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EVALUATING THE ROLE OF SCAPULA MORPHOLOGY IN ROTATOR CUFF TEARS: WHICH IS THE MOST USEFUL PREDICTOR?

ROTATOR MANŞET YIRTIKLARINDA SKAPULA MORFOLOJİSİNİN ROLÜNÜN İNCELENMESİ: EN KULLANIŞLI PREDİKTÖR HANGİSİ?

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ABSTRACT

Objective: The aim of this study was to determine the relationships between glenoid inclination (GI), acromial index (AI), critical shoulder angle (CSA), superior inclination (SI), and symptomatic degenerative full-thickness supraspinatus tears (SSTs).

Materials and Methods: Patients who were diagnosed with SSTs (n=39) between 2015 and 2017 were assessed retrospectively. Controls were matched to age, gender, and side. Measured GI, AI, CSA, and SI values were compared between the SSTs and control groups (n=39). The mean age for the SSTs group was 52.74±5.49 years, and the mean age for the control group was 51.15±5.22 years.

Results: The mean GI for the SSTs group was 19.97°±5.62°, and it was 13.72°±6.55° for the control group ($p<0.001$). The mean AI was 0.7±0.08 and 0.67±0.07 in the SSTs and control groups, respectively ($p=0.035$). The mean CSA for the SSTs group was 35.05°±4.09° and it was 33.06°±3.42° for the control group ($p=0.022$). The mean SI was 25.13°±5.71° and 25.91°±5.81° in the SSTs and control groups, respectively ($p=0.552$). For a cut-off value of GI ≥17.35°, sensitivity was 79.54%, and specificity was 79.51% ($p=0.001$). For a cut-off value of AI ≥0.67, sensitivity was 61.54% and specificity was 56.4% ($p=0.031$). For a cut-off value of CSA ≥33.45°, sensitivity was 64.12%, and specificity was 64.54% ($p=0.014$).

Conclusion: Higher measurement values of glenoid inclination, acromial index, and critical shoulder angle were associated with symptomatic degenerative full-thickness supraspinatus tears, and no correlation was found with superior inclination measurement. The glenoid inclination measurement had the highest

ÖZET

Amaç: Bu çalışmada glenoid inklinasyon (Gİ), akromial indeks (Aİ), kritik omuz açısı (CSA) ve superior inklinasyon (Sİ) ölçümlerinin semptomatik dejeneratif tam kat supraspinatus tendon yırtıkları (SSY) ile ilişkisinin incelenmesi amaçlanmıştır.

Gereç ve Yöntem: 2015 ve 2017 yılları arasında SSY tanılı hastaların verileri retrospektif olarak incelendi. SSY tespit edilen 39 hasta ile yaş, cinsiyet ve taraf yönünden eşleştirilmiş SSY olmadığı tespit edilen 39 hasta çalışmaya dahil edildi. Ölçülen Gİ, Aİ, CSA ve Sİ değerleri SSY grubu (n=39) ve kontrol grubu (n=39) arasında karşılaştırıldı. SSY grubunun yaş ortalaması 52,74±5,49 yıl, kontrol grubunun yaş ortalaması 51,15±5,22 yıl idi.

Bulgular: Gİ ortalaması yırtık grubunda 19,97°±5,62° iken kontrol grubunda 13,72°±6,55° idi ($p<0,001$). Aİ ortalaması yırtık grubunda 0,7±0,08, kontrol grubunda ise 0,67±0,07 idi ($p=0,035$). CSA ortalaması yırtık grubunda 35,05°±4,09°, kontrol grubunda 33,06°±3,42° idi ($p=0,022$). Sİ ortalaması yırtık grubunda 25,13°±5,71°, kontrol grubunda ise 25,91°±5,81° idi ($p=0,552$). Gruplar arasında istatistiksel anlamlı farklılık bulunan Gİ, Aİ ve CSA ölçümlerinin duyarlılık, özgünlük ve cut-off değerleri belirlendi. Buna göre Gİ'nin ≥17,35° cut-off değeri için duyarlılığı %79,54 iken özgünlüğü %79,51 idi ($p=0,001$). Aİ'nin ≥0,67 cut-off değeri icin duyarlılığı %61,54, özgünlüğü %56,4 idi ($p=0,031$). CSA'nın ≥33,45° cut-off değeri icin duyarlılığı %64,12, özgünlüğü ise %64,54 idi ($p=0,014$)..

Sonuç: Yüksek glenoid inklinasyon, akromial indeks, kritik omuz açısı ölçüm değerleri semptomatik dejeneratif tam kat supraspinatus tendon yırtıkları ile ilişkili iken superior inklinasyon ölçümü ile ilişki saptanmadı. Glenoid inklinasyon ölçümü semptomatik

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sensitivity and specificity in predicting symptomatic degenerative full-thickness supraspinatus tears.

Keywords: Acromial index, critical shoulder angle, glenoid inclination, rotator cuff tear, superior inclination

dejeneratif tam kat supraspinatus tendon yırtıklarının öngörülmesinde en yüksek duyarlılık ve özgünlüğe sahipti.

Anahtar Kelimeler: Akromiyal indeks, glenoid inklinasyon, kritik omuz açısı, rotator manşet yırtığı, superior inklinasyon

INTRODUCTION

Although various factors such as age, gender, overuse, and scapula morphology are held responsible for rotator cuff tears (RCTs), there are still many points waiting to be clarified in its etiology (1-3). With a better understanding of the importance of scapula morphology as a risk factor, various radiological parameters have been described consecutively to evaluate this relationship (4). Historically, subacromial impingement owing to scapular morphology as described by Neer had been recognized as a risk factor for RCTs (1). For a long time, the hook acromion in the sagittal plane described by Bigliani et al., as well as the thickening and shortening of coracoacromial ligament, have been considered to be correlated with RCTs (5-6). Attention was then turned to the orientation of the glenoid in the coronal plane (4). While some studies stated that glenoid inclination (GI) is associated with RCTs, no correlation could be demonstrated in a study by Moor et al. (3, 4, 7). This situation will lead to the need to describe the superior inclination (SI), which takes into account the position of the acromioclavicular joint in the coronal plane in the measurement of GI later on (8). The acromial index (AI), which was described by Nyfeller et al. and takes into account the amount of coverage of the humeral head by the acromial extension, found widespread support in revealing the aforementioned relationship (9, 10). On the other hand, the most widely accepted predictor for RCTs has been the critical shoulder angle (CSA) defined by Moor et al., which combines acromial extension with GI (11). However, the evidence in the recent literature is conflicting about the strength of the association of all the aforementioned radiological parameters, including CSA, with RCTs, which is a heterogeneous group (12, 13). Therefore, the aim of this study was to simultaneously evaluate the relationship between CSA, AI, GI, and SI with only full-thickness supraspinatus tears (SSTs). The study also aimed to determine the clinical usability of the parameters that could be correlated with SSTs.

MATERIAL AND METHODS

The data of 218 patients who were admitted with complaints of shoulder pain and underwent magnetic resonance imaging (MRI) at a single center (Acıbadem Maslak Hospital) between 2015 and 2017 were analyzed retrospectively. Exclusion criteria were:

1. having a true shoulder AP radiograph with >5 mm overlapping between the anterior and posterior border of the glenoid,
2. being younger than 40 years of age,
3. having arthrosis,
4. having had a glenoid or humeral fracture or deformity,
5. having an isolated subscapularis and infraspinatus tear or a partial SS tear,
6. having previous shoulder surgery.

Thirty-nine patients diagnosed with SSTs (19 female/20 male, 15 left/24 right) and 39 patients (21 female/18 male, 16 left/23 right) who had intact rotator cuff and were matched for age, gender, and sides were included in the study (Table 1). The control group was formed by matching method from patients who were admitted to the clinic with the complaint of shoulder pain and did not have a rotator cuff tear on MRI within the specified time. While it was determined that in the specified control group 34 patients had at least one of the diagnoses subacromial bursitis (n=21), supraspinatus tendinosis (n=13), or subacromial impingement syndromes (n=11), the shoulder MRI scan evaluation of 5 patients was found to be within normal limits. The mean age of the SSTs group was 52.74±5.49 years, and the mean age of the control group was 51.15±5.22 years. Measurements were carried out on true shoulder AP radiographs using the techniques originally described for GI, AI, CSA, and SI (Figure 1-4) (3, 8, 9, 14).

Table 1: Patient demographics

Variables	SST group (n=39) Mean±SD	Control group (n=39) Mean±SD	*p*
Age (years)	52.74±5.49	51.15±5.22	0.194*
Gender, n			0.651**
Female	19	21	
Male	20	18	
Side, n			0.817**
Left	15	16	
Right	24	23	

*: Independent samples t test, **: Pearson Chi-square test, Max: maximum, Min: minimum, SST: supraspinatus tear, SD: standard deviation

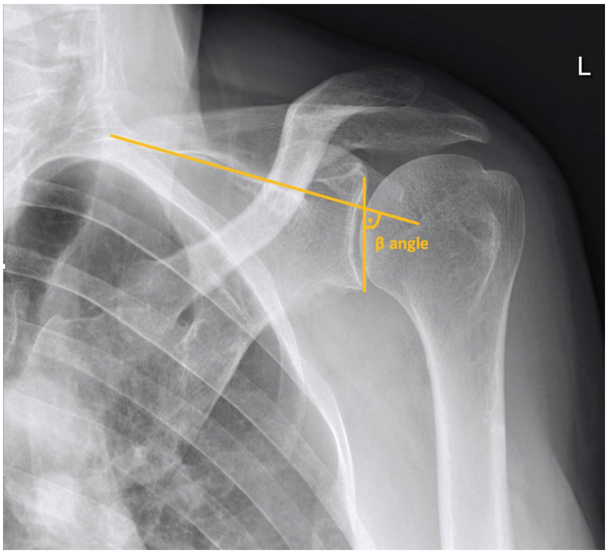

Figure 1: The ß-angle measurement. Glenoid inclination (GI) was obtained as 90° subtracted from the ß-angle

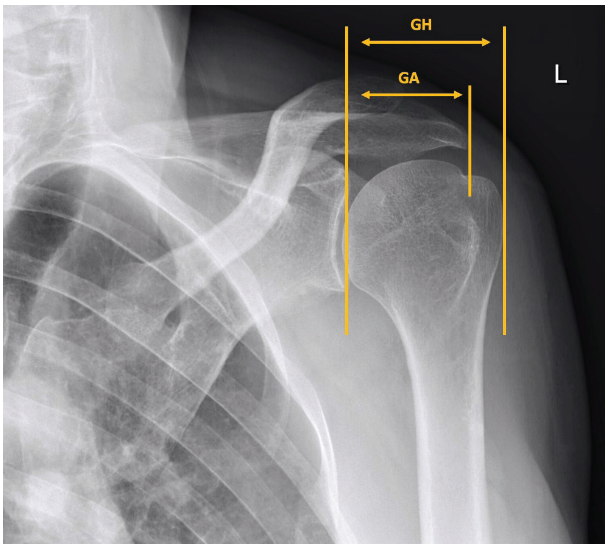

Figure 2: The acromial index (AI) measurement. AI is obtained by dividing the length from the glenoid joint face to the acromion (GA) by the length from the glenoid joint face to the lateral border of the humeral head (GH)

Statistical analysis

A Pearson Chi-Square test was used to compare categorical variables. An independent sample t-test was used to compare measurements between groups. Diagnostic screening tests (sensitivity, specificity) and ROC Curve analysis were used to determine cut-off for variables. Significance was evaluated at the p <0.05 level at least (SPSS 26.0.0.0 MacOS).

This study was approved by the Clinical Research Ethical Committee of the Acıbadem Mehmet Ali Aydınlar University (ATADEK) (Date: 24.06.2022, No: 2022-11/29).

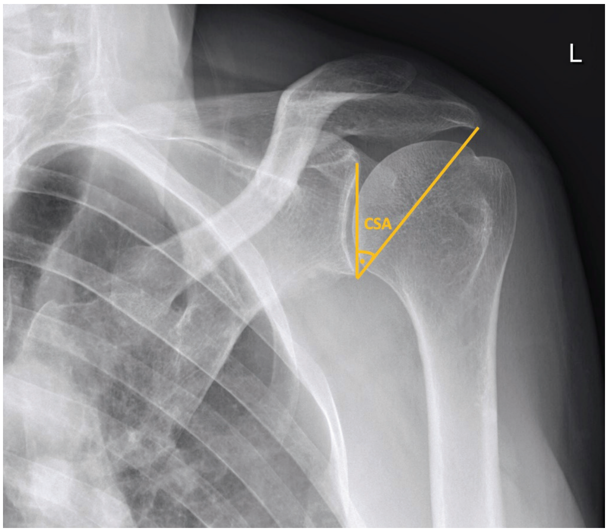

Figure 3: The critical shoulder angle (CSA) measurement

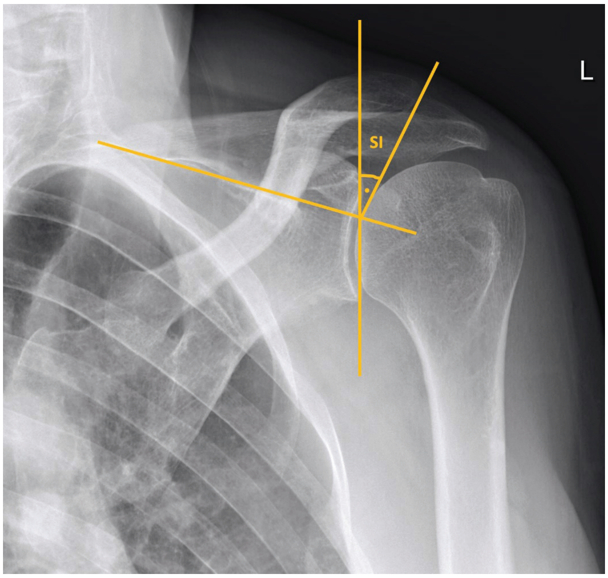

Figure 4: The superior inclination (SI) measurement

RESULTS

A statistically significant difference was found between the groups in all parameters evaluated except SI. The mean GI for the SSTs group was 19.97°±5.62° and it was 13.72°±6.55° for the control group (p<0.001). The mean AI for the SSTs group was 0.7±0.08 and it was 0.67±0.07 for the control group (p=0.035). The mean CSA for the SSTs group was 35.05°±4.09° and it was 33.06°±3.42° for the control group (p=0.022). The mean SI for the SSTs group was 25.13°±5.71° and it was 25.91°±5.81° for the control group (p=0.552) (Table 2). Based on detected significance, the cut-off point, sensitivity and specificity were calculated for GI, AI, and CSA. For a cut-off value of GI ≥17.35°, sensitivity was 79.54%, while specificity was 79.51% (p=0.001). For a cut-off value of AI ≥0.67, sensitivity was 61.54%, while specificity was 56.4% (p=0.031). For a cut-off value of CSA ≥33.45°, sensitivity was 64.12%, while specificity was 64.54% (p=0.014). Table 3 summarizes the values calculated by diagnostic scan tests and ROC Curve analysis for GI, AI, and CSA.

Table 2: The evaluation of measurements between groups

Variables	SST group (n=39) Mean±SD	Control group (n=39) Mean±SD	*p*
CSA	35.05°±4.09°	33.06°±3.42°	0.022*
AI	0.7±0.08	0.67±0.07	0.035*
GI	19.97°±5.62°	13.72°±6.55°	0.000*
SI	25.13°±5.71°	25.91°±5.81°	0.552*

*: Independent samples t test, AI: acromial index, CSA: critical shoulder angle, GI: glenoid inclination, Max: maximum, Min: minimum, SD: standard deviation, SI: superior inclination; SST: supraspinatus tear

The SI measurement technique, which was first described by Chalmers et al., unfortunately does not express that classical glenoid inclination is excessive in the superior direction, which is the connotation of the phrase itself (8). In many studies, the line expressing the scapular spine (1st line) and the line connecting the top and bottom points of the glenoid articular surface (2nd line) are used for measuring the conventional glenoid inclination (14). However, a third line extending from the intersection of the two lines to the acromioclavicular (AC) joint is also needed in this technique. The angle the authors refer to with SI is the angle between this third line and the second line. However, this angle is affected by the position of the AC joint in the coronal plane and lacks an actual expression of the glenoid inclination. In their study comparing patients with full-thickness rotator cuff tears and patients without tears, the authors reported higher SI values in the tear group but stated that this difference was not clinically significant (8). No other study using the technique specified in the current literature could be found. Also, considering the findings of our study, it was concluded that the use of the SI technique has no place in predicting RCT.

Table 3: Diagnostic scan tests for CSA, AI, GI and ROC Curve outcomes

Variables	Diagnostic scan			ROC curve		*p*
	Cut off	Sensitivity	Specificity	AUC	95% CI	
CSA	*≥33.45°*	64.12	66.73	0.655	0.532-0.779	*0.014**
AI	*≥0.67*	61.54	56.4	0.635	0.512-0.758	*0.031**
GI	*≥17.35°*	79.54	79.51	0.778	0.669-0.888	*0.001**

*: Receiver operating characteristic, AI: acromial index, AUC: area under the curve, CI: confidence interval, CSA: critical shoulder angle, GI: glenoid inclination, ROC: receiver operating characteristic

DISCUSSION

Although there are studies in the current literature reporting that scapula morphology may not be a risk factor in the development of rotator cuff tears, our study's findings revealed that scapula morphology may be associated with SSTs (12, 13). Only the superior inclination parameter was not found to be related to SSTs among the parameters evaluated in this study. Otherwise, GI, AI, and CSA have been shown to be associated with SSTs. Based on this relationship, the sensitivity, specificity, and cut-off values of these parameters were determined in a patient who presented with shoulder pain and underwent direct radiography. All three parameters have been found to be clinically usable in making predictions for SSTs. In addition, for a GI ≥17.35° cut-off value, it stood out with 79.54% of sensitivity and 79.51% of specificity (p=0.001).

One of the interesting findings in our study is the conclusion that the glenoid inclination, which was examined in earlier periods, is more useful, with its higher sensitivity and specificity than the more popular predictors, than AI and CSA today. Before interpreting this data, it should be noted that various techniques have been described for GI measurement, and the ß angle is more useful in terms of reproducibility and reliability, as indicated by Maurer et al. (14). Based on this finding, the ß angle was used in GI measurements in our study, and GI was calculated according to the 90-ß definition as stated by Garcia et al. (15). Measuring GI with a standardized, reliable, and reproducible method may have allowed the existing relationship to be clearly demonstrated.

The acromial index refers to the degree of coverage of the humeral head by the acromion. This radiological predictor has continued to attract the attention of clinicians since it was first described. It is widely supported in the literature that it is associated with RCTs (3, 9-11). However, the main reason for the interest is that it is a radiological parameter that can be corrected with lateral acromioplasty during rotator cuff repair (10, 16). Moreover, it has been reported that the risk of re-tear following repair of RCTs is higher in patients with high values of AI (17). Therefore, acromioplasty is usually recommended in patients with high values of AI (10, 16, 17). On the other hand, in a study by Chalmers et al. in which 110 patients with full-thickness RCTs were evaluated, the width of the acromion was evaluated instead of the acromial index (12). Acromion width was not found to be a statistically significant risk factor for retear and lateral acromioplasty was not recommended in that study. Contrary to Chalmers et al., the findings of our study support that lateral acromioplasty can be performed in patients with high values of AI in parallel with other studies reported in the literature (10, 12, 16, 17).

The critical shoulder angle defined by Moor et al. is one of the most popular predictors (3). CSA can be somehow defined as a geometric combination of acromial index and glenoid inclination (3). It has been reported that the high value of CSA is associated with both RCTs and retear after repair (15, 18, 19). However, some recent studies reporting that high values of CSA are not associated with RCTs (12, 13, 20). It was thought that the reason for this might be that CSA measurement can be affected by the anteversion of the scapula (21). Therefore, measurements should be made only on well-standardized true shoulder AP radiographs. In our study, the mean CSA of the patients in the SSTs group was higher than the control group (p=0.022). However, the sensitivity and specificity of CSA were lower than that of the GI predictor (64.12% and 66.73% for CSA, 79.54% and 79.51% for GI; respectively). This may be due to the confounding effect of scapula anteversion. Re-comparison of these two predictors using 3-dimensionally corrected MRI slices may be the subject of future studies.

This current investigation has several limitations. Firstly, it was a retrospective study and may have selection bias by its nature. The fact that the measurements were carried out once by a single observer is another limited aspect of the study. However, the strengths of the study are having detailed exclusion criteria, the fact that measurements were carried out by a senior surgeon trained in shoulder and elbow surgery, that fact that low-quality true anteroposterior shoulder radiographs that do not provide the strictly necessary adequacy were not included, and having a homogeneous control group in terms of age, gender, and side. Also, not including subscapularis tears, infraspinatus tears, or partial thickness supraspinatus tears allowed a homogeneous comparison to be carried out.

CONCLUSION

The findings of this study support the statement that high measurement values of GI, AI, and CSA are associated with SSTs, while high measurement values of SI are not. GI, AI, and CSA can be used in clinical practice to predict SSTs in patients with shoulder pain by taking the cut-off values determined in our study as a reference. Additionally, GI measurement stands out with its high sensitivity and specificity among the parameters examined in the prediction of SSTs.

Ethics Committee Approval: This study was approved by ATADEK (Clinical Research Ethical Committee of Acıbadem Mehmet Ali Aydınlar University) (Date: 24.06.2022, No: 2022-11/29).

Peer Review: Externally peer-reviewed.

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