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Original Article

Relationship between the critical shoulder angle and the development of rotator cuff lesions: a retrospective epidemiological study☆

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A R T I C L E I N F O

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A B S T R A C T

Objective: To perform a retrospective epidemiological study of radiographs in order to evaluate the relationship between the anatomy of the scapula and the development of rotator cuff injuries (RCIs).
Methods: This study retrospectively evaluated the relation of the critical shoulder angle (CSA) and RCIs from January 2011 to November 2013; patients were examined in the Orthopedics and Traumatology Department of a university hospital. The CSA was measured by radiographic standardization of two groups: a control group of 34 asymptomatic shoulders and a study group of 44 shoulders with complete RCIs.
Results: The mean age in the control group was 59.97 years (45–84) and the mean age in the group with RCIs was 59.75 years (45–84). Regarding the CSA, the control group had a mean angle of 33.59° (±3.37) and the group with RCIs had a mean angle of 39.75° (±5.35; $p < 0.007$).
Conclusion: There is an association between CSA and RCIs.

Associação entre o ângulo crítico do ombro e lesão do manguito rotador: um estudo epidemiológico retrospectivo

Palavras-chave:
Acrômio/radiografia
Manguito rotador/radiografia
Amplitude de movimento articular
Articulação do ombro

R E S U M O

Objetivo: Fazer um estudo epidemiológico retrospectivo em radiografias para avaliar a relação entre a anatomia da escápula e o desenvolvimento de lesões do manguito rotador (LMR).
Métodos: O presente estudo avaliou retrospectivamente a relação do ângulo crítico do ombro (ACO) e LMR de janeiro de 2011 a novembro de 2013, em pacientes atendidos em um

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hospital universitário pelo Departamento de Ortopedia e Traumatologia. Para tanto, o ACO foi medido após a padronização radiográfica de dois grupos, um grupo controle de 34 ombros assintomáticos e um segundo grupo de 44 ombros com LMR.
Resultados: A média de idade no grupo controle foi de 59,97 anos (45-84) e de 59,75 anos no grupo com LMR (45-84). Em relação ao ACO, os pacientes do grupo controle tiveram média de 33,59 graus de angulação (± 3,37) e o grupo de pacientes com LMR apresentou uma média de 39,75 graus de angulação (± 5,35; p < 0,007).
Conclusão: Há uma relação entre ACO e LMR.

Introduction

Rotator cuff injuries (RCIs) are frequent, and commonly associated with trauma or degenerative tendon disease; they vary in size and number of tendons involved.[1,2] Their prevalence is high and ranges from 7% to 40%, increasing with age.

The pathogenesis of RCIs is multifactorial and still controversial[3]; however, they have been related to the shape of the acromion.[3,4]

RCI diagnosis is essentially clinical, through a detailed history of the symptoms and their characteristics, as well as a thorough physical examination, which allow evaluation of the integrity of the rotator cuff and the presence of subacromial impingement.[5,6]

Simple shoulder radiography allows the visualization of important indirect signals, such as sclerosis and cysts in the acromion and in the greater tubercle, which are indicative of chronic impingement. It also indicates the morphology of the acromion[7] and the measurement of acromiohumeral space (distance between the anterior acromion and the highest part of the humeral head in the anteroposterior view), which ranges from 7 to 12 mm and may be reduced in rotator cuff injuries.[8–10] Increased retroversion of the glenoid cavity and increased lateral projection of the acromion are related to a higher prevalence oRCI.[7,11]

Through a retrospective study, the authors aimed to assess whether a new radiological parameter, the critical shoulder angle (CSA) developed by Moor et al.,[11] is related to RCI.

Material and methods

This study was approved by the Research Ethics Committee of the institution. Radiographs of 46 study participants (46 shoulders) who underwent surgery for RCI were analyzed, attended to at the outpatient clinic of this service. Inclusion criteria were individuals with lesions confirmed by magnetic resonance imaging (MRI) and in the intraoperative period. Two individuals with RCI due to traumatic causes were excluded, as the main aspect of the study was chronic degenerative lesions; therefore, 44 patients (44 shoulders; 18 men and 26 women) formed group 2.

Control group (group 1) consisted of 35 randomly selected individuals of both sexes, aged 45 years or older, attended to the outpatient clinic due to non-shoulder orthopedic complaints and who never had any shoulder symptoms. They were invited to participate in the study and received information about its objectives and methods. After a positive response, they signed the informed consent form. Participants in group 2 underwent the same steps. Exclusion criteria were patients with radiographic tests that indicated shoulders with evidence of glenohumeral osteoarthritis, rotator cuff arthropathy, prior surgery, infection, humeral head necrosis, history of shoulder girdle fractures, and calcareous tendinitis in such shoulder. One patient was excluded; therefore, control group comprised 34 individuals, 15 men and 19 women.

Table 1 – Epidemiological analysis sheet.

Epidemiological analysis			
Code:			
Age:			
Sex	F ()		M ()
Cuff injury	Yes ()		No ()
Dominant limb	Right ()		Left ()
Side	Right ()	Left ()	Both ()
Status	Operated ()		Non-operated ()

The study included 78 participants (78 shoulders), 34 in the control group and 44 in the affected group.

Epidemiological analysis was initiated by completing the form described in Table 1. Then, shoulder radiographs in anteroposterior view with correction of glenoid anteversion (true AP) were assessed; a vertical line connecting the upper border of the glenoid (point A) to its lower border (point B) was drawn. Subsequently, another line from the lower edge of the glenoid (B) to the lateral portion of the acromion (point C) was drawn, forming the CSA, as shown in Fig. 1. Pursuant to Moor et al.,[11] radiographs considered as acceptable were those with internal or external rotation variation of up to 20°.[11] Such variations of rotation, whether internal or external, are easily identifiable by the oval shape assumed by the glenoid cavity, making it impossible to delineate the upper and lower bone margins.

First step of the analysis was to assess the normality of data in each group, in order to define the type of comparison test to be used. The *t*-test was utilized to compare means when the distribution was normal; the Mann–Whitney test was employed when normal distribution was not observed. The Anderson–Darling (AD) normality test was applied.

Student's *t*-test for independent samples was used to compare means of the groups. However, in the selection of the

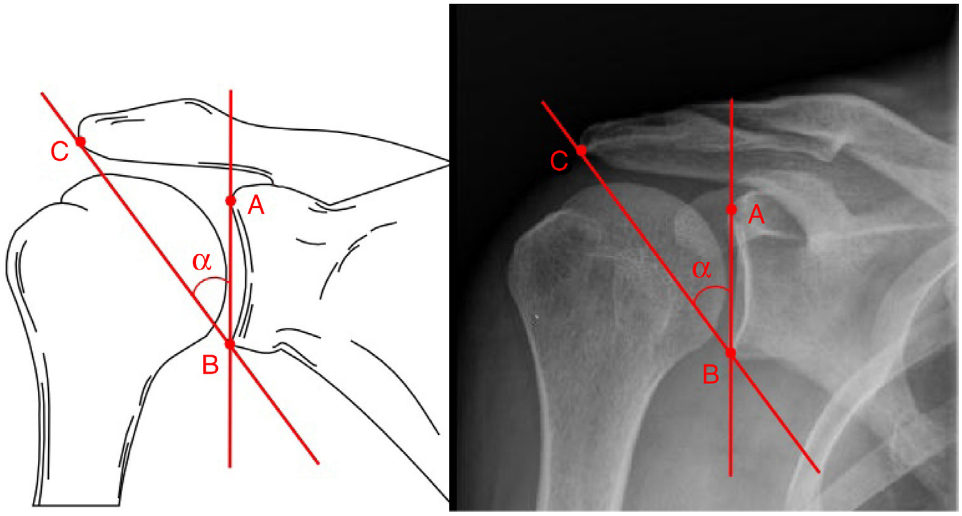

Fig. 1 – Drawing of critical shoulder angle measurement (CSA).

appropriate *t*-test, homoscedasticity was tested using the *F*-test for two variances.

In a second analysis, patients were classified as 1 or 2, according to the angle observed; those who presented angle greater than 35° were classified as 2 and those lesser than 35° were classified as 1. After classification, the Chi-squared test was applied to assess the presence of a dependency relationship between the group to which the patient belonged and their angulation status.

All analytical procedures were performed in Action,[*] which uses the software R (R Development Core Team, 2015),[12] and a 5% significance level was adopted. The statistical analysis procedures used in this study are described by Triola[13] and Ayres et al.[14]

Results

Mean age was similar in both groups. Both had a predominance of women: 44.9% in the control and 59.1% in the affected group. Regarding side, most patients (55.9%) in group 1 had the left side affected. In turn, in group 2, the right side was predominant: 72.7% of cases.

Table 2 shows the distribution statistics for patients stratified by sex and age.

Table 3 presents the distribution statistics for patients in the control group and in the affected group.

In Table 3, as CSA values above 35° were classified as 2, 34 of the 44 affected shoulders presented angles that fit into this category. In turn, in the control group, only ten of the 34 patients presented angulation higher than 35°.

Table 4 shows the CSA statistics for patients in the control group and in the affected group.

Table 4 indicates that the control group showed a mean of 33.58 (±3.36) and the mean in the group of patients with RCI was 39.75 (±5.34; $p < 0.007$).

Table 2 – Distribution by sex and side.

	Group 1: Control	Group 2: Affected
n	34	44
Mean age (years)	59.97 (45–84)	59.75 (45–84)
Sex	19 women (55.9%) 15 men (44.1%)	26 women (59.1%) 18 men (40.9%)
Side	15 right (44.1%) 19 left (55.9%)	32 right (72.7%) 12 left (27.3%)

Mean and median values were relatively close, characterizing a data distribution tending to symmetry; this can be confirmed by the first and third quartile values, which tend to be equidistant from the median, as well as the relatively low standard deviation values in relation to the mean. The relative variability (CV) of the control group was 10.0% and of the affected group, 13.4%, which indicates internal homogeneity of the assessed groups.

The *p*-values in the AD normality test for the affected and control groups were 0.54 and 0.32, respectively. Therefore, it is observed that the angulation within each group followed normal distribution. Thus, the parametric Student's *t*-test is applicable for comparing averages of the two groups.

The *F*-test to verify whether the population variances of the groups could be considered statistically equal presented a *p*-value of 0.007; therefore, the variance of the two groups is statistically uneven and the *t*-test must be applied.

Table 3 – Patient distribution.

Crossed table	1	2	Total
Affected	10	34	44
Control	24	10	34
Total	34	44	78

* Action – www.portalaction.com.br [cited May 2015].

Table 4 – Descriptive statistics of the angle from patients in the control group and in the affected group.

Factor	Minimum	1° quartile	Mean	Median	3° quartile	Maximum	Standard deviation
Affected	30	36	39.75	39.5	43.75	52	5.348875
Control	28	30.75	33.588235	33.5	36	42	3.36756

Table 5 – Proportion of patient distribution.

Proportion in the table	1	2
Affected	0.128205128	0.435897436
Control	0.307692308	0.128205128

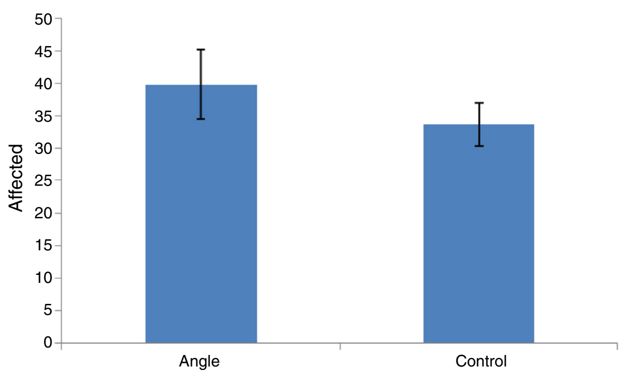

Fig. 2 – Bar chart of the means of the angulation with the respective standard deviation of the affected and control groups.

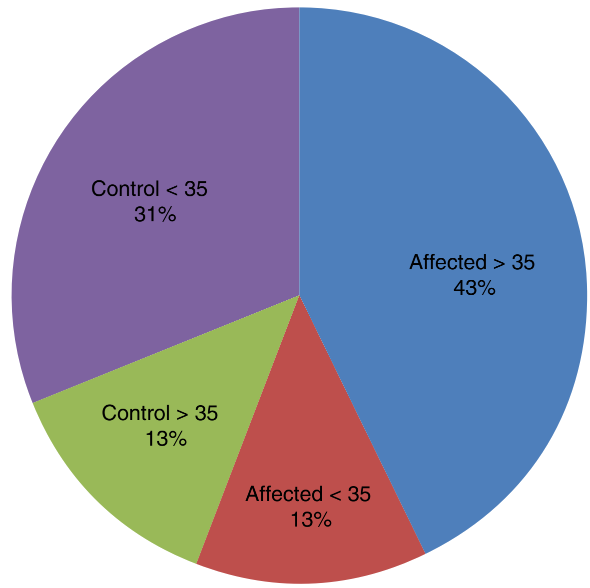

Fig. 3 – Graphic of the angulation sectors greater than and lower than 35° regarding the affected and control groups.

Table 5 presents the proportional distribution of patients between affected and control groups.

Fig. 2 presents means and standard deviation of the analyzed groups.

The *t*-test applied to these results presented a *p*-value of 0.00006, i.e., highly significant; therefore, it can be stated that the angulation in the affected group is statistically different from that of the control group.

Fig. 3 shows the distribution of angles greater than and less than 35° in relation to the groups.

A predominance of angulation greater than 35° was observed in the affected group, vs. a predominance of angulation lower than 35° in the control group.

The Chi-squared test applied to the results shown in Fig. 2 presented a *p*-value of 0.000006, indicating that there is a relationship between patient's group and angulation status (greater or less than 35°).

The contingency coefficient of 0.412 indicates that this relationship between angulation and patient group is moderate to strong, considering that maximum value of this coefficient is 0.71.

Discussion

In 1949, Armstrong[15] was the first to suggest a mechanical impingement between the acromion and the supraspinatus tendon. This theory was later confirmed and popularized by Neer.[5] Bigliani et al.[7] identified three distinct acromial shapes; the hooked type is more associated with RCIs.

More recently, Banas et al.[16] reported the association of the lateral inclination angle of the acromion with a higher prevalence of subacromial disease. These findings were also observed by Hanciau et al.[17] Nevertheless, Nyffeler et al.[4] introduced the concept of acromion index, suggesting that a greater lateral projection of the acromion would be a possible cause of this injury. Miyazaki et al.[18] have confirmed this correlation for the Brazilian population.

The pathogenesis of RCIs is known to be multifactorial. However, in 2013, Gerber et al.[19] proposed the CSA as a new possible cause; the CSA quantifies the extent of acromial coverage without being influenced by a flattening of the humeral head or excessive bone erosion of the posterior glenoid cavity, both of which are typically observed in glenohumeral arthritis. Furthermore, CSA reflects not only the acromial coverage, but also the glenoid inclination, integrating both risk factors into a biomechanical parameter.

The present results support the theory by Moor et al.,[11] as the CSA in patients with RCI was above the mean value observed in the control group. Other authors, such as Gerber et al.,[19] Spiegl et al.,[20] Moor et al.,[21] and Bouaicha et al.,[22] also found similar results. These observations are consistent with the concept that a healthy shoulder depends on a balanced mechanical overload. If the anatomic configuration differs from normal, as measured by CSA, an overload in the supraspinatus tendon can lead to rupture. In 2014, Gerber et al.[19] demonstrated in a biomechanical study that a high CSA may induce overload of the supraspinatus tendon, particularly at low degrees of active abduction.

Only radiographs were used to measure the CSA in the present study, since it was conducted in a public hospital that only serves the Brazilian Unified Health System. Moreover, other authors have confirmed that computed tomography or nuclear magnetic resonance are not necessary, as measurement by radiography is sufficient, as described by Spiegl et al.[20] and Bouaicha et al.[22]

The CSA was not measured separately for sex, dominant side, and affected side, as the studied population was relatively small.

Conclusion

This study supports the correlation observed by Moor et al.[11] between increased CSA value and increased RCI.

Conflicts of interest

The authors declare no conflicts of interest.

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