Case Report

Addressing neurodynamic irritability in a patient with adhesive capsulitis: a case report

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Background: Patients with adhesive capsulitis are commonly seen by physical therapists. Pain and limited shoulder motion from adhesive capsulitis have at times been linked to neural irritation. The purpose of this case is to describe the examination and intervention of a patient with adhesive capsulitis who appeared to have a coexisting, underlying neural irritation. This paper emphasizes how the neurological component must initially be identified and addressed for a successful outcome.

Case description: A 47-year-old female presented with reduced shoulder motion and function, upper extremity neural irritation, diffuse weakness, altered sensation in the involved extremity, and symptoms reproduced with upper limb neurodynamic testing. Her reduced shoulder range of motion was accompanied by limited glenohumeral glides and a report of local neck stiffness. Symptoms began several months earlier after an apparent electrical shock injury to the arm that caused symptoms and guarding of the shoulder. Intervention initially addressed the underlying neural component with spinal mobilizations while avoiding further irritation. Interventions were progressed to include mobilization and exercise to address shoulder mobility.

Outcomes: The patient's neurodynamic irritability, distal symptoms, and neck stiffness were normalized within the first weeks of care. Subsequently, interventions were directed at the shoulder. Outcomes over an 12-week time frame included reduced pain from 10/10 to 2/10. Passive range of motion increases included flexion from 121 to 160°, abduction from 71 to 121°, and external rotation from 18 to 60°. Disability scores on Disabilities of the Arm, Shoulder, and Hand (DASH) dropped from initially 68.3 to 18.3% at discharge. She ultimately regained full upper extremity function.

Discussion: Therapists should be cognizant of possible neural irritation in shoulder disorders, which may contribute to conditions such as adhesive capsulitis. Identifying neural irritation is critical when determining which interventions will achieve optimal outcomes without aggravating the condition.

Keywords: Adhesive capsulitis, Neurodynamic mobility, Physical therapy/rehabilitation, Upper limb tension testing, Manual therapy, Shoulder

Background

Patients with adhesive capsulitis are commonly referred for physical therapy. A recent Clinical Practice Guideline for Shoulder Pain and Mobility Deficits: Adhesive Capsulitis¹ was developed by a panel of experts from the Orthopaedic Section of the American Physical Therapy Association. The Guideline outlines common findings, as well as recommendations for assessment and interventions for this diagnosis. Common findings include limited shoulder range of motion (ROM) and vague shoulder pain that may radiate into the upper arm.^{1,2} Symptoms are typically aggravated with shoulder movement² and treatment strategies vary based upon the stage of the condition.²⁻⁵ In the early stages, pain and the inflammatory component are the focus of care. Once initial irritability is reduced, restrictions of motion and function are addressed. While adhesive capsulitis is commonly

idiopathic, the irritability level, as well as any modifiable causes and contributing factors, must be identified so that appropriate interventions can be utilized.^{2,3,5}

It has been recommended that the entire upper quarter be screened in patients with adhesive capsulitis to rule out the cervical spine or neurologic contributions.^{3,5-10} This must be carried out to ensure that the symptoms are not referred from these areas. The impact of the peripheral or autonomic nervous systems have also been discussed in cases of adhesive capsulitis.⁶⁻⁹ Injury or irritation of the brachial plexus and upper extremity (UE) neural tissues may produce signs and symptoms similar to adhesive capsulitis.^{7,11} Traumatized or irritated neural tissues may become sensitive to movement and elongation,^{10,12,13} such as when the arm is lifted overhead. The nerves of the arm pass inferior to the glenohumeral (GH) joint and are stretched or elongated, particularly during abduction and external rotation, as the humeral head migrates inferiorly and anteriorly. Patients may attempt to protect irritated

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nerves from stretch and irritation by muscle guarding and avoidance of provocative motions.¹³ It is conceivable that this may contribute to secondary adhesive capsulitis development, as seen in this case report.

The recent clinical practice guideline¹ noted above includes assessment of the cervical spine and neurodynamic testing for patients with adhesive capsulitis. If the patient's symptoms are reproduced with these assessments, neural components must be addressed. Adhesive capsulitis interventions typically include aggressive inferior humeral head mobilization and overhead stretching which elongate sensitive neural structures, potentially contributing to further irritation and guarding. In those instances, neural irritation must be addressed for optimal care of adhesive capsulitis.

The purpose of this case report is to demonstrate the diagnostic and intervention strategies employed with a patient referred for adhesive capsulitis who presented with concurrent signs and symptoms consistent with neural irritation. Although the patient demonstrated reduced GH joint mobility, the neural sensitivity required initial attention to reducing the neural irritation before GH mobility could be addressed.^{5,6,8} Thus, it was vital to initially avoid aggressive interventions directed at the shoulder or GH joint until the neural sensitivity subsided.

Patient Characteristics

The patient was a 47-year-old, right-handed, female referred to physical therapy by her family physician for evaluation and treatment of left shoulder adhesive capsulitis. Her primary complaint was constant left shoulder pain with decreased arm mobility and function. The symptoms were located in the deltoid region and intensified with any arm movement. Active arm elevation produced radiation into the lateral and posterior elbow; however, the symptoms did not appear to follow a specific dermatome or peripheral nerve distribution. She noted general hand weakness with discomfort and tingling extending into the palm, again aggravated with arm elevation or moving into 'the wrong position'. These symptoms lasted 10–15 minutes. The patient also had a dull, intermittent pain in the left neck/trapezius region. Shoulder pain was currently rated at a 10/10 and, at best, a 5/10 on a Numeric Pain Rating Scale (NPRS) where 0 means no symptoms and 10 is the maximal pain rating. The minimal detectable change for shoulder pain has been reported to be three points or 27% of the raw NPRS score,¹⁴ with the minimally clinically important change at 2.17 points.¹⁵

The patient reported that the symptoms began approximately 1 month before the initial visit and had slowly worsened. She denied any specific trauma

to the neck or shoulder. When asked about any other associated events, she said that a month ago she had worked on a home improvement project with the involved arm resting on a metal sink. When she turned on a not-yet grounded garbage disposal, she immediately felt a shock into the involved arm with subsequent numbness and tingling throughout her arm that lasted for several hours.

The patient did not initially seek medical attention for the shock incident, but used Advil and thermal wraps that produced slight symptom alleviation. The initial arm pain worsened and slowly turned into a heaviness and ache which was only relieved by not using the arm. She had noticed a lack of shoulder motion over the last several weeks. The shoulder pain was reportedly worse when reaching out to the side, forward, or backward, as in putting on her bra. Sleeping on the arm was difficult and increased soreness to a level that took several hours to subside each morning.

The patient saw her family physician several days prior to the initial physical therapy visit. No diagnostic testing was performed and she was told that she had adhesive capsulitis. Her physician prescribed 'wall crawls' and Codman's exercises, along with pain medication, which she felt was beginning to reduce the general ache and improve her tolerance to the exercises.

Her past medical history included epilepsy with the last seizure 15 years ago. Medications for this were phenobarbital and phenurone. The patient reported no pre-existing limitations in function. Routine activities included work, walking and housework. Demands on the shoulder included her employment in an information technology department where she could spend hours typing and intermittently lifting computers. She reported smoking approximately one pack a day for an unspecified duration. The patient did not report any current significant limitations with daily activities, stating that she just did what she could and put up with the pain. Other activities included walking regularly and doing normal household chores. Her goal for physical therapy was to regain flexibility and use of her arm.

The Disabilities of the Arm, Shoulder, and Hand (DASH) was completed. No tool has been specifically identified for use in patients with adhesive capsulitis,⁵ but the DASH has been used for patients with this condition.¹⁶ This tool has been considered reliable with a minimal detectable change of 6.6–12.2 points¹⁷ and a minimally clinically important difference of around 10.2 points.¹⁸ The initial examination score was 68.3% disability. As per the initial DASH, the patient had difficulty with household tasks, personal hygiene, dressing, and pursuing recreational activities.

Examination

The following tests and measures were performed for adhesive capsulitis, as described by Kelly *et al.*¹ There was no apparent postural asymmetry or muscle atrophy present, but she presented with a slightly rounded thoracic spine and forward head and shoulders. A neurological examination revealed decreased sensation to light touch in the following left UE regions: distal lateral deltoid, palm extending through the thumb and index fingers, radial side of dorsum of hand, and medial elbow. Sensation changes did not appear to follow any specific dermatome or peripheral nerve distribution. Biceps, brachioradialis, triceps, long finger flexors and flexor digiti minimi reflexes were bilaterally symmetrical and considered normal. Tapping along the course of any peripheral nerve in the involved side did not reproduce any symptoms. Gross strength was found to be symmetrical and painless with manual muscle testing except for weakness found in left shoulder abduction (4/5), left triceps (4+/5), and left biceps (4+/5). The patient demonstrated essentially symmetrical three-point pinch strength, tested with a dynamometer at 11.3 pounds on the left and 11.8 pounds on the right. Active and passive shoulder ROM measurements were limited compared to the contralateral side, as reported in Table 1. Range of motion of the involved and contralateral elbow, wrist, and hand were within normal limits. A cervical screen revealed full ROM with the following local symptom reproduction: right side bending produced a pulling sensation in the left upper trapezius region and left side bending and extension both produced left local neck discomfort, but no distal symptoms.

The drop arm test (performed out of painful positioning) and biceps load II test were negative.¹⁹ Local tenderness was produced with palpation of the left acromioclavicular joint, mid-belly of the external rotator musculature region, and posterior GH joint. Decreased glides of the GH joint were noted in all directions compared to the opposite side, primarily limited by muscular guarding. Inferior GH glide, performed with the arm slightly abducted and externally rotated, produced a 'heavy' feeling throughout her arm, as well as the shoulder, elbow, and hand symptoms described in the patient characteristics section. Inferior GH glide, performed with the arm not abducted or externally rotated produced only local shoulder discomfort. A central posterior to anterior glide at C5 produced local discomfort. Posterior to anterior pressure throughout the cervical spine did not reproduce any type of distal symptoms. Decreased mobility of C4–5 and C5–6 was noted with passive physiological extension and left side-bending motions. General stiffness in all directions was noted in the upper thoracic spine, particularly at the T3–6 levels.

Neurodynamic tests were used to determine possible neural irritation through symptom reproduction and via comparison to the contralateral side (Table 1).^{10,12,20–23} These tests have been shown to be reliable in the UE to assess changes in symptoms and determine motion limitations.^{21–32} Changes of 7.7° are considered clinically significant for change in elbow motion with the Upper Limb Tension Test (ULTT).²⁰ ULTT 1, or base test,¹² on the uninvolved side, produced a pulling sensation in the forearm when the elbow was 45° from full extension (Fig. 1A). For

Table 1 Objective outcome measures

Week	AROM flexion	AROM abduction	AROM behind back	PROM flexion	PROM abduction	PROM external rotation	PROM internal rotation*	ULTT 1**	ULTT 2***	NPR	Cervical AROM
1	121°	87°	T12	121°	71°	18°	30°	60°	10°	10/10	See text
Uninvolved side	WNL	WNL	To ~T8	WNL	WNL	101°	57°	45°	30°		
2	112°	80°	To belt	118°	82°	14°	NT	NT	15°	5/10	Full
3	110°	80°	To belt	132°	96°	25°	NT	45°	15°	NT	Full
4	108°	95°	To belt	142°	100°	43°	NT	45°	15°	NT	Full
5	118°	100°	L3	148°	119°	57°	NT	30°	47°	NT	Full
6	128°	97°	L2	145°	112°	38°	41°	30°	60°	NT	Full
7	128°	91°	L2	160°	132°	48°	NT	NT	NT	NT	Full
9	130°	107°	L3	160°	160°	60°	41°	20°	55°	NT	Full
10	137°	93°	L1	150°	120°	41°	NT	NT	NT	NT	Full
12	137°	103°	T 8	160°	121°	60°	53°	0°	70°	2/10	Full
(discharge)											
6-month follow-up	180°	180°	T6	180°	180°	88°	66°	5°	70°	0/10	Full

Note: All measurements were taken at beginning of each session.

AROM: active range of motion taken in standing; PROM, passive range of motion taken in supine; ULTT, Upper Limb Tension Test; NPR, Numeric Pain Rating reported at worst; NT, not tested at this session.

*Shoulder internal rotation measured in 45° of shoulder abduction.

**ULTT 1 or base test with measurements representing range from full elbow extension.

***ULTT 2 or radial bias test with measurements representing range of abduction from side.

Figure 1 Upper Limb Tension Test 1 performed on patient. (A) Positioning for right, uninvolved limb. (B) Positioning for left, involved limb, modified with shoulder abducted 45° and external rotation of 20° . Symptom reproduction with elbow 60° from full extension. (C) Release of wrist extension improves elbow extension. (D) Ipsilateral cervical side bending decreased symptoms.

this patient, neurodynamic tests were adapted on the left side based on the available ROM, as has been described.⁶ On the involved side, approximately 45° of shoulder abduction, 20° of external rotation, and elbow extension produced a pulling sensation in the hand and reproduced her shoulder discomfort with the elbow 60° from full extension (Fig. 1B). Positive findings were noted when further elbow extension reproduced all shoulder and distal symptoms and a release of wrist extension reduced the symptoms (Fig. 1C). From that position, ipsilateral cervical side-bending decreased the symptoms (Fig. 1D), while contralateral side-bending increased the shoulder symptoms. The ULTT 2 (radial nerve biased test)¹² was performed on the uninvolved side with 30° of shoulder abduction attained. This test was also considered positive on the involved side as 10° of abduction reproduced the patient's shoulder symptoms, while wrist extension immediately relieved the shoulder discomfort. The ulnar biased test (ULTT 3) produced limited range versus the opposite side; however, it did not reproduce any of her arm symptoms. Therefore, only ULTT 1 and 2 were used as a basis for further comparisons (Table 1).

Clinical Impression

This patient demonstrated signs and symptoms consistent with adhesive capsulitis including shoulder

pain, decreased shoulder ROM, decreased GH glides, and impaired function. She also had local lower cervical spine symptoms of pain, stiffness, with reduced physiologic motion and accessory mobility. However, no distal symptoms were directly reproduced with spinal provocation testing nor did she have neurological deficits that were consistent with a specific spinal level.

The patient appeared to have neural irritation, as evidenced by reproduction of her shoulder symptoms with the ULTT. The irritation worsened with arm elevation/abduction, particularly when the limb was in a position producing elongation of neural tissues. Reduction of symptoms occurred when the distal extremity was moved out of those positions. During ULTT 1, she had shoulder pain reproduced with elbow extension that was relieved with wrist flexion and ipsilateral cervical side bending implicating the median nerve. During ULTT 2, her shoulder pain was elicited with shoulder abduction, but reduced with wrist extension or positions that decreased tension on the radial nerve.

The specific source of neural irritation was unclear, but may have included the cervical spine or another cause. However, no specific cervical or shoulder trauma had occurred. It was hypothesized that the irritation may have occurred from the electric shock event. When the patient moved into positions similar

to ULTT 1 and 2, her symptoms may have been provoked so she began guarding, potentially contributing to reduced shoulder movement and subsequent reduction of capsular mobility. While shoulder mobilization, stretching, and passive ROM would commonly be used to address adhesive capsulitis, the authors felt it necessary to address the neural irritability first. Aggressive stretching, or humeral head mobilization, may have irritated sensitive neural tissues, potentially delaying recovery and limiting her prognosis.^{1,5,33}

Local mechanical cervical and thoracic problems had the potential to contribute to the neural irritation; thus, these were addressed as well. Treatment included manual interventions directed at the cervical and thoracic spine. The literature supports using the latter for shoulder pain including adhesive capsulitis.⁶ Furthermore, a growing body of evidence suggests that manual therapy for the thoracic spine can improve a patient's UE complaints,^{34,35} such as lateral epicondylitis and chronic regional pain syndrome.

Intervention

The patient was seen 15 times over 12 weeks with a 6-month follow-up. Table 2 outlines the weeks of care, frequency of visits, and interventions utilized. This report focuses on the treatment of the neural irritation and only generally describes the exercises and care of the adhesive capsulitis. Specific adhesive capsulitis exercises and progression protocols have been outlined by others.^{1,2,5,15} The initial decision making algorithm for addressing the shoulder and apparent neural related symptoms is outlined in Fig. 2.

On the first visit, the patient was instructed to continue the exercises prescribed by her physician since they did not appear to aggravate her symptoms. She was educated to avoid positions that would produce tension on neural structures, such as those similar to the ULTT maneuvers.³³ These were positions where both the proximal and distal extremity were elongated (e.g. shoulder abduction with external rotation, elbow and wrist extension). For home, she was given gentle self GH lateral distraction, seated with her shoulder abducted 90°, and thoracic stretching while supine over a pillow roll.

During the two subsequent visits, treatment focused on the neural irritation. Distal nerve gliding techniques were avoided because they immediately reproduced her distal symptoms and her irritability remained high. Instead, treatment was directed at the cervical interface since this has been shown to reduce distal neural irritation and symptoms.^{4,21,26,36} Specifically, C4-6 were targeted because of the reduced mobility discovered at these levels during the examination. McClathchie *et al.*²⁶ used cervical lateral side-glides to

reduce pain and improve shoulder motion, while Coppiters *et al.*²¹ produced 20° improvements in ULTT ROM following lateral glides to the mid-to-lower cervical spine. Spinal techniques moving toward the contralateral side were used to increase intervertebral foramina diameter of the ipsilateral side. These techniques were used in early treatment because they produced neither local nor distal symptoms, unlike cervical spine movements toward the involved side which created symptoms. The UE was always placed in a position that avoided symptom reproduction (neural elongation similar to ULTT positioning). Immediately following these treatments, the patient demonstrated a reduction in symptoms with both cervical and shoulder movement, but no change in ROM. For home exercises, she was also shown supine, passive shoulder stretching for flexion, abduction, and external rotation using a stick.

After the third visit, the patient reported feeling minimal tingling, burning, or pulling in the distal UE and was sleeping without the arm waking her up. Cervical mobilizations were continued, as symptoms associated with the apparent neural irritation were reported to be lessened. Upper extremity neural 'glides' continued to reproduce shoulder symptoms and were not included in her care at this time. She continued her home program of gentle shoulder stretching with a stick and was also given non-painful, active ROM exercises. By the end of the second week, her ability to gain elbow extension with the ULTT 1 had improved to 45° from full extension and to 15° of abduction with the radial biased ULTT 2. These tests no longer reproduced any shoulder symptoms, but still produced distal sensations. By the end of the fifth week, ULTT 1 improved to 30° from full elbow extension and ULTT 2 to 47° of abduction, both equal to the baseline measurements on the uninvolved side. The tests still produced distal sensations and the treatments directed at the spine interface appeared to be providing the desired gains. Thus, distal nerve gliding techniques were still not added. Treatment of the cervical and thoracic spine continued for several more weeks, as there were still symptoms and limitations associated with the ULTT (Table 2). Less treatment time was spent addressing the neural irritation component and the ULTT slowly continued to improve.

During the first week of treatment, thoracic spine manual techniques were also used with a goal of improving local mobility and reducing shoulder²⁵ and cervical pain^{6,24,28-32} and distal complaints.³⁴ Techniques included thrust and non-thrust joint manipulations of the upper and mid-thoracic region (Table 2). She was instructed to continue to work on general postural stretching and strengthening, such as active scapular retraction and gentle, bilateral

shoulder external rotation and horizontal abduction with an elastic band.

During weeks 2–3, the patient demonstrated less neurological irritation, no distal symptoms, and improved range with ULTT positions. Interventions specifically addressing adhesive capsulitis then became the focus. As per Table 1, in week 2, the patient's

passive ROM had not changed more than 10° compared to the initial evaluation. During the third week, passive ROM into flexion increased to 132°, abduction increased to 96°, and ER increased to 25°. Stretching and strengthening were incorporated, as well as GH joint mobilization. Humeral mobilizations (performed near end-range and in multiple directions)

Table 2 Intervention summary emphasis by week

Week	Visits that week	Spine intervention	Glenohumeral/shoulder intervention	Neurodynamic mobility
1	2	<u>Cervical:</u> general traction; low-velocity, mid-range right rotation and transverse glides of ~C5 on C6 in supine <u>Thoracic:</u> Centrally directed low-velocity, mid-range Posterior to Anterior (PA) and transverse glides of mid-thoracic spine in prone followed by high-velocity, end-range rotation thrust directed at T4 on 5 in prone and high-velocity, TJM into flexion directed at upper thoracic spine on mid-thoracic spine. Posture stretching over pillow roll	Begin gentle active/passive ROM and joint traction (Grade II) of GH joint. Included passive shoulder stretching with stick in all planes	None
2	3	Continued as week 1, but less time spent during each session and cervical techniques performed at end-range	Grade II and III GH mobilization including distraction, inferior and anterior glide with arm out of ULTT position. Added gentle self-stretching (PROM) and postural strengthening with elastic band (bilateral external rotation and horizontal abduction)	None
3	3	<u>Cervical:</u> TJM in mid-range, right rotation directed at C3-4-5 in supine <u>Thoracic:</u> TJM as week 1 directed at ~T4-5 and mid-thoracic region	Grade III and IV GH mobilization as week 2. Increased vigor of stretching (more end range holding). Begin shoulder strengthening in cardinal planes with elastic band	None
4	2	<u>Cervical:</u> TJM mid-range right rotation directed at mid-cervical spine on lower cervical spine in supine <u>Thoracic:</u> Repeated flexion TJM upper thoracic spine on mid-thoracic spine in supine. Added supine stretching into extension of mid-thoracic spine over a small wedge	Grade III+ GH mobilization and passive stretch. Continued exercise with progression of stretching and strengthening with more scapular focus (prone retraction with weights). Incorporated resisted shoulder PNF patterns	None
5	1	<u>Cervical:</u> Non-TJM transverse and right rotation directed at C4 on C5 done once <u>Thoracic:</u> Continue self-stretching into extension	Aggressive stretching. Emphasis on strengthening and endurance. Included PNF, elastic band, stretching behind the back and against wall	None
7	1	<u>Cervical:</u> TJM mid-range right rotation directed at mid-cervical spine on lower cervical spine in supine preformed once. <u>Thoracic:</u> TJM mid-range into rotation directed at T4 on T5 in prone	Grade IV GH mobilizations with progressive stretching and strengthening (emphasis included speed along with increased resistance levels)	None
9	1	<u>Cervical:</u> Non-TJM end-range rotation each direction directed at mid-cervical spine on lower cervical spine in supine done once	Grade IV GH mobilizations. Progressed home exercise program	Added distal neurodynamic mobility 'gliding' — ULTT 1
10	1	<u>Cervical:</u> TJM mid-range and non-TJM end-range rotation each direction directed at mid-cervical spine on lower cervical spine in supine done once	Grade IV GH mobilizations. Progressed home program with emphasis on end range strengthening and stretching	Continued mobility exercises, added ULTT 2
12	1	None	Stretch and mobilize GH. Assess home program for discharge	Discharge

Note: TJM: thrust joint manipulation; ROM: range of motion; GH: glenohumeral; PROM: passive range of motion; ULTT: Upper Limb Tension Test; PNF: proprioceptive neuromuscular facilitation.

Figure 2 Initial plan of care. AC: adhesive capsulitis; GH: glenohumeral; UQ: upper quadrant; S/S: signs & symptoms; ULTT: Upper Limb Tension Test; TJM, thrust joint manipulation.

have been shown to be beneficial in improving shoulder ROM.^{4,37} Inferior GH glide initially reproduced distal UE symptoms and, therefore, was not indicated. Once inferior GH glides no longer reproduced local or distal symptoms, they were incorporated into care (Table 2). The patient started a home program for general UE ROM and strengthening using elastic bands and light weights as outlined in Table 2. The patient was advised to avoid any positions or movements that reproduced neural type symptoms. Exercise details are not included here since that is not the focus of this case and models for exercise progression have been described elsewhere.^{1,2,5,15}

Cervical and thoracic manual techniques were continued intermittently, in order to provide symptom relief, reduce irritation, and address local movement restrictions (Table 2). The cervical techniques (side glide, traction, and non-thrust manipulation) were initially performed toward the contralateral side to avoid possible irritation of neural structures. During week 3, the cervical techniques began to include thrust manipulations to address local mechanical restrictions. By the fourth week, remaining mechanical spine limitations were minimal and little time was spent addressing the spine. After week 7, side-bending and rotation toward the involved side were now included since the neural irritation appeared stable and only slight local restrictions remained.

Near the end of the therapy sessions, the patient's symptoms were mildly irritable to neural elongation.

She no longer complained of distal UE tingling, numbness, or heaviness, and any symptoms went away immediately. However, as shoulder ROM increased, some distal UE symptoms were experienced at end ranges of movement. She felt a slight pulling with ULTT 1, with the elbow near 20–30° from full extension and had 50°–60° of shoulder abduction with ULTT 2. Therefore, the patient was given flossing or slider techniques to create movement and gliding of the neural tissues^{12,36,38,39} during the ninth week of treatment. Increasing nerve mobility may reduce pain and sensitivity in the UE with improvements in overall ROM.^{35,38} After performing neural glides for 2 weeks, she had essentially full elbow extension with the ULTT 1 and 50–60° of abduction with ULTT 2, with no symptoms throughout the limb, and was ready for discharge.

Outcomes

The patient made substantial gains in symptom reduction within the first 2 weeks by primarily addressing neurodynamic impairments. These gains allowed subsequent treatment to focus on the shoulder limitations. The patient progressed to the point of return to full activity and function while never missing work. She had near normal shoulder ROM, strength, and function upon discharge with further improvement at the 6-month follow-up. At discharge, and at the 6-month follow-up, the patient demonstrated no distal complaints or sensation changes as well as

normal cervical segmental mobility, shoulder ROM, GH glides, and symmetrical UE strength. Table 1 lists her ROM measurements for the weeks that she was seen in therapy, including the initial visit, at discharge (the twelfth week), and at the 6-month follow-up. The neurodynamic test outcomes show a reduction in neural irritation. Pain ratings dropped from initially 10/10 to 5/10 by the second week and to 2/10 on discharge with no pain reported at the 6-month follow-up. Her initial DASH score was 68.3% disability. At discharge, it was 18.3%, with stiffness and difficulty washing her back noted as the major issues. At the 6-month follow-up, the patient had no disability (0%), as measured by the DASH.

Discussion

This case describes the care of a patient with adhesive capsulitis and associated neural irritation, possibly related to an electric shock episode. The patient had shoulder and distal arm symptoms and may have protected the neural structures by limiting arm movement, possibly contributing to adhesive capsulitis. Interventions initially addressed reducing the neural irritability before beginning aggressive GH mobilization and stretching into her treatment program (Fig. 2). If initial interventions had focused only on shoulder and GH mobilization/stretching, the neural tissues may have remained irritated, possibly worsening the muscle guarding and her overall condition.

During shoulder elevation, the humeral head migrates inferiorly and anteriorly causing nerves to bow-string around the joint and coracoid process.^{3,33} If neural structures are irritated, they may be sensitive to movement and elongation associated with various UE joint positions.^{12,13} In order to prevent further neural irritation, this patient may have developed muscle guarding and avoided provocative motions (reaching up and away from her body). These provocative movements are similar to the ULTT positions, which initially reproduced her symptoms. While standard positions of ULTT could not be attained due to joint restrictions, modifications of the tests were easily performed. During these tests, shoulder positions producing neural symptoms were avoided and distal joint positions (wrist and hand) were modified to assess neural involvement, as demonstrated in Fig. 1.

The nervous system influence with adhesive capsulitis has been described previously in the literature.⁷⁻⁹ Wiffen⁹ discusses a possible role of the sympathetic nervous system in adhesive capsulitis, via thoracic spine involvement, leading to a heightened state of neural sensitivity. Simotas and Tsairis⁷ reported an adhesive capsulitis case that appeared to be related to an underlying neurological disorder, cervical spine amyotrophy. They emphasized that it is critical to determine the presence and extent of neural

sensitivity with adhesive capsulitis in order to develop the appropriate plan of care. Laska and Hannig⁴⁰ described an adhesive capsulitis case following an injury to the spinal accessory nerve post-carotid endarterectomy. The neural injury led to altered cervical and scapular mechanics resulting in shoulder pain with the subsequent development of adhesive capsulitis. Treatment included shoulder ROM, but also focused on cervical and scapular muscle re-education, which led to subsequent resolution of the adhesive capsulitis symptoms. Therefore, the upper quarter should be screened with adhesive capsulitis to rule out cervical spine or neurological contributions.^{1,3,5,7-10,40}

This patient had shoulder and UE symptoms with neurodynamic testing and sensitizing maneuvers. She met the criteria for a positive upper-limb neurodynamic test indicating the presence of peripheral neural pain as outlined by Nee *et al.*²² Neurodynamic tests can be an excellent indicator of neural tissue involvement in the upper quadrant.^{12,20-23} Frequently upper quadrant neural irritation arises from mechanical trauma,^{41,42} but this case describes another potential mechanism, electrical shock. The body can act as a volume conductor when electrical current passes through it. In these cases, peripheral nerves are often impacted since they traverse the length of the limb and have lower resistance⁴³ and higher electrical conductivity.^{41,44} Cell membranes exposed to electricity may experience increased current conductivity and cell membrane permeability (electroporation). Inadvertent electrical current applied to human tissue may cause excessive electroporation and thermal effects resulting in nerve and other tissue trauma.^{41,44} Fan *et al.*⁴¹ reported adherence of neural tissue to surrounding tissues after electrical shock in rats. Given these factors, it is possible that this patient may have had neural irritation related to a mild shock event. Even if this did not directly relate to the adhesive capsulitis, addressing the neural irritation was apparently critical to successful management of this patient.

Cervical traction, transverse glides, and contralateral rotation were used initially to reduce neural irritation. Treatment of the proximal interface has been shown to be effective in conditions with neural irritation, such as carpal tunnel syndrome³⁸ and lateral epicondylitis.^{21,35,36,39} McClathrie *et al.*²⁶ demonstrated improved pain and shoulder abduction ROM following a seated cervical lateral side-glide. Coppieters *et al.*²¹ performed lateral cervical glides to the mid-to-lower cervical spine (C5-7) and any restricted segments with neurogenic cervicobrachial pain. His techniques produced immediate gains in ROM of nearly 20° on the ULTT following the lateral glides when compared to ultrasound.

McCormack⁶ and Wiffen⁹ demonstrated the importance of addressing the thoracic spine in cases of

adhesive capsulitis. McCormack⁶ describes a case where thoracic spine manipulation produced significant improvements with adhesive capsulitis. Wiffen⁹ details how thoracic spine interventions may affect the sympathetic nervous system and produce changes in adhesive capsulitis. Manual therapy was utilized with this patient to impact any mechanical limitations that were present in the cervical and thoracic region.

A key factor of this case was the timing and aggressiveness of the intervention directed specifically at the shoulder or GH joint. Early aggressive intervention to gain GH mobility and shoulder ROM without consideration for the neural irritation may have impeded improvement or worsened the condition. GH joint glides, particularly inferiorly directed glides, are commonly utilized with these patients,^{2,4,5,36} often at end range and at a 'high, sometimes painful, intensity'.^{1,37} These techniques may have led to further symptoms and guarding. In cases of adhesive capsulitis, shoulder manipulation is considered if there is lack of progress. Patients, under the influence of anesthesia or with a nerve block, may demonstrate immediate ROM improvements. Karatas⁴⁵ noted significant gains in shoulder motion after nerve blocks in patients diagnosed with adhesive capsulitis. Kelley *et al.*⁵ report anesthetized patients who immediately gained 10–30°, reportedly due to diminished muscle guarding and pain. Early in her care, aggressive stretching and GH mobilization were considered inappropriate until the neural irritation was minimized. Then, GH capsule tightness and restriction of glides could be addressed and the patient progressed accordingly.

Limitations of this case include the following issues. Although the patient had positive outcomes, a direct relationship between the neural irritation, cervical limitations, and adhesive capsulitis cannot be made. This patient may have had similar outcomes and gains with interventions which initially targeted other tissues, such as the GH joint only. Improvements may also have been due to factors unrelated to the physical therapy care, such as the medication or passage of time; however, improvements within and between sessions seemed to support the working hypothesis. The assumption that the changes were related to a reduction in neural irritation may also have been more directly related to interventions addressing the spinal limitations.

In summary, this patient with adhesive capsulitis had neural irritation, as determined through neurodynamic testing. Clinicians are encouraged to use modified ULTT maneuvers to determine if there is co-existing neural involvement in patients with adhesive capsulitis or similar upper quadrant conditions. Interventions directed at the cervical spine (interface) were used initially to address the neural

irritability in this case. Subsequent interventions could then be directed at the shoulder and GH joint without further aggravation of symptoms. Outcomes over the 12 weeks included significant pain reduction, improved shoulder and cervical ROM, and improved DASH scores.

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