CHARLES UNIVERSITY

Faculty of Physical Education and Sports

Department of Physiotherapy

Rehabilitation of Zone II Flexor Tendons after Surgical Repair

Bachelor Thesis

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Prague, 2017

Abstract

"Rehabilitation of Zone II Flexor Tendons after Surgical Repair"
"Rehabilitace Zone II šlach flexorů po chirurgické korekci" (Title, Czech Language)

Selected surgical procedures, postoperative casting and movement recommendations, along with rehabilitation techniques are paramount in the influence of a positive outcome in this type of injury. Encompassed in this thesis are the theoretical and practical aspects of a case study about a patient that received custom physiotherapy treatment after surgical repair of lacerated flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) in Zone II of his third digit on his left hand. I will attempt to explain the importance of the surgical technique, casting choices, and rehabilitation program, which can affect the outcome. The case study is based on clinical work while at Ustredni vojenska nemocnice (UVN) during the time period of 09.01.2017 – 20.01.2017. The patient involved in this case study is a 31-year-old male who is 52 days after surgical repair of FDS and FDP in Zone II of his third digit on his left hand. The surgical repair was required after a work related accident where the patient lacerated his third digit in Zone II with a chisel.

This thesis has been divided into two sections. The initial section describes general upper limb anatomy and biomechanics, variety of surgical techniques and purpose of the rehabilitation program. Subsequently followed by the case study, which consists of the anamnesis, initial examination/evaluation, therapy, and the final examination/evaluation.

The main goal of the therapy approach for this patient is to reduce pain during activity, increase range of motion of the third digit, and to move closer to full function of the left hand. The methods used in the therapy for this case study were mainly manual techniques and exercises based on active movements to increase the range of motion in the left hand. No invasive methods were used.

There was a positive outcome from the applied therapy program. Pain during active movements of the third digit was significantly reduced, but not eliminated. Range of motion of the third digit did increase, but not to full range and so full function of the left hand had not been restored by the end of the last therapy session.

Key words: Zone II, Flexor Digitorum Superficialis, Flexor Digitorum Profundus, Kessler, "No-Man's Land"

Dates of Practice: 09.01.2017-20.01.2017

Location of Case Study:
Ústřední vojenská nemocnice, U Vojenské nemocnice 1200, 16902 Praha 6 – Břevnov, Czech Republic

Abstrakt

"Rehabilitation of Zone II Flexor Tendons after Surgical Repair"
"Rehabilitace Zone II šlach flexorů po chirurgické korekci" (Title, Czech Language)

Rozhodnutí o způsobu chirurgického zákroku, sádrová fixace po operaci, doporučená cvičení mají spolu s rehabilitačními technikami obrovský vliv na konečný výsledek u tohoto typu zranění. Tato práce je zaměřena na teoretické a praktické postupy u pacienta, který prošel chirurgickou korekci tržné rány flexor digitorum superficialis (FDS) a flexor digitorum profundus (FDP) v Zone II na třetím prstu levé ruky a následnou standartní fyzioterapeutickou léčbou. Na tomto případu se pokusím vysvětlit důležitost způsobu provedení chirurgické korekce, výběru fixace a následného rehabilitačního programu a jejich vliv na celkový výsledek. Případ pacienta je založen na mé klinické praxi v Ústřední vojenské nemocnici (UVN) v době od 9. do 20. ledna 2017. Pacientem byl 31-letý muž, kterému byla provedena chirurgická korekce flexoru digitorum superficialis (FDS), flexoru digitorum profundus (FDP) v Zone II na třetím prstu levé ruky. Důvodem byl pacientův pracovní úraz dlátem, kdy došlo k tržné ráně třetího prstu v Zone II.

Bakalářská práce je rozdělena do dvou částí. V úvodní části popisuji obecnou anatomii a biomechaniku, různé způsoby chirurgických postupů a zdůvodnění následných rehabilitačních programů. Následně se věnuji stanovení anamnezie, postupu vstupního vyšetření a jeho hodnocení, samotné léčbě a výstupnímu hodnocení na základě výstupního vyšetření.

Hlavním cílem hodnocení lečebné terapie v případě tohoto pacienta je uskutečněné snížení bolesti během aktivního pohybu levou rukou, zvýšení rozsahu možného pohybu postiženého třetího prstu levé ruky a následně navrácení plné funkčnosti levé ruky. V tomto případě nedošlo k žádnému dalšímu invazivnímu zákroku, byla navržena manipulační léčba.

Vhodně zvolená metoda léčby přinesla pozitivní výsledek. Bolest, kterou pacient cítil ve třetím prstu levé ruky při pohybu ruky se podařilo výrazně snížit, nepodařilo se jí eliminovat úplně. I přesto, že se rozsah pohybu postiženým prstem zvýšil, nedošlo k návratu rozsahu pohybu do původního rozsahu a tím pádem nedošlo ani k navrácení pohyblivosti celé levé ruky do stavu jako před úrazem.

Klíčová slova: Zone II, Flexor Digitorum Superficialis, Flexor Digitorum Profundus, Kessler, “No-Man’s Land”

Datum praxe: 09.01.2017 - 20.01.2017

Místo praxe:
Ústřední vojenská nemocnice, U Vojenské nemocnice 1200 , 169 02 Praha 6 – Břevnov, Česká republika

Declaration

This thesis is a presentation of my research work compiled from books, articles, journals, and knowledge gathered during lectures and seminars at FTVS. Whenever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature and acknowledgement of collaborative research and discussions.

I also declare that no invasive methods were used during the practical approach and that the patient was fully aware of the procedures at any given time.

The work was performed and completed under the guidance of Mgr. Katerina Marsakova and under the supervision of Mgr. Romana Kozderkova, MDT, physiotherapist at Ustredni vojenska nemocnice, Prague Czech Republic.

Joseph Bruce Truesdale

Prague, April 2017

Acknowledgments

First, I would like to thank Mgr. Romana Kozderkova at Ustredni vojenska nemocnice (UVN) for her time, willingness to share her knowledge and experience, and of course her patience and positive outlook.

I am grateful to my supervisor, Mgr. Katerina Marsakova, for her insight and dedication to detail, which has guided my efforts in the writing of this thesis.

I owe many thanks to my family and friends that have encouraged and stood behind me along this arduous process. My loving thanks and gratitude are due to my wife, Lenka Truesdale. Her patience, understanding, and encouragement have been the stability I needed and without her it would not have been possible to finish my Bachelor's here at UK FTVS.

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1 General: The Wrist/Hand

1.1 Anatomy of the wrist/hand

The anatomy of the wrist and hand is complex, intricate, and fascinating. There are several different forms of joints located here. Such joints are, gliding diarthrosis, saddle diarthrosis, ellipsoidal diarthrosis, and hinge diarthrosis.[1] The wrist and hand has the ability to move in two axes, frontal and sagittal. A sagittal axis in the frontal plane allows for the movements of flexion and extension. A frontal axis in the sagittal plane allows for the movements of abduction and adduction. The wrist and hand is the articulation between the ulna, radius, carpal and metacarpal bones. The hand is innervated by 3 nerves, the median, ulnar, and radial nerves, each of which has sensory and motor components. The muscles of the hand are divided into intrinsic and extrinsic groups.[2]

1.1.1 Bones

A total of 27 bones constitute the basic skeleton of the wrist and hand. These are grouped into carpals, metacarpals, and phalanges. The wrist joint is a complex, multiarticulated joint that allows wide range of motion in flexion, extension, circumduction, radial deviation, and ulnar deviation. The distal radioulnar joint allows pronation and supination of the hand as the radius rotates around the ulna. Eight carpal bones grouped in two rows with very restricted motion between them form it. From radial to ulnar, the proximal row consists of the scaphoid, lunate, triquetrum, and pisiform bones. In the same direction, the distal row consists of the trapezium, trapezoid, capitate, and hamate bones. [3,4]

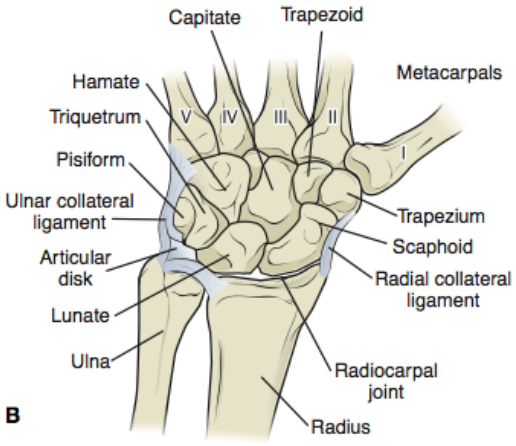

Fig. 1: Carpal Bones

All carpal bones participate in wrist function except for the pisiform, which is a sesamoid bone through which the flexor carpi ulnaris tendon passes. The scaphoid serves as link between each row; therefore, it is vulnerable to fractures. The distal row of carpal bones is strongly attached to the base of the second and third metacarpals, forming a fixed unit. All other structures (mobile units) move in relation to this stable unit. The flexor retinaculum,which attaches to the pisiform and hook of hamate ulnarly and to the scaphoid and trapezium radially, form the roof of the carpal tunnel. [3,4]

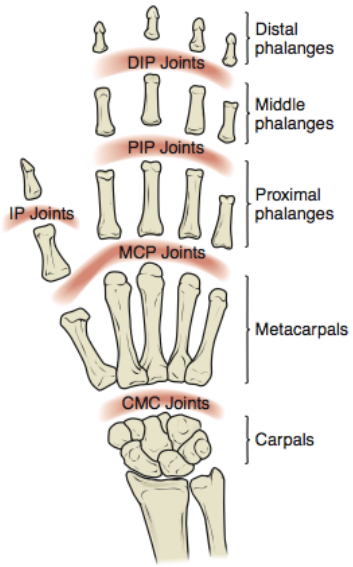

Fig. 2 - Finger Bones

The hand contains 5 metacarpal bones. Each metacarpal is characterized as having a base, a shaft, a neck, and a head. The first metacarpal bone (thumb) is the shortest and most mobile. It articulates proximally with the trapezium. The other 4 metacarpals articulate with the trapezoid, capitate, and hamate at the base. Each metacarpal head articulates distally with the proximal phalanges of each digit. [3,4]

The hand contains 14 phalanges. Each digit contains 3 phalanges (proximal, middle, and distal), except for the thumb, which only has 2 phalanges.[3,4]

1.1.2 **Ligaments**

The wrist and hand contains many small ligaments that connect the 27 bones in a strong, yet mobile unit. There are both extrinisic and intrinsic ligaments in the wrist. The extrinisic ligaments bridge the carpal bones to the radius or metacarpals, which include volar and dorsal ligaments. The intrinsic ligaments originate and insert on the carpal bones. The most noteworthy intrinsic ligaments are the scapholunate interosseous ligament and the lunotriquetral interosseous ligament. The volar ligaments are secondary stabilizers of the scaphoid and are stronger than the dorsal ligaments. [5,16]

The ligaments of the fingers are even more intricate and numerous. These ligaments include: extensor ligaments; retinacular ligaments; digital cutaneous ligaments;

expansion hood; MCP joint collateral ligaments; deep transverse metacarpal ligament; superficial transverse metacarpal ligament ligament; sagittal bands; triangular ligament; and volar plate

Extensor ligaments have a volar and dorsal component, which connect the lumbrical and interossei tendons to the transverse metacarpal ligament. Retinacular ligaments retain and position the common extensor mechanism during PIP and DIP flexion. Digital cutaneous ligaments tether skin to deeper layers and bone to prevent excessive mobility of skin and improve grip. They also stabilize the digital neurovascular bundle with finger flexion and extension. The expansion hood works to extend the PIP and DIP joints. MCP joint collateral ligaments work to stabilize the MCP joint during motion. These ligaments are looser in extension and tighten during increasing flexion, because as the MCP joint flexes, the proximal phalanx moves further away from the metacarpal head, which tightens all the ligaments. The deep transverse metacarpal ligament prevents metacarpal heads from splaying apart, but allows for some dorsal-volar translation. The superficial transverse metacarpal ligament resists abduction. Sagittal bands keep the extensor mechanism tracking in the midline during flexion of the MCP joint. The triangular ligament counteracts pull of the oblique retinacular ligament, preventing lateral subluxation of the common extensor. The volar plate prevents hyperextension. Knowledge of these configurations is of great importance when splinting a hand in order to avoid joint contractures.

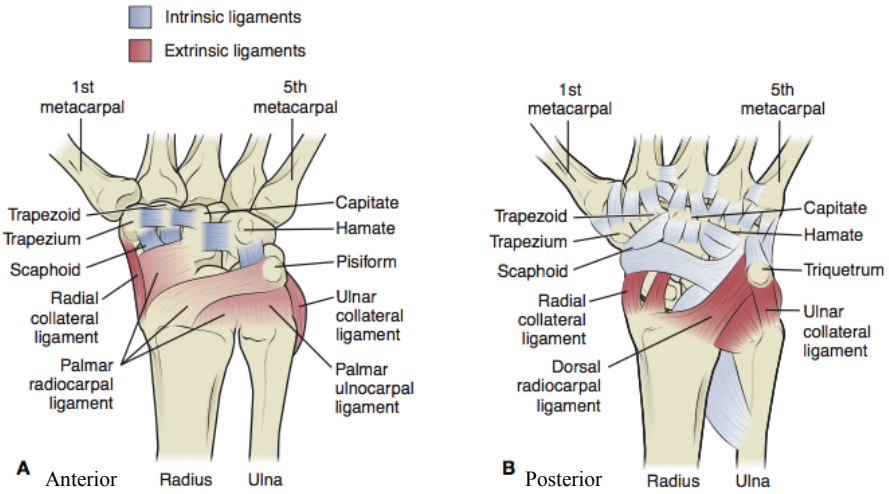

Fig. 3 - Ligaments

The retinacular system is also connected to the flexor compartment. The flexor digitorum superficialis and profundus tendons are enclosed in synovial-lined tunnels, which are maintained against the palmar surfaces of the phalanges by pulleys. Annular (L., ring) pulleys attach to the shafts of the proximal and distal phalanges and to the sides of the volar plates of the MCP, PIP, and DIP joints at the junctions with the extensor hood and the retinaculum. Cruciate pulleys attach on the shafts of the phalanges and cross to form distal attachments on the volar plates of the PIP and DIP joints. Much like the loops for the line on a fishing pole, these pulleys prevent bowstringing of the long flexor tendons during flexor activities. Severance of a pulley causes loss of finger motion.[16]

1.1.3 **Muscles**

The muscles of the hand are divided into intrinsic and extrinsic groups. The intrinsic muscles are located within the hand itself, whereas the extrinsic muscles are located proximally in the forearm and insert to the hand skeleton by long tendons.[6,7]

The extensor muscles are all extrinsic, except for the interosseous-lumbrical complex, which is involved in interphalangeal joint extension. The radial nerve innervates all of the extrinsic extensor muscles. This group of muscles consists of 3 wrist extensors and a larger group of thumb and digit extensors.[7]

The extensor carpi radialis brevis (ECRB) is the main extensor of the wrist, along with the extensor carpi radialis longus (ECRL) and extensor carpi ulnaris (ECU), which also deviate the wrist radially and ulnarly, respectively. The ECRB inserts at the base of the third metacarpal, while the ECRL and ECU insert at the base of the second and fifth metacarpal, respectively.[1,2,5,8]

The extensor digitorum communis, extensor indicis proprius, and extensor digiti minimi extend the digits. They insert to the base of the middle phalanges as central slips and to the base of the distal phalanges as lateral bands. The abductor pollicis longus,

extensor pollicis brevis, and extensor pollicis longus extend the thumb. They insert at the base of the thumb metacarpal, proximal phalanx, and distal phalanx, respectively. [1,2,5,8]

The extensor retinaculum prevents bowstringing of tendons at the wrist level and separates the tendons into 6 compartments. The extensor digitorum communis is a series of tendons to each digit with a common muscle belly and with intertendinous bridges between them. The index and small finger each have independent extension function through the extensor indicis proprius and extensor digiti minimi. [1,2,5,8]

The extrinsic flexors consist of 3 wrist flexors and a larger group of thumb and digit flexors. The median nerve, except for the FCU and the FDP to the small and ring finger, innervates them, which are innervated by the ulnar nerve.[8]

The FCR is the main flexor of the wrist, along with the FCU and the palmaris longus, which is absent in 15% of the population. They insert at the base of the third metacarpal, the base of the fifth metacarpal, and the palmar fascia, respectively. The FCU is primarily an ulnar deviator. The 8 digital flexors are divided in superficial and deep groups. Along with the flexor pollicis longus, which inserts at the thumb distal phalanx, they pass through the carpal tunnel to provide flexion at the interphalangeal joints. [1,2,6,8]

At the palm, the FDS tendon lies volar to the profundus tendon. It then splits at the level of the proximal phalanx and reunites dorsal to the profundus tendon to insert in the middle phalanx. The FDP perforates the superficialis tendon to insert at the distal phalanx. The relationship of flexor tendons to the wrist joint, metacarpophalangeal joint, and interphalangeal joint is maintained by a retinacular or pulley system that prevents the bowstringing effect. [1,2,5,8]

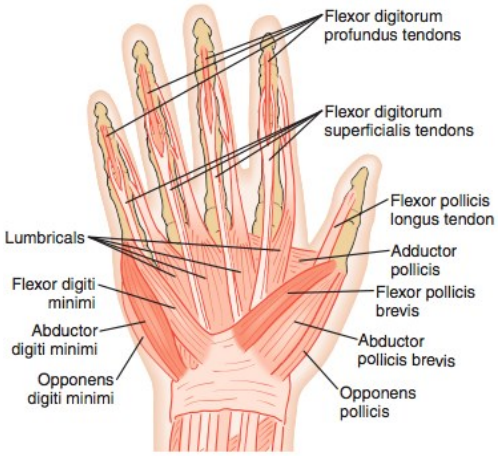

Fig. 4 - Muscles[36]

The intrinsic muscles are situated totally within the hand. They are divided into 4 groups: the thenar, hypothenar, lumbrical, and interossei muscles.[8]

The thenar group consists of the abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, and adductor pollicis muscles. All are innervated by the median nerve, except for the adductor pollicis and deep head of the flexor pollicis brevis, which are innaulnar nerve. They originate from the flexor retinaculum and carpal bones and insert at the thumb's proximal phalanx.[1,2,8]

The hypothenar group consists of the palmaris brevis, abductor digiti minimi, flexor digiti minimi, and opponens digiti minimi. The ulnar nerve innervates them all. This group of muscles originates at the flexor retinaculum and carpal bones and inserts at the base of the proximal phalanx of the small finger.[1,2,8]

The lumbrical muscles contribute to the flexion of the MCP joints and to the extension of the interphalangeal joints. They originate from the FDP tendons at the palm and insert on the radial aspect of the extensor tendons at the digits. The median nerve innervates the index and long finger lumbricals, and the ulnar nerve innervates the small and ring finger lumbricals. [1,2,8]

The interossei group consists of 3 volar and 4 dorsal muscles, which are all innervated by the ulnar nerve. They originate at the metacarpals and form the lateral bands with the lumbricals. The dorsal interossei abduct the fingers, whereas the volar interossei adduct the fingers to the hand axis.[8]

1.1.4 **Pulleys**

The pulley system is critical to flexion of the finger. The retinacular system for each of the fingers contains 5 annular pulleys and 4 cruciate pulleys.[10] The thumb has 2 annular pulleys and 1 oblique pulley. In the finger, the second and fourth annular pulleys (A2, A4) are critical pulleys. The oblique pulley is the critical pulley in the thumb. Deficiency of the pulley system can result in less active flexion of the digit for a certain tendon excursion. If the critical pulleys are missing as a result of injury, the moment arm of the flexor

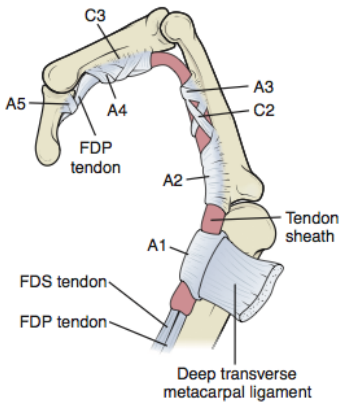

Fig. 5 - Pulleys

tendon–to–bone relationship is increased, resulting in the need for more tendon excursion to flex the finger.[4,]

1.1.5 **Nerves, Dermatomes, and Myotomes**

Three nerves innervate the hand: the median, ulnar, and radial. Each has sensory and motor components.The skin of the forearm is innervated medially by the medial antebrachial cutaneous nerve and laterally by the lateral antebrachial cutaneous nerve.[10]

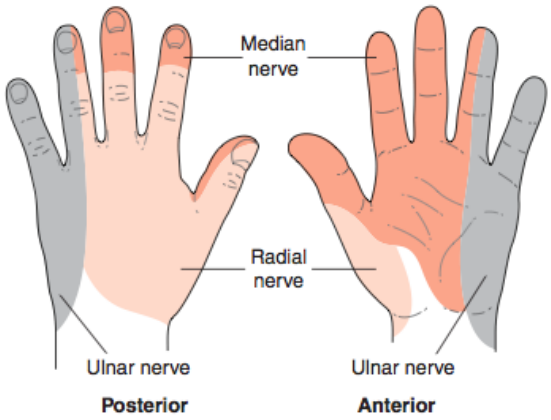

Fig. 6 - Nerves

The median nerve is responsible for innervating the muscles involved in the fine precision and pinch function of the hand. It originates from the lateral and medial cords of the brachial plexus (C5-T1). In the forearm, the motor branches supply the pronator teres, flexor carpi radialis, palmaris longus, and FDS muscles. The anterior interosseus branch innervates the flexor pollicis longus, FDP (index and long finger), and pronator quadratus muscles.[1,5]

Proximal to the wrist, the palmar cutaneous branch provides sensation at the thenar eminence. As the median nerve passes through the carpal tunnel, the recurrent motor branch innervates the thenar muscles (abductor pollicis brevis, opponens pollicis, and superficial head of flexor pollicis brevis). It also innervates the index and long finger lumbrical muscles. Sensory digital branches provide sensation to the thumb, index, long, and radial side of the ring finger.[1,5]

The ulnar nerve is responsible for innervating the muscles involved in the power grasping function of the hand. It originates at the medial cord of the brachial plexus (C8-T1). Motor branches innervate the FCU and FDP muscles to the ring and small fingers. Proximal to the wrist, the palmar cutaneous branch provides sensation at the hypothenar eminence. The dorsal branch, which branches from the main trunk at the distal forearm,

provides sensation to the ulnar portion of the dorsum of the hand and small finger, and part of the ring finger.[1,5]

At the hand, the superficial branch forms the digital nerves, which provide sensation at the small finger and ulnar aspect of the ring finger. The deep motor branch passes through the Guyon canal in company with the ulnar artery. It innervates the hypothenar muscles (abductor digiti minimi, opponens digiti minimi, flexor digiti minimi, and palmaris brevis), all interossei, the 2 ulnar lumbricals, the adductor pollicis, and the deep head of the flexor pollicis brevis.[1]

The radial nerve is responsible for innervating the wrist extensors, which control the position of the hand and stabilize the fixed unit. It originates from the posterior cord of the brachial plexus (C6-C8). At the elbow, motor branches innervate the brachioradialis and extensor carpi radialis longus muscles.[1,5]

At the proximal forearm, the radial nerve divides into the superficial and deep branches. The deep posterior interosseous branch innervates all the muscles in the extensor compartment: supinator, ECRB, extensor digitorum communis, extensor digiti minimi, extensor carpi ulnaris, extensor indicis proprius, extensor pollicis longus, extensor pollicis brevis, and abductor pollicis longus.[1,5]

The superficial branch provides sensation at the radial aspect of the dorsum of the hand, the dorsum of the thumb, and the dorsum of the index finger, long finger, and radial half of the ring finger proximal to the distal interphalangeal joints.[1]

Dermatomes[11]

Upper extremity

C5: Lateral arm sensory branches of the axillary nerve

C6: Lateral forearm sensory branches of the musculocutaneous nerve

C7: Digit III sensory branches of the median nerve

C8: Medial forearm sensory branches of the antibrachial cutaneous nerve

T1: Medial arm sensory branches of the brachial cutaneous nerve

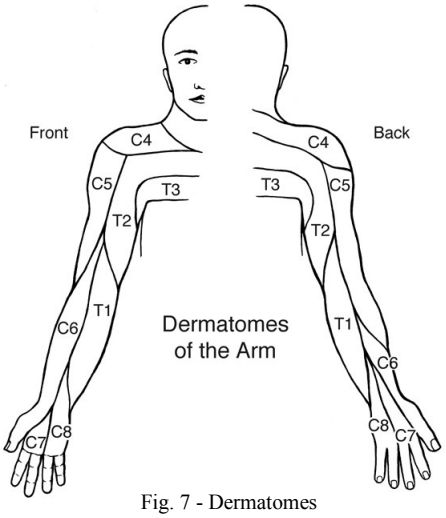

Fig. 7 - Dermatomes

Myotomes[12]

Upper extremity

C3: Cervical lateral flexion

C4: Shoulder girdle elevation

C5: Shoulder flexion/abduction

C6: Elbow flexion/Wrist extension

C7: Elbow extension/ wrist flexion/finger extension

C8: Thumb extension/hand intrinsics

T1: Hand intrinsics

1.1.6 **Blood Supply**

The hand has a complex and rich vascular network. The radial and ulnar arteries, which are branches of the brachial artery, provide the blood supply to the hand. Supplemental arteries in the forearm include the anterior interosseous artery, the posterior interosseus artery, and occasionally the median artery, all of which are branches of the ulnar artery. [6]

The radial artery runs distally in the forearm between the brachioradialis and flexor carpi radialis muscles. At the wrist, it crosses dorsally deep to the tendons of the "anatomic snuffbox" to enter the palm and form the deep palmar arch. A superficial branch arises at the level of the wrist and contributes to the superficial palmar arch.[13]

The ulnar artery runs distally in the forearm under the flexor carpi ulnaris muscle. At the wrist, it travels into the hand through the Guyon canal, where it divides into the deep palmar branch and the superficial palmar branch. The superficial branch forms the superficial palmar arch, and the deep branch contributes to the deep palmar arch. [14]

The superficial palmar arch lies directly deep to the palmar fascia. It gives rise to the volar common digital arteries and multiple branches to intrinsic muscles and skin. Distal in the palm, the common digital arteries bifurcate into the proper digital arteries. In the palm, the arteries lie volar to the corresponding nerves, a relation that is reversed in the digits. At the digits, the neurovascular bundle always lies volar to the ligament of Cleland. This pattern gives protection to the bundle and can serve as a guide for their surgical dissection.

The deep palmar arch lies at the base of the metacarpals deep to the flexor tendons. It is the major blood supply to the thumb and radial half of the index finger by the first metacarpal artery. After giving its branch to the index finger, it is called the princeps pollicis.

The dorsal arteries originate proximally from the posterior interosseous artery and a dorsal perforating branch of the anterior interosseous artery. Dorsal metacarpal arteries

arise from a dorsal carpal arch formed by the previously mentioned arteries and are the source of multiple local hand flaps (dorsal metacarpal artery flaps). These dorsal metacarpal arteries are found more reliably for the first and second metacarpals then for the third and fourth.

Common digital arteries arise from the superficial palmar arch to form proper digital arteries at the webs. The palmar aspect of the digits receives arterial flow through these proper digital arteries. The dorsum of each digit, distal to the proximal interphalangeal joint, is vascularized by dorsal branches of the proper digital arteries.

Veins generally follow the deep arterial system as venae comitantes. A superficial venous system also exists at the dorsum of the hand and contributes to the cephalic and basilic vein in the upper extremity. [14]

1.2 Biomechanics and Kinesiological Function of the Wrist/Hand

1.2.1 Movement/Motion of the Wrist/Hand

The wrist and hand is a complex organ of the upper extremity that has many responsibilities in daily activity. It is used as a sense organ to provide information about the environment. It grasps and carries objects from one destination to another, and it manipulates objects using many varied grasps. Because of its several joints and the complex relationship of its muscles, the hand is able to conform to any object within its grasp. The muscle groups that allow the hand its myriad functions and positions include the extrinsic flexors, extrinsic extensors, and intrinsic muscles. These muscle groups work in concert with each other to provide assistance, stabilization, and motion. Hand motion is dependent upon stabilization obtained from the wrist muscles, especially the wrist extensors. The position of function of the wrist is 20° to 35° of extension; this position allows optimal movement, strength, and dexterity of the fingers. When one of these three muscle groups is injured or unable to function, the entire hand's function is impaired. Injury to a joint, soft tissue, nerve, or bone within the hand has the potential to severely impede the individual's ability to perform even simple activities of daily living.

Most wrist muscles have more than one function. Depending on their location, they will either flex or extend the wrist as well as either radially or ulnarly deviate the wrist. These muscles also serve as important wrist stabilizers during finger and hand motions.[15]

Extension and Flexion

The proximal attachments of the wrist extensors have a common tendon attachment at the lateral humeral epicondyle. The primary muscles that extend the wrist are the ECRL, the ECRB, and the ECU. The extensor digitorum participates in extension of the wrist only when the fingers are simultaneously extended; in fact, the finger extensors then appear to take over the task of wrist extension altogether.

Part of the proximal attachment of the wrist flexors is the common flexor tendon at the medial humeral epicondyle. The primary muscles involved in wrist flexion are the FCR, FCU, palmaris longus, FDS, FDP, flexor pollicis longus, and abductor pollicis longus.[16]

Radial and Ulnar Deviation

The palmaris longus and the ECRB are centrally located at the wrist. In contrast to these two muscles, the other wrist flexors and extensors are situated either toward the radial or toward the ulnar side of the wrist; with this arrangement, they are capable of producing wrist movements from side to side as well as flexion and extension. In the anatomical position, these side-to-side movements of the wrist occur in the frontal plane on an anterior- posterior axis. Wrist movement of the hand away from the side of the body is called radial deviation, while wrist movement of the hand towards the side of the body is known as ulnar deviation.[16]

Motions of the Fingers

The finger's MCP joints have two degrees of motion. When the MCP joint is extended, its collateral ligaments are slack and permit about 20° of abduction and, if adjacent fingers are moved away, about 20° of adduction. In 90° of flexion, the collateral ligaments are taut and abduction or adduction is limited to a few degrees at best.

Proximal and distal interphalangeal (IP) joints are hinge joints with one degree of freedom. The bicondylar heads of the phalanges and the greater tension of the collateral ligaments prohibit abduction and adduction motions of these joints. During flexion and extension of the MCP and IP joints, the roll and slide are in the same direction since the proximal aspects of these joints are convex and the distal aspects are concave. Motion in abduction and adduction movements of the MCP joints also have roll and slide occurring in the same direction.[16]

Grasping

When the fist closes, the fingers fold into the palm of the hand or close around an object by the action of the FDP and FDS. Because these long finger flexors have proximal attachments in the forearm and their tendons pass on the flexor side of the wrist, these muscles—if unopposed—would cause the wrist to flex during grasp. Such action is prevented by the stabilizing action of the wrist extensors. The strength of contraction exerted by the wrist extensors is in direct proportion to the effort of the grip: the harder the

grip, the stronger the contraction of the wrist extensors.[16,36]

There are generally two types of grasps of the human hand: the “power grip” and the “precision grip”. The power grip incorporates the entire hand and is used for gross activities to grasp an object rather than to manipulate it. The power grip involves holding an object between the partially flexed fingers and the palm while the thumb usually applies counter pressure to maintain and stabilize the object within the hand; there is only one power grip in which the thumb is not required to participate, the hook grip. In the precision grip, an object is pinched between the flexor surfaces of one or more fingers and the opposing thumb. The precision grip is used when accuracy and refinement of touch are needed to manipulate or use an object. The thumb postures differ in the two types of grips. In the power grips, the thumb is in adduction or opposition, and it reinforces the pressure of the fingers to stabilize the object in the hand. In precision grips, the thumb is abducted and is usually positioned to oppose the pulp of the fingers. It is state that the nature of the task to be performed determines the grip to be used and that these two types of grips incorporate the whole range of prehensile activity in the human hand.[16,36]

1.2.2 **Hand Grips**

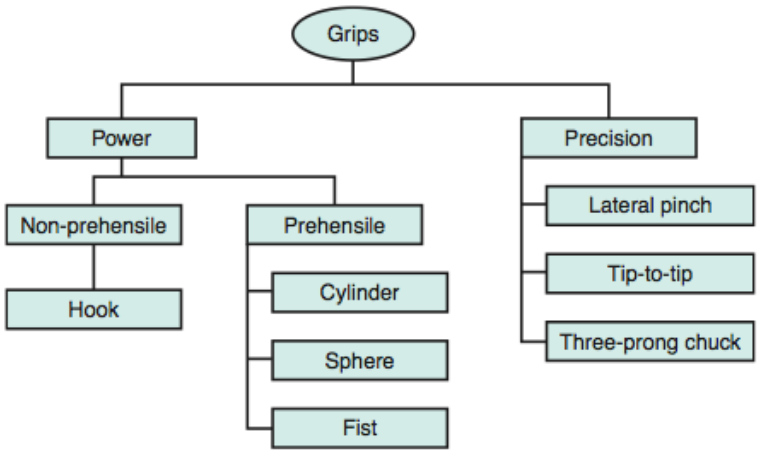

Fig. 8 - Hand Grip Types[16]

1.2.3 **Range of Motion**

Movement	**Degrees**				
Wrist		**Fingers**		**Thumb**	
Flexion	80º	Flexion • MCP • PIP • DIP	 90º 100º 90º	Flexion • MCP • IP	 50º 90º
Extension	70º	Extension • MCP • PIP • DIP	 30-45º 0º 20º	Extension • MCP • IP	 0º 20º
Ulnar Deviation	50º	Abduction	20º	Abduction	70º
Radial Deviation	30º	Adduction	0º	Adduction	0º

Table 1- Range of Motion[11]

1.3 Zone II – 'No Man's Land'

Zone II extends from the middle of the middle phalanx to distal palmar crease. It contains both FDS tendon and FDP tendon. Proximal to zone II, the FDS tendons lie superficial to the FDP tendons. Within zone II and at the level of the proximal third of the proximal phalanx, the FDS tendons split into two slips, collectively known as Camper chiasma. These slips then divide around the FDP tendon and reunite on the dorsal aspect of the FDP, inserting into the distal end of the middle phalanx.[18]

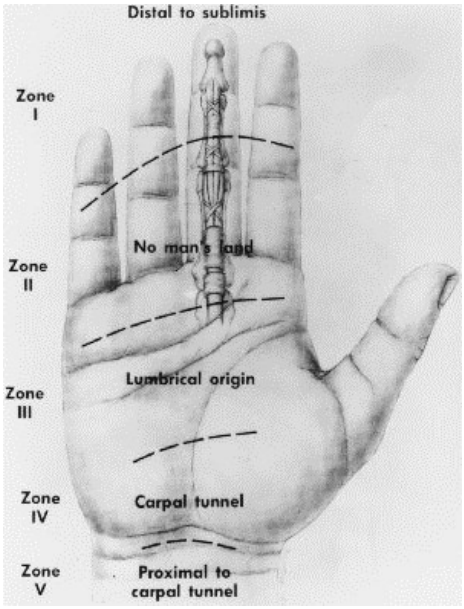

Fig. 9 - Zones of Hand

Bunnell, in 1918, coined the term "no man's land" to describe zone 2 in the hand because at that time it was felt that no man should attempt repair within this zone. While this belief is no longer a common practice, the ability to preserve the smooth gliding properties of both superficialis and profundus tendons within the narrow flexor sheath can be challenging for any hand surgeon.[17]

1.3.1 Clinical Picture

Flexor tendon injuries account for <1% of all hand injuries. Management of these injuries often poses a surgical challenge because the results remain unpredictable results despite the best efforts. The management in view of zone 2 flexor tendon injuries is a highly debatable topic. Most of the hand surgeons use the Verdan's classification based upon chances of adhesion formation, for localisation of the site of flexor tendon injury. This zone has a fibro osseous digital canal where both the tendons interweave in a complex manner. The multiple pulleys increase its complexity because minimal swelling of the epitenon can impair free motion of the tendon. The margin of error, therefore, in this zone is very small. Any infection, fibrosis, cicatrix, overcrowding etc can lead to dense adhesions and hence compromising the results. FDS and FDP have large amplitude, the loss of which will result in marked diminution of either finger flexion or extension or both.[19]

1.3.2 **Etiology of Injury**

Our hands may be affected by many disorders, most commonly by traumatic injury[3], especially in Zone II. An indirect or blunt force can lead to injuries of the tendons or the neurovascular bundles.[20]

1.3.3 **Diagnosis**

The diagnosis of digital flexor tendon severance is confirmed by loss of the position of rest, the ability to perform the test for superficialis action or the test for profundus action, and on clinical examination and radiological findings. If the patient performs these tests but shows pain and weakness, suspect partial division of the tendon.

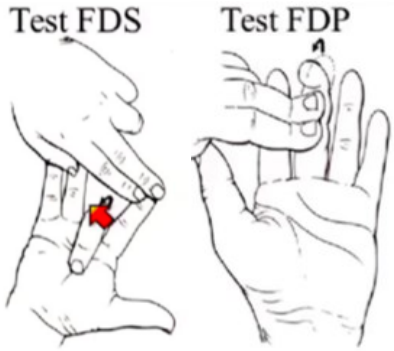

Fig. 10 - Tests FDS, FDP

The level of severance determines the therapeutic approach. Tendons divided distal to ‘no man’s land’ may have their proximal end advanced and sutured into the distal phalanx. Tendons severed proximally to ‘no man’s land’ are anastomosed immediately with nonabsorable suture material.

Before repairing the tendon it is essential to ascertain other possible injuries, which include fracture of the phalanx and metacarpal, as well as the neurovascular damage to the involved digit. Guarded prognosis is expected in presence of these injuries. Ultrasonography of the hand is quite helpful in localization of the proximal cut ends as shown in a cadaveric study and it may help in planning the length of incision. [21]

1.4 Treatment Approach

Flexor tendon injuries in 'no man's land' yield notoriously poor results in anything but optimal circumstances. If divided tendons are sutured primarily, the exuberant fibroblastic outgrowth causes dense adherence between the tendon and sheath with loss of function. Before repairing the tendon it is essential to ascertain other possible injuries, which include fracture of the phalanx and metacarpal, as well as the neurovascular damage to the involved digit. Guarded prognosis is expected in presence of these injuries. Ultrasonography of the hand is quite helpful in localization of the proximal cut ends as shown in a cadaveric study and it may help in planning the length of incision.[35]

The best course of action for the primary physician is to clean the wound, close the skin, and send the patient promptly to an experienced hand surgeon. The surgeon may choose to immediately repair one of or both tendons. If the circumstances are less than ideal, the surgeon will postpone definitive surgery and instruct the patient in exercises to maintain joint support. [21]

1.4.1 Non-invasive

Wound care and early range of motion exercises if there is a partial laceration of <60% of the tendon width. This approach may be associated with a higher likelihood of gap formation and triggering.

1.4.2 **Invasive (Surgical)**

The standard midlateral incision or Brunner's zigzag incision is commonly employed. The midlateral incision prevents scar formation directly over the tendon, is less likely to breakdown during physiotherapy but requires surgical dissection directly over the neurovascular bundle and is therefore a surgically demanding procedure. Bruner's zigzag incision provides excellent surgical exposure but there may be scar formation directly over the tendon and may break in case of infection thereby affecting the physiotherapy. Whichever surgical exposure is used, it is essential that thick flaps are raised and the tissue handling is very meticulous to prevent adhesion formation.

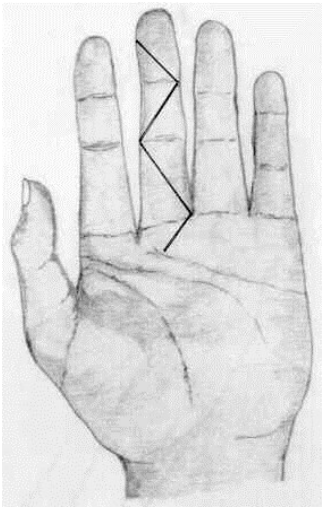

Fig 11 - Brunner's Incision

Zone 2 flexor tendon repairs have improved with advances in the understanding of flexor tendon anatomy, biomechanics, nutrition, and healing.[22] The method of repair however is controversial. The following are the different options of surgical treatment: repair of the FDP tendon only with debridement of the FDS stump; repair of both tendons; or repair of FDP with repair of one slip of FDS tendon. Repair of both tendons in zone 2 is ideal but may be technically demanding. The proximal cut ends of the tendons may be retracted considerably into the palm and can be brought into the wound by milking the palm from proximal to distal end. The distal ends of the tendons can be brought into the wound by passively flexing the DIP joint. At times the digital nerve may be found cut, which can also be repaired along with both the flexor tendons.

The number of core strands that cross the repair site will increase the strength of the repair.[24] The number of suture strands passing through the repair should be 4-6 Increasing the number of strands to more than four has not shown to improve the results in clinical settings although cadaveric models show greater loads for failure for multistrand sutures (four or more than that).[24] Increasing the number of strands to >4 leads to more tissue handling with increase in the surgical time. Different suture techniques have been

described by different authors[22,25,26,27] The two-strand Kessler core with a simple peripheral suture remains the most popular flexor tendon suture technique and that most surgeons favor sheath closure.[28]

Single knotted core suture techniques have been shown to be biomechanically superior to double-knotted techniques (e.g., Double Kessler, modified Becker, Tsuge).[29] The length of suture purchase directly influences the strength and should be at least 1 cm on either side.[30] The suture material used for the core suture is usually nonabsorbable, 3/0 or 4/0 braided or monofilament material. The use of a recently developed 4-0 Fiber Wire is also gaining popularity.[31] The multifilament stainless steel's lower elongation and better knot-holding ability may result in a greater force to produce a 2-mm gap and a greater ultimate tensile strength in a tendon repair.[32] Other technical points that should be followed are a locking loop configuration with the knot placed outside the repair site, a peripheral suture placed deep into the tendon and far from the cut tendon end.[33]

1.4.3 **Differences in Splinting**

After all repairs have been completed, the incision is closed, and the hand and wrist are immobilized in a bulky compression dressing and elevated to control edema. The compression dressing remains in place for 1 to 3 days. When the bulky surgical dressing is removed, it is replaced with a light compressive dressing and splint.

There are three general types of splint used after flexor tendon repair: a static dorsal

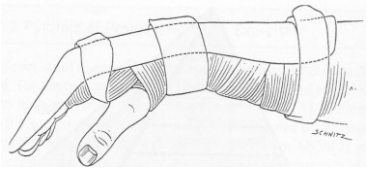

Fig. 12 - Static Dorsal Splint

Fig. 13 - Dorsal Splint with Dynamic Traction

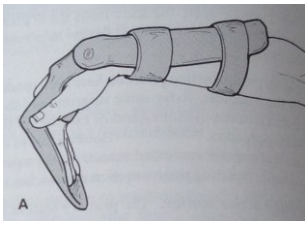

Fig. 14 - Dorsal Tenodesis splint with wrist hinge

blocking splint; a dorsal blocking splint with dynamic traction; and a dorsal tenodesis splint with a wrist hinge. The static dorsal blocking splint restricts wrist and MCP

extension and is used more for delayed motion. The dorsal blocking splint with dynamic traction allows active extension of the involved finger and an elastic band passively returns the finger to a flexed position. The tenodesis splint with a wrist hinge is worn exclusively for exercises sessions. It has no dynamic traction with elastic bands and allows full wrist flexion and limited wrist extension.[34]

1.5 Therapeutic Approach

There are two basic approaches to management after flexor tendon repair characterized by the timing and type of exercises in the program. They are categorized as early controlled motion, either passive or active, and delayed motion. These are to maintain tendon gliding and prevent tendon adhesions.

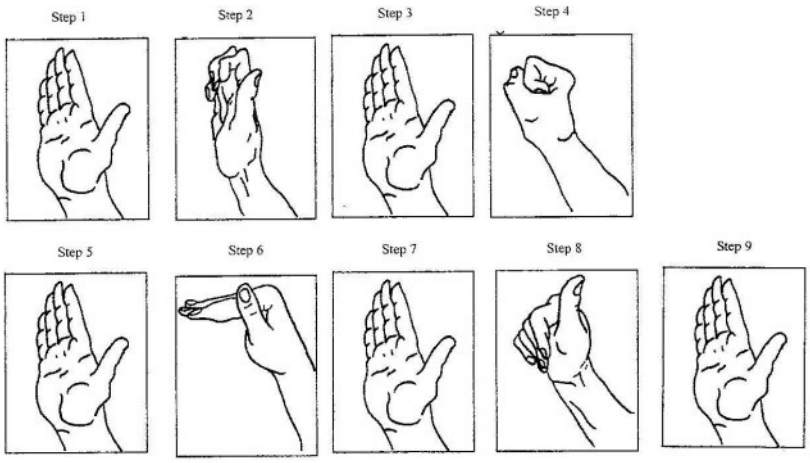

Fig. 15 - Tendon Glides

Numerous published protocols with considerable variability fall within these categories. Most current programs emphasize early controlled, but protected motion after surgery and include both passive and active exercises of the operated digit. These approaches demonstrate superior outcomes when compared with outcomes after extended immobilization.[34]

2 Case Study

2.1 Methodology

The clinical work for this bachelor thesis took place at Ustredni vojenska nemocnice in Prague, Czech Republic, from 09.01.2017 to 20.01.2017. All clinical work during this time period was performed under the supervision of Mgr. Romana Kozderkova.

This case study is of a 31-year-old male that under went surgical repair of FDS and FDP in Zone II of his third digit on his left hand. He was 52 days post-operative on the day of our initial examination. Therapy was mainly performed in a single therapy room well equipped with an electric hydraulic table, thera-bands, physioball, soft foam balls of varying sizes, and other available equipment. The therapy was performed on Monday, Wednesday, and Friday for 45 minutes each session.

The patient was informed of my position as a student and his participation in therapy for the completion of my bachelor's thesis, in which he gave his consent. The Ethics Committee of Charles University, Faculty of Physical Education and Sport, have approved my thesis work with the approval number: 019/2017

Prague, 2017

2.2 Anamnesis

2.2.1 General Demographics

Patient's Name: T.F. **Today's Date:** 09.01.2017 **Date of Surgery:** 18.11.2016

Diagnosis: Injury of extensor muscle, fascia and tendon of other and unspecified finger at wrist and hand level

ICD10 Code: S663

Age: **DOB:** 1986 **Gender:** Male

Martial Status: Girlfriend **Education:** Secondary School

Height: 180cm **Weight:** 107kg **BMI:** 33.0

BP: 120/85 **BPM:** 65/min. **RR:** 16/min.

Alcohol Use: None **Tobacco Use (Amount/Years Used):** None

Somatotype: Mesomorph **Occupation:** Construction

2.2.2 Current symptoms/Chief complaint

Patient states that his only limitations are holding certain items in left hand, such as a fork while eating, cutting the fingernail on DIII feels "weird", and that DIII can inadvertently catch on objects. Since patient is right hand dominant he does not use his left hand for many ALDs, so few functional limitations.

2.2.3 **Mechanism of Present Injury**

On 11.1.2016, while working on a construction site, the patient accidently lacerated DIII at Zone II of his left hand. The FDS and FDP were both severed, while sparing the major blood vessels and nerves.

2.2.4 **Excerpt from Patient's Health Care File**

No X-Ray was performed for diagnostics. Following surgical repair the patient's left hand and wrist were placed in a cast where MCP of DII-DV were limited to 60º of flexion, which limited extension of wrist and all fingers for three weeks post-op with no instruction to flex or move fingers during this time. Cast and stitches were removed on 08.12.2016 and cast was placed back on patient's wrist and hand. On 05.01.2016 cast was removed and patient was instructed to begin rehabilitation, which started on 09.01.2016. Per physician's orders, no resisted flexion of DIII for 8 weeks.

2.2.5 **Past Injuries/Hospitalization/Surgeries**

Date	Reason	Treament
2012	Left knee meniscus tear	Meniscectomy of medial menisus on left knee. 2 surgeries
2013	Right knee meniscus tear	Meniscectomy of medial meniscus on right knee. 3 surgeries
2013	Fracture of left ankle – tibia and fibula	Surgical fixation to stabilize
2013	Nose fracture	No surgery
2013	Dislocation of PIP on DII of right hand	No surgery
	All occurred during football and not all at once	

Table 2 - Past Injuries/Hospitalizations/Surgeries

2.2.6 **Medications**

Medication	Date:	Dose
Ibalgin – 400mg	18.11.2016	1 tablet
Paralen – 500mg	18.11.2016	1 tablet every 6 hours

Table 3 - Medications

2.2.7 **Living Environment**

Patient is currently living with his girlfriend in an apartment on the third floor, which has elevator access. Since the patient is not left hand dominant he is able to perform most daily activities at home, but certain gripping or holding positions with his left hand can be limited, such as, holding a fork while eating or coffee mug or DIII can catch on objects inadvertently while passing by them.

2.2.8 **Personal Care**

Patient has no functional limitations while managing all personal hygiene activities and dressing, primarily because he can use his right hand.

2.2.9 **Social Support System**

Patient has the support of his girlfriend for any activities or limitations he may encounter. Patient has not returned to work yet, but can drive independently, navigate public transportation, and participate in necessary daily activities.

2.2.10 **Indications for Rehabilitation**

Physician's orders include therapy every other day with a total of 12 sessions: soft technique and individual therapeutic exercise for the fingers of the left hand; mobilization of the PIP joint on the left hand and also wrist.

Patient should be instructed on home scar care and moisturizing the scar and patient should leave in stable status and educated in appropriate care.

2.3 Initial Kinesiological Examinations (Date: 20.01.2017)

2.3.1 Observation

Patient presents today with 0/10 level on a pain scale while at rest when 0 equals no pain and 10 equals the worst pain, but 7/10 when extending digit III (DIII) MCP, PIP, and DIP. There is limited dorsal and palmar flexion of MCP, PIP, and DIP of DIII.

2.3.2 Scar Examination

The scar on DIII is fully healed, is of a light pink color, smooth and with no abnormalities. The scar itself, at the injury site, does not move freely from the underlying tissue/structures, which is indicative of soft tissue adhesions. There is minimal swelling in Zone II of DIII. There is numbness at the site of the injury and reduced sensation at distal tip of DIII.

2.3.3 Postural Examination

Posterior View:

- Shoulder width base of support
- Heals are visually equally with no calluses
- Both ankles are in neutral position
- Both Achilles are visually equal in shape and thickness
- Both calf muscles are well developed and equal
- Both knees are in a neutral and symmetrical position
- Both popliteal lines are symmetrical
- Thigh muscles are equal
- Right subgluteal line is slightly higher than left
- Gluteal muscles are equal
- Right iliac crest is higher than left by 1-2cm

- Right paravertebral muscles are more developed
- Left thoracobrachial triangle is larger than the right
- Slight lateral curve in lumbar spine with apex to the left at L2-L3
- Left scapula is elevated and slightly protracted
- Nuchal muscles are more visible on the left side of the spine
- Head position is in the midline with no obvious tilt to either side

Lateral View (right side):

- Neutral position of the ankle
- Shape and contour of the shin is equal, smooth and evenly developed
- Knees are in neutral position
- Evenly developed thighs
- Slight anterior tilt of pelvis
- Increased lumbar lordosis
- Abdominal muscles are not well developed and the belly is protruding anteriorly
- Left shoulder is protracted
- Minimal kyphotic thoracic curve with decreased cervical lordosis and head forward

Lateral View (left side)

- Neutral position of the ankle
- Shape and contour of the shin is equal, smooth and evenly developed
- Knees are in neutral position
- Evenly developed thighs
- Slight anterior tilt of pelvis
- Increased lumbar lordosis
- Abdominal muscles are not well developed and the belly is protruding anteriorly
- Left shoulder is protracted
- Minimal kyphotic thoracic curve with decreased cervical lordosis and head forward

Anterior View:

- Shoulder width base of support
- Slight eversion of both forefeet
- Slight right hallux valgus
- Knees in neutral position
- Both tibialis anterior equal
- Both calf muscles equally well developed
- Patella on both knees are in neutral position
- Thigh muscles are equally well developed
- Right iliac crest slightly elevated
- Abdominal muscles lack muscle tone
- Navel is at the midline
- Left thoracobrachial triangle is larger than the right
- Right nipple slightly lower than left, almost unnoticeable. Barrel chest
- Sternum is in neutral position and symmetrical. No protrusions or abnormalities
- Distal end of left clavicle elevated and left supraclavicular hole more prominent
- Left shoulder is slightly elevated and protracted
- Head position is in the midline with no obvious tilt to either side

2.3.4 **Palpation of Pelvis**

(Examined in standing position)

Iliac crest: right slightly elevated

Anterior Superior Iliac Spine (ASIS): level

Posterior Superior Iliac Crest (PSIS): Level

Slight anterior pelvic tilt when comparing ASIS to PSIS

2.3.5 Gait Analysis

- Shoulder width steps with both feet slightly everted, right more than left
- Average walking speed and rhythmic
- Stride length equal left to right
- Heel strike is on the lateral side of both feet and he maintains his arch throughout step. Early heel and toe off with both feet, while the right foot is more everted.
- Decreased hip extension in both hips
- Slight lateral shift with each step and pelvis is anteriorly tilted
- No noticeable compensation of the abdominal muscles
- Slight lateral thoracic flexion with each step; increased lumbar lordosis, thoracic kyphosis, and cervical protraction.
- Lumbar paravertebral musculature overactive with each step
- Left shoulder is slightly elevated, while both shoulders are protracted
- Forward head position yet stable
- Upper extremity movements are symmetrical with both shoulders flexing and extending approximately 40º with each step.
- Patient is stable while walking

2.3.6 Stereotype of Breathing

Upper Thoracic while standing

2.3.7 Anthropometric Measurements (Circumference, Length)

Measurement - Length	Right	Left
Arm span	96cm	
Arm Length	77cm	78cm
Humerus Length	36cm	36cm
Forearm Length	49cm	49cm

Measurement - Circumference	Right	Left
Hand Length	19cm	19cm
Upper Arm		
• Relaxed	36cm	40cm
• Flexed	35cm	39cm
Forearm	31cm	29cm
Wrist	19cm	19cm
Hand	22cm	21cm
Finger – Zone II		
• DII	8cm	7.5cm
• DIII	7.5cm	8cm
• DIV	7cm	7cm
• DV	6cm	6cm

Table 4 - Anthropometric Measurements

2.3.8 Measurement of ROM (According to Janda & SFTR format)

	Active	Passive
Shoulder		
- Right	S: 30-0-150	40-0-160
	F: 90-0-0	90-0-0
	T: 20-0-115	20-0-120
	R: 90-0-30	90-0-40
- Left	S: 30-0-145	40-0-145
	F: 90-0-0	90-0-0
	T: 20-0-110	20-0-120
	R: 90-0-35	90-0-40
Elbow		
- Right	S: 0-0-140	0-0-140
	T: 85-0-75	90-0-75

	Active	Passive
- Left	S: 0-0-140	0-0-140
	T: 85-0-80	90-080
Wrist		
- Right	S: 65-0-70	65-0-70
	F: 30-0-45	30-0-45
- Left	S: 50-0-60	50-0-65
	F: 30-0-40	30-0-40
Finger – Digit II		
MCP		
- Right	S: 10-0-90	15-0-90
	F: 20-0-0	20-0-0
- Left	S: 10-0-90	15-0-90
	F: 20-0-0	20-0-0
PIP		
- Right	S: 5-0-100	5-0-100
- Left	S: 5-0-95	5-0-95
DIP		
- Right	S: 5-0-80	5-0-90
- Left	S: 5-0-50	5-0-90
Finger – Digit III		
MCP		
- Right	S: 10-0-100	15-0-100
	F: 20-0-0	20-0-0
- Left	S: 0-0-70	0-0-80
	F: 20-0-0	20-0-0
PIP		
- Right	S: 5-0-100	5-0-100
- Left	S: -30-0-65	-30-0-85

	Active	Passive
DIP		
- Right	S: 5-0-80	10-0-90
- Left	S: -20-0-20	-20-0-40
Finger - Digit IV		
MCP		
- Right	S: 10-0-90	15-0-100
- Left	F: 20-0-0	20-0-0
PIP		
- Right	S: 0-0-110	0-0-100
- Left	S: 0-0-90	0-0-90
DIP		
- Right	S: 0-0-90	5-0-100
- Left	S: 0-0-80	5-0-90
Finger – Digit V		
MCP		
- Right	S: 10-0-90	15-0-90
	F: 20-0-0	20-0-0
- Left	S: 10-0-90	15-0-90
PIP		
- Right	S: 0-0-100	0-0-100
- Left	S: 0-0-90	0-0-95
DIP		
- Right	S: 5-0-90	0-0-100
- Left	S: 5-0-90	10-0-100
Thumb		
CMC		
- Right	S: 0-0-10	0-0-15
	F: 40-0-0	40-0-0

	Active	Passive
	Opposition: normal	
- Left	S: 0-0-10	0-0-15
	F: 40-0-0	40-0-0
	Opposition: normal	
MCP		
- Right	S: 0-0-30	0-0-35
- Left	S: 0-0-30	0-0-35
IP		
- Right	S: 0-0-80	0-0-85
- Left	S: 0-0-80	0-0-85

Table 5 - Measurement of ROM

2.3.9 **Joint End Feel and Joint Play Examination**

	Left		Right	
Wrist	**End Feel**	**Joint Play**	**End Feel**	**Joint Play**
- Flexion	Firm	Restricted in	Firm	Free
- Extension	Firm	dorsal and ventral	Firm	Free
- Ulnar Deviation	Firm	directions	Firm	Free
- Radial Deviation	Firm		Firm	Free
DI				
- MCP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
- IP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
DII				

	Left		Right	
- MCP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
- PIP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
- DIP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
DIII				
- MCP		Restricted in		
▪ **Flexion**	Hard	dorsal and ventral	Firm	Free
▪ **Extension**	Hard	directions	Firm	Free
-PIP		Restricted in		
▪ **Flexion**	Hard	dorsal and ventral	Firm	Free
▪ **Extension**	Hard	directions	Firm	Free
- DIP		Restricted in		
▪ **Flexion**	Hard	dorsal and ventral	Firm	Free
▪ **Extension**	Hard	directions	Firm	Free
DIV				
- MCP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
- PIP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
- DIP				
▪ **Flexion**	Firm	Free	Firm	Free

	Left		Right	
▪ **Extension**	Firm	Free	Firm	Free
DV				
- MCP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
- PIP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free
- DIP				
▪ **Flexion**	Firm	Free	Firm	Free
▪ **Extension**	Firm	Free	Firm	Free

Table 6 - Joint End Feel and Joint Play Examination

2.3.10 **Dynamic Spine Examination**

Flexion: Smooth and continuous curve in the thoracic region. Patient feels no pain during motion and is able to touch the floor with the fingertips.

Extension: Smooth movement with no deviation to left or right. No pain

Lateral Flexion: Within physiological limits

- To the right: Decreased lateral flexion compared to left
- To the left: Increased lateral flexion compared to the right

2.3.11 **Muscle Length Tests**

	Right	Left
Pectoralis: Janda		
- Lower	0	0
- Medial	0	0
- Upper/Pectoralis Minor	1	1

	Right	Left
Shoulder Rotation: Kendall		
- External Rotation	Short	Physiological
- Internal Rotation	Physiological	Physiological
Upper Trapezius: Janda	1 - tight	1 - tight
Levator Scapula: Janda	1	1
Sternocleidomastoid: Janda	1	1
Scalene: Janda	Physiological	Physiological

Table 7 - Muscle Length Tests (According to Janda/Kendall)

2.3.12 **Muscle Strength Tests (According to Kendall)**

	Right	Left
ADD pollicis	**5**	**5**
ABD Pollicus Brevis	**5**	**5**
Opponens Pollicis	**5**	**5**
Flexor Pollicis Longus	**5**	**5**
Flexor Pollicis Brevis	**5**	**5**
Extensor Pollicis Longus	**5**	**5**
Extensor Pollicis Brevis	**5**	**5**
ABD Digiti Minimi	**5**	**5**
Opponens Digiti Minimi	**5**	**5**
Flexor Digiti Minimi	**5**	**5**
Dorsal Interossei	**5**	**5**
Palmer Interossi	**5**	**5**
Lumbricales	**5**	**5**
Palmaris Longus	**5**	**3**
Extensor Indicis/ Extensor Digiti Minimi/ Extensor Digitorum	**5**	**3**

	Right	Left
Flexor Digitorum Superficialis		
- DII	**5**	**4**
- DIII	**5**	**3**
- DIV	**5**	**5**
- DV	**5**	**5**
Flexor Digitorum Profundus		
- DII	**5**	**4**
- DIII	**5**	**3**
- DIV	**5**	**5**
- DV	**5**	**5**
Flexor Carpi Radialis	**5**	**4**
Flexor Carpi Ulnaris	**5**	**4**
Extensor Carpi Radialis		
- Longus	**5**	**4**
- Brevis	**5**	**4**
Extensor Carpi Ulnaris	**5**	**4**
Pronator Teres/Quadratus	**5**	**5**
Supinator	**5**	**5**
Brachioradialis	**5**	**5**

Table 8 - Muscle Strength Tests

2.3.13 **Neurological Examination**

Mental Status: Patient is aware of where and what he is doing and being asked to do. No Limitations.

Speech: Patient is able to accurately and clearly communicate his concerns.

Memory: patient is able to recall short and long term thoughts and memories.

Sensation

Dermatome	Right	Left
C6 – Thumb	Physiological	Physiological
C7 – Middle Finger	Physiological	Decreased sensation in Zone II and distal tip
C8 – Little Finger	Physiological	Physiological
T1 – Inner Forearm	Physiological	Physiological
T2 – Upper Inner Arm	Physiological	Physiological

Table 9 - Dermatomes of upper extremities

Pain

	Right	Left
C6 – Thumb	No pain	No pain
C7 – Middle Finger	No pain	Pain in Zone II at the incision site
C8 – Little Finger	No pain	No pain
T1 – Inner Forearm	No pain	No pain
T2 – Upper Inner Arm	No pain	No pain

Table 10 - Sensation on pain in Upper Extremities

Reflexes

Location	Right	Left
C5 – Biceps	Physiological	Physiological
C6 – Brachioradialis	Physiological	Physiological
C7 – Triceps	Physiological	Physiological

Table 11 - Deep Tendon Reflexes

2.3.14 **Muscle Palpation and Examination**

	Muscle Tone		Pain – O, I, B*	
Muscle	**Right**	**Left**	**Right**	**left**
Sternocleidomastoid	Hyper	Hyper	B	B
Scaleni				
- Anterior	-	-	-	-
- Medial	-	-	-	-
- Posterior	-	-	-	-
Trapezius - Cranial	Hyper	Hyper	B	B
Levator Scapula	-	-	-	-
Deltoid	-	-	-	-
Supraspinatus	-	-	-	-
Infraspinatus	-	-	-	-
Teres Minor	-	-	-	-
Biceps	-	-	-	-
Triceps	-	-	-	-
Brachioradialis	-	Hyper	-	B
Flexor Digitorum Radialis	-	-	-	-
Flexor Digitorum Ulnaris	-	-	-	-
Extensor Radilais Longus	Hyper	Hyper	B	B
Pectoralis Major	-	-	-	-
Pectoralis Minor	Hyper	Hyper	B	B
Rhomboid	-	-	-	-
Latissimus Dorsi	-	-	-	-

Table 12 - Muscle Palpation and Examination

*** O = Muscle Origin; I = Muscle Insertion; B = Muscle Belly**

2.3.15 **Conclusion of Initial Examination**

As a result of the injury, surgery and the left hand being immobilized for the majority of 51 days the patient has reduced palmar and dorsal flexion and extension of the wrist and DIII MCP, PIP, and DIP on left hand. There is weakness of the wrist palmar and dorsal flexors and the muscles that flex and extend DII and DIII. Resisted muscle testing was not performed on DIII per physician's orders. There was only active movement against gravity to assess strength.

It was found that the patient has several hypertonic muscles, such as the brachioradialis and extensor radialis longus on the left arm and some postural muscles.

There appears to be adhesions at the incision site along with numbness of DIII. The numbness is located along the incision (medial Zone II on DIII) and decreased sensation on the distal tip of the finger on the left hand. There is minimal swelling in Zone II of DIII.

The patient has a positive outlook and is eager to initiate the rehabilitation plan.

2.4 Rehabilitation Plan

Activities	Short-term/Goals	Time to Complete	Long-term/Goals	Time to Complete
Swelling	Eliminate swelling in DIII	1 wk	None	
Scar adhesions	Mobilize tissue under the scar to reduce restricted movements of MCP, PIP, DIP in DIII	4 wks	Minimize adhesion restrictions of MCP, PIP, DIP in DIII	14 wks
Pain	Decrease level of pain in DIII	2 wks	No pain in DIII MCP, PIP, DIP	3-4 mos
AROM	Increase dorsal and palmar ROM for more functional use in MCP, PIP, and DIP in DIII	4 wks	Increase dorsal and palmar ROM to physiological in MCP, PIP, DIP in DIII	3-4 mos
Strength	Focus is more on mobility of the wrist and DIII MCP, PIP, DIP	2 wks	Increase all wrist and hand strength to physiological level	3-4 mos
Home Exercise program	Independence and knowledge to apply proper therapies at home	1 wk	Knowledge and confidence in mobility and grip strength	6 wks

Table 13 - Plan of Care: Short-term & Long-term

2.5 Patient Visit/Encounter

2.5.1 **Therapy 1**

Today's Date: 09.01.2017

Number of Visit: 01

Frequency/Duration of Therapy: 3x week/45 min. **Date of Surgery:** 18.11.2016

Subjective Report: Patient describes pain with DIII dorsal flexion and limited grasping ability.

Pain Scale: Patient states that he has no pain at rest, but 7/10 with dorsal flexion of DIII.

Assessment: Pain; decrease in motion; edema/swelling

Proposed treatment plan:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Passive dorsal and palmar flexion of fingers on left hand 2 minutes
- Tendon glides – 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers

Today's Therapeutic Unit:

- Scar therapy with scar cream – 10 minutes
- Lymphatic drainage massage – 5 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Passive dorsal and palmar flexion of fingers on left hand – all joints – 15 repetitions
- Patient education

Today's Therapy Results:

This was the first day of meeting with the patient, so a considerable amount of time was spent discussing the patient's history and some evaluation tests and questions. The patient tolerated therapy well with no increased pain and did not fatigue through therapy. Dorsal and palmar flexion ROM of DIII MCP, PIP, and DIP increased slightly (1-2º) from start to finish of treatment with decreased sense of pain. Scar therapy directly over the scar was noticeably painful, but tolerable and did not increase overall sense of pain. Pain level: 7/10

Self-therapy:

- Scar therapy with scar cream – 5 minutes
- Active dorsal and palmar flexion of fingers on left hand - 15 repetitions/3 times per day for MCP, PIP, DIP
- Coban tape wrap around DIII with Silipos over scar

2.5.2 **Therapy 2**

Today's Date: 11.01.2017

Number of Visit: 02

Frequency/Duration of Therapy: 3x week/45 min. **Date of Surgery:** 18.11.2016

Subjective Report: Patient reports that the Silipos wrapped on with Coban tape has noticeably reduced the swelling in Zone II of DIII. DIII is less painful.

Pain Scale: Patient states that he has no pain at rest, but 5/10 with dorsal flexion of DIII.

Assessment: Pain; decrease in motion; edema/swelling

Proposed treatment plan:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Active dorsal and palmar flexion of fingers on left hand - 15 repetitions/3x/day for MCP, PIP, DIP
- Tendon glides – Active with over pressure 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers

Today's Therapeutic Unit:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Active dorsal and palmar flexion of fingers on left hand – all joints – 15 repetitions
- Tendon glides – Active with over pressure 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers

Today's Therapy Results:

The patient tolerated therapy well with no increased pain and did not fatigue through therapy. Dorsal and palmar flexion ROM of DIII MCP, PIP, and DIP increased slightly (1-2º) from start to finish of treatment with decreased sense of pain. Scar therapy directly over the scar was noticeably less painful than last treatment, but tolerable and did not increase overall sense of pain. Pain level: 5/10

Self-therapy:

- Scar therapy with scar cream – 5 minutes
- Tendon glides with overpressure – 5 repetitions each/3 times a day
- Coban tape wrap around DIII with Silipos over scar

2.5.3 **Therpay 3**

Today's Date: 13.01.2017

Number of Visit: 03

Frequency/Duration of Therapy: 3x week/45 min. **Date of Surgery:** 18.11.2016

Subjective Report: Patient feels like the therapy treatment is helping with reducing the swelling, decreasing the pain, and some improvement in ROM.

Pain Scale: Patient states that he has no pain at rest, but 3/10 with dorsal flexion of DIII.

Assessment: Pain; decrease in motion; edema/swelling

Proposed treatment plan:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Active dorsal and palmar flexion of fingers on left hand - 15 repetitions/3x/day for MCP, PIP, DIP
- Tendon glides – Active with over pressure 2 sets of 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers

- Rice bucket exercise – grab handfuls of rice with controlled speed – 10 repetitions/3x/day
- Thera-band – resisted finger extension (all fingers together) – 2 sets of 5 repetitions

Today's Therapeutic Unit:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Active dorsal and palmar flexion of fingers on left hand – all joints – 15 repetitions
- Tendon glides – Active with over pressure 2 sets of 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers
- Rice bucket exercise – grab handfuls of rice with controlled speed – 10 repetitions each
    1. Grab handful of rice – neutral position of wrist
    2. Grab and rotate clockwise
    3. Grab and rotate counterclockwise
    4. Piano
    5. Finger walks
    6. Ulnar/Radial deviation
    7. Fingers extension/abduction
- Thera-band fingers extension – 2 sets of 5 repetitions

Today's Therapy Results:

The patient tolerated therapy well with no increased pain and did not fatigue through therapy. Dorsal and palmar flexion ROM of DIII MCP, PIP, and DIP increased slightly (1-2º) from start to finish of treatment with decreased sense of pain. Scar therapy directly over the scar was noticeably less painful than last treatment, but tolerable and did not increase overall sense of pain. Pain level: 4/10

Self-therapy:

- Scar therapy with scar cream – 5 minutes
- Tendon glides with overpressure – 5 repetitions each/3 times a day
- Thera-band finger extension – 2 sets of 5 repetitions each/3x/day
- Coban tape wrap around DIII with Silipos over scar

2.5.4 **Therapy 4**

Today's Date: 16.01.2017

Number of Visit: 04

Frequency/Duration of Therapy: 3x week/45 min. **Date of Surgery:** 18.11.2016

Subjective Report: Patient continues to do the self-therapy at home as instructed. Patient is encouraged with the improvement after each therapy.

Pain Scale: Patient states that he has no pain at rest, but 3/10 with dorsal flexion of DIII.

Assessment: Pain; decrease in motion; edema/swelling

Proposed treatment plan:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Tendon glides – Active with over pressure 2 sets of 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers

- Thera-band – resisted finger extension (all fingers together) – 2 sets of 10 repetitions
- Tendon blocking – DIII PIP and DIP joints – 5 repetitions each
- Baoding balls – 3 min.
- Active palmar and dorsal flexion of wrist with hand made as a fist – 10 repetitions each

Today's Therapeutic Unit:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Tendon glides – Active with over pressure 2 sets of 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers
- Thera-band fingers extension – 2 sets of 10 repetitions

Today's Therapy Results:

The patient tolerated therapy well with no increased pain and did not fatigue through therapy. Dorsal and palmar flexion ROM of DIII MCP, PIP, and DIP increased slightly (2-3º) from start to finish of treatment with decreased sense of pain. Today is the first time the distal tip of DIII was able to touch the thenar eminence with overpressure. Scar therapy

directly over the scar was noticeably less painful than last treatment, but tolerable and did not increase overall sense of pain. Pain level: 2/10

Self-therapy:

- Scar therapy with scar cream – 5 minutes
- Tendon glides with overpressure – 5 repetitions each/3 times a day
- Thera-band finger extension – 2 sets of 5 repetitions each/3x/day
- Rice bucket – 5 repetitions each/3x/day
- Coban tape wrap around DIII with Silipos over scar

2.5.5 **Therapy 5**

Today's Date: 18.01.2017

Number of Visit: 05

Frequency/Duration of Therapy: 3x week/45 min. **Date of Surgery:** 18.11.2016

Subjective Report: Patient reports that there is no more swelling in DIII. Improvement continues and he is eager to see how much more improvement with DIII palmar flexion is today.

Pain Scale: Patient states that he has no pain at rest, but 2/10 with dorsal flexion of DIII.

Assessment: Pain; decrease in motion; edema/swelling

Proposed treatment plan:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Tendon glides – Active with over pressure 2 sets of 10 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers

- PIR of FDP and FDS
- Thera-band – resisted finger extension (all fingers together) – 2 sets of 10 repetitions
- Tendon blocking – DIII PIP and DIP joints – 5 repetitions each
- Baoding balls – 3 min.
- Active palmar and dorsal flexion of wrist with hand made as a fist – 10 repetitions each

Today's Therapeutic Unit:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Tendon glides – Active with over pressure 2 sets of 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers
- PIR of FDP and FDS – 1 series
- Tendon blocking for FDP and FDS – fixate DIII proximal to PIP joint, active flexion of only FDS. Then fixate DIII proximal to DIP joint, active flexion of only FDP – 5 repetitions each.
- Thera-band fingers extension – 2 sets of 10 repetitions
- Baoding balls – manipulate the balls in palm in a circular motion – 3 minutes

Today's Therapy Results:

The patient tolerated therapy well with no increased pain and did not fatigue through therapy. Dorsal and palmar flexion ROM of DIII MCP, PIP, and DIP increased slightly (1-2º) from start to finish of treatment with decreased sense of pain. Scar therapy directly over the scar was noticeably less painful than last treatment, but tolerable and did not increase overall sense of pain. Pain level: 1/10. Altered sensation on the distal tip of DIII is now only on the medial edge.

Self-therapy:

- Scar therapy with scar cream – 5 minutes
- Tendon glides with overpressure – 5 repetitions each/3 times a day
- Thera-band finger extension – 2 sets of 5 repetitions each/3x/day
- Rice bucket – 5 repetitions each/3x/day
- Baoding balls – 2 min./3x/day
- Coban tape wrap around DIII with Silipos over scar

2.5.6 **Therapy 6**

Today's Date: 20.01.2017

Number of Visit: 06

Frequency/Duration of Therapy: 3x week/45 min. **Date of Surgery:** 18.11.2016

Subjective Report: Patient reports that he has been able to do all the self-therapy exercises at home. He would like to know when he could start more resistance exercises for his wrist and hand.

Pain Scale: Patient states that he has no pain at rest, but 1/10 with dorsal flexion of DIII.

Assessment: Pain; decrease in motion

Proposed treatment plan:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Tendon glides – Active with over pressure 2 sets of 10 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers

- PIR of FDP and FDS
- Thera-band – resisted finger extension (all fingers together) – 2 sets of 10 repetitions
- Tendon blocking – DIII PIP and DIP joints – 5 repetitions each
- Baoding balls – 3 min.
- Active palmar and dorsal flexion of wrist with hand made as a fist – 10 repetitions each
- Small foam ball squeeze – 5 repetitions each
    1. Fist
    2. Pinch

Today's Therapeutic Unit:

- Scar therapy with scar cream – 5 minutes
- Lymphatic drainage massage – 3 minutes
- Foam ball massage – distal to proximal – 3 minutes
- Spikey ball over scar – distal to proximal – 1 min.
- Joint mobilization of left wrist; DIII MCP, PIP, DIP in both dorsal and palmar flexion – 1 series
- Tendon glides – Active with over pressure 2 sets of 5 repetitions each movement
    1. Fist – actively make a fist with all fingers, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    2. PIP/DIP – actively flex all fingers at PIP, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    3. MCP – actively flex all fingers at MCP with DIP extended, then I added overpressure with my hand to further increase flexion, followed by full extension of all fingers
    4. Abduction/adduction – active movement of all fingers
- PIR of FDP and FDS – 1 series
- Tendon blocking for FDP and FDS – fixate DIII proximal to PIP joint, active flexion of only FDS. Then fixate DIII proximal to DIP joint, active flexion of only FDP – 5 repetitions each.

- Thera-band fingers extension – 2 sets of 10 repetitions
- Active dorsal/palmar flexion of wrist with hand as a fist – 2 sets of 10 repetitions
- Baoding balls – manipulate the balls in palm in a circular motion – 3 minutes
- Reevaluate patient's DIII

Today's Therapy Results:

The patient tolerated therapy well with no increased pain and did not fatigue through therapy. Dorsal and palmar flexion ROM of DIII MCP, PIP, and DIP increased slightly (1-2º) from start to finish of treatment with decreased sense of pain. Today, it is much easier to touch the distal tip of DIII to the thenar eminence with overpressure. Scar therapy directly over the scar was noticeably less painful than last treatment, but tolerable and did not increase overall sense of pain. Pain level: 1/10. Altered sensation on the distal tip of DIII is now only on the medial edge. No noticeable selling in DIII.

Self-therapy:

- Scar therapy with scar cream – 5 minutes
- Tendon glides with overpressure – 5 repetitions each/3 times a day
- Thera-band finger extension – 2 sets of 5 repetitions each/3x/day
- Rice bucket – 5 repetitions each/3x/day
- Baoding balls – 2 min./3x/day

2.6 Final Kinesiological Examinations

2.6.1 Observation

Patient presents today with 0/10 level on a pain scale while at rest when 0 equals no pain and 10 equals the worst pain, but 1/10 when extending digit III (DIII) metacarpal phalangeal (MCP), proximal interphalangeal (PIP), distal interphalangeal (DIP). There is still limited dorsal and palmar flexion of MCP, PIP, and DIP of DIII, but the patient is now able to touch the distal tip of DIII to the thenar eminence, which he was not able to do at the initial evaluation. There is no longer swelling/edema in Zone II of DIII.

2.6.2 Scar Examination

The scar on DIII has not changed much since the initial evaluation. The appearance is the same and only minimal improvement in the scar adhesions.

2.6.3 Postural Examination

Posterior View:

- Shoulder width base of support
- Heals are visually equally with no calluses
- Both ankles are in neutral position
- Both Achilles are visually equal in shape and thickness
- Both calf muscles are well developed and equal
- Both knees are in a neutral and symmetrical position
- Both popliteal lines are symmetrical
- Thigh muscles are equal
- Right subgluteal line is slightly higher than left
- Gluteal muscles are equal
- Right iliac crest is higher than left by 1-2cm
- Right paravertebral muscles are more developed

- Left thoracobrachial triangle is larger than the right
- Slight lateral curve in lumbar spine with apex to the left at L2-L3
- Left scapula is elevated and slightly protracted
- Nuchal muscles are more visible on the left side of the spine
- Head has a slight tilt to the left

Lateral View (right side):

- Neutral position of the ankle
- Shape and contour of the shin is equal, smooth and evenly developed
- Knees are in neutral position
- Evenly developed thighs
- Slight anterior tilt of pelvis
- Increased lumbar lordosis
- Abdominal muscles are not well developed and the belly is protruding anteriorly
- Left shoulder is protracted
- Minimal kyphotic thoracic curve with decreased cervical lordosis and head forward

Lateral View (left side)

- Neutral position of the ankle
- Shape and contour of the shin is equal, smooth and evenly developed
- Knees are in neutral position
- Evenly developed thighs
- Slight anterior tilt of pelvis
- Increased lumbar lordosis
- Abdominal muscles are not well developed and the belly is protruding anteriorly
- Left shoulder is protracted
- Minimal kyphotic thoracic curve with decreased cervical lordosis and head forward

Anterior View:

- Shoulder width base of support
- Slight eversion of both forefeet
- Slight right hallux valgus
- Knees in neutral position
- Both tibialis anterior equal
- Both calf muscles equally well developed
- Patella on both knees are in neutral position
- Thigh muscles are equally well developed
- Right iliac crest slightly elevated
- Abdominal muscles lack muscle tone
- Navel is at the midline
- Left thoracobrachial triangle is larger than the right
- Right nipple slightly lower than left, almost unnoticeable. Barrel chest
- Sternum is in neutral position and symmetrical. No protrusions or abnormalities
- Distal end of left clavicle elevated and left supraclavicular hole more prominent
- Left shoulder is slightly elevated and protracted
- Head position is in the midline with no obvious tilt to either side

2.6.4 **Palpation of Pelvis (Examined in standing position)**

Iliac crest: right slightly elevated

Anterior Superior Iliac Spine (ASIS): level

Posterior Superior Iliac Crest (PSIS): Level

Slight anterior pelvic tilt when comparing ASIS to PSIS

2.6.5 **Gait Analysis**

- Shoulder width steps with both feet slightly everted, right more than left
- Average walking speed and rhythmic
- Stride length equal left to right

- Heel strike is on the lateral side of both feet and he maintains his arch throughout step. Early heel and toe off with both feet, while the right foot is more everted.
- Decreased hip extension in both hips
- Slight lateral shift with each step and pelvis is anteriorly tilted
- No noticeable compensation of the abdominal muscles
- Slight lateral thoracic flexion with each step; increased lumbar lordosis, thoracic kyphosis, and cervical protraction.
- Lumbar paravertebral musculature overactive with each step
- Left shoulder is slightly elevated, while both shoulders are protracted
- Forward head position yet stable
- Upper extremity movements are symmetrical with both shoulders flexing and extending approximately 40º with each step.
- Patient is stable while walking

2.6.6 **Stereotype of Breathing**

Upper Thoracic while standing

2.6.7 **Anthropometric Measurements (Circumference, Length)**

Measurement - Length	**Right**	**Left**
Arm span	96cm	
Arm Length	77cm	78cm
Humerus Length	36cm	36cm
Forearm Length	49cm	49cm
Hand Length	19cm	19cm

Measurement - Circumference	Right	Left
Upper Arm		
• Relaxed	36cm	40cm
• Flexed	35cm	39cm
Forearm	31cm	29cm
Wrist	19cm	19cm
Hand	22cm	21cm
Finger – Zone II		
• DII	8cm	**7cm**
• DIII	7.5cm	8cm
• DIV	7cm	7cm
• DV	6cm	6cm

Table 14 - Anthropometric Measurements

2.6.8 Measurement of ROM (According to Janda & SFTR format)

	Active	Passive
Shoulder		
- Right	S: 30-0-150	40-0-160
	F: 90-0-0	90-0-0
	T: 20-0-115	20-0-120
	R: 90-0-30	90-0-40
- Left	S: 40-0-150	30-0-145
	F: 90-0-0	90-0-0
	T: 20-0-110	20-0-120
	R: 90-0-35	90-0-40
Elbow		
- Right	S: 0-0-140	0-0-140
	T: 85-0-75	90-0-75

	Active	Passive
- Left	S: 0-0-140	0-0-140
	T: 85-0-80	90-080
Wrist		
- Right	S: 65-0-70	65-0-70
	F: 30-0-45	30-0-45
- Left	S: 50-0-60	**50-0-70**
	F: 30-0-40	30-0-40
Finger – Digit II		
MCP		
- Right	S: 10-0-90	15-0-90
	F: 20-0-0	20-0-0
- Left	S: 10-0-90	15-0-90
	F: 20-0-0	20-0-0
PIP		
- Right	S: 5-0-100	5-0-100
- Left	S: 5-0-95	5-0-95
DIP		
- Right	S: 5-0-80	5-0-90
- Left	S: 5-0-50	5-0-90
Finger – Digit III		
MCP		
- Right	S: 10-0-100	15-0-100
	F: 20-0-0	20-0-0
- Left	**S: 0-0-80**	**0-0-100**
	F: 20-0-0	20-0-0
PIP		
- Right	S: 5-0-100	5-0-100
- Left	**S: -30-0-70**	**-20-0-90**

	Active	Passive
DIP		
- Right	S: 5-0-80	10-0-90
- Left	**S: -20-0-30**	**-20-0-80**
Finger - Digit IV		
MCP		
- Right	S: 10-0-90	15-0-100
- Left	F: 20-0-0	20-0-0
PIP		
- Right	S: 0-0-100	0-0-110
- Left	S: 0-0-90	0-0-90
DIP		
- Right	S: 0-0-90	5-0-100
- Left	S: 0-0-80	5-0-90
Finger – Digit V		
MCP		
- Right	S: 10-0-90	15-0-90
	F: 20-0-0	20-0-0
- Left	S: 10-0-90	15-0-90
PIP		
- Right	S: 0-0-100	0-0-100
- Left	S: 0-0-90	0-0-95
DIP		
- Right	S: 5-0-100	10-0-100
- Left	S: 5-0-100	10-0-100
Thumb		
CMC		
- Right	S: 0-0-10	0-0-15
	F: 40-0-0	40-0-0

	Active	Passive
	Opposition: normal	
- Left	S: 0-0-10	0-0-15
	F: 40-0-0	40-0-0
	Opposition: normal	
	Active	Passive
MCP		
- Right	S: 0-0-30	0-0-35
- Left	S: 0-0-30	0-0-35
IP		
- Right	S: 0-0-80	0-0-85
- Left	S: 0-0-80	0-0-85

Table 15 - Measurement of ROM

2.6.9 **Joint End Feel and Joint Play Examination**

	Left		Right	
Wrist	**End Feel**	**Joint Play**	**End Feel**	**Joint Play**
- Flexion	Firm	**Free**	Firm	Free
- Extension	Firm	**Free**	Firm	Free
- Ulnar Deviation	Firm	**Free**	Firm	Free
- Radial Deviation	Firm	**Free**	Firm	Free
DI				
- MCP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
- IP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free

	Left		Right	
DII				
- MCP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
- PIP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
- DIP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
DIII				
- MCP		Restricted in		
▪ Flexion	**Firm**	dorsal and ventral	Firm	Free
▪ Extension	**Firm**	directions	Firm	Free
-PIP		Restricted in		
▪ Flexion	Hard	dorsal and ventral	Firm	Free
▪ Extension	Hard	directions	Firm	Free
	Left		**Right**	
- DIP		Restricted in		
▪ Flexion	**Firm**	dorsal and ventral	Firm	Free
▪ Extension	Hard	directions	Firm	Free
DIV				
- MCP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
- PIP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free

	Left		Right	
- DIP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
DV				
- MCP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
- PIP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free
- DIP				
▪ Flexion	Firm	Free	Firm	Free
▪ Extension	Firm	Free	Firm	Free

Table 16 - Joint End Feel and Joint Play Examination

2.6.10 **Dynamic Spine Examination**

Flexion: Smooth and continuous curve in the thoracic region. Patient feels no pain during motion and is able to touch the floor with the fingertips.

Extension: Smooth movement with no deviation to left or right. No pain

Lateral Flexion: Within physiological limits

- To the right: Decreased lateral flexion compared to left
- To the left: Increased lateral flexion compared to the right

2.6.11 **Muscle Length Tests**

	Right	Left
Pectoralis: Janda		
- Lower	0	0
- Medial	0	0
- Upper/Pectoralis Minor	1	1
Shoulder Rotation: Kendall		
- External Rotation	Short	Physiological
- Internal Rotation	Physiological	Physiological
Upper Trapezius: Janda	1 - tight	1 - tight
Levator Scapula: Janda	1	1
Sternocleidomastoid: Janda	1	1
Scalene: Janda	Physiological	Physiological

Table 17 - Muscle Length Tests

2.6.12 **Muscle Strength Tests (According to Kendall)**

	Right	Left
ADD pollicis	5	5
ABD Pollicus Brevis	5	5
Opponens Pollicis	5	5
Flexor Pollicis Longus	5	5
Flexor Pollicis Brevis	5	5
Extensor Pollicis Longus	5	5
Extensor Pollicis Brevis	5	5
ABD Digiti Minimi	5	5
Opponens Digiti Minimi	5	5
Flexor Digiti Minimi	5	5

	Right	Left
Dorsal Interossei	5	5
Palmer Interossi	5	5
Lumbricales	5	5
Palmaris Longus	5	3
Extensor Indicis/ Extensor Digiti Minimi/ Extensor Digitorum	5	**4+**
Flexor Digitorum Superficialis		
- DII	5	**4+**
- DIII	5	3
- DIV	5	5
- DV	5	5
Flexor Digitorum Profundus		
- DII	5	**4+**
- DIII	5	3
- DIV	5	5
- DV	5	5
Flexor Carpi Radialis	5	**4+**
Flexor Carpi Ulnaris	5	**4+**
Extensor Carpi Radialis		
- Longus	5	**4+**
- Brevis	5	**4+**
Extensor Carpi Ulnaris	5	**4+**
Pronator Teres/Quadratus	5	5
Supinator	5	5
Brachioradialis	5	5

Table 18 - Muscle Strength Tests

2.6.13 **Neurological Examination**

Mental Status: Patient is aware of where and what he is doing and being asked to do. No Limitations.

Speech: Patient is able to accurately and clearly communicate his concerns.

Memory: patient is able to recall short and long term thoughts and memories.

Sensation

Dermatome	**Right**	**Left**
C6 – Thumb	Physiological	Physiological
C7 – Middle Finger	Physiological	**Decreased sensation in Zone II, but improved and medial distal tip**
C8 – Little Finger	Physiological	Physiological
T1 – Inner Forearm	Physiological	Physiological
T2 – Upper Inner Arm	Physiological	Physiological

Table 19 - Dermatomes of upper extremities

Pain

	Right	**Left**
C6 – Thumb	No pain	No pain
C7 – Middle Finger	No pain	**Pain in Zone II at the incision site, 1/10**
C8 – Little Finger	No pain	No pain
T1 – Inner Forearm	No pain	No pain
T2 – Upper Inner Arm	No pain	No pain

Table 20 - Sensation on pain in Upper Extremities

Reflexes

Location	Right	Left
C5 – Biceps	Physiological	Physiological
C6 – Brachioradialis	Physiological	Physiological
C7 – Triceps	Physiological	Physiological

Table 21 - Deep Tendon Reflexes

2.6.14 Muscle Palpation and Examination

	Muscle Tone		Pain – O, I, B*	
Muscle	Right	Left	Right	left
Sternocleidomastoid	Hyper	Hyper	B	B
Scaleni				
- Anterior	-	-	-	-
- Medial	-	-	-	-
- Posterior	-	-	-	-
Trapezius - Cranial	Hyper	Hyper	B	B
Levator Scapula	-	-	-	-
Deltoid	-	-	-	-
Supraspinatus	-	-	-	-
Infraspinatus	-	-	-	-
Teres Minor	-	-	-	-
Biceps	-	-	-	-
Triceps	-	-	-	-
Brachioradialis	-	Hyper	-	B
Flexor Digitorum Radialis	-	-	-	-
Flexor Digitorum Ulnaris	-	-	-	-
Extensor Radilais Longus	Hyper	Hyper	B	B

	Muscle Tone		Pain – O, I, B*	
Pectoralis Major	-	-	-	-
Pectoralis Minor	Hyper	Hyper	B	B
Rhomboid	-	-	-	-
Latissimus Dorsi	-	-	-	-

Table 22 - Muscle Palpation and Examination

*** O = Muscle Origin; I = Muscle Insertion; B = Muscle Belly**

2.6.15 Conclusion of Final Kinesioloical Examination

In the final kinesiological examination it was found that the patient has improved in several ways, which were inline with the goals of therapy. There was no significant improvement in the patient's condition outside of the wrist and hand, such as posture, gait, muscle tone, etc. Therapy was focused on the wrist and hand and so this is the area of improvement.

The areas the patient improved in were the reduction in pain and swelling, increase in range of motion, and strength. Pain in Zone II of DIII with extension improved from 7/10 to 1/10 by the last therapy session. The altered sensation improved from the entire distal tip of DIII to only the distal medial edge. The swelling in Zone II was eliminated, which had significant improvement with the assistance of the Silipos wrapped on the palmar side of DIII with Coban tape.

The range of motion of left wrist palmar flexion has increased from 65º to 70º, which allows for more freedom of use of the left hand. The MCP, PIP, DIP on the left DIII all had improved range of motion. The MCP improved from 70º of active palmar flexion to 80º and from 80º of passive palmar flexion to 100º. The PIP improved from 65º of active palmar flexion to 70º, 85º of passive palmar flexion to 90º, and -30 of active dorsal flexion to -20. The DIP improved from 20º of active palmar flexion to 30º and from 40º of passive palmar flexion to 80º.

The joint end feel of each joint improved in DIII. The MCP and DIP improved from a hard end feel to a firm end feel. Strength of the Extensor digitorum, flexor carpi radialis and ulnaris, and the extensor carpi radialis longus and brevis all improved from a level of 4 to 4+ in strength.

2.6.16 **Improvement from Initial to Final Examination**

	Initial Examination		**Final Examination**	
Zone II Pain with extension	7/10		1/10	
Distal Tip Sensation	Entire distal tip		Distal medial edge	
Zone II Swelling	Present		None	
Left Wrist- Palmar Flexion	65º		70º	
Strength				
Extensor digitorum	4		4+	
Extensor carpi radialis	4		4+	
- longus	4		4+	
- brevis	4		4+	
- Flexor carpi radialis	4		4+	
- Flexor capri ulnaris	4		4+	
Left MCP Joint End Feel	Hard		Firm	
Left PIP Joint End Feel	Hard		Firm	
	Active	**Passive**	**Active**	**Passive**
Left MCP Palmar Flexion	70º	80º	80º	100º
Left PIP				
- Palmar Flexion	65º	85º	70º	90º
- Dorsal Flexion	-30º		-20º	
Left DIP Palmar Flexion	20º	40º	30º	80º

Table 23 – Improvement from Initial to Final Examination

2.7 The Effect of Therapy

The patient entered Ustredni vojenska nemocnice after Zone II reconstructive surgery with the goal of proper rehabilitation of his wrist and hand. The rehabilitation priorities were focused on reducing pain and swelling, increasing range of motion, muscle strength, to ensure suitable mobility of joints, and correct muscle firing patterns. The patient was motivated and eagerly performed the self-therapy exercises at home as instructed. He, also, maintained a positive outlook throughout the two weeks, which made for favorable therapy.

The patient was challenged in varying ways to push past his comfort threshold, whether it was discomfort from scar therapy directly on the scar to break up adhesions or from overpressure during tendon glides to aid in proper FDS and FDP tendon movement and to increase joint range of motion. The patient was encouraged at the point in therapy when he was able to take the distal tip of DIII to touch the thenar eminence for the first time. This was something that had been too painful and limitations in the DIII joints would just not allow since the surgery on 18.11.2016.

The prognosis for this patient is good and that he should be able to continue to improve to the point of functional strength and use of his left hand, but regaining full range of motion of PIP of DIII is not likely. He would need to continue with the self-therapy exercises and focused effort to reach a higher level of improvement. Significant adhesions in Zone II are and will be his main limitation.

Some other therapeutic methods that could be applied to this patient later in his rehabilitation plan are principals from the Kenny Method and Proprioceptive Neuromusculature Facilitation (PNF).

2.8 Conclusion of Case Study

The ultimate goal of flexor tendon repair is to restore normal digital function. Historically, repaired flexor tendons were treated with immobilization. This produced a strong repair but also led to uncontrolled tendon adhesion, loss of tendon gliding, secondary joint contracture, and unsatisfactory digital function.

Scientific and clinical research since this time has demonstrated the beneficial effects of applying early controlled stress to the healing tendon. Mobilized tendons gain greater tensile strength, form fewer adhesions, and have better excursion, resulting in improved digital function.[36]

During the two weeks of clinical practice at Ustredni vojenska nemocnice, I was given the opportunity to work with my patient and to visit several other departments and to work with the patients at each. My supervisor did an excellent job of adding to my educational experience by sharing her knowledge and expertise, which provided for a positive learning experience each day that I was at UVN.

The patient for this case study was a pleasure to work with, as he was eager to perform each therapy that he was given at each meeting and for at home. His willingness to work is one factor that contributed to his improvement. I feel that the outcome for this patient could have been even more profound if he would have been prescribed a Dorsal Splint with Dynamic Traction to allow early passive flexion and active extension of DIII instead of being immobilized.

The two weeks spent at UVN was well worth my time and so I am satisfied with my supervisor, location and the result of this case study. This was a valuable opportunity for me to learn more about an area of the human body that I was not as experienced in treating.

3 Bibliography (ISO-690 Format)

1. Martini, F.H.. *Fundamentals of Anatomy & Physiology.* 4th Edition. Upper Side River, New Jersey: Prentice Hall, 1998. ISBN: 0-13-923061-0

2. Zancolli E, Cozzi EP. *Atlas of Surgical Anatomy of the Hand*. New York: Churchill Livingstone; 1992. ISBN: 044308176X

3. Dickson, J.K., Morris, G., Heron, M. The importance of hand anatomy in the accident and emergency department: assessment of hand anatomy knowledge in doctors in training. *Journal Hand Surgery Europe.* 2009 Oct. 34. *Vol*. 5, pp. 682-4.

4. Lister, G. Injury. *Lister's The Hand: Diagnosis and Treatment.* 4th ed. Churchill Livingstone: Edinburgh, Scotland; 1999. 18. ISBN: 0443064164

5. Lindsay, David. T. *Functional Human Anatomy.* Athens, Georgia: Mosby, 1996. ISBN: 0-8016-6471-3

6. Sahin B, Seelig L.L. Arterial, neural and muscular variations in the upper limbs of a single cadaver. *Surg Radiol Anat.* 2000. Vol. 22(5-6) pp.305-8.

7. von Schroeder HP, Botte M.J. Anatomy and functional significance of the long extensors to the fingers and thumb. *Clinical Orthopedic Relat Res*. 2001 Feb. pp.74-83.

8. Windisch G. The fourth lumbrical muscle in the hand: a variation of insertion on the fifth finger. *Surgical Radiology Anatomy*. 2000. VOl.22(3-4) pp.213-5.

9. Hazani R, Engneer R, Zeineh LL, Wilhelmi BJ. Assessment of the distal extent of the A1 pulley release: a new technique. *Eplasty*. Aug 22 2008. Vol. 8: e44.

10. Engineer, N.J., Hazani, R., Wilhelmi, B.J. Variations in the anatomy of the third common digital nerve and landmarks to avoid injury to the third common digital nerve with carpal tunnel release. *Eplasty*. Oct 8, 2008. Vol. 8: e51.

11. Hoppenfeld, S. *Physical Examination of the Spine & Extremities.* Norwalk, Connecticut: Appleton & Lange, 1976. ISBN: 0-8385-7853-5

12. Magee, D. J. *Orthopedic Physical Assessment.* 4th Edition. Philadelphia, Pa: W.B. Saunders. 2000. ISBN: 0721693520

13. Bataineh, Z.M., Habbal, O., Moqattash, S.T. Variations in the superficial palmar arch of the hand. *Italian Journal Anatomy Embryology*. 2009 Jan-Mar. Vol. 114(1) pp.11-20.

14. Gellman, H., Botte, M.J., Shankwiler, J., Gelberman, R.H. Arterial patterns of the deep and superficial palmar arches. *Clinical Orthopdeic Related Research*. 2001 Feb. (383) pp. 41-6.

15. Napier, J.R. The prehensile movements of the human hand. *Journal of Bone and Joint Surgery.* 1956. Vol.38B(4) pp. 902–913.

16. Houglum, P. A., Bertoti, D.B. *Brunnstrom's Clinical Kinesiology. 6th Edition.* Philadelphia, Pa. F.A. Davies Company, 2012. ISBN: 978-0-8036-2352-1

17. Abernathie, B. Datiashvili, R. Zone II Flexor Tendon Injury. *Eplasty.* Jan. 25, 2013; Vol. 13: ic20

18. Idler RS. Anatomy and biomechanics of the digital flexor tendons. *Hand Clin*. 1985 Feb. 1(1) pp. 3-11.

19. Hill C, Riaz M, Mozzam A, Brennen MD. A regional audit of hand and wrist injuries.

Journal Hand Surgery Br. 1998 Apr; Vol. 23(2) pp. 196-200.

20. Kolar, P. et al. *Clinical Rehabiliation.* 1st edition. Prague: Alena Kobesova, 2013. ISBN: 978-80-905438-0-5

21. Liechty, R.D., Soper, R.T. *Fundamentals of Surgery.* 6th Edition. St. Louis, Missori. Mosby, 1989. ISBN: 0-8016-2962-4

22. Strickland, J.W. Flexor tendon repair. *Hand Clin.* 1985 Feb; Vol. 1(1) pp. 55-68.

23. Kotwal, P.P., Gupta, V. Neglected tendon and nerve injuries of the hand. *Clin Orthop Relat Res.* 2005 Feb. pp. 66-71.

24. Gill, R.S., Lim, B.H., Shatford, R.A., Toth, E., Voor, M.J., Tsai, T.M. A comparative analysis of the six-strand double-loop flexor tendon repair and three other techniques: a human cadaveric study. *Journal Hand Surgery Am.* 1999 Nov; Vol. 24(6) pp. 1315-22.

25. Kessler, I. The 'grasping' technique for tendon repair. *Hand*. 1973; Vol. 5. pp. 253–5.

26. Barrie, K.A., Wolfe, S.W., Shean, C., Shenbagamurthi, D., Slade, J.F., 3rd, Panjabi MM. A biomechanical comparison of multistrand flexor tendon repairs using an *in situ* testing model. *Journal Hand Surgery Am.* 2000; Vol. 25 pp. 499–506.

27. Taras, J.S. Primary flexor tendon repair. *Oper Techniques Orthop.* 1993; Vol. 3. pp.270–7.

28. Healy, C., Mulhall, K.J., Bouchier-Hayes, D.J., Kneafsey, B. Practice patterns in flexor tendon repair. *Iran Journal Medical Science.* 2007; Vol. 176. pp. 41–4.

29. Rees, L., Matthews, A., Masouros, S.D., Bull, A.M., Haywood, R. Comparison of 1- and 2-knot, 4-strand, double-modified Kessler tendon repairs in a porcine model. *Journal Hand Surgery Am.* 2009; Vol. 34. pp. 705–9.

30. Cao, Y., Zhu, B., Xie, R.G., Tang, J.B. Influence of core suture purchase length on strength of four-strand tendon repairs. *Journal Hand Surgery Am.* 2006; Vol. 31. pp.107–12.

31. Miller, B., Dodds, S.D., deMars, A., Zagoreas, N., Waitayawinyu, T., Trumble, T.E. Flexor tendon repairs: The impact of fiberwire on grasping and locking core sutures. *Journal Hand Surgery Am.* 2007; Vol. 32. pp. 591–6.

32. McDonald, E., Gordon, J.A., Buckley, J.M., Gordon, L. Comparison of a new multifilament stainless steel suture with frequently used sutures for flexor tendon repair. *Journal Hand Surgery Am.* 2011. Vol. 36. pp. 1028–34.

33. Kim, H.M., Nelson, G., Thomopoulos, S., Silva, M.J., Das, R., Gelberman, R.H. Technical and biological modifications for enhanced flexor tendon repair. *Journal Hand Sureryg Am*. 2010; Vol. 35. pp. 1031–7.

34. Kisner, C., Colby, L.A. *Therapuetic Exercise Foundations and Techniques*. 6th Edition. Piladelphia, Pa. F.A. Davis, 2012. ISBN: 978-0-80-36-2574-7

35. Ravnic, D.J., Galiano, R.D., Bodavula, V., Friedman, D.W., Flores, R.L. Diagnosis and localisation of flexor tendon injuries by surgeon-performed ultrasound: A cadaveric study. *Journal Plastic Reconstruct Aesthetic Surgery.* 2011 Feb; Vol. 64(2), pp. 234-9.

36. Lippert, L.S. *Clinical kinesiology and Anatomy.* 5th Edition. Philadelphia, Pa. F.A. Davis, 2011. ISBN: 0-8036-2363-1

37. Lewit, K. *Manipulative Therapy Musculoskeletal Medicine.* 1st Edition. London: Elsevier, 2010. ISBN: 9-780-7020-3056-7

4 Supplements

4.1 Photos at Initial and Final Kinesiological Testing

Photo 1 – Initial Kinesiological testing viewed palmer side

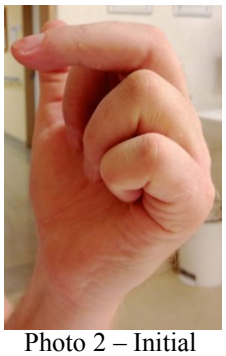

Photo 2 – Initial Kinesiological testing viewed medial side

Photo 3 – Initial Kinesiological teating viewed lateral side

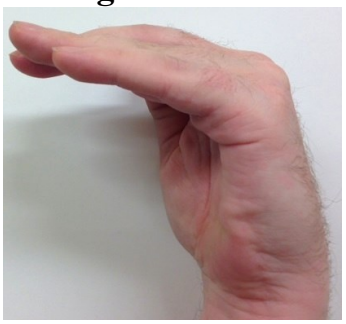

Photo 4 – Final Kinesiological testing viewed medial side

Photo 5 – Final Kinesiological testing viewed medial side

Photo 6 – Final Kinesiological testing viewed medial side

4.2 List of Tables

4.3 List of Figures

4.4 List of Abbreviations

A

ADL – Activities of daily living

ASIS – Anterior superior iliac spine

B

B – muscle Belly

C

C3 – Cervical 3

C4 – Cervical 4

C5 - Cervical 5

C6 – Cervical 6

C7 – Cervical 7

C8 – Cervical 8

cm – centimeter

D

DI – Digit one

DII – Digit two

DIII – Digit three

DIP – Distal Interphalangeal

DIV – Digit four

DV – Digit five

E

ECRB – Extensor carpi radialis brevis

ECRL – Extensor carpi radialis longus

ECU – Extensor carpi ulnaris

F

FCU - flexor carpi ulnaris

FDP – Flexor digitorum profundus

FDS – Flexor digitorum superficialis

I

I - Insertion

ICD-10 - International Statistical Classification of Diseases and Related Health Problems

IP – Interphalangeal

M

MCP - Metacarpal phalangeal

Mos(months) – Month(s)

O

O – Origin

P

PIP – Proximal Interphalangeal

PNF - Proprioceptive Neuromusculature Facilitation

PSIS – Posterior superior iliac spine

R

ROM – Range of motion

S

SFTR – Sagittal frontal transverse rotational

T

T1 - Thoracic 1

U

UK FTVS – Fakulta telesne vychovy a sportu Univerzity Karlovy

UVN – Ustredni vojenska nemocnice

Wk(s) – Week(s)

4.5 Application for Approval by UK FTVS Ethics Committee

CHARLES UNIVERSITY
FACULTY OF PHYSICAL EDUCATION AND SPORT
José Martího 31, 162 52 Prague 6-Veleslavín

Application for Approval by UK FTVS Ethics Committee

of a research project, thesis, dissertation or seminar work involving human subjects

The title of a project: Rehabilitation of Zone II Flexor Tendons after Surgical Repair

Project form: Bachelor´s Thesis

Period of realization of the project: January 2017

Applicant: Joseph Truesdale

Main researcher: Joseph Truesdale

Supervisor (in case of student's work): Mgr. Katrina Marsakova

Project description: The project will include 6 rehabilitation sessions with the patient, at which time an anamnesis and an evaluation of the patient will take place. The aim of the rehabiliration will be to regain full range of motion and strength of the injured finger in order to have no limitarions of his left hand. The methods to be used during the rehabilitation sessions will include, but not limited to, soft tissue massage, scar care of the scar to reduce adhesions, joint mobilization of the fingers of the injured hand, PIR of the finger flexors (i.e. flexor digitorum superficialis, and flexor digitorum profundus), and tendon glides.
Ensuring safety within the research: The patient's safety will be ensured by following the prescribing doctor's orders, a conservative rehabilitation approach, and by the continual presence of the supervising Physiotherapist, Mgr. Romana Kozderková, MDT. The location of the rehabilitation will take place at Ústřední vojenská nemocnice (UVN).
Ethical aspects of the research: The patient participating in this research is an adult and is non-vulnerable. Patient's personal data will remain anonymous, by not using his full name in documentation, nor sharing this information with others.
Informed Consent: attached

It is a duty of **all participants of the research team** to protect life, health, dignity, integrity, the right to self-determination, privacy and protection of the personal data of all research subjects, and to undertake all possible precautions. Responsibility for the protection of all research subjects lies on the researcher(s) and not on the research subjects themselves, even if they gave their consent to participation in the research. All participants of the research team must take into consideration ethical, legal and regulative norms and standards of research involving human subjects applicable not only in the Czech Republic but also internationally.
I confirm that this project description corresponds to the plan of the project and in case of any change, especially of the methods used in the project, I will inform the UK FTVS Ethics Committee, which may require a re-submission of the application form.

In Prague, 12 January 2017 Applicant's signature:

Approval of UK FTVS Ethics Committee

The Committee: Chair: doc. PhDr. Irena Parry Martínková, Ph.D.
Members: prof. PhDr. Pavel Slepička, DrSc.
doc. MUDr. Jan Heller, CSc.
PhDr. Pavel Hráský, Ph.D.
Mgr. Eva Prokešová, Ph.D.
MUDr. Simona Majorová

The research project was approved by UK FTVS Ethics Committee under the registration number: 019/2017
Date of approval: 18.1.2017

UK FTVS Ethics Committee reviewed the submitted research project and **found no contradictions** with valid principles, regulations and international guidelines for carrying out research involving human subjects.

The applicant has met the necessary requirements for receiving approval of UK FTVS Ethics Committee.

Stamp of UK FTVS
UNIVERZITA KARLOVA
Fakulta tělesné výchovy a sportu
José Martího 31, 162 52, Praha 6
– 20 –

Signature of the Chair of
UK FTVS Ethics Committee

4.6 Appendix: Patient Consent Form

UNIVERZITA KARLOVA
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

INFORMOVANÝ SOUHLAS

Vážená paní, vážený pane,

v souladu se Všeobecnou deklarací lidských práv, zákonem č. 101/2000 Sb., o ochraně osobních údajů a o změně některých zákonů, ve znění pozdějších předpisů, Helsinskou deklarací, přijatou 18. Světovým zdravotnickým shromážděním v roce 1964 ve znění pozdějších změn (Fortaleza, Brazílie, 2013) a dalšími obecně závaznými právními předpisy Vás žádám o souhlas s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie prováděné v rámci praxe na ……., kde Vás příslušně kvalifikovaná osoba seznámila s Vaším vyšetřením a následnou terapií. Výsledky Vašeho vyšetření a průběh Vaší terapie bude publikován v rámci bakalářské práce na UK FTVS, s názvem .....

Získané údaje, fotodokumentace, průběh a výsledky terapie budou uveřejněny v bakalářské práci v anonymizované podobě. Osobní data nebudou uvedena a budou uchována v anonymní podobě. V maximální možné míře zabezpečím, aby získaná data nebyla zneužita.

Jméno a příjmení řešitele ..... Podpis:.....

Jméno a příjmení osoby, která provedla poučení..... Podpis:.....

Prohlašuji a svým níže uvedeným vlastnoručním podpisem potvrzuji, že dobrovolně souhlasím s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie ve výše uvedené bakalářské práci, a že mi osoba, která provedla poučení, osobně vše podrobně vysvětlila, a že jsem měl(a) možnost si řádně a v dostatečném čase zvážit všechny relevantní informace, zeptat se na vše podstatné a že jsem dostal(a) jasné a srozumitelné odpovědi na své dotazy. Byl(a) jsem poučen(a) o právu odmítnout prezentování a uveřejnění výsledků vyšetření a průběhu terapie v bakalářské práci nebo svůj souhlas kdykoli odvolat bez represí, a to písemně zasláním Etické komisi UK FTVS, která bude následně informovat řešitele.

Místo, datum .....

Jméno a příjmení pacienta ..... Podpis pacienta: .....

Jméno a příjmení zákonného zástupce .....….

Vztah zákonného zástupce k pacientovi ..... Podpis: .....