2023

Outpatient Physical Therapy Management of a Patient Presenting with Double Crush Syndrome: A Case Study.

Nicholas G. Hatfield
University of North Dakota

OUTPATIENT PHYSICAL THERAPY MANAGEMENT OF A PATIENT PRESENTING WITH DOUBLE CRUSH SYNDROME: A CASE STUDY

by

Nicholas Gerald Hatfield
Bachelor of General Studies with Health Sciences Emphasis, University of North Dakota, 2022

A Scholarly Project Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine & Health Sciences

University of North Dakota

in partial fulfillment of the requirements for the degree of

Doctor of Physical Therapy

Grand Forks, North Dakota

May
2023

This Scholarly Project, submitted by Nicholas Hatfield in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Faculty Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

DocuSigned by:
Richard Morgan
(Graduate School Advisor)

DocuSigned by:
Cindy Flom-Meland
(Chairperson, Physical Therapy)

PERMISSION

Title Outpatient Physical Therapy Management of a Patient Presenting with Double Crush Syndrome: A Case Study.

Department Physical Therapy

Degree Doctor of Physical Therapy

In presenting this Scholarly Project in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in her absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this Scholarly Project or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in this Scholarly Project.

Signature DocuSigned by: Nicholas Hatfield 2B3AE1C43029485...

Date 4/13/2023

TABLE OF CONTENTS

LIST OF TABLES v

ACKNOWLEDGEMENTS vi

ABSTRACT vii

CHAPTER

I. BACKGROUND AND PURPOSE 1

II. CASE DESCRIPTION 5

Patient Subjective History 5

Objective Tests and Measures 6

Clinical Assessment/Impression 8

III. INTERVENTION AND PLAN OF CARE 11

IV. OUTCOMES 16

V. DISCUSSION 19

Reflective Practice 20

REFERENCES 22

LIST OF TABLES

1. Explanation of Intrinsic and Extrinsic causes of neurovascular tunnel narrowing.....3
2. Special Test Reliability Values 7
3. Initial Strength Testing Outcomes 7
4. Initial Muscle Length Testing 7
5. Initial Neural Tension Testing Results 7
6. Problem List 9
7. Goals Developed for Episode of Care 9
8. Daily Treatment Session 1 Interventions 12
9. Daily Treatment Session 2 Interventions 12
10. Daily Treatment Session 3 Interventions 12
11. Daily Treatment Session 4 Interventions 13
12. Daily Treatment Session 5 Interventions 13
13. Daily Treatment Session 6 Interventions 13
14. Daily Treatment Session 7 Interventions 14
15. Objective Metrics Tested on Initial Evaluation and Discharge 17

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to my faculty advisors, Emily Henneman and Ricky Morgan, for their guidance and support during my preparation and finalization of this case study. I would also like to express gratitude to my classmates, Baylee Reiser, and Isaac Scott, for the helpful insight in the form of peer review and support through this process as well.

ABSTRACT

Background and Purpose. This case study evaluates the effectiveness of physical therapy interventions in the treatment of a patient presenting with a potential Double Crush Syndrome. **Case Description.** This patient was a 59-year-old male with reports of right shoulder pain and right upper extremity paresthesia, numbness, and tingling affecting his ability to perform daily tasks at work and at home. **Interventions.** The physical therapy interventions given were all based on findings from the initial evaluation and included a mixture of manual therapy techniques such as shoulder mobilizations, therapeutic exercises/activities such as stretching, resistance training, and carries, and neuromuscular re-education such as nerve flossing and postural retraining. **Outcomes.** The patient saw great improvements in symptoms over the episode of care and was able to get back to doing daily and work tasks with less pain and difficulty. **Discussion.** The patient responded favorably to the interventions provided. Ongoing research is suggested in order to optimize patient treatment protocols when dealing with similar cases.

KEYWORDS

Double Crush Syndrome, Paresthesia, Physical Therapy Interventions, Carpal Tunnel, Shoulder Pain, Neural Dynamics, Nerve Flossing , Manual Therapy, Strengthening

CHAPTER I

BACKGROUND AND PURPOSE

Paresthesia of the upper extremity can stem from several causes due to the complexities of the muscular, bony, and neural anatomy of the upper extremities and surrounding structures. With such complex anatomy comes the risk of pathologies leading to impaired function, specifically in the form of peripheral nerve entrapment, compression, or tension.[1] Having so many opportunities for peripheral nerve entrapment can lead to compression of any nerve at multiple sites. The action of compressing a peripheral nerve at a proximal and distal location is known as Double Crush Syndrome (DCS).[2] Double Crush Syndrome is a diagnosis that is described as compression of a nerve in two or more places and can occur in both the upper and lower extremities. The compression at the proximal location amplifies distal symptoms as this proximal compression compromises the structure's distal integrity, making it more susceptible to things like Carpal Tunnel Syndrome or a different type of tunnel syndrome/entrapment pathology.[3]

Double Crush Syndrome has no specific diagnostic criteria currently, making the estimation of the prevalence difficult. Diagnosis is based purely on subjective history, clinical findings, imaging, and electrophysiologic studies.[4] The rate of DCS is estimated to range anywhere from 6.7% - 73%. [3] Education on DCS is important to address and screen for in order to improve patient outcomes. In a case control study from 2016, Wessel et. al[5] found that patients suffering from DCS prior to nerve decompression surgery found less improvement in

symptoms of Carpal Tunnel or Cubital Tunnel Syndrome after decompression surgery was performed and had significantly lower satisfaction on the Likert scale. Other investigations of patient outcomes states that decompression at only distal sites, versus both proximal and distal sites, saw less successful outcomes following surgical procedures.[6, 7] These studies show the impact and seriousness DCS can have on an individual and the importance of proper intervention and treatment for optimal outcomes.

Risk factors for developing Double Crush Syndrome align with that of other entrapment pathologies like Carpal Tunnel Syndrome, Cubital Tunnel Syndrome, or Thoracic Outlet Syndrome. Mechanical forces cause an increase in tissue loading and is mainly caused by narrowing of the neurovascular tunnel.[1] Other systemic comorbidities include type-2 diabetes mellitus, thyroid disease, excess use of alcohol, metabolic syndrome, smoking, vitamin deficiencies, immune diseases like rheumatoid arthritis, peripheral vascular disease, and obesity.[4,8] Table 1 shows intrinsic and extrinsic causes of the development of tunnel syndromes. Extrinsic causes are factors occurring outside of the tunnel, and intrinsic causes are factors that occur inside of the tunnel.[1] Diagnosis of entrapment pathologies often requires nerve conduction tests to be performed. In a diagnostic study from Sucher and Schreiber[9], it is stated that often motor nerve conduction velocities associated with carpal tunnel are slowed and needle electromyography (EMG) can confirm denervation if there is motor nerve involvement.

Table 1. Explanation of Intrinsic and Extrinsic causes of neurovascular tunnel narrowing[1]	
EXTERNAL TO TUNNEL:	
Category	**Examples**
Congenital	Cervical rib, post fixed plexus
Trauma	Elbow Dislocation, fracture
Infectious	Herpes Zoster
Neoplasm	Pancoast Tumor, Osteogenic Sarcoma
Metabolic	Diabetes Mellitus, Hyperthyroidism
Hormonal	Pregnancy
Toxic	Lead intoxification, some medications
Iatrogenic	Surgical injury, casting, wrapping
INTERNAL TO TUNNEL:	
Category	**Examples**
Congenital	Anomalous scalene muscle
Infectious	Tuberculosis, Abscess
Neoplasm	Schwannoma, hemangioma, myeloma
Hormonal	Pregnancy
Toxic	Lead intoxification, some medications
Iatrogenic	Surgical Injury

Physical therapy treatments found to be beneficial in improving DCS include but are not limited to postural training, mobilizations of appropriate areas, nerve flossing, muscular

strengthening and stretching, and patient education on rest and aggravating factors.[10] Treatments for patients with DCS should be tailored to current symptoms and be focused on the location(s) of compression that are most relevant in reproducing symptoms and increasing disability.[11] Being a compressive mechanism of action, DCS behaves much like nerve entrapment disorders and can see benefit from similar or the same treatments utilized to improve many neural entrapment disorders. These include but are not limited to manual therapy, myofascial release, neural mobilizations, taping or splinting, and therapeutic modalities.[1] A randomized control trial from Wolny et. al[12], and a systematic review from Ballestro-Perez et. al[13] both stated that manual therapy and neural gliding alongside conservative exercises improve recovery and accelerate the rehabilitation process of Carpal Tunnel Syndrome, which can be applied to other neural entrapment disorders. The prognosis of DCS is highly variable depending on where each part of the nerve is entrapped. Conservative treatment will show benefit but those with DCS will likely have worse paresthesia, and likely a weaker grip when compared to individuals with a single entrapment pathology alone.[3] Prognosis also depends on how well both areas respond to treatment as resolution of one "crush" and not the other will likely result in lasting symptoms of numbness, and/or weakness.[8]

The focus of this case study will be on the treatment and progression of a patient with a presentation that matches DCS diagnosis descriptions. The purpose of the following case study will be to show that physical therapy is beneficial in reducing paresthesia, pain, weakness and improving function in nerve entrapment pathologies that present as a DCS. This in cause will help broaden the knowledge and understanding of clinical DCS presentation and responses to treatment that can be utilized in future research.

CHAPTER II

CASE DESCRIPTION

Patient Subjective History:

The patient is a 59-year-old Caucasian male presenting to the clinic with right shoulder pain and right upper extremity numbness. He stated that there was numbness and tingling from his right shoulder blade through his arm, elbow, and into his right third and fourth fingers on the palmar surface. He also had right shoulder pain and fatigue with any overhead activities. The patient reported that he had noticed his grip strength was weakening. He was beginning to have difficulty twisting jar caps, using power tools, and carrying things. The onset of symptoms was insidious beginning near the end of June 2022 with no apparent mechanism of injury. He described the pain as a constant, dull achy numbness that would flare up every night around 3:30 a.m. causing him to wake up due to the pain and numbness. The verbal rating of his current pain upon initial evaluation was a 6/10 with the pain at worst flaring up to 8/10. The patient was still active and worked full-time as an inspector for a construction company where he used power tools and was also required to type on computer keyboards throughout the day. Both typing and using power tools had become much more challenging since symptom onset. His hobbies included woodworking and flyfishing, both of which had become more difficult due to the increasing right shoulder pain, right upper extremity numbness, and grip weakness. The patient stated that he received a course of physical therapy (PT) earlier in the year for similar complaints and saw improvements in his symptoms. He also reported a surgical history including a right

shoulder arthroscopy in the year 2000. The patient stated that his main goals for therapy were to decrease pain and numbness and to increase grip strength in order to type at work, tighten jar caps, and return to woodworking as well as fly fishing.

Objective Tests and Measures:

Upon objective observation the patient was found to have a protracted head posture, with rounded shoulders, as well as humeral internal rotation and protracted scapulae bilaterally. Cervical range of motion screening was cleared and within normal limits. Shoulder active range of motion was cleared and within functional limits. He demonstrated bilateral substitution patterns as noted by scapular elevation/hitching compensation near end range shoulder elevation. Increased right upper extremity paresthesia was noted with active shoulder flexion during a scapulohumeral rhythm assessment. Palpation over the supraspinatus tendon, coracoid process and pec minor were all painful. Pectoralis major and minor were noted as shortened and stiff bilaterally as shown in Table 2. Upper extremity neural tension was found to be positive in the right median nerve and negative in the left median nerve as shown by Table 3. This indicated the presence of potential neural entrapment or impediment to neural motion in the right upper extremity. The special tests utilized were specified towards impingement of the subacromial space at the time of initial evaluation due to description and presentation of pain and symptoms. Table 4 shows the associated reliability of the special tests utilized. The tests used included Hawkins-Kennedy and Empty Can/Supraspinatus Test, which were both found to be positive bilaterally. Strength of the shoulder and scapulothoracic musculature (Table 5) showed deficits in bilateral lower and middle trapezius, right shoulder abduction, right shoulder external rotation, and right shoulder internal rotation.

Table 2. Initial Muscle Length Testing		
	RIGHT	LEFT
Pectoralis Major Muscle Length	Stiff/Short	Stiff/Short
Pectoralis Minor Muscle Length	Stiff/Short	Stiff/Short

Table 3. Initial Neural Tension Testing Results		
	RIGHT	LEFT
Median Nerve Tension Test	Positive	Negative

Table 4. Special Test Reliability Values				
Special Test	Sensitivity	Specificity	Likelihood Ratio (+)	Likelihood Ratio (-)
Hawkins-Kennedy[14]	0.62 – 0.92	0.25 – 1.00	1.20 - 3.33	0.21 - 0.55
Empty Can[15]	88.6%	58.8%	1.35 – 2.93	0.17 – 0.84

Table 5. Initial Strength Testing Outcomes		
	RIGHT	LEFT
Lower Trapezius	3-/5	3-/5
Middle Trapezius	3-/5	3-/5
Shoulder Abduction	4/5 (Pain)	5/5
Shoulder External Rotation	4+/5 (Pain)	5/5
Shoulder Flexion	5/5	5/5

Table 5 Continued. Initial Strength Testing Outcomes Continued		
	RIGHT	LEFT
Shoulder Internal Rotation	4+/5	5/5

The patient had also received a previous nerve conduction and EMG study earlier in the year with his previous bout of physical therapy for similar symptoms. The nerve conduction study found prolonged latencies and slowed nerve conduction velocities in the right median and ulnar nerves. It showed slowed nerve conduction velocities across the elbow when compared to the forearm. The EMG study found moderate sensorimotor primary demyelinating mononeuropathy affecting the right median nerve at or near the wrist and borderline mild motor primary demyelinating mononeuropathy affecting the right ulnar nerve at the elbow. The findings pertaining to the median nerve are congruent with a diagnosis of Carpal Tunnel Syndrome as per what is stated on motor nerve conduction velocity and needle EMG testing in a diagnostic study from Sucher and Schreiber.[9]

Clinical Assessment/Impression:

Upon initial assessment, the patient demonstrated significant right shoulder pain (M25.511), right upper extremity paresthesia/pain (R20.2/M79.621), bilateral scapulohumeral rhythm deficit, positive right median nerve upper limb tension test, positive bilateral supraspinatus impingement (M75.41), bilateral pectoralis minor/major flexibility deficits, and moderate right shoulder/periscapular strength deficits (M62.81). These impairments were contributing to the patient's symptoms and functional limitations regarding overhead reaching, sleep hygiene disruptions, typing, using power tools, carrying heavy objects, and gripping activities.

Table 6. Problem List
1. right shoulder pain 2. right upper extremity paresthesia 3. positive right median nerve upper limb tension test 4. moderate right shoulder/periscapular strength deficits 5. bilateral pectoralis minor/major flexibility deficits 6. bilateral scapulohumeral rhythm deficit 7. positive bilateral supraspinatus impingement

The patient's prognosis and rehabilitation potential were good based off the stated goals. The prognosis was based on the findings and the problem list (Table 6) formed following the initial evaluation and the expected level of function to be gained from the patient. The goals created addressed the patient's personal goals and deficits, as shown in Table 7. These included decreasing pain and paresthesia, increasing shoulder girdle and periscapular strength, improving sleep hygiene, tolerating overhead activities for increased periods of time, carrying heavier objects without difficulty, typing at work without difficulty, and getting back to performing his pastimes.

Table 7. Goals Developed for Episode of Care
Following PT intervention, the patient will decrease pain from 6/10 to 0/10 at time of discharge and a verbal pain rating at the worst from 8/10 to 3/10 (To be met within 4 weeks).
Following PT intervention, the patient will increase their tolerance for repetitive upper extremity activity and overhead activity tolerance for continuous overhead activity lasting at least 20 minutes to type at work and perform woodworking without significant right upper extremity paresthesia. (To be met within 8 weeks)

Table 7 Continued. Goals Developed for Episode of Care Continued.
Following PT intervention, the patient will be able to improve neural dynamics in Right Median Nerve Tension Test from moderate/severe to nil/minimal neural tension in order to carry at least a 10lb object with the involved arm with no difficulty. (To be met within 8 weeks)
Following PT intervention, the patient will be able to improve grip strength to tighten and loosen jar caps without right hand paresthesia. (To be met within 8 weeks)

CHAPTER III

INTERVENTION AND PLAN OF CARE

The physical therapy interventions and plan of care chosen for this patient was based on findings from the objective data on the initial evaluation in collaboration with the patient. The findings indicated that the patient would benefit from a variety of treatment techniques. The plan for the prescribed treatment procedures was to utilize a combination of therapeutic exercise, manual therapy techniques, and neurological re-education. Therapeutic exercise included treatments in the form of strengthening and stretching, such as pectoralis minor and major stretching, latissimus dorsi stretching, and strengthening of the rotator cuff and periscapular muscles. Neurological re-education was included in order to retrain posture and abnormal movement and biomechanics of the upper extremity. Exercises in this category included wall slides, scapular retractions, prone T's or shoulder horizontal abduction, and other exercises as described in Tables 8-14. Manual therapy included glides and distractions of the shoulder joint, in various directions aiming to improve joint mobility, soft tissue mobility, and neural mobilization in the form of flossing/gliding, aiming to improve neural mobility. Treatment sessions were 1 hour long, and the plan of care consisted of 3 times per week for a total of 6 weeks. The frequency was chosen based on clinical experience of the treating physical therapist believed to be the most beneficial plan to improve the patient's primary deficits. Tables 8-14 include all interventions included in daily sessions. Each table is not in order of performed

intervention but is detailed in what intervention was performed and how much of each was performed.

Table 8. Daily Treatment Session 1 Interventions (Not in order performed)
1. Right Median Nerve Gliding (x 20 repetitions) 2. Right Pectoralis minor Stretch (3 sets x 30 sec) 3. Right Anterior/Posterior/Inferior/Lateral Glenohumeral mobilizations (approx. 3-4 mins each @ grade 3-4) 4. Right Supraspinatus insertion static dry needling (1/2" needles; 10 mins) 5. "Y" wall slides (2 sets x10 repetitions) 6. Prone Scapular Retractions w/shoulder extension (3 sets x 10 repetitions) 7. Resisted W's (Yellow band x 3 sets x 10 repetions) 8. Resisted Scaption <90deg (Unweighted x2 sets x 10repetitions; 2lb x 1set x 10 repetitions)

Table 9. Daily Treatment Session 2 Interventions (Not in order performed)
1. Upper Extremity Bike (6 min pedaling backwards only @ mild resistance) 2. Right Median Nerve Flossing (x 20 repetitions) 3. Right Pectoralis Minor Stretch (3 sets x 30 sec) 4. Right Anterior/Posterior/Inferior/Lateral Glenohumeral mobilizations (approx. 3-4 mins each @ grade 3-4) 5. Right median Nerve Gliding performed by Therapist (x 20 repetitions) 6. Massage Gun to R middle Trapezius/rhomboids 7. Right supraspinatus insertion static dry needling (1/2" needles; 10mins)

Table 10. Daily Treatment Session 3 Interventions (Not in order performed)
1. Upper Extremity Bike (6 min pedaling backwards only @ mild resistance) 2. Right Median Nerve Flossing (x 20 repetitions) 3. Right Pectoralis Minor/Major stretching (3 sets x 30sec) 4. Right Anterior/Posterior/Inferior/Lateral Glenohumeral mobilizations (approx. 3-4 mins each @ grade 3-4) 5. Right Median Nerve Gliding performed by therapist (x 20 repetitions) 6. Massage gun and STM to R middle trapezius/rhomboids 7. "Y" wall slides with hand lift off (2 sets x 10repetitoins) 8. Prone Scapular Shoulder Extensions with shoulder External Rotation (3 sets x 15 repetitions, with 3 sec hold @ top) 9. Prone T's (3 sets x 15 repetitions) 10. Resisted Rows with ER (Red Tube x 1 set x 10 repetitions)

Table 11. Daily Treatment Session 4 Interventions (Not in order performed)
1. Right Supraspinatus insertion static dry needling (1/2" needles; 10 mins) 2. Right Median Nerve Gliding Performed by therapist 3. Upper Extremity Bike (3 min x forward & backward) 4. Prone Y's on Incline Bench (3 sets x15 repetitions) 5. Prone Scapular Shoulder Extension with ER on Theraball (1 set x15 repetitions, 2lb x 2sets x15 repetitions w/3 sec hold at top) 6. Prone T's on Theraball (3 sets x 15 repetitions)

Table 12. Daily Treatment Session 5 Interventions (Not in order performed)
1. Upper Extremity Bike (3.5 min x forward & backward @ moderate resistance) 2. Right Median Nerve Gliding Performed by therapist 3. Single Arm Extension on theraball (2lb x 3 sets x 10 repetitions each arm) 4. Resisted W's (Green Tube x 3 sets x 10 repetitions) 5. Resisted Scaption to 90 deg (4lb x 3 sets x 10 repetitions) 6. Resisted Horizontal Abduction @ 90deg (Green Tube x 3 sets x 10 repetitions) 7. Horizontal Abduction from Overhead to Chest (Yellow Theraband x 3 sets x 10 repetitions)

Table 13. Daily Treatment Session 6 Intervention (Not in order performed)
1. Upper Extremity Bike (4 mins x forward & backward @ moderate resistance) 2. Prone Y's on Incline Bench (3 sets x 18 repetitions) 3. Standing Scaption shoulder press (5lb x 2sets x 10 repetitions) 4. Kneeling Prayer Stretch on theraball (4 sets x 30 sec) 5. Right Anterior/Posterior/Inferior/Lateral Glenohumeral mobilizations (approx. 3-4 mins each @ grade 3-4) 6. Right Median Nerve Gliding performed by therapist (2-3 sets x 10-20 repetitions) 7. Massage gun and Soft Tissue Massage to Right Middle Trapezius/Rhomboids 8. Resisted Rows with ER (Green Tube 2 sets x 15 repetitions) 9. Flexion Wall Rollups with foam roller (2 sets x12 repetitions) 10. Prone Scapular Shoulder Extension with ER on Theraball (2lb x 2 sets x 20 repetitions each arm with 3 sec hold)

Table 14. Daily Treatment Session 7 Intervention (Not in order performed)
1. Upper Extremity Bike (4 min x forward & backward @ moderate resistance) 2. Rope Facepulls (10lb x 2 sets x10 repetitions) 3. Rope Rows (10lb x 2 sets x 15 repetitions) 4. Kneeling Prayer Stretch on Bench (4 set x30 sec) 5. Pectoralis Major Stretch @ 90 deg (2 sets x 30 sec bilaterally) 6. Right Ant/Post/Inf/Lat Glenohumeral Mobilizations (grade 3+) 7. Right Median Nerve Gliding performed by therapist (2-3 sets x 10-20 repetitions) 8. Massage Gun and Soft Tissue Massage to middle trapezius/rhomboids 9. Prone T's on Theraball (2lb x 3 sets x 15 repetitions with 3 sec hold) 10. Resisted I's/Y's/T's (Yellow Band x 2sets x 10 repetitions each position)

The interventions chosen are specific to addressing and improving each of the dysfunctions and deficits found upon initial assessment. Each daily treatment session consisted of manual therapy techniques and neural mobilizations along with other stretching and strengthening. The performance of these interventions in combination has been found to be far more effective and beneficial than either treatment utilized alone. A randomized control trial from Wolny et. al[12], and a systematic review from Ballestro-Perez et. al[13] both stated that manual therapy and neural gliding alongside conservative exercises improve recovery and accelerate the rehabilitation process of Carpal Tunnel Syndrome. Coordination was made with the physical therapy assistants about the patient's plan of care. All strengthening exercises were supervised by the treating clinician in order to stress proper form and posture to improve biomechanics of the shoulder and decrease any scapular elevation or protraction with upper extremity movements. The plan for re-evaluation of the patient's progress was intended for week 3, or the midpoint of the established plan of care. The patient's home exercise program consisted of nerve glides of the median nerve, stretching of shoulder and pectoral musculature, and strengthening of scapular

musculature in order to improve posture and strength with upper extremity movements. The patient was educated on the purpose of the nerve glides as well as each exercise selected and how they will improve his current condition.

Upon the ninth visit, the patient was discharged per patient request secondary to insurance reasons. Discharge assessment found improvements on all tested metrics (see Chapter IV for details). The patient was provided with a detailed home exercise program with education provided on the proper performance of each exercise at home.

CHAPTER IV

OUTCOMES

The patient saw favorable improvements during their episode of care. To assess progress during treatment, the patient's subjective reports of symptoms (i.e., pain, paresthesia, daily function/ADL performance, etc.) were recorded to provide accurate progression of symptoms. Objective tests (i.e., strength, range of motion, special tests, etc.) were measured and compared to prior records to show improvements from the prescribed treatments and exercise programs.

Subjective reports showed that the patient was sleeping much better than on the initial examination and was rarely waking up from pain or paresthesia. On nights when he woke up, he reported that it wasn't pain as much as it was the sensation that his hand fell asleep, which typically subsided within 20 minutes or less. His verbal rated pain decreased to a 2/10 (6/10 at initial evaluation) (0 = no pain, 10 = maximum pain) on the day of the last session and experienced his worst pain at a 5/10 (8/10 at initial evaluation) with mild tingling in the 3rd and 4th fingers. This showed a significant difference in pain levels from start to finish. The patient stated he was able to get back to woodworking without weakness in his hands. He stated he was not having difficulties at work, reporting that he was able to type 12 minutes without symptoms. He reported that he was able to tighten and loosen jar caps, something that he was unable to do when his treatment started.

Objective retesting showed that he increased strength of his shoulder and periscapular musculature. Specific strength increases are shown in Table 15 below. He mildly improved

shoulder range of motion, but since goniometric measurements were not taken to show initial and final range of motion differences, improvements were hard to quantify. Neural tension retesting showed improvements without tension in the right median nerve tension test. Findings for objective testing in the discharge summary compared to the initial evaluation are listed in Table 15 below.

Table 15. Objective Metrics Tested on Initial Evaluation and Discharge

	Right (Initial 08/24/2022)	Left (Initial 08/24/2022)	Right (Discharge 09/14/2022)	Left (Discharge 09/14/2022)
Pectoralis Major/Minor Length	Stiff	Stiff	Stiff but improved motion Bilat	Stiff but improved motion Bilat
Median Nerve Tension Test	Positive	Negative	Negative	Negative
Cross-Body Adduction Test	Positive	Positive	Positive	Negative
Empty Can/Supraspinatus Test	Positive	Positive	Negative	Negative
Lower Trapezius Strength	3-/5	3-/5	4/5	4/5
Middle Trapezius Strength	3-/5	3-/5	4/5	4/5
Shoulder Abduction Strength	4/5 (pain in shoulder)	5/5	4+/5 (mild pain in shoulder)	5/5

The patient was discharged per his request due to insurance limitations and the number of therapy visits remaining. He stated he wanted to save his remaining visits in physical therapy for a future date. The progress made towards his goals regarding strength, hand function, right upper extremity and hand paresthesia, and shoulder pain were more than adequate to justify this request. Discharge to independent home exercise was deemed appropriate by the therapist for this reason. The stated goals included subjective reports, objective testing, and functional

activities like carrying objects. Upon discharge, the patient demonstrated the ability to carry 20 pounds for 15 feet, showing completion of one of the functional goals. In addition, during the episode of care, the patient demonstrated high adherence and compliance with his home exercise program showing that he will likely maintain progress after discharge.

Upon the discharge visit the patient showed high satisfaction with the results he achieved during the episode of care. He was able to function at a level that allowed him to perform the activities in his daily life that he needed and wanted to do. The treatments performed in this patient's care plan were effective in improving his functional performance. Suggestions for additional objective testing measures in future cases include initial and final range of motion measurements to show quantitative improvements in this metric. Other suggestions for additional objective testing include grip dynamometer testing and a functional outcome measure such as the DASH or QuickDASH to further quantify improvements made by the patient.

CHAPTER V

DISCUSSION

The results of orthopedic physical therapy treatment of a patient presenting with a potential Double Crush Syndrome showed promise in the fact that multimodal conservative interventions can improve patient symptoms. Current research suggests the benefits of both manual therapy techniques and exercise versus either of these treatments individually.[16,17] Just as current research shows, this case demonstrates how treatments of manual therapy that include things like neural dynamics and joint mobilizations, and various exercises are beneficial in relieving pain, paresthesia and improving strength, which lead to increases in function. This patient was able to delay Carpal Tunnel surgery due to successes seen in symptom reduction via conservative treatment approaches that included exercise and manual therapy.

The patient treated in this report showed positive results with the interventions outlined in Chapter III. There were significant reductions in shoulder pain, hand paresthesia, and overall functional disability. The majority of the patient's goals established upon initial evaluation were met upon discharge. Patient progress in this episode of care showed promise in meeting all goals within prescribed duration of care. If the patient continued with his established plan of care, he would have likely met all his goals. If the patient continues with his independent home exercise program, he will likely reach his goals.

These findings can help to solidify current research findings regarding conservative approaches for treatment of neural entrapment syndromes presenting as a double or single

"crush." Clinically, this case study shows how important it is to have a mixed modality approach to help improve every aspect of patient care. Having the ability to incorporate interventions like neural dynamics, dry needling, and other manual therapy techniques on top of exercise gives the most opportunity for the best progression of the patient.

There were limitations in the case study. First, the patient was not seen for the entire planned episode of care and number of visits due to patient request. In future case studies, it is highly recommended that assessments of grip strength are performed, and a functional outcome measure is completed upon initial assessment also. These things are two variables that will be valuable to see improvements throughout the episode of care. In addition to these findings, it is recommended that the patient completes their full plan of care in order to achieve maximum rehabilitation potential, as opposed to what happened in this case study where the patient opted to be discharged early. Patient education on sticking to the prescription of the plan of care is seen as important for future studies. The interventions utilized for the patient in this case study were effective. More research should be done on conservative treatment for neural entrapments affecting more than one site and avoiding surgery.

Reflective Practice:

After handling a case of this type and reading the research utilized in this paper, the methods used in my clinical practice would remain largely the same to how this patient was evaluated and treated. The suggestions made in previous chapters still stand. For example, during the evaluation, an outcome measure such as the DASH should be utilized, and grip strength dynamometry should be utilized to assess progressive strength improvements as symptoms and function improves. The main focus of my treatment would be the same by using manual therapy techniques at the shoulder to manage and improve symptoms, nerve flossing of

the upper extremity to improve neural dynamics, and therapeutic exercise/activity to encourage stretching, strengthening and functional activities. This patient responded well to this and as previously stated research reports, the most effective treatment is treatment that incorporates manual techniques, neural dynamics, and strengthening exercises.

References

1. O'Hearn T. Entrapment Neuropathy in the Forearm, Wrist, and Hand. In: Carp SJ. eds. Peripheral Nerve Injury. McGraw Hill; 2015. Accessed January 05, 2023. https://fadavispt-mhmedical-com.ezproxylr.med.und.edu/content.aspx?bookid=1885&sectionid=139910576
2. Ochoa-Cacique D, Córdoba-Mosqueda ME, Aguilar-Calderón JR, et al. Double crush syndrome: Epidemiology, diagnosis, and treatment results. *Neurochirurgie*. 2021;67(2):165-169. doi:10.1016/j.neuchi.2020.09.011
3. Kane PM, Daniels AH, Akelman E. Double Crush Syndrome. J Am Acad Orthop Surg. 2015;23(9):558-562. doi:10.5435/JAAOS-D-14-00176
4. Phan A, Shah S, Hammert W, Mesfin A. Double Crush Syndrome of the Upper Extremity. *JBJS Rev*. 2021;9(12):10.2106/JBJS.RVW.21.00082. Published 2021 Dec 15. doi:10.2106/JBJS.RVW.21.00082
5. Wessel LE, Fufa DT, Canham RB, La Bore A, Boyer MI, Calfee RP. Outcomes following Peripheral Nerve Decompression with and without Associated Double Crush eSyndrome: A Case Control Study. *Plast Reconstr Surg*. 2017;139(1):119-127. doi:10.1097/PRS.0000000000002863
6. Molinari WJ 3rd, Elfar JC. The double crush syndrome. J Hand Surg Am. 2013;38(4):799-801. doi:10.1016/j.jhsa.2012.12.038
7. Osterman AL. The double crush syndrome. Orthop Clin North Am. 1988;19(1):147-155.
8. Whitten R. The 'double crush': When a nerve pinches in 2 places. Mayfield Brain & Spinal Column. May 22, 2019. Accessed Jan 17, 2023. https://mayfieldclinicblog.com/?p=5447#:~:text=A%20double%20crush%20is%20also,peripheral%20vascular%20disease%2C%20and%20obesity.
9. Sucher BM, Schreiber AL. Carpal tunnel syndrome diagnosis. *Phys Med Rehabil Clin N Am*. 2014;25(2):229-247. doi:10.1016/j.pmr.2014.01.004
10. Physiopedia Contributors. Double Crush Syndrome. Physiopedia. 18 July 2019. Accessed 5 January 2023. https://www.physio-pedia.com/index.php?title=Double_Crush_Syndrome&oldid=216851
11. Ebraheim N. Double Crush Syndrome - Everything You Need To Know - Dr. Nabil Ebraheim [Video]. Youtube. https://www.youtube.com/watch?v=8ZjK5How7pU. Published Aug 1, 2014. Accessed Jan 16, 2023.
12. Wolny T, Saulicz E, Linek P, Shacklock M, Myśliwiec A. Efficacy of Manual Therapy Including Neurodynamic Techniques for the Treatment of Carpal Tunnel Syndrome: A Randomized Controlled Trial. *J Manipulative Physiol Ther*. 2017;40(4):263-272. doi:10.1016/j.jmpt.2017.02.004

13. Ballestero-Pérez R, Plaza-Manzano G, Urraca-Gesto A, et al. Effectiveness of Nerve Gliding Exercises on Carpal Tunnel Syndrome: A Systematic Review. *J Manipulative Physiol Ther*. 2017;40(1):50-59. doi:10.1016/j.jmpt.2016.10.004
14. Physiopedia contributors. Hawkins / Kennedy Impingement Test of the Shoulder. Physiopedia. March 24, 2022. Accessed January 20, 2023. https://www.physio-pedia.com/index.php?title=Hawkins_/_Kennedy_Impingement_Test_of_the_Shoulder&oldid=298760
15. Holtby R, Razmjou H. Validity of the supraspinatus test as a single clinical test in diagnosing patients with rotator cuff pathology. *J Orthop Sports Phys Ther*. 2004;34(4):194-200. doi:10.2519/jospt.2004.34.4.194
16. Hamzeh H, Madi M, Alghwiri AA, Hawamdeh Z. The long-term effect of neurodynamics vs exercise therapy on pain and function in people with carpal tunnel syndrome: A randomized parallel-group clinical trial. J Hand Ther. 2021;34(4):521-530. doi:10.1016/j.jht.2020.07.005
17. Ijaz MJ, Karimi H, Ahmad A, Gillani SA, Anwar N, Chaudhary MA. Comparative Efficacy of Routine Physical Therapy with and without Neuromobilization in the Treatment of Patients with Mild to Moderate Carpal Tunnel Syndrome. Biomed Res Int. 2022;2022:2155765. Published 2022 Jun 22. doi:10.1155/2022/2155765