.1)
	Casual	4 (21.1)
	Unemployed	6 (31.6)
	Student	1 (5.3)
Highest level of education $^{\$}$		
	Grade 6	1 (5.3)
	Grade 9	4 (21.1)
	Grade 10	3 (15.8)
	Grade 11	3 (15.8)
	Grade 12	5 (26.3)
Dominance		
	Right	19 (100)
	Left	0 (0)
Smoking status		
	Yes	14 (73.7)
	No	5 (26.3)
Side of injury		
	Right	8 (42.1)
	Left	11 (57.9)

Complex injuries *	
Nerve	5 (26.3)
Fracture	1 (5.3)
Extensor tendon	2 (10.5)
Skin	1 (5.3)
Nerve and fracture	1 (5.3)
Fingers involved #	
Thumb	5 (13.5)
Index	12 (32.4)
Middle	9 (24.3)
Ring	7 (18.9)
Little	3 (8.1)
Zone of injury	
1	1 (5.3)
2	7 (36.8)
3	3 (15.8)
4	0 (0)
5	8 (42.1)

$ 3 participants did not disclose
* 9 participants had only flexor tendon injury
# 1 participant had wrist flexor involvement only

Table 8 outlines the treatment descriptors for each participant. Number and percentage or median and range are reported where applicable. As noted in the data collection section, adherence was measured subjectively by the treating occupational therapist and was assumed to be 'good' if no mention was made in the treatment notes. Adhesion formation was measured in the same way.

Table 8: Treatment descriptors (n=19)

Expertise of surgeon	**Number (Percentage)**
Medical Officer	7 (36.8)
Registrar	10 (52.6)
Orthopaedic surgeon	2 (10.5)
Hand surgeon	0 (0)

Expertise of OT	
Community service	4 (21.1)
>3 years	3 (15.8)
>4 years	12 (63.2)
Pre-operative OT treatment	
Yes	7 (36.8)
No	12 (63.2)
Protocol used	
Early Active Motion	5 (26.3)
Passive flexion, active extension	13 (68.4)
Place and Hold	1 (5.3)
Adherence (subjective)	
Poor	4 (21.1)
Fair	1 (5.3)
Good	14 (73.7)
Adhesion formation (subjective)	
Mild	4 (21.1)
Moderate	7 (36.8)
Severe	8 (42.1)
Treated by physiotherapist	
Yes	5 (26.3)
No	14 (73.7)
Rupture	
Yes	2 (10.5)
No	17 (89.5)
	Median (Range)
Number of days with pain	84 (10-112)
Number of post-operative occupational therapy treatment sessions	7.5 (3-13)
Number of post-operative occupational therapy treatment sessions missed	3.0 (0-7)

5.4. Outcome measure results

As discussed in the methodology chapter, three outcomes were measured: TAM, muscle strength (using the Jamar dynamometer) and hand function (using the DASH questionnaire). Table 9, shows the results for each outcome measure at each of the four time points.

Table 9: Outcomes at the four assessment time intervals

		Week 4	**Week 8**	**Week 12**	**Week 16**
Total Active Motion *#*		***No. (%)***	***No. (%)***	***No. (%)***	***No. (%)***
(Strickland & Glogovac scoring system, 1980)	*Poor (<50%)*	30 (83.3)	26 (76.5)	22 (62.9)	17 (53.1)
	Fair (50-69%)	3 (8.3)	3 (8.8)	5 (14.3)	5 (15.6)
	Good (70-84%)	1 (2.8)	2 (5.9)	4 (11.4)	6 (18.8)
	Excellent(>85%)	2 (5.6)	3 (8.8)	4 (11.4)	4 (12.5)
DASH*		**Median (Range)**	**Median (Range)**	**Median (Range)**	**Median (Range)**
		39.16 (19-70)	26.67 (10-88)	27.67 (3-72)	13.33 (1-56)
Muscle Strength				**Median (Range)**	**Median (Range)**
				32.95 (0-56)	40.96 (0-78)
				No. (%)	***No. (%)***
(Riaz & Khan scoring system, 1999)	*Poor (<50%)*			16 (88.9)	14 (73.7)
	Fair (50-74%)			2 (11.1)	4 (21.1)
	Good (75-90%)			0 (0)	1 (5.3)
	Excellent (>90%)			0 (0)	0 (0)
				Median (Range)	**Median (Range)**
(percentage of unaffected hand)				47.83 (0-93.1)	52.09 (0-107)

TAM was calculated per finger (n=36)
* Higher score indicates a greater level of disability with a lowest possible score of 0 and highest possible score of 100

5.5. Rate of recovery

5.5.1. Total Active Motion (TAM)

TAM was evaluated per finger as has been done in previous studies (Cooper et al., 2015; Farzad et al., 2014; Spark et al., 2018; Trumble et al., 2010). Figure 4 illustrates the change over time for the percentage of fingers that fell into each of the four categories for TAM (i.e. poor, fair, good, excellent). Although the number of fingers in the poor group for TAM decreased over time, Spearman's Rank Correlation Coefficient showed that this was not statistically significant (r_s(df=2)=-0.06, p=0.78).

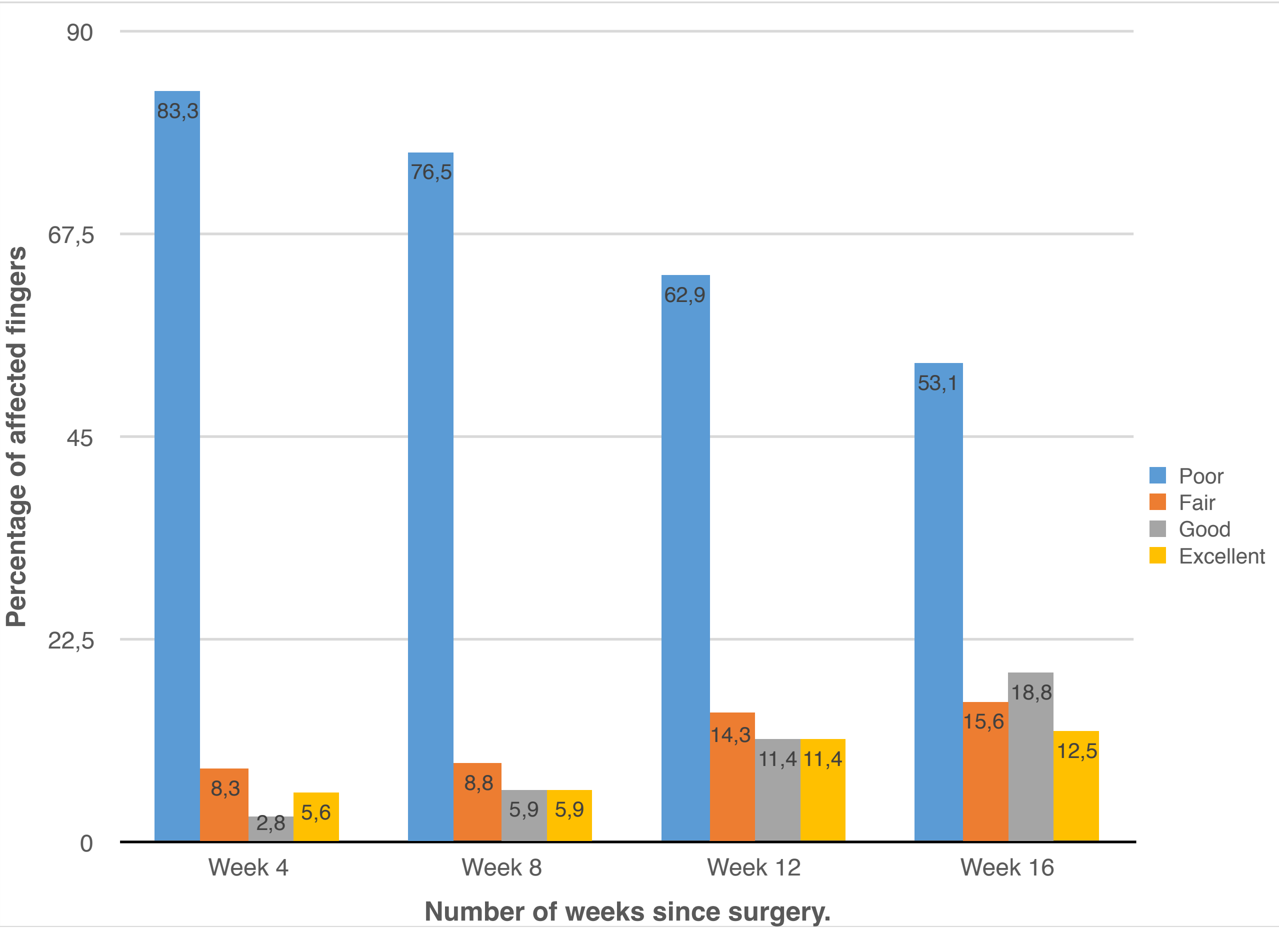
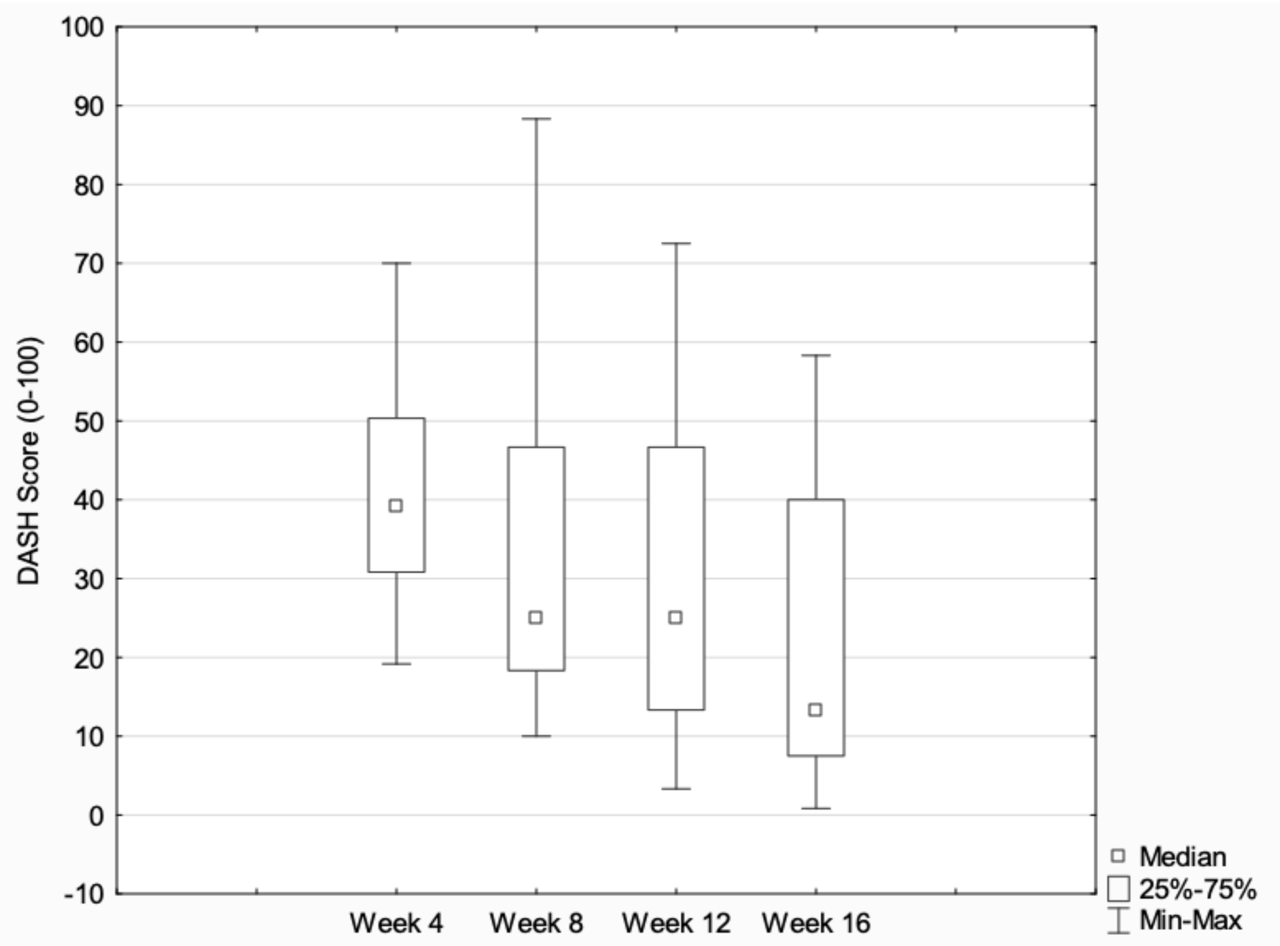


Figure 4: Rate of recovery of range of movement (measured with TAM)

5.5.2. Disabilities of the Arm, Shoulder and Hand (DASH)

Friedman's ANOVA showed that the difference in DASH scores over time was statistically significant ($F(df=3)=12.98$, $p=0.005$). These data report change over time for the whole sample. However, when considering Figure 5, the greatest change in median scores were between the four- and eight-week as well as twelve- and sixteen-week time points.



Number of weeks since surgery

Figure 5: Rate of recovery for Disabilities of the Arm, Shoulder and Hand.

5.5.3. Muscle Strength

Due to tissue healing considerations, muscle strength was only assessed at twelve- and sixteen-week time frames. Figure 6 illustrates that muscle strength increased between these time points. The Wilcoxon Matched Pairs Test showed this increase to be significant (Z=3.076, p=0.002).

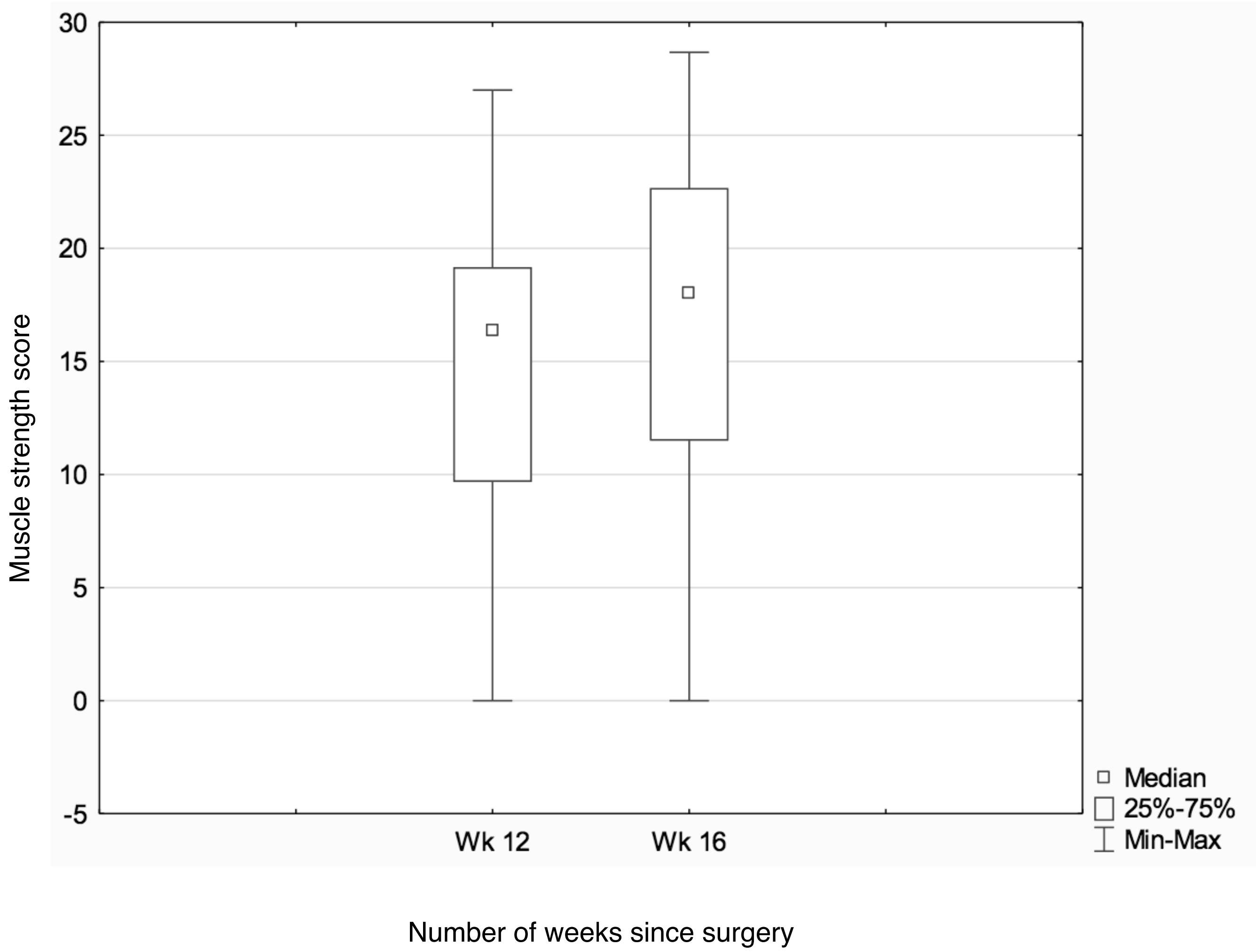


Figure 6: Rate of recovery for muscle strength.

5.6. Factors that influence functional outcome

The scores from the DASH are considered ordinal categorical data type and were therefore analysed using non-paramedic methods. As two participants did not return for the sixteen-week assessment, the data from the twelve-week assessment were used to ensure that the data analysis was as rich as possible as described by Kang (2013). “Smoking status” and “pre-operative occupational therapy” both had two variables in their category and were analysed using the Mann-Whitney U Test. The remaining categories were analysed using the Kruskal-Wallis ANOVA Test as these categories had more than two variables in each. Five hypotheses (refer to chapter 1, page 13) were tested to establish which variables significantly influenced the outcomes, namely: Expertise of the surgeon, type of rehabilitation, smoking status, complex injury and time to repair as these have been shown to affect outcome in previous studies (Momeni, Grauel, & Chang, 2010; Spark et al., 2018; Trumble et al., 2010). Table 10 below shows a summary of these results.

Table 10: Factors that influence outcome

Factor	**Mann-Whitney U**		**p-value**	**Interpretation**
Smoking Status	30.0		0.677	Not statistically significant
Pre-operative occupational therapy	22.5		0.108	Not statistically significant
Factor	**Kruskal-Wallis H**	**Degrees of freedom (df)**	**p-value**	**Interpretation**
Expertise of surgeon	2.62	2	0.198	Not statistically significant
Time to repair	15.3	9	**0.049**	**Statistically significant**
Zone of Injury	5.73	4	0.445	Not statistically significant
Type of Rehabilitation	0.13	2	0.397	Not statistically significant
Number of days with pain	8.43	5	0.228	Not statistically significant
Adherence to recommendations	1.23	2	0.212	Not statistically significant

There was a statistically significant difference between the DASH score and time to repair ($H(9) = 15.3$, $p = 0.049$), with a the highest mean ranks for days one (15.0), two (15.0), eight (16.0) and eleven (17.0) and the lowest mean ranks for days four (6.0), five (6.0) and six (2.75). A higher DASH score indicates a higher level of disability and vice versa (i.e. DASH scores for days one, two eight and eleven were higher than those for days four, five and six). Figure 7 shows this relationship between the DASH score and time to repair. The scores show that participants who were received surgery on day one, two and three as well as eight, nine and eleven had poorer outcomes than those operated on day four, five and six with an outlier at day 10.

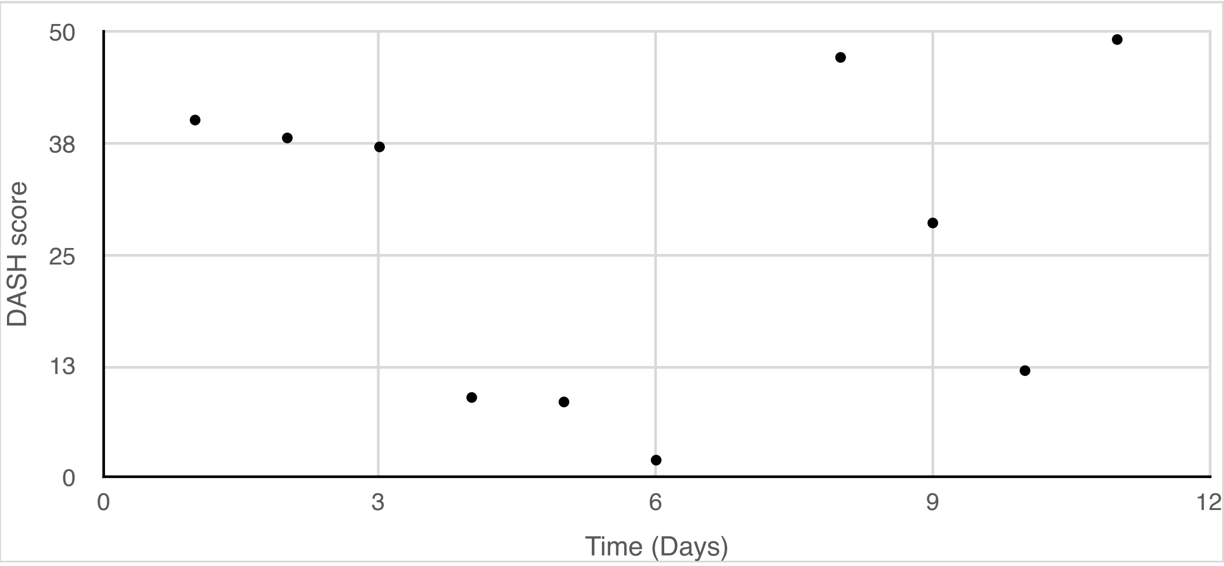


Figure 7: Relationship between DASH score and time to repair.

5.7. Chapter Summary

There were 22 participants who met the inclusion criteria and gave informed consent to participate in the study of which three were lost to follow up. The demographics showed that 74% of participants were male. The majority were between the ages of 20 and 30 years with a median age of 30. Only 31% had obtained their matric certificate. About 63% were employed in some capacity. 74% of the participants were active smokers. Participants travelled a median of nine kilometres for treatment at the hospital. All the participants were right handed and 42% sustained an injury to their dominant hand. In total, 36 fingers were involved, the majority being the index, middle and ring fingers. On average, participants waited 5.6 days for surgery with the shortest waiting time being one day and the longest, 11 days. Only 10% of participants were operated on by an orthopaedic surgeon, none by a specialist hand surgeon whilst the remainder were operated on by surgeons in the process of specialising to become orthopaedic surgeons or medical officers working in the orthopaedic department at the time. Most participants were treated by an occupational therapist with over four years of experience and mostly made use of the PFAE protocol. Only 26% of patients were referred to a physiotherapist for dry needling of scar tissue. On average, participants received eight occupational therapy treatment sessions post operatively (as an in-patient and out-patient) with a mean of three missed sessions per participant.

Rate of recovery was analysed for each of the three outcome measures. TAM did not show a statistically significant change over time (p=0.78) but the number of fingers falling in the "poor" category did decrease from week-four to week-sixteen. Muscle strength showed a statistically significant change over the twelve- and sixteen-week time points (p=0.002). In addition, DASH scores also showed statistically significant change over the total time frame (p=0.005) with Figure 5 illustrating the change in median scores at each time point. The only factor that showed statistical significance in comparison to DASH scores was time to repair (p=0.049) with Figure 7 illustrating the relationship. These results will be discussed in the next chapter.

Chapter 6: Discussion

6.1 Introduction

In this chapter, a discussion of the results from chapter 5 will be presented in relation to the study aim and objectives. Firstly, the outcomes of the study will be compared to those reported in previous literature. After which, the overall study aim, to describe the determinants of positive functional outcomes at sixteen weeks post flexor tendon repair, will be examined. The demographic profile of patients presenting to a tertiary hospital in the Eastern Cape of South Africa will be unpacked before the discussion regarding the rate of recovery between the four different time points. Thereafter, the strengths and limitations of the study will be presented.

6.2 Outcomes in light of current literature

For the purpose of this study, three outcome measures were used namely: TAM, muscle strength and the results from the DASH questionnaire. The TAM scores showed that the majority of participants fell within the poor outcome category at four weeks post operatively (83.3%). The results at sixteen weeks showed that just over half of the sample fell within the poor outcome category (53.1%), over a tenth fell into the fair category (12.5%) and a third fell into the good and excellent categories (34.4%). Wong and Peck (2014) reported in a review of current literature that the best possible outcomes that were described at the time were 71-75% good to excellent TAM. These results stem from two case series studies of zone II flexor tendon injuries published 34 years apart (Wong & Peck, 2014). Wong and Peck (2014) were highlighting the lack of change in improving overall results despite advances in surgical and rehabilitation technique. When comparing this result to those reported in the current study, the outcomes of the latter are significantly worse. However, the outcomes reported by Wong and Peck (2014) were for samples that excluded complex injuries, such as peripheral nerve injuries and fractures, unlike the sample in this study. A more realistic comparison would be with the results reported by Spark. (2018) whose sample more closely resembled that of this study. The results from their study using the American Society for Surgery of the Hand criteria for TAM showed that 34% had good to excellent results, 32% had fair outcomes and 34% had poor outcomes. The results from Spark et al. (2018) are more similar to those achieved in the present study with a third falling into the good-excellent result category. However, a greater proportion of the sample from the current study fell into the poor category than in the study by Spark et al. (2018). This could possibly be attributed to the fact that Spark et al. (2018) measured their results at six months post operatively as opposed to four months in the present study. It has been previously noted that the different methods for reporting

TAM for flexor tendon repair research has made comparison between studies difficult (Dy et al., 2012; Libberecht, Lafaire, & Van Hee, 2006). One author suggested that for the outcome of ROM, reporting TAM categories should no longer be used (Libberecht et al., 2006). Rather, the percentage of TAM return for the whole hand should be used for better statistical analysis (Libberecht et al., 2006). For the future of reporting and comparing literature in the field of flexor tendon repairs, there needs to be consensus in the way TAM is reported (Dy et al., 2012; Libberecht et al., 2006).

Muscle strength was assessed with cylindrical grasp using a calibrated Jamar Dynamometer and categorised using the Riaz et al. (1999) classification system for muscle strength. The scores at the sixteen-week time frame showed that the majority of participants had poor muscle strength (73.7%) in comparison to the South African Normative Scores for elementary workers (Pretorius et al., 2005). It is difficult to compare these results with those currently available in the literature pertaining to flexor tendon repair and rehabilitation. Riaz et al. (1999) used muscle strength to assess outcomes ten years following primary flexor tendon repair and found that 85% had good to excellent return of muscle strength. It is unrealistic to compare the results from this study to those described by Riaz et al. (1999) due to the difference in time frame. The South African normative scores used for comparing muscle strength were obtained from a single study from one site in the Western Cape of South Africa (Pretorius et al., 2005). Due to the data originating from one site with a relatively small sample for the type of study, a large proportion of the sample happened to be elementary workers (i.e. people who perform work that comprise of repetitive tasks with the use of tools often requiring physical effort), and may have negatively skewed the data in preference of those with stronger grip strength (Pretorius et al., 2005). This would mean that comparing the present study sample to the normative scores obtained by Pretorius et al. (2005) may not be fair as the sample for the their study is not representative of the sample of the present study. Spark et al. (2018) on the other hand, compared the scores of the injured hand to the uninjured hand of each participant and reported that six months following primary flexor tendon repair, the average cylindrical grasp strength was 60% that of the unaffected hand. This result is similar to the result of comparative median grip strength at sixteen weeks for this study (52%). The difference in styles for the reporting of muscle strength results makes comparison challenging. Despite this, the muscle strength results from the current study point toward a potential problem related to the return of hand function in comparison to the general elementary working population of South Africa.

In the DASH questionnaire, scores can range between zero to 100 with a score of zero indicating no impairment and 100 indicating complete disability. The results showed that, at the sixteen-week follow-up, the median DASH score was 13.33 (range 1-56). In a randomised control trial comparing EAM with place and hold to passive motion protocols in zone II injuries, Trumble et al. (2010) found that DASH scores were low in both the experimental (2.0) and control (3.1) groups. Moriya et al. (2015) found that in their case series study of patients with zone I, II and III injuries followed up six months post operatively, the mean score for the QuickDASH was 1.7. Unfortunately, the study by Spark et al. (2018) did not include DASH as an outcome measure. Though the results from the studies conducted by Trumble et al. (2010) and Moriya et al (2015) are lower than those of this study, the differences in scores do not appear to be as divergent as the comparative scores for TAM and muscle strength appear to be to the studies by Wong and Peck (2014) and Riaz et al. (Riaz et al., 1999). It could mean, that the DASH is not a good PROM for the evaluation of hand function after flexor tendon injury as argued by Libberecht (2006). It could also be interpreted that muscle strength and ROM are not good predictors of overall hand function (Bohannon, 2015; Gracia-Ibanez, Vergara, Sancho-Bru, Mora, & Piqueras, 2017). Generally, consensus for the reporting of ROM, muscle strength and overall hand function is needed in the field of flexor tendon repair.

6.3 Factors affecting functional outcome

The overarching aim of the study was to determine which factors were linked to positive functional outcomes at sixteen weeks after flexor tendon repair. Many factors were considered for analysis against the sixteen-week scores of the DASH, the results of which will be discussed below.

Factors that were chosen for analysis included those that were described to have an impact on functional outcomes in previous literature including smoking status, expertise of the surgeon, zone of injury, type of rehabilitation protocol used and adherence. While smoking status was previously found to predict a negative functional outcome (Spark et al., 2018; Trumble et al., 2010), it did not have a significant impact on functional outcome (p=0.677) in this study. In addition, the expertise of the medical staff operating on and treating patients did not determine better outcomes in the results (p= 0.198) as previously suggested by Momeni et al. (2012). Spark et al. (2018) found that zone of injury did have a significant impact on the outcome in their study in Pretoria, South Africa. However, zone of injury did not generate statistically significant data in this study (p 0.445). In addition, the type of rehabilitation protocol used did not to have a significant impact on the functional outcome (p=0.397). This finding contrasts with findings by many other authors that suggest that more active rehabilitation protocols (such as EAM) have better outcomes than those that are more passive (Trumble, Vedder et al. 2010, Chesney, Chauhan et al. 2011, Dy, Hernandez-Soria et al. 2012, Tang 2012, Starr, Snoddy et al. 2013, Spark et al. 2018). Adherence to recommendations was also examined in relation to DASH scores at sixteen weeks. The data showed no statistical significance (p=0.212). However, the manner in which adherence was measured was not reliable as it was based on the opinion of the treating therapist and whether or not adherence was documented in the clinical notes. Although the findings of this study contradict the findings from other literature, the under powering of the study due to a small sample size may have affected the capacity for stronger statistical associations to be made.

Other factors not previously quantified in past literature were also analysed in this study. The concept of pre-operative rehabilitation for those patients waiting longer than three days for primary repair of a flexor tendon injury has not been described in previous literature, but has been introduced at the tertiary hospital in order to curb the effects of prolonged immobilisation, stiffness and soft tissue shortening as described in chapter 1. It was hypothesised that those participants who received pre-operative rehabilitation would have a better functional outcome than those who did not. However, the findings showed no statistical significance in functional outcome between those who did receive pre-operative rehabilitation, and those who did not (p=0.108). The results may be attributed to the under-powering of the study, other confounding variables that could influence these results including that of “time to repair” or the fact that there is no difference between these two groups.

Another factor not previously addressed in literature is pain. Though pain can have a significant effect on a person’s experience of an injury and views on rehabilitation (Fitzpatrick & Finlay 2008), this factor has had little attention in the field of flexor tendon repair. An attempt was made to gather data on the degree of pain experienced by means of a daily log and a visual analogue scale, but most participants found this task difficult to understand and did not persist in recording this information consistently in the four months thereafter. The only information related to pain that could be deduced from the raw data, was the number of days the participants had pain. These data did not show statistically significant results (p=0.228). However, this does not suggest that pain does not impact on functional outcome. Further research is needed to clearly define this relationship.

Of all of the factors reviewed at the time of data analysis, time to repair was the only factor that showed statistical significance (p=0.049). This could be attributed to the under powering of the study as a result of the short period during which data collection occurred as well as recruitment challenges as mentioned in chapter 3. However, the result is noteworthy. Other authors have noted that delayed time to repair can have negative effects on the formation of granulation tissue on the tendon, retraction and collagen clotting (Tang et al. 2001). However, the ‘optimal’ time to repair has not been defined (Dy & Daluiski, 2014; Tang, 2007). Delayed primary repair between one and even seven months has been reported in literature after the initial injury (Spark et al., 2018). As seen in figure 7 of chapter 5, the DASH scores from day one to three post operatively were poorer than those obtained between day four and day six before worsening again from day eight to day twelve. This pattern was not in keeping with the beliefs regarding delayed repair as reported by Tang et al. (2001). Furthermore, the hypothesis that patients with a shorter time to surgery would have a better functional outcome than those who waited longer, was not demonstrated. On closer review, participants who underwent surgery within the first three days, were more commonly those who had complex and possibly limb threatening injuries. These participants were given preference for emergency theatre time as a result. The participants who were operated on later were considered stable on admission and had better functional outcomes as seen in figure 5 of chapter 5. When participants waited longer than a week, their outcomes were again poorer. These results could point to two important concepts. Firstly, that it is not harmful to wait up to a week to perform a primary flexor tendon repair, provided the injury is not considered life or limb threatening, after which time, outcomes are more likely to be poorer. Secondly, that complex injuries may influence functional outcomes, though this was not found to have a statistically significant impact. This association has been noted in a previous study that showed delayed time to repair and the presence of a complex injury has a negative influence on recovery in muscle strength and ROM (Spark et al, 2018). Further studies will be needed to clearly understand this relationship.

6.4 Exploring the rate of recovery

The second objective of the study was to determine the rate of recovery between the four, eight, twelve and sixteen-week time frames. Rate of recovery has not been documented in literature pertaining to flexor tendon injures and rehabilitation since 1993 and therefore valuable information was uncovered in this study. In the study by May and Silfverskiold (1993), TAM was used to determine the rate of recovery for each finger. It was found that ROM improves the most within the first six months after flexor tendon repair (May & Silfverskiold, 1993). However, in the present study, TAM did not show to have a statistically significant change over the four intervals as noted in the results chapter (p=0.78). There is little in the way of evidence to show that TAM is less sensitive to change over time than the DASH, as literature to date has focused on intra- and inter-rater reliability and validity (Norkin & White, 2016). Though Libberecht (2006) found that DASH is not sensitive enough to detect change over time, this study showed statistically signifiant result between the first and last assessment for both the DASH and muscle strength scores.

DASH scores showed statistically significant change over time for the entire data set (p=0.005) with the greatest change in median scores noted between weeks four and eight and weeks twelve and sixteen (refer to figure 5, chapter 5). In addition, muscle strength showed a strong relationship to change over the twelve- and sixteen-week intervals (p=0.002). May and Silfverskiold (1993), looked at the rate of recovery for ROM after primary zone II flexor tendon repair at five time intervals over one year period. This was the only article that could be found describing rate of recovery in the field. They found that the mean active ROM had the greatest change between weeks four and six followed by weeks six and twelve after which the rate of recovery slowed to a plateau by one year (May & Silfverskiold, 1993). The results from the present study mimic those described by May and Silfverskiold (1993) except for the halt in recovery noted between weeks eight and twelve. The reasons for the logarithm-type curve in recovery could be attributed to the nature of tendon healing and anatomy.

The changes over time for the present study seem to follow the pattern of tissue healing for soft tissue injuries. The remodelling phase begins at four weeks post operatively (Goggins, Syme et al. 2014, Thomopoulos, Parks et al. 2015). During this phase, which continues until twelve weeks, collagen fibres form, which increase the tensile strength of the tendon and surrounding tissues (Goggins, Syme et al. 2014, Thomopoulos, Parks et al. 2015). In addition, at four weeks post operatively, the dorsal blocking POP is removed and the patient is allowed to move the fingers and wrist more freely whilst still avoiding using the hand in daily tasks until eight weeks post operatively. Fitzpatrick and Finlay (2008) noted that patients found the dorsal blocking splint to be restrictive and prevented them from performing their ADLs with ease. Though in their study, participants had thermoplastic splints as opposed to splints made of POP in the current study, the design and functional limitations are similar, if not more pronounced due to the weight and bulk of POP compared to thermoplastic splints. From twelve to sixteen weeks the maturation phase begins and the laying down of collagen is slowed (Thomopoulos, Parks et al. 2015). This results in the tendon reaching maximum tensile strength whilst still having the capacity to adapt to forces exerted upon the tendon. It is at this stage that a patient is allowed to use their hand actively in all meaningful occupations including heavy duty tasks. The alignment of collagen fibres will be altered depending on the stress exerted on the tissues further improving strength and stretch of the tendon (Goggins, Syme et al. 2014). By actively using the hand in their daily occupations, patients assist in the process of collagen realignment resulting in better hand function. The changeover from remodelling to the maturation phase in conjunction with the increased exertion upon the tendon (Goggins et al., 2014; Strickland, 1995) could account for the improvement in scores between the twelve- and sixteen-week time frames .

The challenges identified in this study between weeks eight and twelve during the remodelling phase where recovery is slowed is troublesome. It is expected that recovery should continue to improve during this stage as patients are allowed to start using their injured hand in light tasks for the first time from weeks eight to twelve (Kannas, Jeardeau, Bishop, 2015; Tang, Amadio, Guimberteau, Chang, et al., 2012). However, the results show that the rate of recovery appears to halt at this stage, with the median DASH scores between week eight and week twelve remaining the same. De Klerk et al. (2016) argued that from the South African perspective, occupation based hand therapy is just as important as biomedical protocols that are religiously adhered to by hand therapists in order to translate improvements in muscle strength and ROM into meaningful movement in activities and occupations. Powell and von der Heyde (2014) also emphasised the importance of the inclusion of occupation and activity into hand therapy home programmes to improve patient satisfaction and outcomes but found that this was often lacking in treatment sessions. The stagnation in recovery at this stage could be as a result of therapists lacking the clinical reasoning and confidence to introduce light tasks in therapy sessions due to the rigidity of the exercise dominated regime suggested in rehabilitation protocols up until the eighth week. However, this relationship was not demonstrated in this study and supports the need for further investigation. The current challenges related to functional limitations of the injured hand from the time of operation to eight weeks post operatively might soon be negated by the improvements made with the Manchester protocol and Manchester short splint (Wong & Peck, 2014). The Manchester protocol allows the use of the uninjured fingers of the injured hand in light daily tasks within the first eight weeks with the use of a short dorsal blocking splint as opposed to the long dorsal blocking splint or POP that has predominated protocols in the past (Wong & Peck, 2014). The results to date are promising, but further longitudinal investigation is needed to assess longterm outcomes (Tang, 2018; Wong & Peck, 2014).

6.5 Understanding the demographics and treatment profile

An additional objective of the study was to describe the demographic profile of the population with a flexor tendon injury presenting to the tertiary hospital. The results show that the demographic profile was similar to those found elsewhere in the country and across the globe. The majority of participants were male (73.7%) aged between 21 and 52 years with a median age of 30 years. These results are similar to those described in other flexor tendon injury study populations. Spark et al. (2018) found that 63% of the population presenting to a hospital in Pretoria, South Africa with flexor tendon injuries were males with a mean age of 32 years. Similar results have been reported for the United States of America, where 68% of the sample were males with a mean age of 29 years (Trumble et al, 2010), and Japan, where 76% were male with a mean age of 35 years (Moriya et al, 2015). These trends indicate that young males are at greater risk of sustaining a flexor tendon injury which suggests a need for prevention programmes. Following flexor tendon repair, all rehabilitation protocols mentioned in the literature review (i.e. PFAE, Place-and-hold and EAM) require patients to refrain from using the injured hand for a period of eight weeks (Asmus et al., 2015; Chesney et al., 2011; Tang et al., 2012). During this time a patient is unable to use the affected hand in any daily tasks, including those required at work. Considering that work is the main occupation during this life stage (Cronin, 2016), the possible consequences are loss of income or, in cases of unprotected work, loss of employment. In addition, complex injuries, delayed repair, smoking and the presence of adhesions have been noted to be indicators for poorer outcomes (Trumble, Vedder et al. 2010, Wong & Peck 2014, Pulos & Bozentka 2015). In this study, 70% of the participants were active smokers, half had complex injuries, and 80% had moderate or severe adhesions. These compounding factors could have had a negative impact on the patients' recovery and overall functional outcome.

Despite 63% of participants being employed in some capacity, only 42% were permanently employed and therefore protected by The Employment Equity Act of South Africa (Africa, 1998). This act stipulates that persons who are permanently employed are protected from unfair dismissal as a result of a disability induced by injury or illness. South Africa's open labour market is extremely competitive due to the high unemployment rate and demand for jobs (Lehohla 2014). As a result, it is unlikely that those with an existing impairment would be considered for a job where more able-bodied candidates could be employed (Van der Merwe, Sutton, & Taunyane, 2017). When considering this, the possibility of returning to work in the open labour market for patients with flexor tendon injuries in South Africa poses a challenge when the functional outcome is less than adequate. In particular, if the dominant hand is affected, as was the case for half the study participants, productivity will be affected in light as well as heavy duty tasks. This emphasises the need for research to look at return to work data in this population which was not obtained in this study.

A factor that is not well described in flexor tendon injury literature is level of education. Of all the articles on flexor tendon repairs and rehabilitation examined for the purpose of this dissertation, none collected data on education level. Indeed, less focus is placed upon personal factors such as level of education, occupation or type of work than those of age, gender, smoking status or hand dominance as reported by others (Trumble et al., (2010), Chesney et al., (2011), Starr et al., (2013), Spark et. al, (2018), which may point to the strong foundation of research in the biomedical model. In this study, only 26% obtained a National Senior Certificate which is in keeping with the provincial statistics from the 2011 Census that found that only 28.5% of the population had completed twelve years of education (Lehohla, 2014). This has a significant impact on the type of work opportunities available, most of which is unskilled, manual labour requiring stronger hand function than an office job. With the aim of maintaining a safe working environment, employers are not obliged to employ a person whose physical, psychological or cognitive function may be considered an injury risk to themselves and others, particularly in the open labour market (Africa, 1998). However, the sample could be skewed as patients who received private care or those who lives outside of the catchment area for the tertiary hospital were excluded.

For the purpose of this study, participants were treated once a month by the orthopaedics department and once every two weeks by occupational therapists at the tertiary hospital. This is not always usual practice as patients are sometimes referred to the occupational therapist at their closest clinic. This was done in order to monitor and follow up on the treatment and progress of the participants on their scheduled appointment dates at the hospital. Participants travelled between three and 88 kilometres to attend therapy at the tertiary hospital. Within the local district, there are only six district level occupational therapists serving five base clinics and over thirteen satellite clinics in the area. As a result, the waiting time for an outpatient appointment at one of the district level clinics can range between one and three months depending on how often the occupational therapist visits the clinic in question. In an attempt to achieve better outcomes, patients with hand injuries are booked at the tertiary hospital occupational therapy outpatient department where they can be seen once every two weeks by one of three occupational therapists designated to the outpatient department. By travelling to the tertiary hospital for treatment, patients incur personal transport costs and loss of productivity at work with the additional time needed to travel to the hospital. One of the implications of these factors is missed treatment sessions; three sessions were missed on average per participant in this study. However, this is not a true reflection of what is seen outside of the study parameters as participants may have been motivated to attend sessions more regularly due to the compensation awarded them for their travel costs for the purpose of the study.

Literature suggests that gold standard treatment for patients with flexor tendon injuries should include weekly rehabilitation sessions in order to ensure adherence to recommendations, identify potential complications early and ensure better outcomes overall (Tang, Amadio et al. 2012, Kannas, Jeardeau et al. 2015). The implications of the lack of district occupational therapy services and the two week waiting list for the nearest outpatient booking at the occupational therapy department at the tertiary hospital means that this “gold standard” achieved in high income countries is unattainable in this context. This impacts quality of care and overall functional outcomes for patients with flexor tendon injuries. According to the principles of the Primary Health Care system adopted by South Africa (Maillacheruvu & McDuff 2014), there should be sufficient district level services to serve the people at their local clinic for primary level health care (Health 2018). The Framework and Strategy for Disability and Rehabilitation (Matsoaledi, Phaahla, & Motsoso, 2015) clearly states that rehabilitation services should be decentralised and accessible to people within their communities with clear down-referral systems (Matsoaledi et al., 2015). Until rehabilitation services are improved at clinic based levels in the Province of the Eastern Cape, functional outcomes for patients requiring rehabilitation of any kind will continue to be less than adequate.

It is confirmation of the staffing and expertise void that exists in the Eastern Cape that only 10% of participants were operated on by an orthopaedic surgeon and none by the specialist hand surgeon. The remainder (90%) were operated on by a registrar[11] or a medical officer[12] working in the orthopaedic department at the time. The orthopaedic department at the tertiary hospital has six qualified orthopaedic surgeons. Each orthopaedic surgeon heads a unit of two medical officers (of which one can be a registrar) and two internship doctors. Each unit can be responsible for ten to 100 patients at any given time. The number of years of experience of each of the medical officers or registrars post-community service can range from none to five or even ten years of experience. Due to the high incidence of trauma presenting to the hospital, it is not always possible for the Orthopaedic Surgeon heading the unit to perform all surgical procedures needed for each patient. As a result, registrars and medical officers are required to assist and perform surgeries unsupervised depending on their skill level and expertise. Wong and Peck (2014) reported that tendon repairs are one of the first skills learnt by a surgeon in

[11] A doctor in the process of specialising to become an orthopaedic surgeon who has completed their internship and community service years.

[12] A doctor who has completed their internship and community service years.

training. As flexor tendon repair is not seen as potentially life-threatening or complicated surgery, the majority of these operations are performed by less qualified staff in state hospitals in South Africa (Spark et al., 2018). Whether this trend is true to all state centres in South Africa is unclear.

Despite this lack of experience, it is standard practice at the tertiary hospital for flexor tendon injuries to be repaired with a four or six-strand core and epitendinous sutures as recommended in literature (Strickland 1995, Chesney, Chauhan et al. 2011, Tang, Amadio et al. 2012, Wong and Peck 2014, Tang 2018). Although such repairs are strong enough to withstand the forces exerted by EAM protocols (Groth 2004; Taras, Martyak et al. 2011; Tang, Amadio et al. 2012), most occupational therapists in this study chose to follow protocols that exert less force upon the repair and considered less risky. The results showed that 68% of participants were given the PFAE protocol, 5.3% place and hold and 26.3% EAM. In institutions based in China, New Zealand, Germany, United Kingdom and the United States of America, EAM is the standard of care where passive-assisted protocols are used in exceptionally difficult or complex cases where caution is advised (Tang, Amadio, Guimberteau, Chang, et al., 2012). It is interesting to note this discrepancy considering that most participants were treated by occupational therapists with over four years of experience in hand therapy. However, unlike the United Kingdom, United States of America and China that offer post-graduate qualifications in hand therapy, none of the treating therapists in this study had a postgraduate qualification. Despite having an occupational therapy departmental meeting at the beginning of the recruitment period to discuss different protocols and the clinical reasoning process to follow when deciding which protocol to follow (see chapter 3), the majority of the occupational therapy staff chose 'safer' protocols for their patients. This could suggest a lack of clinical reasoning, training in more active protocols and confidence in choosing an appropriate protocol, especially in light of the resounding evidence supporting EAM (Trumble, Vedder et al. 2010, Chesney, Chauhan et al. 2011, Tang, Amadio et al. 2012, Starr, Snoddy et al. 2013, Kannas, Jeardeau et al. 2015, Singh, Rymer et al. 2015, Spark, Godlwana et al. 2018). EAM is perceived as a potentially 'dangerous' protocol stemming from higher rupture rates recorded in early research (Riaz, Hill et al. 1999, Tang, Amadio et al. 2012). However, in more recent years, the rupture rate with EAM has been shown to be the same as any other treatment method (4-5%) due to the development of stronger repair techniques and materials (Tang, Amadio et al. 2012, Wong and Peck 2014, Tang 2018). Evidence based practice should be at the core of occupational therapy and hand therapy practice across the board as this promotes better functional outcomes and promotes better quality of care (Bennett and Bennett 2000, MacDermid 2004). It is also troubling that only 26% of participants were referred for physiotherapy despite the potential benefits of more one-on-one therapy time and better outcomes.

The study of zone II injuries appears to predominate in the literature pertaining to flexor tendon injury and repair (Strickland 1995, Thurman, Trumble et al. 1998, Tang, Wang et al. 2001, Trumble, Vedder et al. 2010, Tang, Amadio et al. 2012). The apparent trend could be attributed to the longstanding battle between surgeons and “no-man’s land” as mentioned in chapter 2. Furthermore, zone II injuries have been the preferred zone of study (Chinchalkar, Pipicelli, Agur, & Athwal, 2015) as potential confounding variables such as an associated peripheral nerve injury could be naturally excluded (Trumble et al., 2010). In this study, only 36% of participants had an injury in zone II, while most had a zone V injury (n=42.5%). Interestingly, Spark et al (2018) noted similar patterns of injury to those of the current study with the highest proportion being in zone V (40%). However, Edinburg (1987) reported that in a study of mine workers in Pretoria, 29% of injuries occurred in zone V with the rest occurring in zones I to III. This may indicate that the majority of flexor tendon injuries occur within zone V where associated nerve injuries occur more frequently due to anatomical arrangement. In addition, literature has shown that patients with complex injuries have poorer functional outcomes than those with a pure flexor tendon injury (Trumble, Vedder et al. 2010, Pulos and Bozentka 2015, Spark, Godlwana et al. 2018). The skewed focus of literature pertaining to flexor tendon injury, specifically in zone II, may have resulted in the under-reporting of the challenges that come about as a result of zone IV and V injuries as previously found in a South African study (Spark, Godlwana et al. 2018).

A factor that is known to influence functional outcome but was difficult to measure and quantify in this study was adherence to recommendations. In this study, adherence was rated according to subjective comments recorded in the treatment notes by a treating occupational therapist. If no mention of the participant’s adherence was noted, it was assumed to be good. Adherence is difficult to quantify in the context of rehabilitation and mostly stems from the therapist’s subjective point of view (Daly et al., 2002). Where studies have measured adherence, they have done so by documenting how many therapy sessions were attended, though it is agreed that there are many factors that can influence adherence (Daly et al., 2002). In this study, participants attended a median of seven sessions in the sixteen-week study period with a range of three to thirteen attended sessions. The median number of sessions missed per participant was three with a range of none to seven missed sessions. There are many factors that could influence attendance including the challenges related to financial constraints, time costs to attend therapy, loss of income for the day, accessibility as well as the occurrence of strikes in the area making it unsafe to travel to the hospital (Masa, Chowa, & Nyirenda, 2017).

Another factor that potentially affects functional outcome is pain experience. The results from the log books and DASH items on participants pain experience yielded troubling data. Of the 112 days of the study period, participants reported a median number of 84 days with pain, the range being ten to 112 days. Though the log book had a section for the participants to rate their pain with a visual analogue scale provided, they struggled to use the scale, and more often than not, left this section blank. Despite this, the data obtained is valuable. Pain beliefs that foster kinesiophobia[13] and movement avoidance have a detrimental affect on participants adherence to home programmes as well as attendance of treatment sessions (Vlaeyen & Linton, 2000). The extended period of pain experienced by participants could point to inadequate management of post-operative pain. According to the clinical practice guideline for the management of post operative pain, less than half of those who experience post-operative pain following any surgical procedure receive adequate analgesia for effective pain relief (Chou et al., 2016). Poor post-operative pain management has been shown to correlate positively with prolonged periods of pain outside of expected timeframes for tissue healing (Chou et al., 2016). Adequate pre- and post-operative pain management has been strongly recommended in order to minimise long term complication, such as chronic pain (Chou et al., 2016).

[13] Fear of movement.

6.6 Strengths and Limitations

This was the first study in the field of hand therapy and hand surgery to be conducted exclusively in the province of the Eastern Cape of South Africa. The lack of studies conducted in this province in the field could be attributed to the lack of Health and Rehabilitation Science Faculties at the four universities of the Eastern Cape. Furthermore, only one of these universities offers a medical education in the province. This disparity perpetuates the ongoing imbalance in health care across provinces particularly in the context of the historically under-resourced Eastern Cape. This study has the potential to spark future interest in research in the field of hand therapy and hand surgery in the Eastern Cape.

Unlike other study designs such as randomised control trials or case control series, the descriptive, analytical design used in this study allowed for a greater diversity within the sample. Participants who would normally be excluded from a study due to the presence of a complex injury or differences in zone of injury were included in the study making the results more representative of the population. However, the study parameters were such that only patients presenting to the tertiary hospital with a flexor tendon injury who lived within the district were included. This meant that possible participants who lived outside this area but still received surgery at the tertiary hospital were excluded from the study, resulting in curbing the diversity of the participants. Moreover, data from participants younger than 18 were not collected, limiting the results.

Another strength emerged from the rigour used for each of the outcome measures. The researcher performed all of the assessments for each participant at the four time points. This meant that only intra-rater reliability was imposed, resulting in consistency in the recording and assessment of raw data. In addition, the researcher was blinded to information pertaining to the participant's injury, surgery, rehabilitation and socioeconomic factors until data collection was completed. Furthermore, three outcome measures were used, each assessing a different parameter of hand function. This meant that the results measured different attributes related to hand function, thus giving a more holistic picture of the outcome.

In order to compensate participants for travel to the hospital for the purpose of the study, participants were given a small stipend of R50 per assessment. In view of this, participants may have been motivated to return for therapy more consistently than what is normally seen at the occupational therapy outpatient department. This meant that the data were not truly reflective of everyday case management at the hospital. However, the study is as true a representation of the state of flexor tendon rehabilitation and repair in this context as possible. The methodology could have been strengthened by including assessments at two-week time intervals and by having a longer follow up time of up to six months. This was, however, not possible given financial and time constraints for both the participants and occupational therapy department.

Time constraints and recruitment challenges lead to the under powering of the study. As this study was completed for a Masters degree, there were time pressures to complete data collection in a one year period. Recruitment was therefore scheduled to start in February 2017 and continue for a period of six months until the end of July 2017 to allow for data collection to be completed in December 2017. Problems arose within the first month of recruitment with only two participants being recruited; this suggested that the target sample size of 59 participants would not be achieved given the recruitment rate. In response to this challenge, an amendment was submitted to the University of Cape Town Human Research Ethics Committee in March 2018 in an attempt to rectify the problem before more recruitment time was lost. In the following four months, 30 patients were identified, and of those, only 20 were recruited. This resulted in a final sample size of 22 participants. Additionally, three participants were lost to follow up, a rate of 13%, in the first month of data collection resulting in a total of 19 participants at the end of the study. The study was therefore under-powered resulting in insufficient inferential data for the aim of the study as the required sample size of 56 was not achieved. In addition, two participants did not return for the sixteen week follow up. This meant that data from the twelve week assessment had to be used for these two participants. Kang (2013) reported that this is acceptable practice but results in bias for estimate of treatment or change over time.

In order to determine the rate of recovery, participants needed to be assessed at four different time points. In this way the study design was strengthened. In previous studies, participants were followed up at one or two time points (Cooper et al., 2015; Moriya et al., 2015; Quadlbauer et al., 2015; Spark et al., 2018). By following up with each participant at four different time points, the amount of data collected quadrupled for each participant lending to a deeper understanding of the rate of recovery.

6.7 Chapter Summary

This chapter discussed the results in light of the study aims and objectives. The results for each of the outcome measures demonstrates that the functional outcome achieved in this study is worse than those reported in previous literature. However, comparison to these studies is not equitable as the samples and timeframes are dissimilar. When comparing the results of the present study to one with a similar demographic profile, the results are more alike, highlighting the under reporting of outcomes in zones IV and V. In addition, challenges related to comparison were also discussed as different methods of reporting for TAM and muscle strength require uniformity as has been mentioned by Dy et al. (2012). The factors affecting functional outcome were discussed and analysed in comparison to literature within the field of flexor tendon repair and rehabilitation. Many factors were not found to have a statistically significant impact. This is in contrast to previous literature. Time to repair was the only factor that had a statistically significant impact on functional outcome and appears to be influenced by the complexity of the injury, although further study is needed to more clearly define this relationship.

Rate of recovery was considered in relation to soft tissue healing times and rehabilitation protocol phases; potential challenges to recovery were proposed. It is an important factor to consider when planning the rehabilitation journey for those who have suffered a flexor tendon injury. The results from this study could help therapists understand at which time frames a greater improvement in function can be expected. The results also point to difficulties experienced by patients between the eighth and twelfth-week time frames and possible reasons for this phenomenon were discussed. The similarities and differences of the demographic profile of this study to other national and international literature was discussed. Although there are similarities in the sample of this study and those nationally and internationally, there are other factors that are unique to this population. Level of education, proximity and availability of quality rehabilitation services at community clinic level and the employment status of this population pose unique barriers to patients with flexor tendon injuries. Finally the strengths and limitations of the study were presented. The strengths stemmed from variance within the sample, the rigorous process followed and data collected at four time points, while limitations related to sample size and restricted study parameters.

Chapter 7: Conclusion

7.1. Introduction

This chapter constitutes the conclusion to the dissertation. The findings in relation to the study aim and objectives will be discussed. Recommendations for practice, education, research and policy arising from the study results will be made. The chapter ends with a final concluding statement.

7.2. Conclusion

The aim of this study was to identify the determinants of positive functional outcomes sixteen weeks post flexor tendon repair at a tertiary hospital in the Eastern Cape of South Africa. The findings suggest that time to repair had a significant impact on functional outcomes, but not in a linear manner as hypothesised. Instead, patients who were operated between day four and day seven had the best outcomes in the sample. Other variables that influenced this event were the complexity of the injury, which at times necessitated an earlier repair, negatively influencing the outcomes noted for those participants operated within the first three days of the injury. Further statistically significant data were not obtained due to under-powering of the study as well as study design weakness resulting from the exclusion criteria. The findings raised two relevant points. Firstly, it appears not to be harmful to wait a week for a primary flexor tendon repair, and secondly, in support of literature locally and internationally, complex injuries (i.e. flexor tendon laceration with one or more additional injuries) have a detrimental impact on functional outcomes (Pulos & Bozentka, 2015; Spark et al., 2018; Tang, 2012).

The second objective of the study was to analyse the rate of recovery between four-, eight-, twelve- and sixteen-week time frames after a flexor tendon injury. The findings showed that the greatest change in median scores were between four- and eight-week as well as twelve and sixteen-week time frames. These findings could be explained by the timeline for soft tissue healing as well as the changes in functionality of the protocols at these stages. However, it is a concern that little change in median scores were noted between weeks eight and twelve. Powell and Heyde (2014) alluded to this problem arguing that therapists fail to include ADLs in practice due to time constraints, insufficient knowledge and therapists' assumption that the patient would intrinsically know how to return to their daily activities. Further investigation into this 'state of doldrums' between weeks eight and twelve is necessary to further understand this event.

Another objective of the study was to describe the demographic profile of the sample population. The data showed that the demographic profile of the sample was similar to those of other studies in South Africa and across the globe. Young males carry the greatest burden of disease for flexor tendon injuries. Factors that have been documented in previous literature that influence functional outcomes include smoking status, the presence of adhesions and complex injuries. Of the participants of this study, 70% were smokers, 80% had moderate or severe adhesions and half had complex injuries. In addition, fewer than a third of participants had completed their school leaving certificate, limiting work opportunities available to them. It was argued that the nature of tissue healing for such an injury could have a negative impact on participation in work, leisure or self-care activities. Within the context of the competitive open labour market of South Africa, impairment, disability and fewer years in school would have a detrimental impact on obtaining employment.

The treatment profile of the participants highlighted the reality of provision of health care by government institutions in South Africa. Due to a lack of occupational therapy staff, let alone skilled hand therapists at local clinics in the Eastern Cape, patients have to travel long distances to the tertiary hospital to receive outpatient care on a bi-monthly basis. Although most therapists in this study had over four years of experience, they more often chose conservative protocols. This is suggestive of a lack of confidence, lack of awareness of the evidence supporting more intensive early active protocols and limited clinical reasoning, even in experienced therapists. Further research is warranted to understand therapists thoughts and clinical reasoning in this field. Due to a lack of qualified orthopaedic surgeons, 90% of participants' surgery was undertaken by doctors working in the orthopaedic surgery department. Despite this, repair techniques most commonly used were 4-strand core with epitendinous sutures resulting in strong repairs. This illustrates that the medical officers and registrars were familiar with the literature pertaining to flexor tendon repair and by applying it, were engaging in evidence based practice.

Three outcome measures were chosen in order to deepen the data derived from this study. The results for TAM, muscle strength and DASH scores in the present study showed that the outcome achieved for the present study was poorer than those described previously by international studies. However, comparison to results from randomised control trials and case control series was not realistic considering the timeframes and inclusion and exclusion criteria of these studies. When comparing the results to those obtained by Spark et al. (2018) in Pretoria, with a similar timeframe and sample population, the outcomes mirror each other more closely. The findings highlight the discouraging reality of present functional outcomes of flexor tendon repair and rehabilitation in the Eastern Cape of South Africa whilst also placing the challenges related to this context in the spotlight.

7.3. Recommendations

From the findings of this study, the following actions for practice, research, education and policy are made.

PRACTICE

- Occupational therapists in the Eastern Cape need to be provided with further training through Continuous Professional Development Activities regarding the different treatment options for flexor tendon injuries to increase their understanding of the benefits of the early active approaches and develop their clinical reasoning.
- Discussions with physiotherapists at the tertiary hospital and at the primary health care level are needed in order to recruit them to assist in assessing and treating these patients so that they can be seen more frequently at their nearest health care facility.
- A mobile hand clinic equipped with materials and therapists necessary to treat hand injuries is needed in order to provide quality services at a primary health care level for the district.
- Graded return to meaningful activities should be incorporated in the flexor tendon treatment protocol of the tertiary hospital from eight-weeks post surgery in order to improve rate of recovery at this stage.

EDUCATION

- Undergraduate occupational therapy training in hand therapy should focus on more recent, evidence based protocols so that passive flexion, active extension protocols are not adopted as the norm in practice. This will be done by sending a short summary of the study findings and implications for undergraduate education to each of the eight universities in South Africa that offer undergraduate occupational therapy education.
- Continuous professional development training opportunities should be made available to occupational therapists and physiotherapists in the Eastern Cape. This would ensure that the standard of practice can be disseminated across levels of care in the province. In order to address this need, a summary of the research findings and implications will be sent to the Occupational Therapy Association of South Africa, the South African Society for Hand Therapy and the South African Society of Physiotherapy to inform them of the need for such courses to be made available in the Eastern Cape.

POLICY

- With the rolling out of the National Health Insurance of South Africa in the year 2020, consideration for the provision of community based rehabilitation at a primary health care level is essential to the delivery of quality, accessible health care as stipulated by the Batho Pele Principles of Public Service in South Africa. A short summary of the findings of the study with recommendations for improving quality of rehabilitation services will be made. The recommendations will highlight the need for the appointment of more primary level clinical support staff in order to address the issues of waiting times, cost to patients for unnecessary travel to tertiary institutions and overall functional outcomes on the gross domestic product as a result. This will be in line with the Framework and Strategy for Disability and Rehabilitation Services in South Africa (Matsoaledi et al., 2015).

RESEARCH

- Research pertaining to flexor tendon injury and repair has focused on improving outcomes at the level of zone II, resulting in the skewing of data and treatment protocols to suit challenges at this level. Future research in the field of flexor tendon rehabilitation should aim to address the challenges encountered in each specific zone of injury.
- In order to help policy makers and government institutions understand the widespread and longitudinal implications of poor functional outcomes on the population of patients with flexor tendon injuries, it is recommended that a cost benefit analysis study be done. This type of study will highlight not only the cost to the Department of Health, but also the longitudinal impact on Disability Adjusted Life Years for patients with flexor tendon injuries.
- It is also recommended that a study that delves into the lived experience of patients with a flexor tendon injury be conducted in order to better understand the day to day implications on function that having a flexor tendon injury has upon a person within the South African context.
- A qualitative study is needed to understand the clinical reasoning of therapists treating flexor tendon injuries. This will assist in identifying areas that need to be addressed in continuous professional development platforms.
- A study delving into the reasons for the 'state of doldrums' in recovery between weeks eight and twelve is needed in order to understand this phase better. This study will help to suggest changes in the protocols to address the issues that will emerge from the study.
- The findings of this study will be disseminated by publishing the dissertation on the OpenUCT website. Furthermore, articles will be submitted to the American Journal of Hand Therapy on the cross-cultural translation of the DASH and to the European Journal of Hand therapy regarding the findings pertaining to the overarching aim and objectives of the study.

7.4. Overall conclusion

Although there is a plethora of literature on surgical and rehabilitative interventions for flexor tendon injuries, to the researcher's knowledge, this is the first study on flexor tendon injury rehabilitation in the Eastern Cape of South Africa. The findings of this study show that therapists, surgeons and patients in the Eastern Cape face multiple challenges to the access and provision of quality, evidence based practice for flexor tendon injuries. As a result of contextual factors, the current quality of practice, lack of experienced staff and patient factors, the functional outcomes achieved in this study are below those obtained in high income countries. The study results have identified recommendations within practice, education, research and policy that could improve the quality of care currently being provided for this group.

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Appendix A: Information Sheet

Dear ________________________________(name of patient)

I am an Occupational Therapist working at xxxxxxxx Tertiary Hospital and am currently a Masters student with the University of Cape Town. I enjoy working in the field of hand therapy and have always tried to give the best care possible to my patients. In my years working at xxxxxxxx Tertiary Hospital I have found that one of the most difficult injuries to treat are flexor tendon injuries. I want to know more about this injury and try to find out why some people have better hand function than others after therapy. To do this I am asking any patient with a flexor tendon injury admitted to xxxxxxxx Tertiary Hospital between (time frame) to participate in the study.

I understand that you have had an injury to your hand that involves your flexor tendons. I would like to ask you to participate in my study. If you choose to participate, it will mean that:

1. You will complete a form with your therapist to collect information about: your age, gender, employment status, highest grade passed, address, side of injury, smoking status, information regarding your injury, time waiting in hospital and adherence to rehabilitation recommendations. This is needed in order to find out what may be impacting on your recovery and rehabilitation.

2. You will be given a log book by your occupational therapist. This will help you to record when you do your exercises, any pain you feel and how much you did in the day during your rehabilitation time. You will be asked to bring your log book with you to each assessment for me to see how you are doing. At week 16, this log book will be collected from you to be stored with your assessment forms.

3. You will have to come to xxxxxxxx Tertiary Hospital for therapy at 2, 4, 6, 8 and 12 weeks after your operation. The days at 2, 4 and 8 weeks will be on the same day as your doctor's clinic appointments. An extra testing session at 16 weeks will help me to see you well you are doing a long time after the operation and to find out if you had any other problems in your hand.

4. The day before you are supposed to come for your testing session, you will be contacted on your phone to remind you to come. On the days that you come for therapy at 4, 8 and 12 weeks after the operation, you will be asked to spend 10 to 15 minutes with me (the researcher) to complete a few tests to see how you are doing. At 16 weeks, you will only be asked to see me for the final testing.

5. The tests will see how much you move, how strong you are and how well you are using the hand in your everyday tasks.

You may feel some physical or emotional discomfort during the testing as some of the tests require that you bend or squeeze as much as you can to see how well you are doing. However, the tests used should not cause you long term pain or discomfort and you will be offered assistance in the form of counselling or extra therapy as needed.

I understand that xxxxxxxx Tertiary Hospital is quite far away for some people and that transport to the hospital can be expensive. Therefore, you will be paid R 50.00 for your taxi or bus fair to and from the hospital. You will be given this money when you come for your testing with me only (i.e. 4, 8, 12 and 16 weeks).

Your participation is completely voluntary and you are free to withdraw from the study at any time during the next four months. You will not need to provide any reason for your choice to withdraw and there will be no punishment and nothing bad will happen to you if you decide not to participate. You will be able to continue receiving therapy at xxxxxxxx Tertiary Hospital if you wish.

All forms used in the study will not have your name on them but a research number will be allocated to you. This is to protect your confidentiality. This means that no one will be able to read the assessment forms and know that they belong to you. The researcher will keep a list of your name and your research number in a locked drawer during the assessment period but this will be destroyed at the 16 week assessment so that your study number cannot be linked to your name. Once all the assessments for all the participants have been completed, the researcher will look at your therapy notes to find out if there were any difficulties during your treatment and how there were addressed. This information is important to help me understand what worked in your therapy and what didn't. The information from the assessment sheets will be entered into a password protected computer for analysis, after which the assessment forms will be destroyed. At this point, you will no longer be able to withdraw from the study as there will be no way to match your research number to the correct form.

Thank you for your time and for helping to improve the knowledge in hand injuries in South Africa. Please feel free to contact me if you have any questions about the research by contacting me at:

Email: mngamy001@myuct.ac.za

Telephone: 041 405 2517

or the research supervisor Dr. Helen Buchanan:

Email: helen.buchanan@uct.ac.za

Tel: 021 406 6383

Should you have any concerns about your rights or welfare as a participant in this study please contact the chairperson of the University of Cape Town Faculty of Health Sciences, Human Research Ethics Committee, Professor Marc Blockman:

Email: marc.blockman@uct.ac.za

Tel: 021 406 6338

The University of Cape Town Faculty of Health Sciences Human Research Ethics Committee can also be contacted on 021 406 6338 in case participants have any questions regarding their rights and welfare as research subjects on the study.

Kind regards

____

Amy Menegaldo

Occupational Therapist at xxxxxxxx Tertiary Hospital

Masters by Dissertation student at the University of Cape Town

Appendix B: Informed Consent form

RESEARCH TITLE:
The determinants of a positive functional outcome on patients with flexor tendon injuries at a tertiary hospital in South Africa. A descriptive, analytical study.

RESEARCHER:
Amy Menegaldo (BSc OT UCT 2012)
ETHICS NUMBER:
HREC REF: 713/2016

No:	Question:	Answer:
1	Do you understand what you will be required to do should you decide to participate in the study?	Yes / No
2	Have you read the information sheet or have it read to you?	Yes / No
3	Have you had the chance to ask questions about the study or any concerns that you may have?	Yes /No
4	Have all your questions been answered to your satisfaction?	Yes / No
5	Do you feel that you have enough information about the study to make an informed decision regarding your participation?	Yes / No
6	Do you understand that you are free to withdraw from the study at any time?	Yes / No
7	Do you understand that you do not have to give a reason if you choose to withdraw from the study?	Yes / No
8	Do you understand that there will be no penalties or repercussions to you withdrawing from the study?	Yes / No
9	Do you agree to participate in the study?	Yes / No

Participant's name: ____________________

Signature:___________________________

Date and place:______________________

Witness' name:__________________________

Signature:______________________________

Date and Place:_________________________

Researcher's name:____

Signature:____

Date and place:____

Appendix C: Proposed Timetable

Activity	Date
Submission of protocol to DHRS	August 2016
Corrections to Proposal	September 2016
Resubmissions of proposal to DHRS	October 2016
Submission of proposal to Ethics Committee	November 2016
Corrections to Proposal	December 2016
Submission of proposal to the Eastern Cape Department of Health for approval	January 2017
Submission of proposal to Tertiary Hospital for approval	January 2017
Literature review and DASH translation	December 2016/January 2017
Inservices to Occupational Therapy and Orthopaedics Department	January 2017
Data collection	February - December2017
Data analysis	December 2017 - March 2018
Write up	March - June 2018
Corrections to Dissertation	June 2018
Final Draft	July 2018
Submission	August 2018
Dissemination of findings - Submit an article to the Journal of hand therapy regarding research and findings - Submit article to South African Journal of Occupational Therapy regarding DASH translation - Present findings to the annual South African Society of Hand Therapists congress - Present findings to International Federation of Societies for Hand Therapy.	January - December 2019

Appendix D: Proposed budget

Translation of DASH

Item	Description	Approximate budget
Translator fees		R 10 000.00
Printing	paper and ink	R435.00
Text messaging and calls		R 500.00
Internet access		R 500.00
Total		R 11 435.00

Dissertation

Item	Description	Approximate budget
Jamar dynamometer	1 x	R11800
Finger goniometer	1 x	R810
A4 printing paper	3 x 500 sheets package	R135.00
Ink cartirages	2 x black	R600.00
Text messaging		R1 000.00
Consultant to assist with statistical analysis		R2 000.00
Internet access		R1 500.00
Transport stipend	R50/visit x 4	R 20 000.00
Total		R 37 845

Appendix E: DASH translation procedure

The following procedure will be followed as per the guidelines outlined by the Institute for Work & Health by Beaton et al. (2007):

1. Two versions of the DASH will be forward translated from the original English version into isiXhosa by two isiXhosa speaking translators One from the Language Department at Nelson Mandela Metropolitan University and another being a health professional. This will include a report highlighting challenging phrases or uncertainties in the translation to review.
2. A third translator will then act as a mediator in the discussion of the translations by the two isiXhosa speaking translators to synthesise the two translations into a single document.
3. Two additional blinded translators will then backward translate two versions of the isiXhosa version of the DASH back into English to ensure that the translation remains true to the original text.
4. The backward translations as well as the forward translations will be reviewed by an expert committee consisting of the methodologist, health professional, language professional as well as all translators and the researcher. This is to ensure that the newly translated version is culturally appropriate as well as to develop the pre-final version of the DASH for testing.
5. A field test of the pre-final DASH will involve recruiting 30 - 40 isiXhosa speaking people from the Xhosa community to complete this version of the DASH. Each person will be asked to sign informed consent after reading the information sheet (see below). They will be asked to complete the questionnaire and tell inform the researcher what they thought was meant by each question, the assessment as a whole as well as their responses. The researcher will then review which questions were most commonly unanswered.
6. The results of the field test in addition to all the work accumulated in the process will be submitted to the Institute for Work and Health for review. This version will only be used once approval has been obtained.

Information Sheet: Disability of the Arm Shoulder and Hand Questionnaire:

My name is Amy Menegaldo. I am an Occupational Therapist at xxxxxxxx Hospital and am currently doing research to complete my Masters by Dissertation Degree. In order to complete my research, I have translated the Disability of the Arm Shoulder and Hand questionnaire from English into isiXhosa. This questionnaire helps therapists and doctors to understand how a person with a hand injury is coping in their everyday tasks and activities.

Before I can use this questionnaire on patients or people with hand injuries, I need to make sure that it makes sense, it is culturally appropriate and can be used by the everyday isiXhosa speaking person. To do this I am asking you as a home language isiXhosa speaking person to fill out the questionnaire. I will then ask you some questions regarding the assessment's relevance to you and your life, if there were any questions that were difficult, confusing or offensive and what your thoughts are of the assessment as a whole. It will only take 5 – 10 minutes of your time and will be a great help to me and those who wish to use this assessment in the future.

Your participation is completely voluntary and you are free to withdraw from the test at any time whilst doing the questionnaire or question and answer session. You will not need to provide any reason for your choice to withdraw and there will be no punishment and nothing bad will happen to you if you decide not to participate. Thank you so much for your time. Please feel free to contact me if you have any questions about the research by contacting me at:

Email: mngamy001@myuct.ac.za Tel: 041 405 2517

or the research supervisor Dr. Helen Buchanan:

Email: helen.buchanan@uct.ac.za Tel: 021 406 6383

Should you have any concerns about your rights or welfare as a participant in this study please contact the chairperson of the University of Cape Town Faculty of Health Sciences, Human Research Ethics Committee, Professor Marc Blockman:

Email: marc.blockman@uct.ac.za Tel: 021 406 6338

Amy Menegaldo
Occupational Therapist
MSc Occupational Therapy Student (UCT)

Informed Consent: Disability of the Arm Shoulder and Hand Questionnaire:

No:	Question:	Answer:
1	Do you understand what you will be required to do should you decide to participate in the study?	Yes / No
2	Have you read the information sheet?	Yes / No
3	Have you had the chance to ask questions about the study and have all your questions been answered to your satisfaction?	Yes /No
5	Do you feel that you have enough information about the study to make an informed decision regarding your participation?	Yes / No
6	Do you understand that you are free to withdraw from the study at any time?	Yes / No
7	Do you understand that you do not have to give a reason if you choose to withdraw from the study?	Yes / No
8	Do you understand that there will be no penalties or repercussions to you withdrawing from the study?	Yes / No
9	Do you agree to participate in the study?	Yes / No

Participant's name: ____________________ Researcher's name:_____________________

Signature:___________________________ Signature:____________________________

Date and place:_____________________ Date and place:________________________

Appendix F: General Information Sheet

Participant Number:………………………

Item	Descrition	Answer
Age	Number in years	
Gender	Male/Female	
Employment status	Permanently employed/Unemployed/Casual worker	
Highest level of education	Highest grade passed	
Proximity to xxxxxxxx Tertiary Hospital	Kilometers	
Dominance	Right/Left	
Side of injury	Right/Left	
Smoker	Yes/No	
Complex injuries	Nerve injury/fractures/extensor tendons	
Number of tendons involved	Number	
Fingers involved	Name (e.g. index finger)	
Zone of injury	Number	
Expertise of surgeon	Medical Officer/Registrar/Consultant	
Expertise of therapist	Community Service/ >1/ >2 / >3/ > 4 years	
Time to repair	Days	
Pre-operative OT	Yes/No	
Type of rehabilitation	Early Active/Duran	
Adherence to recommendations	Yes/No	
Pain experienced	Days	
	Level (average)	
Activity Level	nothing/light duty/medium duty/heavy duty/went to work/stayed at home	

Completed by: ……………………………………….

Date: ………………………………………………….

Appendix G: Participant list

Participant Name	Folder number	Research number	Date recruited	Date completed	Telephone Number (2)
Example: John Doe	234567	P0001	01/01/2017	30/04/2016	083 555 7777 073 111 0000

Appendix H: Assessment form week 4

Participant number: ………………………………….. Date: ……………………………………………..

ROM assessment:
(make * next to affected side)

Finger		Right		Left	
		Flexion	Extension	Flexion	Extension
Thumb	DIPJ				
	PIPJ				
Index	DIPJ				
	PIPJ				
Middle	DIPJ				
	PIPJ				
Ring	DIPJ				
	PIPJ				
Little	DIPJ				
	PIPJ				

TAM:
To be calculated in the formula
[Flexion of PIPJ + DIPJ] - [Extension of PIPJ + DIPJ] = TAM

Finger	Degrees	Interpretation
Thumb		
Index		
Middle		
Ring		
Little		

DASH score:

Total: ………………………………

(taken from DASH form to be attached)

Completed by: ……………………………………..

Appendix I: Assessment form week 8

Participant number: ………………………………… Date: ……………………………………………..

ROM assessment:
(make * next to affected side)

Finger		**Right**		**Left**	
		Flexion	Extension	Flexion	Extension
Thumb	DIPJ				
	PIPJ				
Index	DIPJ				
	PIPJ				
Middle	DIPJ				
	PIPJ				
Ring	DIPJ				
	PIPJ				
Little	DIPJ				
	PIPJ				

TAM:
To be calculated in the formula
[Flexion of PIPJ + DIPJ] - [Extension of PIPJ + DIPJ] = TAM

Finger	**Degrees**	**Interpretation (ASSH)**
Thumb		
Index		
Middle		
Ring		
Little		

DASH score:

Total: ………………………………

(taken from DASH form to be attached)

Completed by: ……………………………………..

Appendix J: Assessment form week 12

Participant number: ………………………………….. Date: ……………………………………………..

ROM assessment:
(make * next to affected side)

Finger		**Right**		**Left**	
		Flexion	Extension	Flexion	Extension
Thumb	DIPJ				
	PIPJ				
Index	DIPJ				
	PIPJ				
Middle	DIPJ				
	PIPJ				
Ring	DIPJ				
	PIPJ				
Little	DIPJ				
	PIPJ				

TAM:
To be calculated in the formula
[Flexion of PIPJ + DIPJ] - [Extension of PIPJ + DIPJ] = TAM

Finger	**Percentage**	**Interpretation (ASSH)**
Thumb		
Index		
Middle		
Ring		
Little		

DASH score:

Total: ………………………………

(taken from DASH form to be attached)

Muscle Strength:
(make * next to affected side)

Tes t	Right	Left
1		
2		
3		
M e an		

Completed by: ……………………………………..

Appendix K: Assessment form week 16

Participant number: ………………………………… Date: ……………………………………………..

ROM assessment:
(make * next to affected side)

Finger		**Right**		**Left**	
		Flexion	Extension	Flexion	Extension
Thumb	DIPJ				
	PIPJ				
Index	DIPJ				
	PIPJ				
Middle	DIPJ				
	PIPJ				
Ring	DIPJ				
	PIPJ				
Little	DIPJ				
	PIPJ				

TAM:
To be calculated in the formula
[Flexion of PIPJ + DIPJ] - [Extension of PIPJ + DIPJ] = TAM

Finger	**Percentage**	**Interpretation (ASSH)**
Thumb		
Index		
Middle		
Ring		
Little		

DASH score:

Total: ………………………………

(taken from DASH form to be attached)

Muscle Strength:
(make * next to affected side)

Test	Right	Left
1		
2		
3		
M e a n		

Information from treatment notes:

Number of OT sessions post operatively	Adhesion formation	Need for physio intervention	Other complications (sepsis/rupture)	Need for further surgical intervention
	Yes / No Comment: Mild / Moderate / Severe	Yes / No		Yes / No Tenolysis/ Reoperation/ delayed staged flexor tendon reconstruction

Completed by: ……………………………………..

Appendix L: Outline for training sessions

Agenda for training for Department of Orthopaedic Surgery

Welcome and apologies

Introduction of researcher

Aim of research and procedure

Requested assistance:
- Thorough operation notes
- Suggested protocol in operation notes
- Book Occupational Therapy rehabilitation with doctors appointments

Questions and Comments

Thank you and closing

Agenda for training for Department of Occupational Therapy

- Welcome and apologies
- Introduction of researcher
- Aim of research and procedure
- Requested assistance:
    - Informing researcher of patients with flexor tendon injuries in the hospital
- Recruitment procedure
    - Use of General Information form
    - Thorough note taking in standardised OT notes documenting the intervention session content, outcomes and plan of each session. (for cross reference if needed)
- Suggested protocols
    - Book Occupational Therapy rehabilitation in line with doctor's appointments at 2, 4 and 8 weeks. In addition a booking at 12 weeks for rehabilitation needs to be made.
- Quick recap of protocols:
    - Pre- and post-operative
    - Passive flexion, Active extension
    - EAM
- Questions and Comments
- Thank you and closing

Appendix M: Pre-operative protocol for flexor tendon injuries

1. Educating the patient regarding the role of occupational therapy, mechanism of injury, possible operation as well as the importance of adhering to home programme.
2. Checking the POP to ensure the degree of immobilisation is correct and correcting it as needed (wrist 0-20º flexion, metacarpal-phalangeal (MCP) joints in 60-70º flexion and inter-phalangeal (IP) joints in full extension or slight flexion).
3. Discussing adaptations to ADLs with the loss of function of the one hand.
4. Unwrapping the bandaging around the POP until only the fingers are exposed (below MCP joint crease) and perform passive flexion and active extension of the DIP, PIP and MCP joints respectively. In addition, composite passive flexion with composite active extension of each digit is performed if the patient can tolerate it. (The clinical reasoning behind this protocol is discussed in more detail within the literature review).

Appendix N: Post-operative protocols for flexor tendon injuries

Duran-Houser Protocol (Passive Flexion Active Extension):

Time frame	What to do
Day 0-3	Immobilisation in Dorsal POP back-slab (i.e. wrist 0-20º flexion, metacarpal-phalangeal (MCP) joints in 60-70º flexion and inter-phalangeal (IP) joints in full extension or slight flexion)
Day 4 - Week 2	Open up bandage around fingers and cut open ortho-wool to allow for movement. Within Dorsal POP: 1. Full passive flexion and active extension of DIPJ, PIPJ, MCPJ respectively. 2. Full composite flexion and active extension of each digit.
Week 2 - 4	Within Dorsal POP: 1. Full passive flexion and active extension of DIPJ, PIPJ, MCPJ respectively. 2. Full composite flexion and active extension of each digit. 3. Scar massage.
Week 4 - 8	Remove Dorsal POP, only to be worn at night: 1. Hand Bath. 2. Allow patient to flex 100% of composite flexion and 100% of composite extension within limitations pain. 3. Full passive flexion and active extension of DIPJ, PIPJ, MCPJ respectively. 4. Full composite flexion and active extension of each digit. 5. Tendon gliding exercises. 6. Scar massage. 7. NO RESISTED MOVEMENT
Week 8 - 12	Discontinue Dorsal POP. 1. Scar massage, if not improving, refer to Physiotherapist for dry needling. 2. Allow patient to flex 100% of composite flexion and 100% of composite extension within limitations pain. 5. Tendon gliding exercises. 6. Start with light resisted movement in flexion and extension plane in appropriate functional task. Slowly grade resistance up.
Week 12 +	1. Scar massage, if not improving, refer to Physiotherapist for dry needling. 2. Allow patient to flex 100% of composite flexion and 100% of composite extension within limitations pain. 5. Tendon gliding exercises. 6. Start with medium to heavy resistance tasks. Allow hand function in all ADLs.
Week 16	If no improvement noted, refer back to Orthopaedic surgeon for assessment for further surgical intervention. If a good or excellent result obtained, patient may start with contact sports at this stage.

Early Active Motion:

Time frame	What to do
Day 0-3	Immobilisation in Dorsal POP back-slab (i.e. wrist 0-20º flexion, metacarpal-phalangeal (MCP) joints in 60-70º flexion and inter-phalangeal (IP) joints in full extension or slight flexion)
Day 4 - Week 2	Open up bandage around fingers and cut open ortho-wool to allow for movement. Within Dorsal POP: 1. Allow patient to flex 25% of composite flexion and 100% of composite extension within limitations of POP. 2. Full passive flexion and active extension of DIPJ, PIPJ, MCPJ respectively. 3. Full composite flexion and active extension of each digit.
Week 2 - 4	Within Dorsal POP: 1. Allow patient to flex 50% of composite flexion and 100% of composite extension within limitations of POP. 2. Full passive flexion and active extension of DIPJ, PIPJ, MCPJ respectively. 3. Full composite flexion and active extension of each digit. 4. Scar massage.
Week 4 - 8	Remove Dorsal POP, only to be worn at night: 1. Hand Bath. 2. Allow patient to flex 100% of composite flexion and 100% of composite extension within limitations pain. 3. Full passive flexion and active extension of DIPJ, PIPJ, MCPJ respectively. 4. Full composite flexion and active extension of each digit. 5. Tendon gliding exercises. 6. Scar massage. 7. NO RESISTED MOVEMENT
Week 8 - 12	Discontinue Dorsal POP. 1. Scar massage, if not improving, refer to Physiotherapist for dry needling. 2. Allow patient to flex 100% of composite flexion and 100% of composite extension within limitations pain. 5. Tendon gliding exercises. 6. Start with light resisted movement in flexion and extension plane in appropriate functional task. Slowly grade resistance up.
Week 12 +	1. Scar massage, if not improving, refer to Physiotherapist for dry needling. 2. Allow patient to flex 100% of composite flexion and 100% of composite extension within limitations pain. 5. Tendon gliding exercises. 6. Start with medium to heavy resistance tasks. Allow hand function in all ADLs.
Week 16	If no improvement noted, refer back to Orthopaedic surgeon for assessment for further surgical intervention. If a good or excellent result obtained, patient may start with contact sports at this stage.

How to choose and appropriate protocol:

What to consider:	Early Active Motion	Duran-Houser
Oedema	Subsided by day 3	Subsided by day 3-5
Surgical technique used *	4 or 6 strand with an epitendinous/ circumferential/oversew suture	4 strand or 2 strand without an epitendinous/circumferential/ oversew suture
Adherence to rehabilitation in the past (if applicable) *	Good/Fair	Good/Fair/Poor
Capacity to understand importance of following protocol.	Good/Fair	Good/Fair/Poor
Surgeons recommendations *	Strong repair/Go for Early Active	Weaker repair/many complications/ sacrifice of a pulley/ increased tension on the repair
Technique to be used (tick):		

* THRESHOLD POINTS TO INDICATE EARLY ACTIVE PROTOCOL.

Appendix O: Assessment form for flexor tendon injury

Surname:____________________________ Name:________________________M/F

Address:____

Folder No:_________________________ DoB (Age):_____________________

Date of admission:___________________ Date of referral:___________________

Ward: _____________ Referring MDT:___________________

Diagnosis:____

Previous injuries to the upper limb:____

____

Medical History:	Social history:
Date of injury	Smoker / ETOH use (circle if applicable)
Mechanism of injury	Single / Married / Divorced / Widowed
Structures affected	Children
Zone	Lives with
Date _______________ Surgical intervention:	Permanently Employed / Unemployed / Part time Description:
Fingers involved: Right and Left T / IF / MF / RF / LF T / IF / MF / RF / LF	Highest level of education obtained
Number of tendons involved:	
Fracture / Extensor tendon / Nerve involvement median / ulnar	Dominance R / L

Pain: ____

Oedema: ____

POP:____

Stiffness: ____

Sensation:

Right	Left

Range of movement (approximation):

RIGHT	MCPJ	PIPJ	DIPJ
Thumb			
IF			
MF			
RF			
LF			
Wrist	Flexion	Extension	
Elbow	Flexion	Extension	
Shoulder	Flexion	Extension	Adduction / Abduction

LEFT	MCPJ	PIPJ	DIPJ
Thumb			
IF			
MF			
RF			
LF			
Wrist	Flexion	Extension	
Elbow	Flexion	Extension	
Shoulder	Flexion	Extension	Adduction / Abduction

Goals	Name of therapist
	Date
	Signature

Appendix P: Log book

Patients name: ___________________________ Patients folder number: _______________

How to use this logbook:

Please complete this as honestly as possible. The information is needed to help me understand what you do in your day, how much pain your feel and how often you do your exercises. It will not be used to make any judgements about you but as a way to better understand what happens in your day.

1. Tick when you did your exercises or make a cross when you didn't.
2. Write down if you had any pain on the day
3. Circle how much you did in the day (nothing/light duty/medium duty/heavy duty/ went to work/stayed at home)

Date	**Time**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
I did the exercises at these times								
Pain		Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
		Level:	Level:	Level:	Level:	Level:	Level:	Level:
Activity level		Nothing Light Medium Heavy	Nothing Light Medium Heavy	Nothing Light Medium Heavy	Nothing Light Medium Heavy	Nothing Light Medium Heavy	Nothing Light Medium Heavy	Nothing Light Medium Heavy

Pain Scale:

____

0 1 2 3 4 5 6 7 8 9 10

no pain moderate worst pain

Appendix Q: Human Research Ethics Committee Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

18 November 2016

HREC REF: 713/2016

Dr H Buchanan
Health & Rehab
F-floor, OMB

Dear Dr Buchanan

PROJECT TITLE: DETERMINANTS OF POSITIVE FUNCTIONAL OUTCOMES AT 16 WEEKS AFTER FLEXOR TENDON REPAIR AT A TERTIARY HOSPITAL IN SOUTH AFRICA. A DESCRIPTIVE, ANALYTICAL STUDY (MSc CANDIDATE - MS A MENEGALDO)

Thank you for your response to the Faculty of Health Sciences Human Research Ethics Committee dated 14 November 2016.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th November 2017.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period. (Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval before the research may occur.

The HREC acknowledge that the student Amy Menegaldo will also be involved in this study.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

HREC 713/2016

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI),and Declaration of Helsinki (2013) guidelines.
The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Appendix R: National Health Research Database Approval

Eastern Cape Department of Health

Enquir1es:	Madoda Xokwe	Tel No:	040 608 0856
Date:	12 January 2017	Fax No:	043 642 1409
e-mail address:	madoda.xokwe@echealth.gov.za		

Dear Ms. A. M. Menegaldo

Re: Determinants of positive functional outcomes at 16 weeks after flexor tendon repair at a tertiary hospital in South Africa. A descriptive, analytical study. (EC_2016RP53_47)

The Department of I lealth would like to inform you that your application for conducting a research on the abovementioned topic has been approved based on the following conditions:

1. During your study, you will follow the submitted protocol with ethical approval and can only deviate from it after having a written approval from the Department of Health in writing.
2. You are advised to ensure, observe and respect the rights and culture of your research participants and maintain confidentiality of their identities and shall remove or not collect any information which can be used to link the participants.
3. The Department of Health expects you to provide a progress on your study every 3 months (from date you received this letter) in writing.
4. At the end of your study, you will be expected to send a full written report with your findings and implementable recommendations to the Epidemiological Research & Surveillance Management. You may be invited to the department to come and present your research findings with your implementable recommendations.
5. Your results on the Eastern Cape will not be presented any where unless you have shared them with the Department of Health as indicated above.

Your compliance in this regard will be highly appreciated.

SECRETARIAT: EASTERN CAPE HEALTH RESEARCH COMMITTEE

PGDP EASTERN CAPE 2004 - 2014

Ikamva eliqaqambileyo!

Appendix S: Human Research Ethics Committee Approval of Amendment to Protocol

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

HUMAN RESEARCH
ETHICS COMMITTEE
- 4 APR 2017
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

Form FHS006: Protocol Amendment

HREC office use only (FWA00001637; IRB00001938)			
☑ Approved	☐ Type of review: Expedited	☐ Full committee	
This serves as notification that all changes and documentation described below are approved.			
Signature Chairperson of the HREC		Date	6/4/2017

Note: All major amendments must include a local PI ~~Synopsis justifying~~ the changes for the amendment. Please note that incomplete amendment submissions will not be reviewed.

Comments from the HREC to the Principal Investigator:
Note: The approval of this protocol amendment does not grant annual approval. Please complete the FHS016 / FHS017 form for annual approval at least one month before study expiration.

Principal Investigator to complete the following:

1. Protocol information

Date (when submitting this form)	27/03/2017	
HREC REF Number	713/2016	
Protocol title	Determinants of positive functional outcomes at 16 weeks after flexor tendon repair at a tertiary hospital in South Africa. A descriptive, analytical study.	
Protocol number (if applicable)	N/A	
Principal Investigator	Dr. Helen Buchanan	
Department / Office Internal Mail Address	Helen.Buchanan@uct.ac.za Department of Occupational Therapy Old Main Building	
1.1 Is this a major or a minor amendment? (see FHS006hlp) Major (tick box) Minor (tick box)	☐ Major	☐ **Minor**
1.2 Does this protocol receive US Federal funding?	☐ Yes	☐ **No**
1.3 If the amendment is a major amendment and receives US Federal Funding, does the amendment require full committee approval?	☐ Yes	☐ No

4 March 2016 Page 1 of 3 FHS006