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Original Article

Investigation of the efficacy of dry needling added to physical therapy in supraspinatus tendinopathy

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ABSTRACT

Objectives: In this study, we aimed to investigate the effectiveness of dry needling (DN) in addition to conventional physical therapy and rehabilitation (PTR) program in patients with supraspinatus tendinopathy presenting with shoulder pain.

Patients and Methods: Our study was designed as a single-center, prospective, observational study. Between November 2023 and January 2024, 64 patients diagnosed with supraspinatus tendinopathy were included in our study. The patients were divided into two groups: group 1, in which DN and conventional PTR program were applied together, and group 2, in which only conventional PTR program was applied. Primary endpoint of our study was shoulder pain [visual analog scale (VAS)] and secondary outcome measurements were shoulder pain and disability index (SPADI), passive shoulder range of motion (ROM), handgrip (HG) strength, Tampa kinesiophobia scale (TKS), supraspinatus tendon and muscle thickness. These parameters were evaluated at the beginning, 1st and 3rd months. Independent sample t-test, and Mann-Whitney U test, Kruskal-Wallis H test were used to compare quantitative data. Two-way ANOVA test was used for repeated measurements of the participants.

Results: Significant improvements were observed over time in both treatment groups in pain level, ROM, functional capacity, and other parameters. Patients in group 1 had a statistically significant increase in passive shoulder ROM, muscle thickness and tendon thickness in patients with partial tear at 3 months compared to pre-treatment (all $p<0.05$). There was a significant decrease in VAS scores, SPADI scores, and TKS scores in favor of group 1 (all $p<0.05$). There was a statistically significant increase in HG strength scores at 3rd month in favor of group 1 compared to 1st month ($p=0.029$). There was also a statistically significant increase in supraspinatus tendon thickness in partial tear patients in group 1 ($p<0.001$).

Conclusion: We think that the addition of DN to the conventional PTR program in treatment of patients with supraspinatus tendinopathy is beneficial in terms of both pain and functionality until the 3rd month after treatment.

Keywords: Physical therapy, dry needling, supraspinatus tendinopathy, ultrasonography.

Subacromial impingement syndrome (SIS) is caused by compression of the supraspinatus tendon and subacromial bursa between the humeral head and the coracoacromial arch formed by the acromion, coracoacromial ligament and coracoid process.[1,2] SIS can lead to tendinosis, tendinitis, partial or full-thickness tears of the rotator cuff tendons and ultimately degenerative joint disease of the shoulder girdle joints.[2] Supraspinatus tendinopathies in the SIS are the most common cause of shoulder pain in people over 35 years of age and mainly cause pain and loss of function.[3] The goals in treating supraspinatus tendinopathies, which make up the majority of SIS, are to reduce inflammation and pain, maintain shoulder range of motion (ROM), and prevent progressive pathologic changes. Conservative and surgical treatments are used for this purpose. Conservative treatments include rest, medical drugs, injections, various physical therapy modalities, and exercise.[4] Various conventional physical therapy and rehabilitation (PTR) modalities are available for supraspinatus tendinopathy; superficial heaters (hot-pack, infrared) and deep heaters [ultrasound (US) diathermy], electrotherapy [transcutaneous electrical nerve stimulation (TENS), interferencial current, etc.] are

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applied in combination with exercises and are effective in the treatment.[5,6]

Tendon dry needling (DN) refers to repeated puncturing of the affected tendon, which is thought to disrupt the chronic degenerative process and promote local bleeding and fibroblastic proliferation. The procedure is called DN to emphasize that the procedure does not involve the injection of any substance.[7] The aim of tendon DN is to treat a tendon injury by converting a chronic lesion with a low healing capacity into an acute lesion with a higher healing potential. The mechanism is that the microbleed formed by needling tendinosis or scar tissue releases mediators and growth factors that activate tissue healing.[8] Tendon DN can be used in common sites of tendinopathy.[7] Looking at the literature, there are few studies on DN of tendons. Therefore, primary aim of our study was to investigate the effect of DN in addition to conventional PTR on shoulder pain in patients with supraspinatus tendinopathy. Secondary outcome measures were shoulder ROM, disability, kinesiophobia, handgrip (HG) strength, thickness of supraspinatus tendon and muscle.

PATIENTS AND METHODS

Study design

Our study was designed as a single-center, prospective, observational study. Patients who presented to our outpatient clinic with shoulder pain between November 2023 and January 2024 were selected for the study. Sixty-four patients with supraspinatus tendinopathy diagnosed by clinical evaluation and imaging methods were included in the study by meeting the inclusion criteria. All patients were given detailed information about the study and written informed consent form was obtained from the patients. The study protocol was approved by the University of Health Sciences Türkiye, Ankara Training and Research Hospital Ethics Committee (date: 22.11.2023, no: E-93471371-514.99). This study was conducted in accordance with the principles of the Helsinki Declaration.

Inclusion criteria were patients aged 20-65 years, complaints of pain and/or limitation in one shoulder for at least 3 months, positive results in at least three of the shoulder tests (Hawkins, Neer sign, painful arc test, Jobe, drop-arm test) which were performed by a physician. Hawkins sign: The arm was elevated to 90° and then was forcibly rotated medially. Pain with movement makes the test positive. Neer sign: The scapula was stabilized by the examiner, and the arm was forward flexed by the examiner until the patient reported pain or until full elevation was reached. Pain in the shoulder between 90° and 140° flexion is a positive test. Painful Arc Test: The patient is asked to actively elevate the arm in the scapular plane until full elevation is achieved, and then lower the arm in the same arc. The test is positive if the patient experiences pain or painful catching between 60-120° of elevation.

Jobe test: The physician resists abduction with the arm of the patient elevating to 90° and internally rotating. If the patient gives up, the test is considered positive. Drop arm test: The patient brings his arm into full abduction and then slowly lowers it back in the same axis. If the patient drops his arm quickly or feels pain with this movement, the test is positive.[9]

Other inclusion criteria; no benefit from medical treatment, willingness to participate in the study, evidence of supraspinatus tendinopathy by imaging methods (magnetic resonance imaging and/or US). US imaging was performed by the same physiatrist with at least 3 years of experience in musculoskeletal US, using a 6-11 MHz device (NemioXH, Toshiba, Japan) available at our clinic.

Exclusion criteria were history of trauma, fracture and/or surgery on the same side of the upper extremity, presence of complex regional pain syndrome, entrapment neuropathy, vascular disease, adhesive capsulitis, full-thickness tear of the supraspinatus, calcific tendinitis, presence of musculoskeletal abnormalities, uncontrolled diabetes mellitus, hypertension, severe chronic respiratory disease and/or congestive heart failure, intraarticular, periarticular, or suprascapular block injections and/or physical therapy agents to the shoulder region within the last 3 months, presence of coagulation defects, presence of cervical disc pathology causing radiculopathy, presence of malignancy, neurological and/or inflammatory disease, presence of mental problems or severe psychiatric illness, pregnancy, not volunteering to participate in the study.

Outcome measurements

Demographic and clinical information (age, gender, occupation, educational status, duration of complaint, dominant extremity, type of shoulder pathology, treatment group) were recorded on a standardized form before treatment.

The visual analog scale (VAS) score was used to assess the patients' pain intensity.[10] Patients were asked to rate their pain on a scale from 0 (no pain) to 10 (most severe pain). Separate VAS scores were obtained for pain with motion, at rest, and at night.

Functionality was assessed using the shoulder pain and disability index (SPADI).[11] The SPADI is a scale consisting of two subscales. The pain subscale consists of 5 questions and the disability subscale consists of 8 questions. Three SPADI scores, the pain score (SPADI-P), the disability score (SPADI-D), and the total score (SPADI-T), are calculated as a percentage of the

total score of the responses to the questions. A high score indicates increased pain and impaired shoulder function. A study on the validity and reliability of the SPADI was conducted previously.[12]

Passive flexion, abduction, internal and external rotation of the affected shoulder joint were measured. A goniometer was used to measure passive ROM values. Measurements were taken with the patient in a standing position and the shoulder abducted for rotation measurements.

HG strength on the affected side was measured with a Jamar hand dynamometer in our clinic. During this test, the patient sits in a chair with the shoulder in neutral position and the elbow in 90° flexed position. The patient grasps the device with hand and squeezes with all strength by bringing the fingers closer to the palm. In this way, the amount of force is applied is measured. The measurement is repeated three times and the highest measurement is recorded in kilograms.

Tampa kinesiophobia scale (TKS)[13] which is consist of 17-questions was used to assess fear and avoidance of movement. It is a Likert scale with a maximum of 4 points and a minimum of 1 point for each question (1-4). The numerical values according to the answers are (1) strongly disagree, (2) disagree, (3) agree and (4) strongly agree. The scoring for questions 4, 8, 12 and 16 is calculated in reverse. When all questions are answered, the total score ranges from 17-68. The higher score shows the more intense of kinesiophobia. A study on the validity and reliability of this scale was conducted by Yılmaz et al.[14]

US imaging was performed by the same clinician with at least 3 years of experience in musculoskeletal US, using a 6-11 MHz device (NemioXH, Toshiba, Japan)[15] available at our clinic, with the patient in the modified Crass position (the shoulder in a neutral position, elbow in 90°, the shoulder was brought into extension and external rotation with the palmar side of the hand to the gluteal region). The thickness of the supraspinatus tendon was measured with the patient sitting in a chair and the measurement was made in the short axis 10-15-20 mm lateral to where the intra-articular portion of the long head of the biceps tendon passes through the rotator interval, and the average of these three measurements was taken and recorded in patients without tears. In patients with partial tears of the supraspinatus tendon, the thinnest part of the tendon was visualized and measured.

For the measurement of supraspinatus muscle thickness; the midpoint of the spina scapula was taken as the base and the linear probe was placed in the supraspinatus fossa in an upright position 90° and measured from the region where the muscle was visualized widest in the sagittal plane. The measurement was made from the thickest middle region of the muscle.

The measurements were repeated three times and averaged. VAS scores, passive shoulder ROM, SPADI scores, HG strength, TKS score, supraspinatus muscle and tendon thickness values were recorded at the beginning and 1st and 3rd months after treatment.

Interventions

Both treatment modalities were explained to the patients in detail and the patients were assigned to 2 groups by their own accord. Patients in group 1 (n=30) received DN and conventional PTR program. Patients in group 2 (n=28) received only conventional PTR program. Patients in both groups underwent hot-pack, conventional TENS and US treatments on the affected shoulder by an experienced physiotherapist for 2 weeks, 5 days each weekday for a total of 10 days. Hot-pack was planned for 15 minutes according to the temperature that the patients could tolerate. TENS was applied for 15 minutes with a current intensity of 1-100 mA, a frequency of 50-100 Hz, and a pulse duration of 200 msec by adjusting the current at a level that the patient felt but did not disturb. US therapy was applied at 1.5 watts/cm^2 for 5 minutes. Simultaneously with the PTR program, the patients were shown ROM and Codman pendulum exercises by the same physiotherapist. After the 10 days of PTR program, isometric strengthening exercises for the muscles around the shoulder and scapula and stretching exercises at the limit of pain were shown to the patients who could tolerate and a home program was created. Patients were asked to perform the home exercise program every day, twice a day for 30 minutes during their follow-ups.

In addition to conventional PTR program, the patients in group 1 received 3 sessions of DN treatment by a physiatrist experienced in DN, at one week intervals at the beginning, in the middle and at the end of PTR. The shoulder was placed in the modified Crass position with the patient in a sitting position for the DN procedure (Figure 1). The patient's supraspinatus tendon was visualized with linear probe, the painful pathological region of the tendon was detected by palpation of the probe and this region was cleaned with isopropyl alcohol. 0.30x50 mm acupuncture needle was inserted into this area with the out of plane method under US guidance (Figure 2). After reaching the site of tendinopathy, the tip of the needle was visualized with US and moved back and forth 15-20 times with the peppering method and then the needle was removed. No anesthetic agent was administered during the procedure. Only one needle was applied in each session. After the DN procedure, the patients were kept under control for half an hour in terms of side effects.



Figure 1. For dry needling, the patient was seated and the shoulder was placed into the modified Crass position.

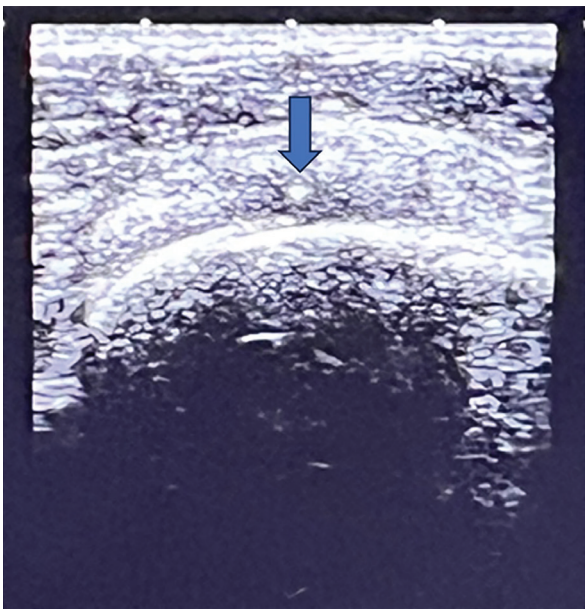


Figure 2. Out-of-plane dry needling image in supraspinatus tendinopathy with US.

US: Ultrasound.

Sample size

G*Power analysis was performed for sample size calculation before the study. The reference study was evaluated.[16] With G*Power, the sample size was calculated as 28 patients in each group and 56 patients in total with an effect size of 0.80, 90% power and alpha error of 5%. It was planned to include 32 patients in each group and 64 patients in total, in case the patients did not attend the follow-ups.

Statistical analysis

While evaluating the findings obtained in the study, SPSS (Statistical Package for Social Sciences for Windows) 27.0 program was used for statistical analysis. Descriptive statistics of continuous variables were expressed as mean and standard deviation, and descriptive statistics of categorical data were expressed as frequency and percentage. Independent sample t-test (for those who met the assumption of normal distribution) and Mann-Whitney U test, Kruskal-Wallis H test (for those who did not meet the assumption of normal distribution) were used to compare quantitative data. Two-way repeated-ANOVA test was used for repeated measurements of the participants to study the evolution of each variable over time and to establish comparisons in each group. Greenhouse-Geisser correction was used to evaluate ANOVA. $p<0.05$ was considered statistically significant.

RESULTS

A total of 176 patients with shoulder pain and supraspinatus tendinopathy were evaluated. As a result of the evaluation, 64 patients met the inclusion criteria and were included in the study after signing an informed consent form. During the study period, 2 patients were excluded from the study because 1 patient underwent an algological interventional procedure for the shoulder and 1 patient was decided to undergo surgical intervention. 4 patients were not included in the study because they stated that they could not come to the follow-up visits. Our study was completed with a total of 58 patients (group 1 n=30, group 2 n=28). A consort flow chart was

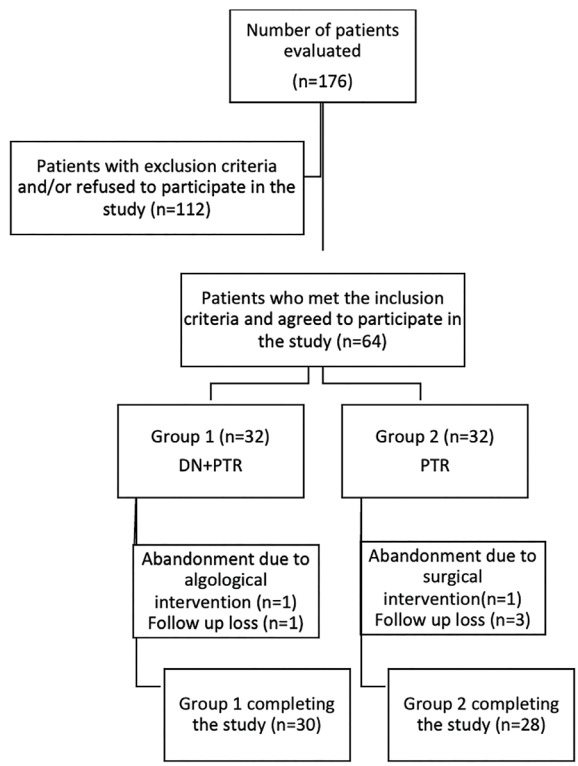


Figure 3. Flow chart of the study.

DN: Dry needling; PTR: Physical therapy and rehabilitation.

shown in Figure 3. When we analyzed the demographic and clinical characteristics of the patients, 74.1% (n=43) were female and 25.9% (n=15) were male. Partial tears were detected in 75.9% (n=44), tendinosis in 20.7% (n=12) and tendinitis in 3.5% (n=2). The mean age of the patients was 52.4±9.2 years.

Both groups were similar in terms of demographics and initial clinical findings (p>0.05) (Table 1). There was no significant difference between the two treatment groups in the comparison of the pre-treatment VAS, SPADI, TKS values and measurements of ROM, HG strength, muscle and tendon thickness of the patients according to the treatment groups (p>0.05) (Table 2).

When the changes over time were evaluated across the groups, a significant improvement trend was observed in VAS pain scores in both groups. Pain during movement was highest at baseline and decreased significantly in both groups at 1 and 3 months; however, the decrease was more pronounced in the PTR + DN group. Rest pain and night pain decreased more significantly in the PTR + DN group after 3 months. These findings suggest that the treatment had an effect on pain parameters over time, and this effect was particularly strong in the PTR + DN group (Table 3).

ROM measurements also generally increased over time. Although there were improvements in flexion and abduction values in both groups, internal and external rotation values resulted in a more significant increase in the PTR + DN group. In particular, the mean values for the internal rotation parameter at 1 and 3 months were significantly higher in the PTR + DN group compared to baseline. In external rotation, both groups showed improvements, but the PTR + DN group exhibited a stronger augmentative response. These results suggest that shoulder ROM improved more rapidly and significantly in the PTR + DN group.

HG strength increased in both groups at 1 and 3 months, but the increase was both greater and more sustained in the PTR + DN group. The "a-c" transition between 0 and 3 months in the PTR + DN group indicates a significant functional improvement in HG strength. These findings suggest that DN, added to physical therapy, also has a positive impact on muscle strength.

SPADI scores showed significant decreases in both the pain and function subcomponents at 1 and 3 months compared to baseline. While both groups demonstrated clinical improvement, both pain and function scores decreased more rapidly and more profoundly in the PTR + DN group. The decrease in total SPADI scores corresponded to less than half of the baseline level at 3 months in the PTR + DN group. This suggests that the intervention provided a significant benefit over time on disability levels.

TABLE 1
Comparison of categorical variables according to treatment groups

		Group 1 (DN + PTR)	Group 2 (PTR)	X^2	p
		n (%)	n (%)		
Sex	Female	23 (76.7%)	20 (71.4%)	0.207	0.649*
	Male	7 (23.4%)	8 (28.6%)		
Pathology	Partial tear	22 (73.3%)	22 (78.6%)	0.529	0.872**
	Tendinosis	7 (23.3%)	5 (17.9%)		
	Tendinitis	1 (3.3%)	1 (3.6%)		
Education	Uneducated	1 (3.3%)	3 (10.7%)	4.835	0.163**
	Primary education	20 (66.7%)	17 (60.7%)		
	High school	9 (30%)	5 (17.9%)		
	University	0 (0%)	3 (10.7%)		
Occupation	Unemployed-housewife	20 (66.7%)	19 (67.9%)	4.531	0.205**
	Worker	4 (13.3%)	4 (14.3%)		
	Officer	0 (0%)	3 (10.7%)		
	Retired	6 (20%)	2 (7.1%)		
Affected side	Left	16 (53.3%)	15 (53.6%)	0.978	1.000**
	Right	14 (46.7%)	13 (46.4%)		
Dominant extremity	Left	3 (10%)	1 (3.6%)	0.978	0.323**
	Right	27 (90%)	27 (96.4%)		

*: Chi-squared test; ** Fisher's exact test, p=significance (p<0.05).
DN: Dry needling; PTR: Physical therapy and rehabilitation; n: Number; %: Percentage distribution.

TABLE 2
Evaluation of pre-treatment clinical findings according to treatment groups

	Group 1 (DN + PTR)		Group 2 (PTR)		t/Z	p
	Mean ± SD	Median (min-max)	Mean ± SD	Median (min-max)		
Age	51.4±9.9	52.5 (32-65)	53.5±8.6	54 (30-65)	t=-0.891	0.377*
Pain duration (month)	11.6±8.8	8.5 (3-24)	10.9±7.5	7(3-24)	t=0.360	0.720*
VAS-movement	7.7±1.9	8 (5-10)	7.4±2.5	8 (2-10)	t=0.583	0.562*
VAS-rest	5.2±2.8	5 (0-10)	4.6±2.9	5 (0-10)	t=0.831	0.409*
VAS-night	8±2.3	9 (2-10)	7.8±2.1	8.5 (4-10)	t=0.254	0.800*
Flexion	151.8±23.4	160 (90-180)	159.3±26.2	170 (80-180)	Z=-1.947	0.052**
Abduction	147.5±23.6	145 (90-180)	157.1±28.1	165 (70-180)	t=-1.418	0.162*
Internal rotation	43.3±19.4	45 (10-90)	47.3±21	45 (5-90)	t=-0.752	0.455*
External rotation	62.5±20.5	70 (10-90)	66.8±23.8	77.5 (10-90)	t=-0.737	0.464*
Hand grip strength	18.9±7.7	17 (5-37)	18.7±8.8	17.3 (6.5-41)	t=0.062	0.950*
SPADI-P	81±15.9	84 (34-100)	76.4±17	81 (28-100)	t=1.058	0.295*
SPADI-D	71.8±19.8	75 (12.5-100)	68.5±19.4	70.6 (17.5-96.3)	t=0.633	0.529*
SPADI-T	75.5±17.5	78.2 (20.7-100)	71.6±17.8	74.2 (21.5-96.2)	t=0.830	0.410*
TKS	44.3±5.6	44.5 (33-57)	42.8±5.8	44 (29-54)	t=1.017	0.313*
Muscle thickness	20.8±4	19.9 (15.7-33.6)	22±4.3	22.7 (15.4-32.5)	t=-1.121	0.267*
Tendon thickness (PT)	5.5±0.7	5.6 (4-7)	5.3±0.9	5.2 (4-7.5)	Z=-0.693	0.488**
Tendon thickness (WPT)	6.1±1.4	6.1 (4.5-8.9)	6.1±1	6 (5.1-8)	t=0.006	0.995*

*t: Independent sample t-test; **Z: Mann-Whitney U test; p=significance (<0.05).
DN: Dry needling; PTR: Physical therapy and rehabilitation; VAS: Visual analog scale; SPADI-P: Shoulder pain and disability index pain score; SPADI-D: Shoulder pain and disability index disability score; SPADI-T: Shoulder pain and disability index total score; TKS: Tampa kinesiophobia scale; PT: Partial tear; WPT: Without partial tear; SD: Standard deviation; Min: Minimum; Max: Maximum.

TABLE 3
Group × time interaction with two-way repeated measures ANOVA

Variable	Group	Measurements			RM ANOVA (group x time)		
		0. month	1. month	3. month	Effect size	F tests	p value
VAS							
Movement	2	7.39±2.54[a]	4.86±2.83[b]	4.82±2.99[b]	0.024	3.64	**0.029**
	1	7.73±1.87[a]	4.30±2.42[b]	3.23±2.52[c]			
Rest	2	4.61±2.91[a]	3.18±2.63[b]	3.18±3.12[ab]	0.034	4.58	**0.012**
	1	5.23±2.83[a]	2.67±2.20[b]	1.43±1.94[c]			
Night	2	7.82±2.09[a]	5.07±3.09[b]	5.18±3.12[b]	0.039	5.58	**0.005**
	1	7.97±2.25[a]	4.37±2.11[b]	2.87±2.61[c]			
Range of motion							
Flexion	2	159.29±26.20	166.43±12.24	167.50±14.31	0.015	2.88	0.060
	1	151.83±23.36	166.67±13.28	170.50±14.88			
Abduction	2	157.14±28.10	168.93±11.00	169.82±10.93	0.018	2.57	0.081
	1	147.50±23.63	167.33±11.80	171.50±15.38			
Internal rotation	2	47.32±21.02	50.18±19.79	53.04±18.48	0.025	6.29	**0.003**
	1	43.33±19.36[a]	56.83±21.15[b]	64.00±18.73[c]			
External rotation	2	66.79±23.77[a]	71.43±18.60[a]	75.89±16.89[b]	0.009	3.14	**0.047**
	1	62.50±20.50[a]	75.67±17.16[b]	78.50±17.82[b]			
Hand grip	2	18.71±8.79[a]	21.71±8.05[b]	22.09±8.62[b]	0.004	3.33	**0.039**
	1	18.85±7.74[a]	22.63±8.27[b]	24.70±7.94[c]			

TABLE 3
Continued

Variable	Group	Measurements			RM ANOVA (group x time)		
		0. month	1. month	3. month	Effect size	F tests	p value
SPADI							
Pain	2	76.43±17.01[a]	54.57±27.04[b]	54.00±31.74[b]	0.046	6.85	**0.002**
	1	81.00±15.90[a]	49.87±23.27[b]	33.33±25.97[c]			
Disability	2	68.53±19.38[a]	46.88±26.59[b]	45.54±30.60[b]	0.024	4.05	**0.020**
	1	71.79±19.76[a]	39.16±26.77[b]	29.93±25.06[c]			
Total	2	71.60±17.84[a]	49.83±26.07[b]	48.79±30.42[b]	0.033	5.39	**0.006**
	1	75.45±17.54[a]	43.27±25.04[b]	31.24±24.89[c]			
TKS	2	42.75±5.81	40.89±6.86	41.00±6.93	0.019	3.16	**0.046**
	1	44.27±5.55[a]	41.63±5.70[a]	38.60±6.28[b]			
Muscle thickness	2	21.98±4.27	22.72±3.97	23.93±3.38	0.004	2.13	0.124
	1	20.76±3.98	22.01±4.67	23.89±3.20			
Tendon thickness	2	5.49±0.98	5.35±0.74	5.28±0.93	0.010	1.14	0.324
	1	5.67±0.94	6.24±2.96	5.81±0.70			

Post-hoc comparisons were made with Bonferroni correction. Statistical significance between values in the same row is indicated by different letters (a, b, c); values with different letters are significantly different from each other (p<0.05). Group 1 (DN + PTR), group 2 (PTR).
PTR: Physical therapy and rehabilitation; DN: Dry needling; VAS: Visual analog scale; SPADI: Shoulder pain and disability index; TKS: Tampa kinesiophobia scale; RM: Repeated measures.

A significant decrease in TKS scores was observed only in the PTR + DN group. While very limited change was observed over time in the PTR group, a significant decrease occurred in the PTR + DN group at 1 and especially at 3 months. This difference suggests that the PTR + DN group responded more effectively to treatment at both physical and psychosocial levels.

Muscle and tendon thickness measurements did not show significant differences between groups or over time. While a slight increase in muscle thickness was observed in both groups, this change did not reach statistical significance. Similarly, no significant change was observed in tendon thickness. These findings suggest that the change in structural parameters was more limited compared to clinical and functional improvement.

Overall, time had a strong effect on pain, function, ROM, and grip strength, but the PTR + DN group showed more significant and rapid improvement in many areas. These findings support an effective treatment response, particularly in the PTR + DN group, compared to baseline, at both 1 and 3 months. Despite no significant changes in muscle and tendon structure, significant improvements in pain, functionality, muscle strength, and kinesiophobia were observed in the PTR + DN group.

DISCUSSION

As a result of our study, more improvements were observed in group 1 in most of the measurement parameters. In this case, we concluded that the combination of DN and conventional PTR treatment is more effective in treatment of patients with supraspinatus tendinopathy. For supraspinatus tendinopathy resistant to other treatments, DN added to conventional PTR stands out as a beneficial treatment option, particularly in terms of pain and functionality, persisting up to three months. We believe that intratendinous application of DN creates microbleeding sites, initiating the regenerative process, and thus, improving tendon healing and resulting in increased thickness in patients with tears, thus contributing positively to treatment. Therefore, supraspinatus tendon DN added to PTR should be considered as an easily applicable and effective treatment option under US guidance for patients with resistant supraspinatus tendinopathy who frequently present to our outpatient clinics.

Tendinopathy is a set of changes in unhealthy or damaged tendons that cause pain and loss of function.[17] Tendinopathy was previously thought to be an inflammatory condition (tendinitis). However, later studies have shown that tendons do not contain inflammatory cells such as macrophages, lymphocytes or neutrophils, but a degenerative process (tendinosis).[18-20] We hypothesized that DN may be one of the treatment modalities to prevent the progression of rotator cuff tendinopathies, which is a degenerative process and develops as a result, and to provide regeneration of that area.

In the literature, there are numerous studies about DN. Hando et al.[21] investigated the effectiveness of trigger point DN added to standard PTR in 130 patients

with SIS. The strengths of this study are that it was randomized study, had a sham DN group as a placebo group and a 12-months follow-up. However, this study focused on the application of DN to trigger points and not to tendons, but in our study DN was applied only to the supraspinatus tendon. A meta-analysis investigated the effects of DN alone and in combination with exercise in individuals with SIS.[22] They said that DN alone or in combination with exercise therapy can lead to a slight reduction in pain in the short to medium term. However, the evidence on the impact of this treatment on disability is very unclear In contrast to this study, in our study, there was no difference in pain and disability between both groups at 1 month, but DN was found to be beneficial on both pain and disability at 3 months.

There are few studies on tendon DN and these studies include tendons in different regions and different methods. Uygur et al.[23] compared conservative treatment (splint and oral drugs) with tendon DN in 92 patients diagnosed with lateral epicondylitis, and found significant improvement in 6-months follow-up with DN, which was applied twice a week for a total of 5 sessions, compared to conservative treatment.

Brennan et al.[24] performed DN in 21 and corticosteroid injection in 22 patients with greater trochanteric pain syndrome and found similar improvements in both groups at 6-weeks follow-up. Jacobson et al.[25] compared DN with platelet rich plasma (PRP) in a group of patients with greater trochanteric pain syndrome and found that they had similar effects on pain scores at 2-weeks follow-up.

Dragoo et al.[26] also compared PRP with DN in a study of 23 patients with patellar tendinopathy and found that although PRP provided faster improvement in pain and activity, the effects were similar at 26-weeks follow-up.

There are very few studies in the literature on DN applied to tendinopathies in the shoulder.[16,27,28] McDevitt et al.[27] applied DN to the most painful point of 10 patients with chronic biceps tendinopathy with 0.3x40 mm needles, between 2-8 sessions, 1 or 2 sessions per week, 20-30 times in each session and created an exercise program for the patients. They evaluated the disability with Quick Disabilities of the Arm, Shoulder and Hand and pain with numeric pain scale. It was found that improvements in these parameters and they said that DN may be beneficial for treatment of patients with chronic biceps tendinopathy.[27]

In a case report published by Settergren[28], a patient with supraspinatus tendinopathy was needled 15 times with a 0.50x75 mm acupuncture needle in a single session and single entry, and the patient's shoulder was imaged with US at the 10-days follow-up. When compared with the pre-treatment US images, it was shown that the heterogeneous hypoechogenic areas in the tendon were significantly reduced and echogenicity increased.[28] This suggested that the tendon could be evaluated with US imaging in patients in whom we performed DN in our study. For this purpose, we wanted to evaluate tendon thickness measurement, which is a parameter that we can compare quantitatively instead of tendon echogenicity. We think that supraspinatus tendon thickness measurement may be useful in showing the effect of DN treatment on tendon healing.

In another study of DN in shoulder tendinopathies, Rha et al.[16] compared the efficacy of tendon DN and PRP in patients with tendinosis or partial tear in the supraspinatus. Thirty-nine patients were followed for 6 months and SPADI and passive ROM parameters were evaluated. As a result, although PRP treatment improved passive internal rotation, flexion measurements and SPADI-T more than DN, there was no difference between the two treatment methods in terms of SPADI-P and SPADI-D scores, external rotation and abduction measurements, and all ROM and SPADI values showed significant improvement over time in both treatments.[16] Rha et al.[16] performed DN of the tendon on patients with supraspinatus tendinopathy and similarly to our study, they have evaluated ROM and SPADI parameters. They found that the clinical effect of the PRP injection was superior to the DN from 6 weeks to 6 months after initial injection. In our study, significant improvement was found in all SPADI scores in both groups at 3-month follow-up. SPADI scores in group 1 were significantly better than the other group. Furthermore, improvements in passive internal and external rotation values in group 1 were significantly greater than group 2.

In our study, we used 0.30x50 mm acupuncture needles for DN and applied 3 sessions of treatment with one week intervals, needling the tendon with peppering method 15-20 times in each session. There was a heterogeneity in the size of the needles in studies on DN. Brennan et al.[24] used needles with a thickness between 0.30-0.50 mm and a length between 50-100 mm in their study in patients with greater trochanteric pain syndrome, while Rha et al.[16] used 25 gauge (0.45 mm) needles and performed 40-50 needling in patients with supraspinatus tendinopathy. Abate et al.[29] also used 21 gauge (0.71 mm) needles and performed 10 times needling in patients with Achilles tendinopathy. Therefore, since we were not going to apply local anesthesia at the beginning of the study, we preferred a relatively thinner needle with a length that could reach the supraspinatus tendon, considering patient tolerance.

The number and frequency of DN sessions are also quite variable and it is thought that this does not affect the outcome measurements.[30] Uygur et al.[23] reported a

decrease in pain after 5 sessions of DN in the treatment of lateral epicondylitis, similar to that reported by Jacobson et al.[25] after 1 session in greater trochanteric pain syndrome.

One of the evaluation criteria of our study was the measurement of supraspinatus tendon thickness. In the study by Michener et al.[31], the hyperechogenic appearance of the biceps tendon in the rotator interval in the short axis was taken as a reference point and measurements were taken 10, 15, 20 mm lateral to this reference point in the short axis (transverse plane) and averaged. In the study of Cholewinski et al.[32], the supraspinatus tendon thickness was measured 15 mm lateral to the biceps tendon, but in case of tear, the thinnest part of the tendon was measured. In case of tendon heterogeneity, they took the average of three measurements as in Michener's[31] study. This method has been reported to have high reliability in tendon measurement. Similar to these studies, we performed measurements by visualizing the thinnest part of the tendon in patients with supraspinatus partial tears and recorded the average of three measurements in patients without tears.

According to some researchers, there is a decrease in the thickness of the rotator cuff tendons during the development of SIS[33,34]. According to Hedtman and Fett[35], a one-third decrease in tendon thickness compared to the unaffected shoulder is in favor of a tendon tear. Cholewinski et al.[32] compared tendon thicknesses on the affected side and the intact side and found a significant decrease in tendon thickness due to SIS. We did not evaluate the intact side in our study.

In the literature, there were also studies showing an increase in tendon thickness in the case of tendinopathy caused by SIS. Michener et al.[31] measured tendon thickness 0.6 mm more in the shoulder with SIS and in another study, an increase in tendon thickness of 0.8 mm was considered significant in the diagnosis of SIS.[33,36] In our study, tendon thickness was measured separately for both groups during treatment follow-up, depending on whether there was a partial tear or not. However, although changes in tendon thickness over time were observed depending on the shoulder pathology, these measurements were not significant. There are conflicting results in the literature regarding the change in tendon thickness in the diagnosis of supraspinatus tendon pathologies. Therefore, randomized controlled studies on changes in tendon thickness in tendinopathies are needed.

Another evaluation criterion was supraspinatus muscle thickness measurement. The supraspinatus muscle was visualized in the sagittal plane with the US probe placed perpendicular to the suprascapular fossa and the supraspinatus muscle was imaged in the sagittal plane with the patient seated and the shoulder in the neutral position, based on the midpoint of the spina scapula, and the measurement was made from the thickest middle region of the muscle. For this measurement, the studies of Kim et al.[37,38] were taken as reference.

A similar study examining the efficacy of DN therapy added to PTR in supraspinatus tendinopathy has not been found in the literature. In our study, in addition to evaluating pain and functionality, we also compared different parameters such as HG strength, kinesiophobia in the same patient groups. We also measured supraspinatus muscle and tendon thickness by using US. In this way, radiographic evaluations of the effectiveness of our treatments were also made. The groups of patients who participated in our study were homogeneously distributed. US measurements were performed by the same physiatrist who measured muscle and tendon thickness was blinded to the study groups in which she measured. These were the strengths of our work.

The most important limitation of our study was the absence of a placebo group. Sham injections could have been administered to the placebo group, but since we were working in a group of patients who had shoulder pain for at least 3 months and been refractory to medical treatments, our study was planned without placebo group due to both loss of time in treatment and ethical concerns. All patients who agreed to participate in our study received specific treatments. Another limitation is that we did not use randomization when selecting patients. This is primarily because patients with needle phobia and concerns about complications wanted to choose their own treatment group with their own consent. In our study, the same physiatrist who performed the all US measurements was blind to the treatment groups. On the other hand, the another physician who performed the clinical assessments and made physical examination and DN application, was not blinded to the groups. This may also have caused bias for results of our study. Another important limitation was that patients were followed up for a limited period of 3 months. Considering the healing process of tendinopathies, long-term follow-up will be more useful in evaluating the effectiveness of treatment.

We think that the addition of DN to the conventional PTR program in treatment of patients with supraspinatus tendinopathy is beneficial in terms of both pain and functionality until the 3rd month after treatment.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Myers JB, Guskiewicz KM, Schneider RA, Prentice WE. Proprioception and neuromuscular control of the shoulder after muscle fatigue. J Athl Train. 1999;34:362-7.
2. Özsoy MH, Fakıoğlu O, Aydoğan NH. Subacromial impingement syndrome. TOTBID Dergisi. 2013;12:340-52.
3. Redondo-Alonso L, Chamorro-Moriana G, Jiménez-Rejano JJ, López-Tarrida P, Ridao-Fernández C. Relationship between chronic pathologies of the supraspinatus tendon and the long head of the biceps tendon: systematic review. BMC Musculoskelet Disord. 2014;15:377.
4. Taşçıoğlu F, Dalkıran İ, Öner C. Parsiyel supraspinatus tendon rüptürü olan subakromiyal sıkışma sendromlu hastalarda düşük doz lazer tedavisinin etkinliği. Turk J Phys Med Rehab. 2003;49:18-22.
5. Öztürk C. Tedavide Sıcak ve Soğuk. İç: Oğuz H, editör Tıbbi Rehabilitasyon 3. Baskı İstanbul: Nobel Tıp Kitapevleri; 2015;181-200.
6. Gunay Ucurum S, Kaya DO, Kayali Y, Askin A, Tekindal MA. Comparison of different electrotherapy methods and exercise therapy in shoulder impingement syndrome: A prospective randomized controlled trial. Acta Orthop Traumatol Turc. 2018;52:249-55.
7. Stoychev V, Finestone AS, Kalichman L. Dry Needling as a treatment modality for tendinopathy: a narrative review. Curr Rev Musculoskelet Med. 2020;13:133-40.
8. Housner JA, Jacobson JA, Misko R. Sonographically guided percutaneous needle tenotomy for the treatment of chronic tendinosis. J Ultrasound Med. 2009;28:1187-92.
9. Park HB, Yokota A, Gill HS, El Rassi G, McFarland EG. Diagnostic accuracy of clinical tests for the different degrees of subacromial impingement syndrome. J Bone Joint Surg Am. 2005;87:1446-55.
10. Hjermstad MJ, Fayers PM, Haugen DF, Caraceni A, Hanks GW, Loge JH, et al.; European Palliative Care Research Collaborative (EPCRC). Studies comparing Numerical rating scales, verbal rating scales, and visual analogue scales for assessment of pain intensity in adults: a systematic literature review. J Pain Symptom Manage. 2011;41:1073-93.
11. MacDermid JC, Solomon P, Prkachin K. The shoulder pain and disability index demonstrates factor, construct and longitudinal validity. BMC Musculoskelet Disord. 2006;7:12.
12. Bumin G, Tüzün EH, Tonga E. The Shoulder Pain and Disability Index (SPADI): cross-cultural adaptation, reliability, and validity of the Turkish version. J Back Musculoskelet Rehabil. 2008;21:57-62.
13. Weermeijer JD, Meulders A. Clinimetrics: tampa scale for kinesiophobia. J Physiother. 2018;64:126.
14. Yılmaz ÖT, Yakut Y, Uygur F, Uluğ N. Turkish version of the Tampa scale for Kinesiophobia and its test-retest reliability. Fizyoterapi Rehabilitasyon. 2011;22:44-9.
15. Crass JR, Craig EV, Feinberg SB. The hyperextended internal rotation view in rotator cuff ultrasonography. J Clin Ultrasound. 1987;15:416-20.
16. Rha DW, Park GY, Kim YK, Kim MT, Lee SC. Comparison of the therapeutic effects of ultrasound-guided platelet-rich plasma injection and dry needling in rotator cuff disease: a randomized controlled trial. Clin Rehabil. 2013;27:113-22.
17. Millar NL, Silbernagel KG, Thorborg K, Kirwan PD, Galatz LM, Abrams GD, et al. Tendinopathy. Nat Rev Dis Primers. 2021;7:1. Erratum in: Nat Rev Dis Primers. 2021;7:10.
18. Dela Rosa T, Wang A, Zheng M. Tendinosis of the rotator cuff: a review. J Musculoskel Res 2001;5:143.
19. Khan KM, Cook JL, Kannus P, Maffulli N, Bonar SF. Time to abandon the "tendinitis" myth. BMJ. 2002;324:626-7.
20. Khan KM, Cook JL, Taunton JE, Bonar F. Overuse tendinosis, not tendinitis part 1: a new paradigm for a difficult clinical problem. Phys Sportsmed. 2000;28:38-48.
21. Hando BR, Rhon DI, Cleland JA, Snodgrass SJ. Dry needling in addition to standard physical therapy treatment for subacromial pain syndrome: a randomized controlled trial protocol. Braz J Phys Ther. 2019;23:355-63.
22. Para-García G, García-Muñoz AM, López-Gil JF, Ruiz-Cárdenas JD, García-Guillén AI, López-Román FJ, et al. Dry needling alone or in combination with exercise therapy versus other interventions for reducing pain and disability in subacromial pain syndrome: a systematic review and meta-analysis. Int J Environ Res Public Health. 2022;19:10961.
23. Uygur E, Aktaş B, Özkut A, Erinç S, Yilmazoglu EG. Dry needling in lateral epicondylitis: a prospective controlled study. Int Orthop. 2017;41:2321-5.
24. Brennan KL, Allen BC, Maldonado YM. Dry needling versus cortisone injection in the treatment of greater trochanteric pain syndrome: a noninferiority randomized clinical trial. J Orthop Sports Phys Ther. 2017;47:232-9.
25. Jacobson JA, Yablon CM, Henning PT, Kazmers IS, Urquhart A, Hallstrom B, et al. Greater trochanteric pain syndrome: percutaneous tendon fenestration versus platelet-rich plasma injection for treatment of gluteal tendinosis. J Ultrasound Med. 2016;35:2413-20.
26. Dragoo JL, Wasterlain AS, Braun HJ, Nead KT. Platelet-rich plasma as a treatment for patellar tendinopathy: a double-blind, randomized controlled trial. Am J Sports Med. 2014;42:610-8. Erratum in: Am J Sports Med. 2016;44:NP38.
27. McDevitt AW, Snodgrass SJ, Cleland JA, Leibold MBR, Krause LA, Mintken PE. Treatment of individuals with chronic bicipital tendinopathy using dry needling, eccentric-concentric exercise and stretching; a case series. Physiother Theory Pract. 2020;36:397-407.
28. Settergren R. Treatment of supraspinatus tendinopathy with ultrasound guided dry needling. J Chiropr Med. 2013;12:26-9.

29. Abate M, Di Carlo L, Salini V. Platelet rich plasma compared to dry needling in the treatment of non-insertional Achilles tendinopathy. Phys Sportsmed. 2019;47:232-7.

30. Nuhmani S, Khan MH, Ahsan M, Abualait TS, Muaidi Q. Dry needling in the management of tendinopathy: a systematic review of randomized control trials. J Bodyw Mov Ther. 2023;33:128-35.

31. Michener LA, Subasi Yesilyaprak SS, Seitz AL, Timmons MK, Walsworth MK. Supraspinatus tendon and subacromial space parameters measured on ultrasonographic imaging in subacromial impingement syndrome. Knee Surg Sports Traumatol Arthrosc. 2015;23:363-9.

32. Cholewinski JJ, Kusz DJ, Wojciechowski P, Cielinski LS, Zoladz MP. Ultrasound measurement of rotator cuff thickness and acromio-humeral distance in the diagnosis of subacromial impingement syndrome of the shoulder. Knee Surg Sports Traumatol Arthrosc. 2008;16:408-14.

33. Wiener SN, Seitz WH Jr. Sonography of the shoulder in patients with tears of the rotator cuff: accuracy and value for selecting surgical options. AJR Am J Roentgenol. 1993;160:103-7; discussion 109-10.

34. Seibold CJ, Mallisee TA, Erickson SJ, Boynton MD, Raasch WG, Timins ME. Rotator cuff: evaluation with US and MR imaging. Radiographics. 1999;19:685-705.

35. Hedtmann A, Fett H. Atlas und Lehrbuch der Schultersonographie. 2nd edn Ferdinand Enke Verlag, Stuttgart 1991.

36. Joensen J, Couppe C, Bjordal JM. Increased palpation tenderness and muscle strength deficit in the prediction of tendon hypertrophy in symptomatic unilateral shoulder tendinopathy: an ultrasonographic study. Physiotherapy. 2009;95:83-93.

37. Kim S, Bleakney R, Boynton E, Ravichandiran K, Rindlisbacher T, McKee N, et al. Investigation of the static and dynamic musculotendinous architecture of supraspinatus. Clin Anat. 2010;23:48-55.

38. Kim SY, Bleakney RR, Rindlisbacher T, Ravichandiran K, Rosser BW, Boynton E. Musculotendinous architecture of pathological supraspinatus: a pilot in vivo ultrasonography study. Clin Anat. 2013;26:228-35.