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ORIGINAL PAPER
PŮVODNÍ PRÁCE

Evaluation of the Relationship between Acromiohumeral Distance and Supraspinatus Tendon Thickness Measured by Ultrasonography and Rotator Cuff Pathologies, Pain, and Function

Hodnocení vztahu mezi akromiohumerální vzdáleností a tloušťkou šlachy *m. supraspinatus* měřenou ultrasonografií a bolestí a funkcí rotátorové manžety

B. T. DEDE[1], Y. P. DOĞAN[2], M. OĞUZ[2], B. BULUT[2], H. COŞKUN[2], E. AYTEKİN[2]

[1] Cemil Taşcıoğlu City Hospital, Physical Medicine and Rehabilitation Clinic, Istanbul, Turkey
[2] Istanbul Training and Research Hospital, Physical Medicine and Rehabilitation Clinic, Istanbul, Turkey

ABSTRACT

PURPOSE OF THE STUDY

In this study, we aimed to evaluate acromiohumeral distance (AHD) and supraspinatus tendon (ST) thickness measurements and their relationship with pain and function in ST pathologies.

MATERIAL AND METHODS

The study included 111 patients and 25 healthy controls (HC). Patients were divided into 3 groups according to their diagnosis: non-tear tendinopathy (NTT), partial thickness tear (PTT), and full thickness tear (FTT). The AHD and ST thickness of the participants were measured with ultrasound. The pain and functional status of the patients were evaluated with the Numeric Rating Scale (NRS), The *Quick*DASH shortened version of the DASH Outcome Measure – Disabilities of the Arm Shoulder and Hand (QDASH), and Simple Shoulder Test (SST).

RESULTS

The AHD value was significantly higher in the NTT group (p=0.000). The AHD value was significantly lower in the FTT group (p=0.000). ST thickness value was significantly lower in the PTT group compared to the NTT group (p=0.000). There was a positive correlation between ST thickness and BMI (r=0.553,p<0.01). There was a negative correlation between ST thickness and SST and a positive correlation between ST thickness (r=-0.223,p<0.05) and QDASH (r=0.276,p<0.05).

CONCLUSIONS

We found that AHD and SST thicknesses significantly differed in the NTT, PTT, FTT, and HC groups. This difference may be important for diagnosis. In addition, the effect of obesity on ST thickness and the relationship between ST thickness and functional scores may be considered. Weight control may be effective at this point.

Key words: acromiohumeral distance, supraspinatus tendon thickness, ultrasound.

INTRODUCTION

Rotator cuff pathology is the underlying cause of shoulder pain in 45–65% of patients with shoulder pain (9). The most common cause of rotator cuff pathology is supraspinatus tendon (ST) pathology. Supraspinatus tendinopathy is a chronic tendon disorder in which inflammation may contribute to a very small extent, accompanied by a degenerative process with excessive use of ST. Various mechanisms have been described in the pathophysiology of supraspinatus tendinopathy. In previous studies, extrinsic mechanisms such as biomechanical factors, and intrinsic mechanisms such as vascular factors were emphasized (14, 20, 23).

In recent years, different measurements have been used with different imaging methods, and the relationships between these measurements and shoulder pathologies have been examined (10, 14, 27, 29, 33). With the widespread use of ultrasound (US), it has been shown that acromiohumeral distance (AHD) measurement can be used in the evaluation of shoulder pathologies in clinical practice; however, there are conflicting results on this subject when we look at the literature. Some of the authors found no significant difference in the AHD value in the studies they conducted on patients with subacromial pain and the painless control group (5, 6, 11, 15, 24). On the contrary, other authors found a significant difference in AHD values between these two groups (13, 14). On the other hand, it has been stated that sonographic AHD measurement is a cost-effective method that defines the presence of extrinsic mechanisms in patients with rotator cuff disease, is used to determine prognosis, and is used as a basis for evaluating treatment response (27). In subacromial impingement syndrome (SIS), it has been stated that ST thickness may also change in addition to AHD. Some authors

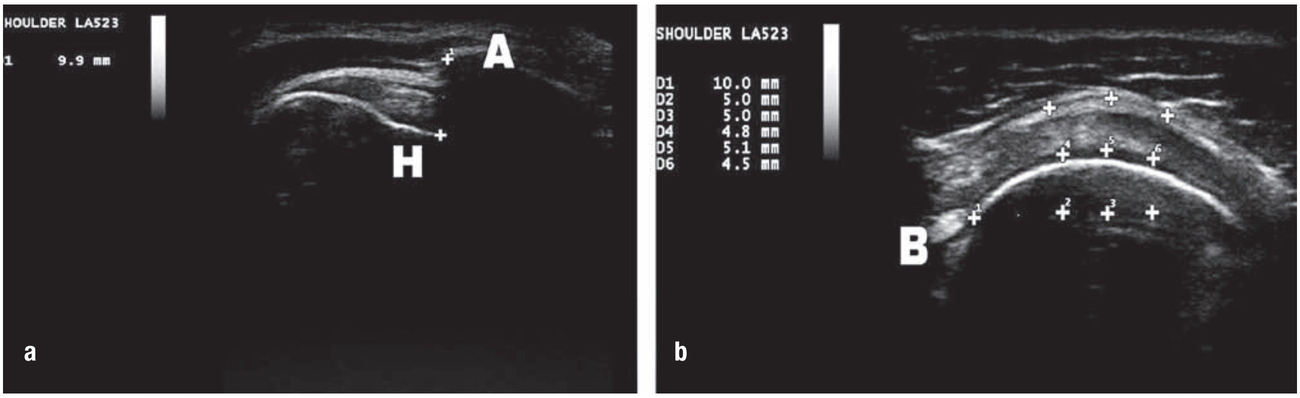

Fig. 1. a – acromiohumeral distance measurement, acromion (A), humerus (H); b – supraspinatus tendon thickness measurement, tendon thickness measurement from 3 points 10, 15, and 20 mm lateral to the biceps (B) tendon.

stated that ST thickness increased in patients with SIS; other authors also reported a decrease in tendon thickness in their studies (11, 18, 20).

In this area, which was previously controversial in the literature, we aimed to contribute to the literature by investigating the differences in terms of AHD and ST thickness by evaluating the pathologies separately rather than under the umbrella term SIS. Thus, the underlying mechanism of supraspinatus tendon pathologies can be understood more clearly. As far as we know, it was the first study in the literature with this feature. Our secondary aim is to evaluate the relationship between AHD and ST thickness with scales assessing pain and function.

MATERIAL AND METHODS

Methods

This single-center, randomized study was conducted at Istanbul Training and Research Hospital between June 2021 and June 2022. The study was approved by the Ethics Committee of Istanbul Training and Research Hospital, Decision no: 2823, date: 21/05/2021.

Written informed consent was obtained from each participant. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patients

The study included 111 patients presenting with shoulder pain and diagnosed with SIS and 25 healthy controls (HC). SIS was diagnosed by the presence of at least three positive clinical tests (Neer, Hawkins-Kennedy, painful arch, Jobe, and external rotation resistance) (1). Inclusion criteria: SIS patients aged 40–65 years with pain lasting more than 6 weeks. Patients were visualized by direct radiography after a clinical examination. Exclusion criteria: bilateral shoulder pain, history of rheumatological diseases, cervical pathologies, shoulder pain increasing with neck movements, previous upper extremity trauma, surgery and fracture, positive anxiety test, adhesive capsulitis, calcific tendonitis, major humeral head deformity, advanced glenohumeral osteoarthritis, history of diabetes mellitus. In addition to the exclusion criteria listed above, the control group consisted of healthy volunteers with no symptoms, no restriction in the range of motion of the shoulder joint, negative impingement tests, and no pathological changes in the tendon when examined by ultrasound. Patients were grouped as non-torn tendinopathy (NTT) or tendinosis, partial thickness tear (PTT), and full thickness tear (FTT) according to US images (8, 17). In the patient group, patients with a normal appearance of the supraspinatus tendon during US imaging were excluded from the study.

Clinical examination

Demographic data (age, gender, dominant side, height, weight, and body mass index (BMI) of the participants were recorded. Pain duration (6-12 weeks or >12 weeks) and painful shoulder (dominant or non-dominant) were also recorded in the patient group. A Numeric Rating Scale (NRS) was used to evaluate pain during daily activities. Functional status was assessed with the Quick The Disabilities of the Arm, Shoulder and Hand (QDASH) test and the Simple Shoulder Test (SST). Turkish validity and reliability of QDASH and SST have been shown in previous studies (4, 19). In order to avoid positive or negative effects, the investigator who performed the US examination was blinded to the clinical evaluation scales.

US examination

The US examination was performed with MyLab50 (Esaote Biomedica, Genova, Italy). A 6–12 MHz linear probe was used during the evaluations. Observers with 3 (BTD) and 10 (YPD) years of experience in musculoskeletal ultrasound performed the US examinations. AHD measurement was performed with the patients in a seated position with neutral body posture, resting on their knees with the forearm supinated; the probe was placed on the anterior surface of the acromion in the coronal plane. The acromion and humeral head were visualized. The shortest distance between the humeral head and the anteroinferior surface of the acromion was measured and recorded as AHD (14). In the patient group, AHD was measured in the affected shoulder, whereas in the healthy control group, measurements were performed in both shoulders without clinical or sonographic pathology.

ST thickness measurement was performed in the modified crass position. The biceps tendon was visualized, and ST thickness was measured at 3 points, 10, 15, and 20 mm lateral to the biceps tendon. The arithmetic mean of the three measurements was taken. Thickness measurements were taken from the anechoic area, where the articular cartilage ends at the lower point, to the subdeltoid bursa at the upper point. In the patient group, ST was measured in the affected shoulder, whereas in the healthy control group, measurements were made in both shoulders without clinical or sonographic pathology. Tendon thickness measurements were excluded in cases where a full-thickness tear was detected during the evaluation of ST pathology (11, 12, 23).

Before starting our study, the AHD and ST thickness measurements of 10 patients with ST pathology were repeated three times at 1-day intervals to calculate intraclass and interclass correlation coefficients. After the measurements, intraclass and interclass correlation coefficients were calculated.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, IL, USA). Normal distribution was evaluated with kurtosis-skewness values and Kolmogorov-Smirnov/Shapiro-Wilk test. Mean and standard or median and 1st–3rd quarter (25th–75th quarter) were used for descriptive analyses. Mann Whitney U Test or T-test was used for comparison between the two groups. Kruskal Wallis Test or ANOVA test was used when comparing more than two groups. While presenting the categorical variables, the frequency and percentage values of the variables were used, and the analysis of the categorical variables was performed with the Chi-square (Fisher exact) Test. Spearman or Pearson Correlation test was used to evaluate the relationships between quantitative variables. We considered r values < 0.3 to represent a weak association, 0.3–0.7 to represent a moderate association, and > 0.7 to express a strong association (20). P-values below 0.05 were considered as statistically significant results.

RESULTS

Interrater and interrater reliability coefficients were excellent for both measurements (ICC>95%).

A total of 111 patients with ST pathology (NTT (n:65), PTT (n:31), FTT (n:15)) and 25 HC (17 bilateral shoulders; 8 unilateral shoulders (n:42)) were included in the study. The demographic and clinical characteristics of the groups are summarized in Table 1.

In the correlation analysis between AHD and ST thickness and demographic variables in the HC group,

Table 1. The demographic and clinical characteristics of the groups

	NTT (n:65)	PTT (n:31)	FTT (n:15)	HC (n:25)
Age (years) Mean±SD	51.4 ± 7.8	53.4 ± 7.4	55.9 ± 7.9	53.6 ±5.9
BMI (kg/cm²) Mean±SD	28.3 ± 5.3	27.2 ± 3.1	29.8 ± 3.8	27.0 ± 1.3
Height (cm) Median (1Q-3Q)	165 (160–170)	165 (157–169)	163 (158–165)	164 (159–173)
Weight (kg) Median (1Q–3Q)	76 (68–87)	75 (70–80)	78 (70–85)	78 (68–82)
Gender Female n (%) Male n (%)	38 (58.5%) 27 (41.5%)	20 (64.5%) 11 (35.5%)	11 (73.3%) 4 (26.7%)	13 (52%) 12 (48%)
Pain duration 6–12w n (%) >12w n (%)	20 (30.8%) 45 (69.2%)	9 (29.0%) 22 (71.0%)	3 (20.0%) 12 (80.0%)	–
Painful side Dominant n (%) Non (dominant n (%).	45 (69.2%) 20 (30.8%)	21 (67.7%) 10 (32.3%)	10 (66.7%) 5 (33.3%)	–
NRS Mean±SD	7.5 ± 1.6	6.8 ± 2.0	8.1 ± 1.5	–
SST Mean±SD	3.4 ± 2.3*	5.0 ± 2.8	3.7 ± 2.4	–
QDASH Mean±SD	59.5 ± 21.8	48.0 ± 23.2	55.2 ± 24.5	–

NRS – Numeric Rating Scale; SST – Simple Shoulder Test; QDASH – Quick the Disabilities of the Arm, Shoulder and Hand
* Significant difference between NTT and PTT

Table 2. Relationship between quantitative variables in control group

		BMI	Weight	Height
AHD	r	0.104	-0.043	-0.003
	n	42	42	42
ST thickness	r	**0.553***	0.299	0.128
	n	**42**	42	42

AHD – acromihumeral distance; ST – supraspinatus tendon, BMI – body mass index
* The correlation was significant at the level of p<0.05.

Table 3. The Relationship Between Quantitative Variables in the Patient Group

		NRS[s]	QDASH[p]	SST[s]
ST thickness	r	0.178	**0.276***	**-0.223***
	n	96	96	96

ST – supraspinatus tendon; NRS – Numeric Rating Scale; SST – Simple Shoulder Test; QDASH – Quick the Disabilities of the Arm, Shoulder and Hand
* The correlation was significant at the level of p<0.05.

there was a significant correlation only between BMI and ST thickness (r = 0.553) (Table 2).

ST thickness and AHD in dominant and non-dominant shoulders were compared in individuals with bilateral healthy shoulders (n:17) in the HC group. No statistically significant difference was found (p > 0.05). The linear relationship between clinical data and AHD and ST thickness was analyzed in patient groups (NTT and PTT), regardless of shoulder pathology. A significant correlation was found between ST thickness and QDASH (r=0.276, p<0.05) and SST (r=–0.223, p<0.05) (Table 3).

AHD was significantly higher in the NTT group compared to the other groups (p=0.000). AHD was significantly higher in the PTT group than in the FTT group (p=0.000); however, although AHD was lower than in the HC group, there was no significant difference (p>0.05). AHD was significantly lower in the NTT group than in the HC group (p=0.000) (Table 4).

ST thickness was significantly higher in the NTT group than in the other groups (p=0.000); however, although ST thickness was lower in the PTT group than in the HC group, there was no statistically significant difference (p>0.05) (Table 4).

In the patient group, there was no statistically significant difference between the groups in terms of gender, pain duration, and painful side distribution (p>0.05).

In the patient group, ST thickness and AHD values did not differ significantly between the NTT, PTT, and FTT groups with pain for 6-12 weeks and longer than 12 weeks (p>0.05).

There was no significant difference between male and female genders in terms of AHD and ST thickness in HC, NTT, PTT, and FTT groups (p>0.05).

DISCUSSION

In this study, we found AHD to be significantly different between groups. While it was significantly higher in the NTT group than in the other groups, it was significantly lower in the FTT group. There was no significant difference between the PTT and HC groups. ST thickness was significantly higher in the NTT group than in the PTT and control groups. Although the mean tendon thickness in the PTT group was lower than in the HC group, there was no statistically significant difference between them. In addition, there is a negative correlation between SS thickness and BOT and a positive correlation between ST thickness and QDASH.

The range of AHD measured in previous studies has been approximately 2–17 mm. It has been stated that some of the reasons for this wide range in AHD measurement may be due to age, race, gender, shoulder position, shoulder pathologies, different imaging methods, and measurement techniques (32). In a study by de Witte et al. (13), in which they evaluated tendinopathy and partial tear cases as SAS, the mean AHD was 11.1 mm in the SAS group, 7.6 mm in the full-thickness tear group, and 8.9 mm in the control group. The reason why AHD was found to be higher in the SIS group, unlike the control group, may be due to the numerical superiority of the tendinopathy cases among the cases.

Azzoni et al. (5, 6), in which they evaluated tendinopathy, partial tear, full-thickness tear, and normal ST, stated that AHD was significantly different between the 4 groups. Xu et al. (32) evaluated AHD in a study and found that AHD was significantly reduced in the full-thickness tear group than in the partial tear and control groups; however, they did not find a significant difference between the partial tear group and the control

Table 4. Comparison of AHD and ST thickness between groups

	NTT (n:65)	PTT (n:31)	FTT (n:15)	HC (n:42)	P value
AHD (mm) Mean±SD	10.4 ± 0.9* †‡	9.6 ± 0.7 †	7.9 ± 1.0 ‡	9.7 ± 0.2	**0.000**
ST thickness (mm) Mean±SD	6.7 ± 0.7* ‡	5.5 ± 0.5	–	5.6 ± 0.2	**0.000**

AHD – acromiohumeral distance; ST – supraspinatus tendon
* Significant difference with the PTT; † Significant difference with the FTT; ‡ Significant difference with the HC

group in terms of AHD. In this study, it was stated that reduced AHD may be a predictive parameter for full-thickness tears. Thus, Saupe et al. (26), found a full-thickness tear in the ST in 19 of 21 patients with AHD <7 mm. Therefore, they stated that values below AHD <7 mm may be evidence for a full-thickness tear. Although we found AHD to be significantly decreased in the FTT group, similarly, in our study, AHD>7 mm was detected in most of the cases in the FTT group. This may be due to the different imaging modalities used to evaluate AHD.

It has been emphasized in many studies that tendon thickness increases in cases of tendinopathy (23, 30). Arend et al. (3) found the ST to be thicker in the tendinopathy group than in the control group. In their study, they found the accuracy of diagnosing tendinopathy according to maximal ST thickness >6 mm or abnormal tendon structure as 93% and 93.2%, respectively. When the maximal ST thickness and abnormal tendon structure were evaluated together, they stated that the accuracy of diagnosing tendinopathy was 99%. In our study, we measured the tendon thickness of the patients in the NTT and HC groups, similar to this study. According to their study, when we accept the tendon thickness as >6 mm in order to identify the cases with tendinopathy, our accuracy rate is 89.2%. However, unlike our study, they measured the tendon thickness in the longitudinal plane, where the tendon is thickest. In this study, we calculated the mean value by measuring the ST thickness from three different points in the transverse plane; since the tendon thickness is not uniform, we think that it is healthier to measure from several points.

Cholewinski et al. (11) found the ST to be thinner in patients with SIS than in the control group. This may be due to the inclusion of partial tears in SIS cases. In addition, they evaluated the point tendon thickness by measuring the tendon thickness from the narrowest part of the tendon, which was different from our measurement. Jacobson et al. (17) found thinning of tendon thickness in 71% of full-thickness tears, 30% of articular tears, and 40% of bursal facial tears. At the same time, in the comparison of full-thickness and partial tears with non-tear cases, they found the sensitivity of the decrease in tendon thickness to be 56%, specificity 86%, positive predictive value 91%, and accuracy 64%.

In a systematic review, a correlation was found between AHD and scales evaluating patient-reported symptoms, and improvement in the scales was demonstrated with the increase in AHD over time (24). Another systematic review has shown that the relationship between AHD and pain is controversial (31). Mayerhoefer et al. (22) divided the patients into two groups according to their AHD: <7 mm and >7 mm. When this distinction was made with US, there was no significant difference in Constant scores between the groups; when this distinction was made with MRI, a significant difference was found in Constant scores. Hunter et al. (16) stated that the symptoms in patients with SIS were related to ST thickness rather than AHD.

We did not find a relationship between AHD and STT, NRS, and Q-DASH. However, we found a significant correlation between ST thickness and SST and Q-DASH. Based on this, we emphasize that ST thickness should be emphasized rather than AHD when evaluating symptoms and function in ST pathologies. Because, rather than subacromial decompression surgery, which was stated to be no different from placebo in the treatment of patients with SIS in previous studies, it has been stated that taking measures to reduce the thickness increase in the tendon, which occurs as a result of tendon degeneration, may be more effective (2,7).

Cholewinski et al. (11) found a significant relationship between the length of the individual and the AHD in their study. Hunter et al. (16), similar to our findings, said that BMI is a factor that positively affects tendon thickness. Obesity has been noted to cause tendinopathy with overload and inflammation (21). Therefore, the significant relationship between ST thickness and BMI that we found in our study should be taken into consideration.

In this study, we found that the mean ST thickness was significantly different between the NTT group and the PTT group. To the best of our knowledge, this is the first study in the literature. In countries like ours, where the patient population is high, this difference may save time in terms of diagnosis. As a result of a rapid and accurate diagnosis, the effects and complications of the treatment to be applied can be predicted. As a matter of fact, it is important at this point that the effectiveness of the treatment applied in previous studies and the treatment complications are different (25). The limitations of our study are that we did not specify the size and type of tear in the PTT group and the small number of patients in the full-thickness tear group.

CONCLUSIONS

Considering the study data, we found that AHD and SST thicknesses significantly differed in the NTT, PTT, FTT, and HC groups. This difference may be important for diagnosis. In addition, the effect of obesity on ST thickness and the relationship between ST thickness and functional scores may be considered. Weight control may be effective at this point.

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Corresponding author:
Burak Tayyip Dede, MD, Prof. Dr.
Kaptan Paşa Mah. Darülaceze Cad. No:27 34384
Şişli/İstanbul, Turkey
E-mail: drbrk22.94@gmail.com