SELÇUK TIP DERGİSİ
SELCUK MEDICAL JOURNAL
DOI:http:/dx.doi.org/10.30733/std.2024.01730
Selcuk Med J 2024;40(3): 134-139

OPEN ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

Is The Presence of Subscapularis Tear with Supraspinatus Tear Related to Scapular Morphology?

Supraspinatus Yırtığı İle Birlikte Subscapularis Yırtığının Varlığı Skapular Morfoloji İle İlişkili midir?

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ÖZET

Amaç: Yapılan çalışmalarda skapular morfolojinin supraspinatus yırtıkları ile ilişkili olduğu gösterilmiştir. Ancak subskapularis yırtıkları ile skapular morfoloji arasındaki ilişki tartışmalıdır. Bu çalışmanın amacı supraspinatus yırtığına eşlik eden subskapularis yırtığının skapular morfoloji ile ilişkili olup olmadığını araştırmaktır.

Gereçler ve Yöntem: 2016-2020 yılları arasında ortopedi ve travmatoloji kliniğimizde rotator manşet yırtığı nedeniyle yapılan 679 omuz artroskopisi ameliyatının kayıtları ve görüntülemeleri retrospektif olarak analiz edildi. İzole tam kat supraspinatus yırtığı olan 162 hasta ve supraspinatus yırtığına eşlik eden subskapularis yırtığı olan 83 hasta çalışmaya dahil edildi. Hastaların kritik omuz açısı (CSA), glenoid versiyonu (GV), glenoid inklinasyonu (GI) ve kritik korakoid proses açısı (CCPA) ölçüldü.

Bulgular: İzole supraspinatus yırtığı olan hasta grubunda ve supraspinatus yırtığına eşlik eden subskapularis yırtığı olan grupta; ortalama yaş sırasıyla 53.8±8.9 ve 61.1±8.4 idi ve anlamlı bir fark vardı (P<0.001); ortalama CSA değerleri 36.9º±4. 25º ve 35.6º±5.1º, (P=0.32); GI ortalama değerleri sırasıyla 7.72º±5.4º ve 8.4º±5.3º, (P=0.51); GV ortalama değerleri sırasıyla 2.1º±4,5º ve 2.5º±4.7º, (P=0.85); CCPA ortalama değerleri sırasıyla 21.4º±4.5º ve 22.3º±4.9º, (P=0.73). Cinsiyet açısından gruplar arasında anlamlı bir fark yoktu (P=0.59). Ölçülen açılar, yaş ve cinsiyet kriterleri kullanılarak yapılan lojistik regresyon analizinde, ileri yaşın diğer parametrelerden bağımsız olarak supraspinatus yırtığına eşlik eden subskapularis yırtığı üzerinde etkili olduğu görüldü (P < 0.001 OR:1.09).

Sonuç: İzole supraspinatus yırtığı ile supraspinatus yırtığına eşlik eden subskapularis yırtığı arasında skapular morfolojiye ilişkin radyolojik parametreler açısından anlamlı bir fark olmadığı görülmektedir. Supraspinatus yırtığına eşlik eden subskapularis yırtığında yaş en önemli faktör olarak görünmektedir. Supraspinatus yırtığı olan hastalarda yaşın bir birim (yıl olarak) artması, subskapular yırtık olasılığını 1,09 kat artırmaktadır.

Anahtar Kelimeler: Subskapularis, supraspinatus, skapular morfoloji

ABSTRACT

Aim: In previous studies it has been shown that scapular morphology is associated with supraspinatus tears. However, the relationship between subscapularis tears and scapular morphology is controversial. The aim of this study is to investigate whether or not subscapularis tear accompying supraspinatus tear is related to scapular morphology.

Materials and Method: Records and imaging of 679 shoulder arthroscopy surgeries performed for rotator cuff tear in our orthopedics and traumatology clinic between 2016 and 2020 were retrospectively analyzed. 162 patients with isolated full-thickness supraspinatus tear and 83 patients with subscapularis tear accompanying supraspinatus tear were included in the study. The critical shoulder angle (CSA), glenoid version (GV), glenoid inclination (GI) and critical coracoid process angle (CCPA) of the patients were measured.

Results: In the patient group with isolated supraspinatus tear and in the group with subscapularis tear accompanying supraspinatus tear; The mean age was 53.8±8.9 and 61.1±8.4 respectively, and there was a significant difference (P<0.001); the mean CSA values were 36.9º±4.25º and 35.6º±5.1ºrespectively, (P=0.32); GI mean values were 7.72º±5.4º and 8.4º±5.3ºrespectively, (P=0.51); GV mean values were 2.1º±4,5º and 2.5º±4.7º respectively,(P = 0.85); mean CCPA values were 21.4º±4.5º and 22.3º±4.9ºrespectively, (P=0.73). There was no significant difference between the groups in terms of gender (P=0.59). In the logistic regression analysis performed by using criteria of the measured angles, age and gender, it was observed that advanced age had an effect on the subscapularis tear accompanying the supraspinatus tear, independent of the other parameters (P < 0.001 OR:1.09).

Conclusion: There appears not to be a significant difference between isolated supraspinatus tears and subscapularis tear accompanying supraspinatus tear, in terms of radiological parameters regarding scapular morphology. Age seems to be the most important factor in subscapularis tear accompanying supraspinatus tears. In patients with supraspinatus tear, an increase in age by one unit (in years) increases the odds of subscapularistear by1.09 times.

Keywords: Supraspinatus, subscapularis, scapular morphology

Geliş Tarihi/Received: 3 April/Nisan 2024 **Kabul Tarihi/Accepted:** 7 July/Temmuz 2024 **Yayın Tarihi/Published Online:** 27 September/Eylül 2024

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Atıf yapmak için/ Cite this article as: Yaka H, Ozer M, Yilmaz C, Kucuksen MF, Baako Y, Kanatli U. Is The Presence of Subscapularis Tear with Supraspinatus Tear Related to Scapular Morphology? Selcuk Med J 2024;40(3): 134-139

Disclosure: *Author has not a financial interest in any of the products, devices, or drugs mentioned in this article. The research was not sponsored by an outside organization. Author has agreed to allow full access to the primary data and to allow the journal to review the data if requested.*

INTRODUCTION

Subscapularis tear is rare in patients with rotator cuff tear, and incidence is reported to be between 4 and 8% (1, 2). Subscapularis (Ssc) tear generally occurs traumatically owing to forced external rotation and abduction (3) (Figure-1). Ssc tear may occur in isolation, likewise it could co-exist with a supraspinatus (Ssp) tear, or may superimpose on a pre-existing Ssp tear (4) (Figure-2). The majority of rotator cuff tears are related to degeneration, and prevalence data have shown that degenerative cuff tears are associated with age (5, 6). On the other hand, it is a known fact that risk factors caused by different scapular morphologies can accelerate age-related degeneration (7). Previously, it has been shown that the critical shoulder angle (CSA) is a strong determinant in rotator cuff tears (8). According to reports, CSA is linked to common shoulder problems, including osteoarthritis and rotator cuff issues (8, 9). Glenoid inclination (GI), as defined by Mauer et al. (10), has been linked to prevalent shoulder issues like rotator cuff pathology and shoulder osteoarthritis. Tollemar et al.(11) demonstrated that there was no relationship between the coracohumeral distance and Ssc tears . Brunkhorst et al. (12) also indicated in their studies that the coracohumeral distance may vary depending on position of the arm. Wynel-Mayow et al.(13) defined the critical coracoid angle in relation to the glenoid and coracoid, and showed that there is an association between low critical coracoid angle and type-B osteoarthritis.

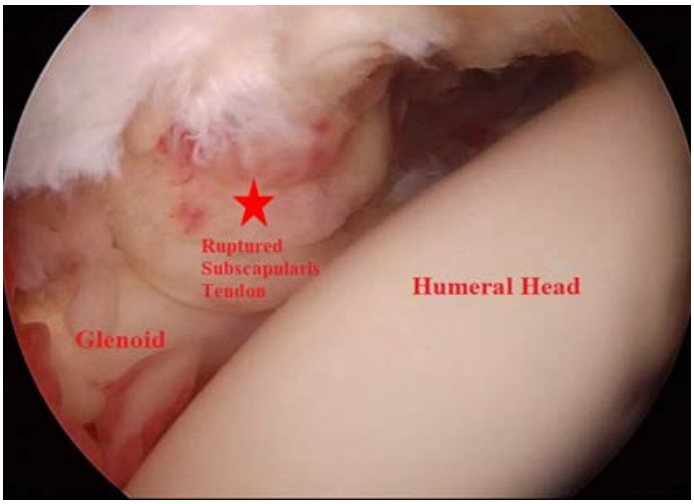

Figure 1. Arthroscopic view of subscapularis tear

Figure 2. Arthroscopic view of supraspinatus tear

Previous studies have shown a relationship between increased critical shoulder angle and Ssp tear. Whereas Watson et al. (14) reported a relationship between coracoid morphology and Ssc tear, Tollemar et al. (11) reported there was no relationship between the two . Although it is widely accepted that isolated Ssp tears and scapular morphology are related, the connection between Ssc tears and scapular morphology remains a subject of debate. This study aims to examine whether the presence of Ssc tears accompanying Ssp tears is associated with scapular morphology.

MATERIALS AND METHOD

Ethical clearance was granted by the "Necmettin Erbakan University Ethical Committee" (IRB number: 2024/4861). Patients who underwent shoulder arthroscopy in the Orthopedics and Traumatology Department of Necmettin Erbakan University Faculty of Medicine between 2016 and 2020 were retrospectively analyzed. Among 679 patients operated on in our clinic due to rotator cuff tear, 83 patients with Ssc tear accompanying Ssp tear (La Fosse type 1 and Type 2) were identified. For the control group, 162 patients who were operated on due to isolated full-thickness Ssp tear were included in the study. Exclusion criteria for the study were history of instability, glenohumeral arthrosis, traumatic rotator cuff tears, history of previous upper extremity fracture, massive irreparable tears, history of previous upper extremity surgery, neurological disease and upper extremity deformity.

The true anteroposterior (AP) radiographs and magnetic resonance imaging (MRI) of both patient groups were assessed. In the true AP radiographs, the CSA was measured by two independent observers in two sessions. The glenoid inclination (GI), glenoid version (GV), and critical coracoid process angle (CCPA) values were also measured in the MRI. The CSA was defined as the angle formed between the line connecting the superior aspect of the glenoid to the inferior aspect of the acromion and the line connecting the inferior aspect of the glenoid to the inferolateral aspect of the acromion (8) (Figure-3).

As Tetreault et al.(15) described, the term GV refers to the angle in the axial plane that is formed by the tangents of two lines. The first line is drawn between the anterior and posterior glenoids, and the second line is drawn from the most medial part of the scapula to the midpoint of the first line (15). The definition of retroversion is a positive angle, while anteversion is a negative angle (15) (Figure-4).

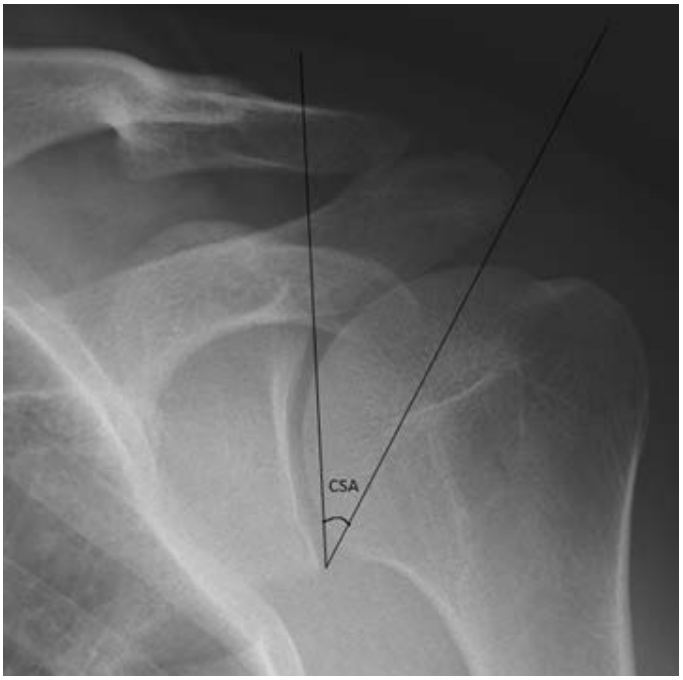

Figure 3. Demonstration of critical shoulder angle (CSA) measurement in a true AP radiograph

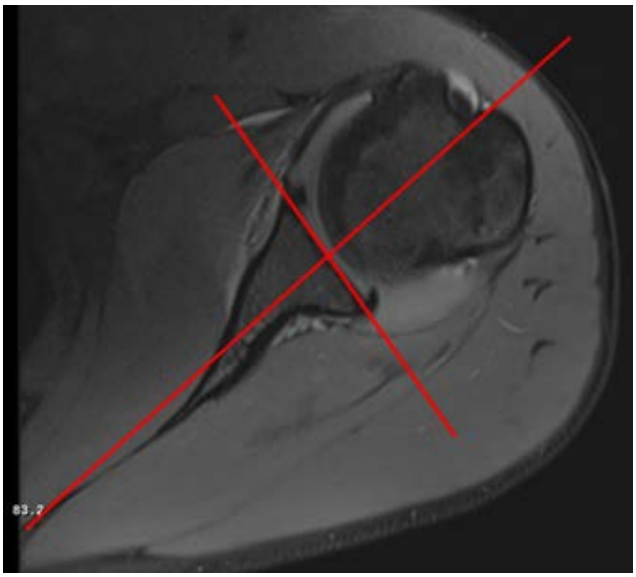

Figure 4. Demonstration of glenoid version measurement by intersecting the scapula body axis lines with a line from the anterior and posterior edges of the glenoid

In a coronal oblique view, the β angle is determined using the scapular body line, which signifies the deepest point on the supraspinatus fossa, and the line that connects the upper and lower glenoid borders, as described by Maurer at al. (10). The Glenoid angle (GI) was determined by subtracting 90° from the angle that is formed by the glenoid surface and the scapular body (β) (10). The upper and lower glenoid angles are referred to as positive and negative angles, respectively (10) (Figure-5).

On computerized tomography, CCPA is defined as the

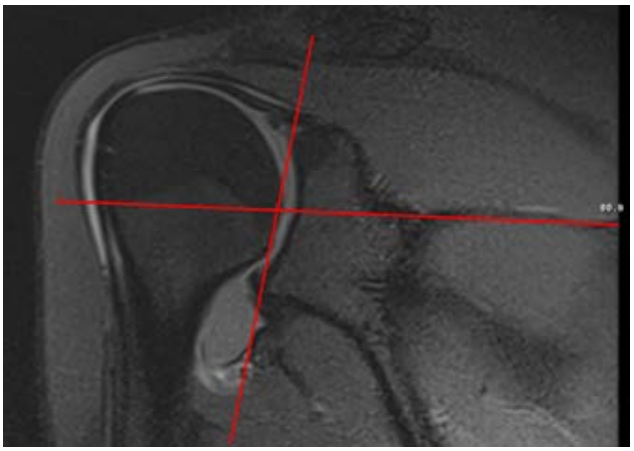

Figure 5. Demonstration of glenoid inclination measurement in a patient with Slap-5 lesion by intersecting the line passing through the superior and anterior borders of the glenoid and the lines passing through the base of the supraspinatus fossa

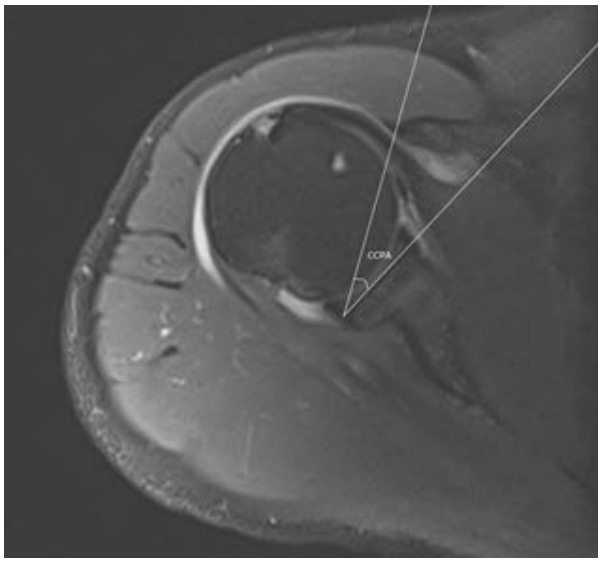

Figure 6. Demonstration of the critical coracoid process angle. The critical coracoid process angle is the angle between the line through the glenoid articular face and the line from the posterior corner of the glenoid to the apex of the coracoid process in the axial section where the coracoid process is most prominent.

angle between the line passing through the glenoid joint surface and the line extending from the posterior corner of the glenoid joint surface to the coracoid apex, in the section where the coracoid process apex is visible in the axial plane (13) (Figure-6). In this study, CCPA measurements were done as described by Wynell-Mayow et al.(13), but only on magnetic resonance imaging.

Data analysis was performed using SPSS software (IBM-SPSS 22.0, Armonk, NY, USA). Descriptive statistics and frequency analysis were used to evaluate the data. In addition, Cronbach's alpha test was used to assess the intra- and inter-class correlations between measurements made by the same observer in two separate sessions two weeks apart, and between measurements carried out by two different observers. The Shapiro-Wilk test was used to check the skewness of the data. T-test and Mann-Whitney U test were used to compare independent sample groups. Statistical significance was established at P<0.05. Logistic regression analysis was performed to investigate which of the radiologic parameters known to be associated with rotator cuff pathologies and age, which are known to be associated with rotator cuff tendon degeneration, had an independent effect on subscapularis tear accompanying supraspinatus tear.

RESULTS

Cronbach's alpha values were between 0.83 and 0.95 for all measurements.Whereas the mean age of the patient group with isolated Ssp tear was 53.8±8.9 (40-79), the mean age of patients with Ssc tear accompanying Ssp tear was 61.1 ±8.4 (48-79), and there was significant difference between the two groups in terms of age (P<0.001) (Table-1). While 97 of the 162 patients with isolated Ssp tear were females and 65 were males, the group of patients with Ssc tear accompanying Ssp tear consisted of 54 females and 29 males, and there was no significant difference between the two groups in terms of gender (P = 0.59 chi-square) (Table-1). While the mean CSA in patients with isolated Ssp tear was 36.9º±4.25º (28.8º/48.2º), it was 35.6º±5.1º (26.4º/45.9º) in the patient group with Ssc tear accompanying Ssp tear, and there was no significant difference between them (P=0.32) (Table-1). While the mean GI values were 7.72º±5.4º (-4.2º / 18.4º) in the patient group with isolated Ssp tear, it was 8.4º±5.3º (-6.7º / 17.9º) in the patient group with Ssc tear accompanying Ssp tear, and there was no significant difference between them (P = 0.51) (Table-1). While the mean GV values were 2.1º±4.5º (-9.5º / 13.1º) in the patient group with isolated Ssp tear, it was 2.5º±4.7º (-9.6º / 13.1º) in the patient group with Ssc tear accompanying Ssp tear, and there was no significant difference between them (P=0.85) (Table-1). While the mean CCPA values were 21.4º±4.5º (11.4º / 32.6º) in the patient group with isolated Ssp tear, it was 22.3º±4.9º (11.2º/39.16º) in the patient group with Ssc tear accompanying Ssp tear, and there was no significant difference between them (P=0.73) (Table-1). In the group of patients with isolated Ssp tears, there was no significant difference between male and female sexes in terms of CSA, GI, GV and CCPA (P=0.27, P=0.79, P=0.60, P=0.18 respectively). In the group of patients with Ssc tear accompanying Ssp tear, there was no significant difference between male and female sexes in terms of CSA, GI, GV and CCPA (P=0.17, P=0.62, P=0.77, P=0.91 respectively). In the logistic regression analysis performed by including the measured angles, age and gender criteria, it was seen thatonly age had an effect on Ssc tear accompanying Ssp tear, independent of other parameters (P<0.001 OR:1.09). In other words, an increase in age by one unit (in years) increases the odds of Ssc tear by 1.09 times.

DISCUSSION

The most important finding of this study is that age has a significant effect on Ssc tear accompanying Ssp tear, and that in patients with isolated Ssp tear and in those with Ssc

Table 1. Patients' Demographic Data

	Isolated Ssp tears (Number of Patients=162)	Ssp tears with Ssc tears (Number of Patients=83)	P-value
Age(years)±SD (min/max)	53.8±8.9 (40/79)	61.1 ±8.4 (48/79)	<0.001
Gender (M/F)	65/97	29/54	0.59
Side (R/L)	89/73	44/36	0.63

Table 2. Mean values and comparisons of radiological measurement parameters

	Isolated Ssp tears (Number of Patients=162)	Ssp tears with Ssc tears (Number of Patients=83)	P-value
CSA ±SD (min/max)	36.9º±4.25º (28.8º / 48.2º)	35.6º±5.1º (26.4º / 45.9º)	0.32
GI±SD (min/max)	7.72º±5.4º(-4.2º / 18.4º)	8.4º±5.3º (-6.7º / 17.9º)	0.51
GV±SD (min/max)	2.1º±4.5º (-9.5º / 13.1º)	2.5º ± 4.7º (-9.6º / 13.1º)	0.85
CCPA±SD (min/max)	21.4º ±4.5º (11.4º /32.6º)	22.3º±4.9º(11.2º / 39.16º)	0.73

(CSA: critical shoulder angle, GI: glenoid inclination, GV: glenoid version CCPA: critical coracoid process angle)

accompanying Ssp tear, the radiological parameters related to scapular morphology are similar.

The rotator cuff muscles serve to centralize the humeral head in the glenoid by pressing it against the glenoid, they as well attempt to neutralize the force exerted by the deltoid muscle, to prevent migration of the humeral head superiorly. Theoretically, as CSA increases, the point of attachment of the deltoid muscle on the acromion shifts more laterally, and as a result the superior vector of the force applied by the deltoid on the humeral head tend to increase, while the medial vector tend to decrease. Owing to an increased CSA, there is an increased superior vector of the deltoid's muscle strength, therefore in order to centralize the humeral head in the glenoid, the force exerted by the rotator cuff muscles must increase accordingly. Rotator cuff tears easily occur due to the increased workload on them, owing to increasing tendon degeneration caused by advanced age and an increased CSA (9). Moor et al. in their study demonstrated that Ssp tear increased significantly in patients with CSA>35º (9). On the other hand, Chalmers et al.(16), in their study investigating the correlation between rotator cuff tear progression and CSA, reported that although they found a significant correlation between CSA and tear sizes, they found a negative correlation between CSA and tear length. They also stated that they could not yet provide a biological explanation for these results . In our study, CSA values in patients with isolated Ssp tear and in patients with Ssc tear accompanying Ssp tear was above 35º, thus being consistent with the study by Moor et al, and there was no significant difference between them (9). In our study, while there was no difference between the two patient groups in terms of the radiological parameters measured, the difference in age may explain Ssc tear accompanying Ssp tear in two ways. The first of these explanations is that the degeneration patterns of Ssp and Ssc tendons may be different; Ssc may degenerate later than Ssp. However, there is no data on this in our study. Secondly, the increase in CSA may biomechanically affect the Ssp more than it does the Ssc, and after Ssp tears, the load on the Ssc to centralize the humeral head in the glenoid may increase further and the degeneration rate of the Ssc may increase indirectly. Repairing supraspinatus tears without neglect can prevent a possible subscapularis tear as it will restore shoulder biomechanics.

In their study, Tetreault et al.(15) indicated that increased glenoid retroversion was associated with Ssp tears. Doğan et al.(17) in their study on patients with Ssp and Ssc tears could not find a significant relationship between rotator cuff tears and GV. Although common theories regarding the etiology of degenerative rotator cuff tears primarily suggest an age-related decrease in tendon tissue quality, the potential importance of bony anatomy remains controversial. While the effects of GV on shoulder biomechanics were investigated in relation to rotator cuff tears, their relationship with glenohumeral instability was also investigated. Whereas Hohman et al.(18) and Aygün et al.(19) found a significant relationship between increased glenoid anteversion and anterior shoulder instability, Moroder et al.(20) and Peltz et al.(21) could not find a significant relationship between GV and anterior shoulder instability. In our study, no significant difference was found in terms of GV between isolated Ssp tear and Ssc tear accompanying Ssc tear. In light of the results obtained in our study on GV and by data in the literature, it appears the relationship between GV and shoulder biomechanics may continue to be controversial.

In their study where they defined the critical coracoid angle, Wynell-Mayow et al. found a significant relationship between low CCPA and shoulder osteoarthritis (13). They detailed the possible biomechanical explanation of this relationship in the following manner; the more medially the coracoid is located, the more medially the conjoint tendon inserting on the coracoid becomes, thus the anterior vector of the force of the pectoralis major, which courses anteriorly to the conjoint tendon decreases. Thus, they interpreted that the anterior-posterior translation balance of the humeral head becomes disrupted and the humeral head tends to be translated posteriorly. In our study, we evaluated the relationship between CCPA, which has been shown to affect the anterior-posterior translation of the humerus, and Ssc tears accompanying Ssp tears, but we could not find a significant relationship. Possible reasons for this may be that the control group did not have patients with normal MRI images without pathology, rotator cuff biomechanics may have been impaired in both patient groups, or that one of the patient groups did not have patients with isolated Ssc tears.

This study had some limitations. Unknown patient professions, activity levels and body mass indexes were a limitation. Unknown patient shoulder complaint duration was a limitation too.

CONCLUSION

There appears not to be a significant difference between isolated supraspinatus tears and subscapularis tear accompanying supraspinatus tear, in terms of radiological parameters regarding scapular morphology. Age seems to be the most important factor in subscapularis tear accompanying supraspinatus tears. In patients with supraspinatus tear, an increase in age by one unit (in years) increases the odds of subscapularis tear by 1.09 times.

Conflict of interest: *The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.*

Financial conflict of interest: *Author declares that he did not receive any financial support in this study.*

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REFERENCES

1. Constant C, Murley A. A clinical method of functional assessment of the shoulder. Clinical orthopaedics and related research. 1987(214):160-4. PMID:3791738
2. Flury MP, John M, Goldhahn J, et al. Rupture of the subscapularis

tendon (isolated or in combination with supraspinatus tear): when is a repair indicated? Journal of shoulder and elbow surgery. 2006;15(6):659-64. https://doi.org/10.1016/j.jse.2005.07.013
3. Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle. Clinical features in 16 cases. The Journal of Bone & Joint Surgery British Volume. 1991;73(3):389-94. https://doi.org/10.1302/0301-620x.73b3.1670434
4. Sano H, Uhthoff HK, Backman DS, et al. Structural disorders at the insertion of the supraspinatus tendon: relation to tensile strength. The Journal of Bone & Joint Surgery British Volume. 1998;80(4):720-5. https://doi.org/10.1302/0301-620x.80b4.8203
5. Minagawa H, Yamamoto N, Abe H, et al. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: from mass-screening in one village. Journal of orthopaedics. 2013;10(1):8-12. https://doi.org/10.1016/j.jor.2013.01.008
6. Tempelhof S, Rupp S, Seil R. Age-related prevalence of rotator cuff tears in asymptomatic shoulders. Journal of shoulder and elbow surgery. 1999;8(4):296-9. https://doi.org/10.1016/s1058-2746(99)90148-9
7. Sano H, Ishii H, Yeadon A, et al. Degeneration at the insertion weakens the tensile strength of the supraspinatus tendon: A comparative mechanical and histologic study of the bone-tendon complex. Journal of orthopaedic research. 1997;15(5):719-26. https://doi.org/10.1002/jor.1100150514
8. Moor B, Bouaicha S, Rothenfluh D, et al. Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint?: A radiological study of the critical shoulder angle. The bone & joint journal. 2013;95(7):935-41. https://doi.org/10.1302/0301-620x.95b7.31028
9. Moor B, Röthlisberger M, Müller D, et al. Age, trauma and the critical shoulder angle accurately predict supraspinatus tendon tears. Orthopaedics & Traumatology: Surgery & Research. 2014;100(5):489-94. https://doi.org/10.1016/j.otsr.2014.03.022
10. Maurer A, Fucentese SF, Pfirrmann CW, et al. Assessment of glenoid inclination on routine clinical radiographs and computed tomography examinations of the shoulder. Journal of shoulder and elbow surgery. 2012;21(8):1096-103. https://doi.org/10.1016/j.jse.2011.07.010
11. Tollemar VC, Wang J, Koh JL, et al. Coracoid morphology is not associated with subscapularis tears. Journal of Shoulder and Elbow Surgery. 2020;29(6):1162-7. https://doi.org/10.1016/j.jse.2019.11.008
12. Brunkhorst JP, Giphart JE, LaPrade RF, et al. Coracohumeral distances and correlation to arm rotation: an in vivo 3-dimensional biplane fluoroscopy study. Orthopaedic journal of sports medicine. 2013;1(2):2325967113496059. https://doi.org/10.1177/2325967113496059
13. Wynell-Mayow W, Chong CC, Musbahi O, et al. A lower critical coracoid process angle is associated with type-B osteoarthritis: a radiological study of normal and diseased shoulders. JSES international. 2022;6(3):447-53. https://doi.org/10.1016/j.jseint.2021.10.007
14. Watson AC, Jamieson RP, Mattin AC, et al. Magnetic resonance imaging based coracoid morphology and its associations with subscapularis tears: a new index. Shoulder & Elbow. 2019;11(1_suppl):52-8. https://doi.org/10.1177/1758573217744170
15. Tetreault P, Krueger A, Zurakowski D, et al. Glenoid version and rotator cuff tears. Journal of orthopaedic research. 2004;22(1):202-7. https://doi.org/10.1016/s0736-0266(03)00116-5
16. Chalmers PN, Salazar D, Steger-May K, et al. Does the critical shoulder angle correlate with rotator cuff tear progression? Clinical Orthopaedics and Related Research®. 2017;475:1608-17. https://doi.org/10.1007/s11999-017-5249-1
17. Dogan M, Cay N, Tosun O, et al. M. Glenoid axis is not related with rotator cuff tears—a magnetic resonance imaging comparative study. International orthopaedics. 2012;36:595-8. https://doi.org/10.1007/s00264-011-1356-x
18. Hohmann E, Tetsworth K. Glenoid version and inclination are risk factors for anterior shoulder dislocation. Journal of shoulder and elbow surgery. 2015;24(8):1268-73. https://doi.org/10.1016/j.jse.2015.03.032
19. Aygün Ü, Çalik Y, Işik C, et al. The importance of glenoid version in patients with anterior dislocation of the shoulder. Journal of Shoulder and Elbow Surgery. 2016;25(12):1930-6. https://doi.org/10.1016/j.jse.2016.09.018
20. Moroder P, Ernstbrunner L, Pomwenger W, et al. Anterior shoulder instability is associated with an underlying deficiency of the bony glenoid concavity. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2015;31(7):1223-31. https://doi.org/10.1016/j.arthro.2015.02.009
21. Peltz CD, Zauel R, Ramo N, et al. Differences in glenohumeral joint morphology between patients with anterior shoulder instability and healthy, uninjured volunteers. Journal of shoulder and elbow surgery. 2015;24(7):1014-20. https://doi.org/10.1016/j.jse.2015.03.024