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CASE SERIES

# STRENGTH EXERCISES COMBINED WITH DRY NEEDLING WITH ELECTRICAL STIMULATION IMPROVE PAIN AND FUNCTION IN PATIENTS WITH CHRONIC ROTATOR CUFF TENDINOPATHY: A RETROSPECTIVE CASE SERIES

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## ABSTRACT

***Background and Purpose:*** Rotator cuff tendinopathy (RTCT) is regularly treated by the physical therapist. Multiple etiologies for RTCT exist, leading an individual to seek treatment from their provider of choice. Strengthening exercises (SE) have been reported to be effective in the treatment of RTCT, but there is limited evidence on the effectiveness of dry needing (DN) for this condition. The purpose of this retrospective case series was to investigate DN to various non-trigger point-based anatomical locations coupled with strengthening exercises (SE) as a treatment strategy to decrease pain and increase function in healthy patients with chronic RTC pathology.

***Case Descriptions:*** Eight patients with RTCT were treated 1-2 times per week for up to eight weeks, and no more than sixteen total treatment sessions of SE and DN. Outcomes were tested at baseline and upon completion of therapy. A long-term outcome measure follow up averaging 8.75 months (range 3 to 20 months) was also performed. The outcome measures included the Visual Analog Scale (VAS) and the Quick Dash (QD).

***Outcomes:*** Clinically meaningful improvements in disability and pain in the short term and upon long-term follow up were demonstrated for each patient. The mean VAS was broken down into best ($VAS^{B}$), current ($VAS^{C}$), and worst ($VAS^{W}$) rated pain levels and the mean was calculated for the eight patients. The mean $VAS^{B}$ improved from 22.5 mm at the initial assessment to 2.36 mm upon completion of the intervention duration. The mean VASC improved from 28.36 mm to 5.0 mm, and the mean $VAS^{W}$ improved from 68.88 mm to 13.25 mm. At the long-term follow up (average 8.75 months), The mean $VAS^{B}$, $VAS^{C}$, and $VAS^{W}$ scores were 0.36 mm, 4.88 mm, and 17.88 mm respectively. The $QD^{mean}$ for the eight patients improved from 43.09 at baseline to 16.04 at the completion of treatment. At long-term follow-up, the $QD^{mean}$ was 6.59.

***Conclusion:*** Clinically meaningful improvements in pain and disability were noted with the intervention protocol. All subjects responded positively to the intervention and reported quality of life was improved for each subject. The results of this case series show promising outcomes for the combination of SE and DN in the treatment of chronic RTCT.

***Level of Evidence:*** Level 4

***Keywords:*** Dry needling, rotator cuff tendinopathy, shoulder pain

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## BACKGROUND AND PURPOSE

Shoulder pain is a common condition treated by Physical Therapists (PTs). It is the third most common condition treated by PTs following low back pain and neck pain.[1] In the year 2000, the direct costs for the treatment of shoulder dysfunction in the United States totaled $7 billion.[2] Shoulder pain occurs as a result of of many different etiologies, and according to Magarey et al, the ability of a PT to accurately diagnose specific pathology in the clinic was inconsistent at best when compared to arthroscopic findings.[3] Add this information to the lack of evidence supporting a specific exercise protocols and various "manual therapy" techniques to properly prescribe a rehabilitative program in the treatment of various shoulder conditions, evidence-based rehabilitation prescriptions unfortunately are scarce at best.[4-9] In this age of evidence-based practice, therapists must have a foundation in best evidence to treat one of the most common conditions seen clinically.

The rotator cuff (RTC) performs multiple functions during shoulder movements, including glenohumeral abduction (ABD), external rotation (ER) and internal rotation (IR). The RTC also provides stability to the glenohumeral joint and controls translation of the humeral head. The infraspinatus and subscapularis muscles play major roles when the shoulder is abducted in the scapular plane, generating forces that are two to three times greater than supraspinatus force.[10] The supraspinatus still remains more effective in ABD of the humerus due to having a more effective moment arm.[10] The deltoid muscle and RTC provide significant ABD torque, and these forces are generated not only to ABD the humerus, but also to stabilize the glenohumeral joint and counter the antagonistic muscle actions or compensatory actions when pain or weakness is present.[10] Relatively high force from the rotator cuff not only helps ABD the shoulder but also neutralizes the superiorly directed force generated by the deltoids at lower abduction angles.[10] This all plays an important role when the RTC is kinematically out of sync due to pain and/or weakness associated with RTC tendinopathy, especially once this condition becomes chronic and compensatory activities of the shoulder complex become the preferred movement pattern employed by the body.

Dry needling (DN) research continues to be sought in the therapy community regarding its effectiveness as a treatment strategy for various conditions. Currently, there is a paucity of randomized control trials (RCT) that exists investigating the effectiveness of DN used with electrical stimulation for treatment of shoulder RTC tendinopathy. According to a recent case series, no recent systematic reviews regarding the effectiveness of dry needling for trigger points (TrPs) and myofascial pain syndromes have noted positive clinical responses to DN interventions.[11] Rha et al investigated plasma-rich-platelet (PRP) injections versus DN with ultrasound guided injections into the supraspinatus tendon and found both had positive outcomes with regard to function and symptom relief (though PRP was superior at six months for symptomatic relief and functional improvement).[12] To date, the majority of the studies examining the effectiveness of DN intervention have focused on TrP issues as the origin of pain.[13-62] Among the DN studies published, few have looked at the effectiveness of DN outside of the TrP realm. Therefore, it seems researchers have neglected to look at the musculo-tendinous and osseo-tendinous junctions of the RTC for DN intervention, which is what clinicians are typically attempting to influence with exercise and manual therapy interventions, versus regularly focusing on treating TrP's for shoulder pain.

Fenwick et al presented the following important information, specific to this case series, regarding the vascularity of tendons: 1) mature tendon are poorly vascularized and rely more on synovial fluid diffusion than vascular perfusion for nutrition; 2) vessels at the tendon-bone insertion anastomose with vessels of the periosteum, forming a indirect link with the osseous circulation; and 3) grafted tendons, after lengthy periods of time, are histologically identical to the original tendon.[63] It has been long though that the supraspinatus, in particular has a specific de-vasdcularized region, which could be the reason for it's implication in a majority of RTC pathologies, but evidence has since questioned the validity of this thought process. [63] The vascular supply to tendons has been demonstrated to arise from three specific regions: the musculotendinous junction; the tendino-osseous junction; and vessels from the surrounding tissues including the paratenon, mesotenon, and the vincula.[63] If this is the case, it stands to reason that DN to the musculotendinous and tendino-osseous junctions could play a

role in pain mitigation and healing of chronic RTC tendinopathies.

Both myofascial DN and TrP-DN terminology is commonly being used to denote DN intervention, yet DN is not just limited to myofascial pain or TrP intervention.[11] DN is commonly used for the treatment of myofascial pain and TrPs, but may also be beneficial to treat peri-neural conditions, intramuscular conditions, symptomatic scar tissue and other various conditions that might benefit from the use of DN.[11,12,64] Given the paucity of evidence for the use of DN that is not TrP directed, there is a need for the documentation and presentation of clinically relevant interventions that can assist in the treatment of chronic RCT pain. The purpose of this retrospective case series was to investigate DN to various non-TrP-based anatomical locations coupled with strengthening exercises (SE) as a treatment strategy to decrease pain and increase function in healthy patients with chronic RTC pathology.

## CASE DESCRIPTIONS

The case series included eight patients with chronic rotator cuff tendinopathy of duration > 90 days. A retrospective review of patients for this case series included those patients who performed the exact protocol chosen for this case series, which the author does not always use for every person to avoid "cookie cutter" therapy. There were no specific inclusion/ exclusion criteria, as would be used for a randomized control trial.

All eight patients were regularly engaged in exercise of some type for health and social engagement at least four times per week. Subjective questions were asked of each patient, and included thorough questioning about sleep deficit due to pain, limitations in lifting/ reaching, exercise limitations, and impaired self-care abilities due to pain, such as dressing and bathing, to provide the author with an idea of self-reported functional limitations. A review of patient histories found several common functional deficits including difficulty sleeping due to pain caused by rolling onto the affected side, limited functional use of the involved upper extremity with exercise and lifting items such as a gallon of milk due to pain and strength deficits, and other various self-care activities. The patients were all in good relative health without serious underlying pathology. A few of the patients had been previously treated by physicians and physical therapists for interventions including, but not limited to: corticosteroid injections and/ or "traditional" physical therapy interventions including stretching and exercise activities, light and deep friction tissue mobilization (such as cross-friction massage/ myofascial release techniques), and therapeutic ultrasound. All had taken or were currently taking over-the-counter NSAIDs for pain mitigation. Patients had not been treated for at least two months prior to the intervention for this retrospective case series. Temporary relief was reported with the previous treatment strategies, but pain had not been eliminated and there was no long-term improvement per subjective reports by each of the patients. Informed consent to participate in the series was retrospectively obtained from the patients. Human subjects research review was not required for this case series. Patients were advised that all HIPPA protected health information standards would be upheld and none of their identifying information would be released per the policies and procedures of the clinic where the treatment was performed.

## CLINICAL IMPRESSION 1

Given the fact all eight patients had 1) previous treatment consisting of SE (either self treatment or therapist-guided), and 2) chronic shoulder pain since that time, the patients were considered appropriate for inclusion in the case series to examine the effectiveness of adding DN to a SE program. An examination of each patient was initially performed prior to intervention, in order to assess common functional limitations, strength deficits, upper extremity use limitations, and to rule out serious neurovascular pathology that might require referral to another medical specialist based upon findings. These examinations were performed before the retrospective review of subject charts for inclusion in this case series.

## EXAMINATION

Examination took place at baseline, and upon completion of the therapy intervention period. The number of treatment sessions and duration of treatment depended on each patient's response to the intervention. The number of treatment sessions ranged from four to eight. Treatment was not rendered > eight

weeks due to maximal measureable improvement being attained by each patient during that time frame.

Posture and upper extremity active range of motion (AROM) was assessed in standing and sitting and compared bilaterally. Posture assessment included observation of cervical and thoracic curvature and head positioning at rest, scapular positioning, and, scapulothoracic kinematics with AROM in abduction and flexion. Physical examination of each of the patients revealed an exaggerated flexed position of the mid to lower cervical spine and exaggerated extension of the upper cervical spine. AROM of the involved upper extremity in all eight patients showed a "painful arc" sign ranging between 70 to 125 degrees of shoulder abduction, though AROM was normal in all eight patients. No other postural abnormalities were noted.

Bilateral upper extremity (BUE) strength was assessed via manual muscle testing. Global bilateral UE MMT of each of the eight patients was normal (5/5) except for abduction and external rotation, which was found to range from 3+/5 to 4/5 for abduction, and 3+/5 to 4-/5 for external rotation in each of the patients. Pain was reported by each of the patients with MMT in combined ABD and ER.

An upper quarter neurological examination was performed to screen each patient for symptoms of spinal origin. This included dermatomal, myotomal, and deep tendon reflex (DTRs) examination. Dermatomal testing assessed light touch sensory palpation to the upper extremities. Myotomal testing was assessed via MMT of the upper extremities. DTRs were assessed via testing of the C5, C6, and C7 nerve roots in bilaterally and were found to be normal in all patients. Radiculopathy testing included Spurling's for radiculopathy (SP = .95, SN = .93, +LR = 18.6), Centralization for discogenic origin (SP = .94, SN = .40, +LR- 6.7), and Passive Accessory Intervertebral Movement (PAIVM) palpation for zygaphophyseal joint pain syndromes (SP = .81, SN = .94, +LR = 4.9)[65]. There were no neurovascular or cervical syndrome abnormalities noted.

Special testing included tests for determining shoulder pain origin as proposed in a systematic review by Biederwolf.[66] Biederwolf suggested that using the internal rotation manual muscle test (IRMMT) and external rotation manual muscle test (ERMMT) at 90 degrees abduction and 80 degrees external rotation can help determine if the shoulder pain origin is of RTC, intra-articular, or extra-articular origin. Special tests for ruling in/out a partial rotator cuff tear (PRTC) followed a recommended shoulder special test algorithm for clinical diagnostic accuracy. PRTC tear of the supraspinatus, infraspinatus, and teres minor were ruled out via the IRMMT < ERMMT and a negative External Rotation Lag Sign (SP = .98, SN = .69-.98, +LR = 15.5- 34.5) and negative Hornblower's Sign (SP = .93, SN = 1.0, +LR = 14.29). Subscapulis tears were ruled out with a negative internal rotation lag sign (SP = .96, SN = .97, +LR = 24.3).

Subacromial impingement syndrome (SAIS) was assessed via the Biederwolf cluster as follows: IRMMT > ERMMT, 1) Painful Arc Sign, 2) Hawkins-Kennedy Test, and 3) Infraspinatus MMT. If all of three of these tests are (+), there is a +LR = 5.03 and a post-test probability (PTP) = 95% (91% if 2/3 are positive). According to Park et al, the Painful Arc Sign is the most sensitive (73.5%) and the infraspinatus MMT was the most specific (90.1%).[67] Internal impingement was ruled out with a (-) ERMMT > IRMMT and (-) Posterior Impingement Sign according to Biederwolf. If both of these tests are (+), there is a PTP nearing 100%, and if both are (-), there is a 2.5% chance of having internal impingement.

Labral pathology special testing lacks high quality clinical test clusters according to Hegedus et al, and according to Jones et al, thus superior labral anterior-posterior (SLAP) specific physical examination results cannot be used as the sole basis for a SLAP lesion diagnosis.[68,69] Given this information, a newer combination of individual tests per Biederwolf was used to rule out SLAP pathology, and this combination included a (-) Biceps Load I Test (SP = .97, SN = .90, +LR = 30), and a (-) Biceps Load II Test (SP = .97, SN = .90, +LR = 30). According to Biederwolf, the psychometric properties of long head of the biceps (LHB) testing is not clinically useful, hence the author used palpation of the LHB to determine pain in this region.

Partial RTC tears, subscapular tears, internal impingement, and SLAP tears were ruled out based on the examination results. A few of the patients were (+) for SAIS and all reported significant tenderness to palpation in the proximal biceps tendon region in the anterior shoulder. It was determined from the examination that the origin of all eight of the patients' non-specific

shoulder pain (NSSP), likely had a RTC (supraspinatus and/ or Infraspinatus/ Teres Minor) tendinopathy component based upon examination synthesis.

## CLINICAL IMPRESSION 2

Based upon examination findings, all eight patients were deemed appropriate to receive the intervention described in the "Intervention" section of the case series. There were no contraindications that would preclude any of the eight patients from receiving DN with electrical stimulation and SE. All patients reported no previous limitations in sleep, lifting/ reaching, or general self-care function prior to the onset of their shoulder pain. All eight patients had ongoing shoulder pain affecting their daily activity tolerance and sought long-term pain relief, which they had not received with prior treatment. Progressive shoulder pain coupled with negative contraindications for DN intervention made the patients appropriate for DN to be performed.

## OUTCOME MEASURES

The outcome measures used in this case series were the Visual Analog Scale (VAS) and the Quick DASH (QD), and are reported in Table 1 and Table 1a. The VAS is a 100 mm scale where the patient marked a line at the area most closely associated with their respective pain levels. At baseline, the mean VAS for "best, current, and worst" level scores was 22.5, 28.36, and 68.88 (out of 100) respectively. The VAS has moderate to good reliability (correlation coefficient 0.60-0.77)[70] to detect disability and high reliability for pain (correlation coefficient 0.76-0.84).[71] The minimal clinical significant change has been reported to be 11 points (mm) on a 100 point (mm) scale.[70]

The QD was used to assess functional disability. The higher the recorded score, the greater the disability the patient experienced. The QD is a quick and reliable patient self-report functional outcome tool that can be easily completed and demonstrates good test- retest reliability (0.90) and responsiveness in patients with shoulder pain.[72] The minimal clinically important difference (MCID) was found to be 8 points, and the minimal detectable change (MDC) was found to be 11 points.[72,73] At baseline, the mean QD score for all subjects was 43.09 points.

## INTERVENTION

The patients were treated for one to two times per week for up to eight weeks, and no more than sixteen total treatment sessions. Patients were treated

**Table 1.** *Outcome Measure Scores at Baseline and Upon Completion of Treatment*

| Outcome Measure | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 | Subject 8 |
|---|---|---|---|---|---|---|---|---|
| **QD** *Initial* | 68.18 | 90.0 | 25 | 28.36 | 21.15 | 50 | 18 | 43.09 |
| **QD** *Final* | 34.09 | 47.72 | 15.90 | 0 | 0 | 4.50 | 0 | 26.09 |
| **QD** *Follow Up* | 0 | 34.1 | 15.90 | 0 | 0 | 6.81 | 2.27 | 18.20 |
| **VAS** *(mm)* ***Initial:*** | | | | | | | | |
| Best | 81 | 43 | 0 | 56 | 0 | 0 | 0 | 0 |
| Current | 81 | 72 | 11 | 30 | 0 | 0 | 0 | 33 |
| Worst | 100 | 90 | 43 | 68 | 62 | 61 | 54 | 73 |
| **VAS** *(mm)* ***Final:*** | | | | | | | | |
| Best | 11 | 2 | 0 | 6 | 0 | 0 | 0 | 0 |
| Current | 22 | 3 | 9 | 6 | 0 | 0 | 0 | 0 |
| Worst | 44 | 10 | 32 | 7 | 0 | 2 | 1 | 10 |
| **VAS** *(mm)* ***Follow Up:*** | | | | | | | | |
| Best | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Current | 0 | 21 | 4 | 7 | 7 | 0 | 0 | 0 |
| Worst | 0 | 48 | 27 | 7 | 15 | 3 | 3 | 40 |

QD= Quick DASH
VAS= Visual Analog Scale

**Table 1a.** *Outcome Measure Means for All Subjects*

| Outcome Measure | Mean for 8 Subjects |
|---|---|
| **QD** *Initial* | 43.09 |
| **QD** *Final* | 16.04 |
| **QD** *Follow Up* | 6.59 |
| **VAS** *(mm)* | |
| ***Initial:*** | |
| Best | 22.5 |
| Current | 28.36 |
| Worst | 68.88 |
| **VAS** *(mm)* | |
| ***Final:*** | |
| Best | 2.36 |
| Current | 5 |
| Worst | 13.25 |
| **VAS** *(mm)* | |
| ***Follow Up:*** | |
| Best | 0.36 |
| Current | 4.88 |
| Worst | 17.88 |

QD= Quick DASH

VAS= Visual Analog Scale

with a specific exercise protocol outlined in Appendix A and Table 2, and a five-point DN protocol to the involved shoulder focusing on pain mitigation. The SE protocol was prescribed based on exercises provided in two studies, which suggest evidence-based exercises for improving RTC, deltoid, and scapular strengthening important for optimal shoulder complex kinematics.[10,74] Patients performed three sets of 15 repetitions for each exercise, with a weight that was reported by each patient to cause significant fatigue and muscular burning during the last three to four repetitions of each exercise. Resistance was provided in the form of hand weights (dumbbells) and an exercise cable machine.

During the DN intervention, patients were positioned seated in a chair with the involved upper extremity resting at their side and the hand on the thigh. The following structures were treated: (1) supraspinatus musculo-tendinous junction at the humeral head; (2) supraspinatus anterior and (3) posterior teno-osseous junctions on the greater tuberosity; (4) supraspinatus teno-osseous junction in the muscle belly at the supraspinous fossa; and (5) the deltoid teno-osseous insertion at the deltoid tuberosity. The location of the needles were determined based on the author's DN training and clinical experience with the performance of DN for shoulder pain, and this has become a semi-standardized approach to the application of DN for this condition in the author's private practice. Each patient performed the SE program exactly as listed in Table 2 prior to DN, without variation from one patient to the next.

The needles used in this case series were solid monofilament Seirin J-type sterile needles (Seirin Corp., 1007-1 Sodeshi-Cho, Shimizu-ku, Shizuoka-shi, Shizuoka 424-0036 Japan), 0.30 diameter (DIA) x 50 mm. and 0.25 DIA x 30 mm. Needles were held in the therapist's dominant hand for application and manipulation of the needle within the tissue. Before needle insertion, an application of 70% isopropyl alcohol was performed to the areas and allowed to dry for a least ten-seconds, which reduces the resident micro-flora of the skin by 80-91%.[75] All DN interventions were performed according to the Dry Needling Institute (DNI) of the American Academy of Manipulative Therapy (AAMT) Fellowship training program.[75] Periosteal pecking to the humerus in various teno-osseous regions was used to attempt to elicit pain relief at the RTC and deltoid attachments throughout the shoulder complex. The electrical stimulation unit used to apply current to the needles was an AWQ-104L digital electro-acupunctoscope, four-channel, eight-lead device (Lahasa OMS, 230 Libbey Parkway, Weymouth, MA 02189). The use of electrical stimulation applied to the needles was performed according to the following parameters outlined by the DNI:[75] 2 Hz, 250 microseconds, running continuously for twenty minutes in the form of an asymmetric biphasic square wave at an intensity described by the patients as "mild to moderate". Call bells were left with each patient receiving DN.

Needle insertion points are described in Figure 1 and shown in Figure 2. Manual needle manipulation was utilized after needle insertion, including periosteal pecking and clockwise needle winding. After 10 "periosteal pecks" at bony attachments, the needles were wound clockwise to attain needle grasp between the needle and soft tissue, and left in-situ for 20 minutes.

## OUTCOMES

The demographic characteristics of the patients are outlined in Table 3. All patients subjectively reported improvements in sleep. The efficacy of DN was

**Table 2.** *Strengthening Exercise Protocol*

| Variable | Intervention | Dosage | Illustration(s) |
|---|---|---|---|
| **Strengthening Exercise Activities** | 1. Side-lying ER w/ Towel Roll<br>2. Supine Serratus Punch<br>3. Prone Horizontal Shoulder ABD at 100°FLEX & 10° ER. (V's)<br>4. Standing Shoulder FLEX (I's)<br>5. Standing Shoulder ABD (T's) with 10° ER.<br>6. Standing Full Can (V's) with 10° ER.<br>7. Standing Machine Shoulder EXT 90-0.<br>8. Standing Machine Rowing<br>9. Machine IR at 20° ABD.<br>10. Machine ER at 20° ABD.<br>11. Machine D1 FLEX & EXT.<br>12. Machine D2 FLEX & EXT. | 3 sets x 15 reps for all interventions. | See Appendix A for images of all exercises utilized in the case series. |

ER= external rotation; ABD= abduction; FLEX= flexion; IR= internal rotation; EXT= extension

assessed by pain response(s), MMT improvement, disability level as reported by the QD, and through subjective reports of improvement in the patient's general daily activity and sleep tolerance. At baseline and upon completion of the intervention, pain and disability were assessed via the VAS and QD outcome measures. Strength of the abductors and external rotators in all eight patients improved to 5/5. The results of these outcome measures are shown in Table 1. Means of the outcome measure scores were used to measure the overall improvement in pain and disability levels, as this gives a general representation of improvement between the eight patients. Each patient met the MCID and MDC for the QD as shown in Table 1. The final QD scores upon completion of the intervention ranged from 0 to 47.72 points versus the initial range of 18 to 90.9 points. The mean improvement between the eight patients demonstrated a mean improvement from 43.09 at baseline to 16.04 at completion of treatment, which is well above the MDC/ MDIC indicating clinically meaningful improvement. At long term follow up, obtained by calling the patients during preparation of the case series (average of 8.75 months after completion of the treatment sessions); the QD average score was 6.59.

The VAS scores were broken down into reported best ($VAS^{B)}$), current ($VAS^{C)}$), and worst ($VAS^{W}$) levels. Individual VAS ranges were as follows: $VAS^{B}$ at baseline, scores ranged from 0 mm to 81 mm and improved to a range of 0 mm to 11 mm at completion of treatment. The $VAS^{C}$ ranged from 0 mm to 81 mm and improved to 0 mm to 22 mm upon completion. The $VAS^{W}$ scores at baseline ranged from 43 mm to 100 mm and improved to 0 mm to 44 mm upon completion. Means were then calculated to average the eight patient's raw scores for ease of interpretation. The mean $VAS^{B}$ score improved from 22.5 mm to 2.36 mm (at completion of treatment). The mean $VAS^{C}$ improved from 28.36 mm to 5.0 mm. The mean $VAS^{W}$ improved from 68.88 mm to 13.255 mm.

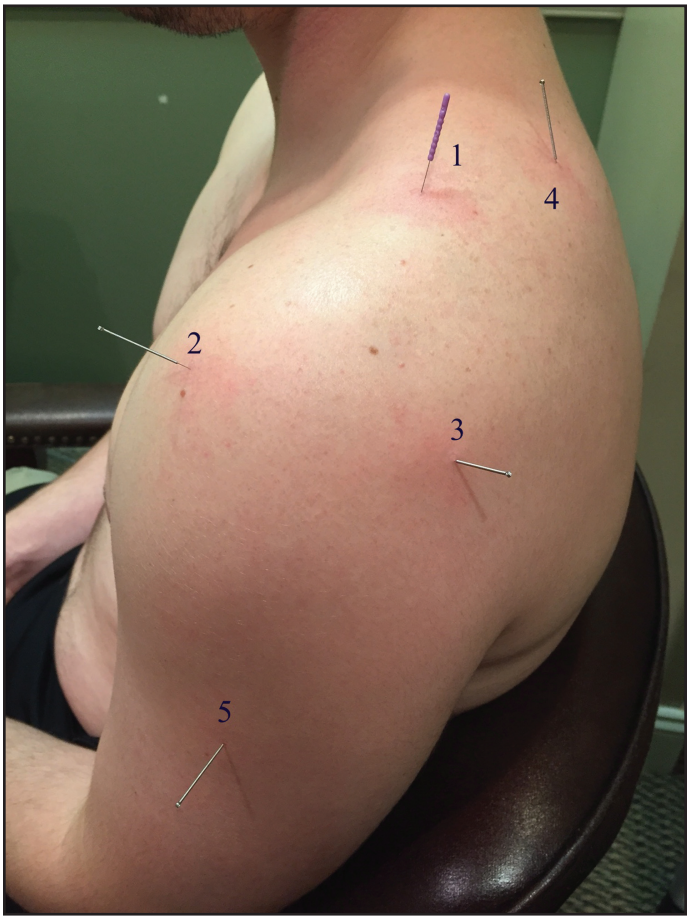


**Figure 1.** *Legend (DN Placement).*

| Needle Number | Location |
|---|---|
| 1 | 1.5 fingerbreadths medial to the medial acromial border angled inferior and slightly laterally. |
| 2 | Anterior "eye" dimple on the greater tuberosity (found by ABD the shoulder to 90 degrees). |
| 3 | Posterior "eye" dimple on the greater tuberosity (found by ABD the shoulder to 90 degrees. |
| 4 | 1 fingerbreadth superior to the midpoint scapular spine angled inferior and posterior. |
| 5 | Deltoid tuberosity attachment on the Humerus. |

At follow up, the mean $VAS^{B}$ was 0.36 mm, the mean $VAS^{C}$ was 4.888 mm, and the mean $VAS^{W}$ was 17.88 mm. All eight patients verbally reported subjective reports of improved sleep, significantly less pain with activities such as grabbing a gallon of milk form the refrigerator, and general improved tolerance to daily activities such as self care/ dressing activities upon completion of treatment, and at the follow-up. Sleep, lifting/ reaching, and general self-care activity limitation was noted as limited prior to initiation of treatment. At the long-term follow up, there were no significant reports of functional limitations reported by any of the eight patients.

## DISCUSSION

Clinical results were positive, indicating improvements in pain and disability per the outcome measures used in this retrospective case series. Patient reports of improved sleep, reaching/ lifting ability, and general self-care activity tolerance was also reported at follow up. All patients demonstrated improvements strength, which allowed them to return to independent exercise activities without limitation from shoulder pain, where a lack of ability to exercise was a common report prior to intervention.

Justification for DN to tendinous junctions, was supported by the following concepts: poor tendon vascularization, vessel anastomosis at the tendon-bone, and grafted tendons becoming histologically identical to the original tendon.[63] DN techniques such as needle winding may have a local and/ or remote therapeutic effect based on mechanical coupling of connective tissue and the needle, thereby causing a "downstream" pain modulating effect (from the central nervous system to the periphery) on the generation of a mechanical signal caused by needle grasp pulling.[75] These downstream effects may include cell secretion, modification of extracellular matrix, enlargement and propagation of the pain signal along connective tissue planes, and afferent input modulation by changes in the connective milieu.[76-79] Considering the idea that the supraspinatus has a specific devascularized region, and the vascular supply to tendons has been demonstrated to arise from multiple structures, implications for DN to the tendinous regions of RTC structures appears to be a legitimate area for further investigation[63]

It should be noted that studies comparing the use of DN with and without electrical stimulation should be performed in the future, as there are no current studies examining DN alone vs. DN with electrical stimulation in the treatment of chronic RTC tendinopathy. There is a good deal of evidence for the use of electrical "acupuncture" in the literature, but minimal evidence for DN alone without the use of electrical stimulation, hence, the author's clinical experience determined the use of electrical stimulation to be an effective adjunct to dry needling. There is also a lack of quality evidence to support specific exercise protocol for the rehabilitation of this condition, so the use of an evidenced-based exercise pro-

**Table 3.** *Demographic Characteristics of Patients with Chronic RTC Tendinopathy*

| Subject | Age (years) | Sex | Time Since Onset (days) | Number of Treatment Sessions Attended Weeks 1 4 | Number of Treatment Sessions Attended Weeks 5 8 |
|---|---|---|---|---|---|
| **1** | 63 | M | > 90 days | 6 | 0 |
| **2** | 59 | F | > 90 days | 9 | 6 |
| **3** | 73 | M | > 90 days | 8 | 2 |
| **4** | 29 | M | > 90 days | 3 | 0 |
| **5** | 63 | M | > 90 days | 6 | 1 |
| **6** | 78 | F | > 90 days | 7 | 1 |
| **7** | 39 | M | > 90 days | 7 | 2 |
| **8** | 41 | M | > 90 days | 5 | 2 |
| **Average** | 55.62 | | | 9.75 | 1.75 |

tocol is necessary to guide Physical Therapists in the rehabilitative process for this condition.

There are limitations to case series such as this. There was a small sample size (n = 8). This is an inherent limitation to a case series, though results are more clinically meaningful than a single case report based on having more patients in the series. Given the lack of randomization and no specific inclusion or exclusion criterion, only descriptive outcomes can be reported, and statistical analysis cannot be inferred or provided, thus the level of evidence remains low. The small sample size also makes generalization of the intervention difficult. Also, all eight patients performed SE that may have contributed to the overall positive outcomes, which makes it difficult to determine how much of the improvements were specifically attributable to DN with electrical stimulation, and how much was attributable to the exercise program prescribed. The clinical results were positive, indicating the selected intervention shows promise as a treatment strategy for chronic RTC tendinopathy. Larger randomized control studies looking at DN interventions need to be performed in order to fully assess the effectiveness of DN as an intervention strategy for chronic RTC tendinopathy. Further research is recommended in order to determine if DN with or without electrical stimulation and SE's is clinically beneficial for RTC tendinopathy. There is a fair amount of evidence in support of thrust manipulation to the cervical spine, thoracic spine, and ribs for shoulder pain, and this may be another area of research from a manual therapy approach to include with DN.[80-89] Another area of further research should also compare the use of DN with electrical stimulation versus DN alone.

## CONCLUSIONS

SE and DN were tolerated well by the patients, demonstrating improvements in pain and function, without significant adverse effects. Given the clinically meaningful reduction in pain and improvements in reported function, the addition of DN to SE for NSSP etiologies shows promise. Future higher-level research is needed to fully explore the effectiveness of DN for chronic RTC tendinopathies when compared to traditional interventions.

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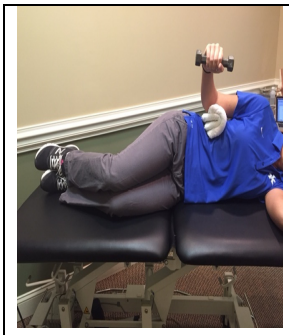
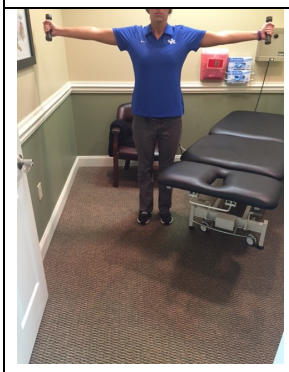
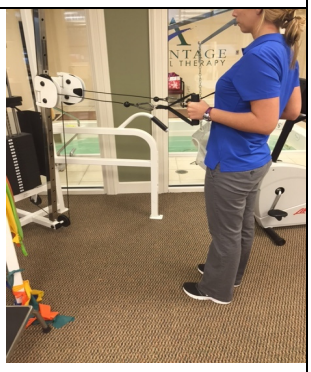
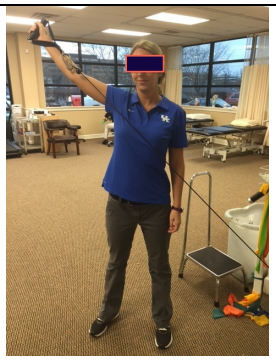
## APPENDIX A

### Images of SE activities

| | | | |
|---|---|---|---|
|  Side-lying ER w/ Towel Roll |  Supine Serratus Punch |  Prone Horiz. Shoulder ABD at 100° FLEX & 10° ER. (Y's) |  Standing Shoulder FLEX (I's) with 10° ER |
|  Standing Shoulder ABD (T's) with 10° ER |  Standing Full Can (V's) with 10° ER |  Standing Machine Shoulder EXT 90-0 |  Standing Machine Rowing |
|  Machine IR at 20° ABD |  Machine ER at 20° ABD |  Machine D1 FLEX & EXT |  Machine D2 FLEX & EXT |