Knee Surg Sports Traumatol Arthrosc (2016) 24:2200–2205
DOI 10.1007/s00167-014-3499-y

SHOULDER

Differences in acromial morphology of shoulders in patients with degenerative and traumatic supraspinatus tendon tears

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Received: 11 July 2014 / Accepted: 22 December 2014 / Published online: 30 December 2014

Abstract

Purpose Distinct characteristics of acromial morphology seem to be one factor for the development of degenerative supraspinatus tendon tears. Thus, it is questionable whether patients with traumatic tendon tears also present these parameters. The hypothesis of the present study was that the acromial morphology of patients with degenerative supraspinatus tendon tears differs from patients with traumatic tears.

Methods One hundred and thirty-six patients that were treated by arthroscopic rotator cuff repair from 2010 to 2013 were included in this study. Seventy-two patients had degenerative (group 1), and 64 had traumatic (group 2) supraspinatus tendon tears. On preoperative radiographs the Bigliani type, acromial slope, acromiohumeral (AH) distance, lateral acromial angle (LAA), acromion index (AI), and critical shoulder angle (CSA) were measured. Medians of these parameters as well as of age of both groups were compared using the *t* test.

Results The percentaged distribution of the Bigliani type differed (group 1 vs. 2: type 1: 18/38, type 2: 56/55, type 3: 26/8). All parameters showed significant differences between degenerative and traumatic tears. Slope: 21.2° (SD 7.6°) versus 19.2° (SD 7.9°, $p = 0.026$), AH distance: 8.4 mm (SD 2.3 mm) versus 9.9 mm (SD 1.9 mm, $p = 0.0006$), LAA: 77.0° (SD 4.0°) versus 82.5° (SD 4.7°, $p < 0.0001$), AI: 0.77 (SD 0.07) versus 0.73 (0.06, $p = 0.0239$), and CSA: 36.8° (SD 3.6°) versus 35.3° (SD 2.9°, $p = 0.007$). An LAA <70° or an AH distance of <5 mm only occurred in degenerative tears. Patients with degenerative tears were significantly older (60 vs. 54 years).

Conclusions The hypothesis that the acromial morphology of patients with degenerative supraspinatus tendon tears differs from patients with traumatic tears was confirmed. Shoulders with degenerative tears show a narrower subacromial space and a larger lateral extension as well as a steeper angulation of the acromion than with traumatic tears. Thus, the results of this study support the theory of external impingement as a cause for degenerative rotator cuff tears.

Level of evidence IV.

Keywords Shoulder trauma · Rotator cuff tear · Acromial morphology · Subacromial decompression · Bigliani

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Introduction

Rotator cuff (RC) tears are very common disorders leading to surgical treatment. With increasing age, the incidence of these tears also increases significantly [25]. The aetiology of RC tears is multifactorial. The factors leading to injuries of the tendons can be categorized in intrinsic, extrinsic, and traumatic causes [4–11, 13, 15, 18, 23, 25, 26, 28, 29, 31, 33, 37, 39]. Intrinsic degeneration of the tendon is mainly associated with age of the patient, decreased vascularization

Table 1 Descriptive parameters for degenerative and traumatic rotator cuff tears

	Degenerative supraspinatus tear	Traumatic supraspinatus tear
N	72	64
Sex male/female	34/38	49/15
Complete SST tears	47	42
+infraspinatus	15	11
+subscapularis	36	28
Fox & Romeo 1	10	10
Fox & Romeo 2	11	9
Fox & Romeo 3	9	6
Fox & Romeo 4	6	3
Partial SST tears	25	22
Time from symptoms/trauma until surgery (days)	357 (2–1,877)	127 (3–798)

SST supraspinatus tendon

of the tissue, atrophy and fatty infiltration of the muscle, and genetic predisposition. Most important extrinsic factors are characteristic changes in the acromial morphology [2], internal impingement [16], and altered scapulothoracic kinematics [21]. Extrinsic factors lead to a mechanical compression of the RC, and its surrounding soft tissue causing the external impingement syndrome. The theory of the typical outlet impingement as first described by Armstrong in 1949 [1] postulates that a bursa-sided compression of the undersurface of the acromion leads to a narrowing of the subacromial space and thus to injuries of the RC, mainly the supraspinatus tendon (SST). Neer also focused on the extrinsic aspect and stated that the impingement syndrome is responsible for the development of most RC tears [25]. Since these initial descriptions the intrinsic as well as extrinsic theories have been supported by various studies.

Despite intrinsic and extrinsic reasons for RC tears, there are also mainly traumatic causes leading to injuries of the tendons [22]. The literature only provides very limited data on the acromial morphology in these cases [30], which led to the hypothesis of this study: The acromial morphology of patients with degenerative supraspinatus tendon tears differs from patients with traumatic tears. The results are of importance for understanding the development of rotator cuff tears and might be useful for decision-making in worker's compensation cases.

Materials and methods

Between 2010 and 2013, approximately 300 patients were surgically treated for rotator cuff tears at the author's institution. All patients routinely received digital anteroposterior and outlet view radiographs prior to surgical treatment. The respective patient documentation files and surgical protocols were reviewed. All patients with arthroscopically proven reconstructable rotator cuff tears were included in this study. Patients with insufficient radiographs, history of surgery of the respective shoulder, history of trauma (other than the index injury for traumatic cases), fracture, tumour, or infection as well as patients with irreparable rotator cuff tears were excluded. This resulted in 136 patients. Patients were defined as traumatic cases if they reported a sudden injury with an accepted mechanism e.g. a fall to the retroverted or externally rotated arm or a dislocation of the shoulder [19, 20]. Patients had to report pain and/or loss of function directly after trauma and to be previously without any complaints or impairments. Seventy-two patients had degenerative (group 1) and, 64 had traumatic (group 2) supraspinatus tendon tears. Thirty-six of the 64 traumatic cases were workers compensation patients.

From the patient files and surgical protocols age, time from injury/symptoms to surgery, type of injury (partial or complete supraspinatus tendon tear), and additional tendon injuries (infraspinatus and subscapularis) were documented (Table 1).

On digital preoperative radiographs the Bigliani type, acromial slope, acromiohumeral (AH) distance, lateral acromial angle (LAA), acromion index (AI), and critical shoulder angle (CSA) were measured. Lengths measurements were taken in millimetre with accuracy of one decimal, and angle measurements were taken in degree with accuracy of one decimal.

The true anteroposterior radiograph was obtained with the arm in neutral position, the elbow extended, and the thumb aiming anterior. The patient's scapula was positioned adjacent to the radiograph cassette, and the beam was aligned 20° caudal. The outlet view radiograph was obtained with the affected arm hanging and the injured shoulder turned away 30° from the radiograph stand. The beam was aligned 10°–15° caudo-cranial, tangential to the scapula. Acromion type and slope were measured on outlet

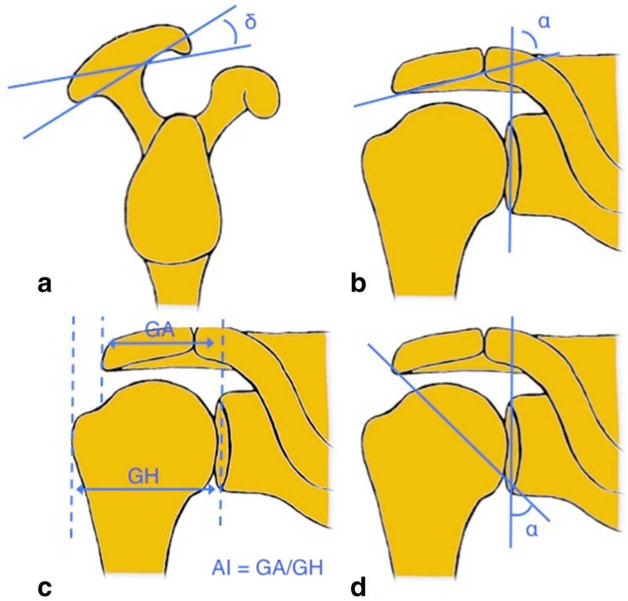

Fig. 1 Radiographic parameters of acromial morphology. **a** Acromial slope (δ) [5, 17], **b** lateral acromial angle (LAA, α) [3], **c** acromion index (AI) [27], **d** critical shoulder angle (CSA, α) [24]

Table 2 Descriptive statistics for degenerative and traumatic rotator cuff tears

	Median	Min.	Max.	SD
Group 1 *(degenerative SST tears)*				
Age (years)	61	31	79	11
Slope (°)	21.2	0.0	40.3	7.6
AH (mm)	8.4	2.2	13.8	2.3
LAA (°)	77.0	64.1	85.2	4.0
AI	0.77	0.62	0.9	0.07
CSA (°)	36.8	30.9	48	3.6
Group 2 *(traumatic SST tears)*				
Age (years)	56	24	76	13
Slope (°)	19.1	0.0	42.4	7.9
AH (mm)	9.9	5.9	15.4	1.9
LAA (°)	82.5	71.5	98.8	4.7
AI	0.73	0.6	0.88	0.06
CSA (°)	35.3	28.2	44.2	2.9

SST supraspinatus tendon, *Y* years, *SD* standard deviation, *AH* acromiohumeral distance, *AT* acromial tilt, *LAA* lateral acromial angle, *AI* acromion index, and *CSA* critical shoulder angle

view and AH distance, LAA, AI, and CSA on anteroposterior radiographs.

According to Bigliani et al. [5], the acromion type was classified as type I (flat), type II (curved), or type III (hooked).

According to Bigliani et al. [5] and Kitay et al. [17], two lines were drawn at the inferior acromion. The first connects the most anterior point and the midway point of the inferior acromion, and the second connects the most posterior point with the same midway point. The angle (δ) formed by these two lines represents the acromial slope angle (Fig. 1a).

The acromiohumeral distance was measured from the subchondral lamina of the humeral head to the dense cortical bone at the inferior aspect of the acromion [32].

According to Banas et al. [3], the angle (α) formed by a line along the superior and inferior most lateral points of the glenoid and a line parallel to the acromion undersurface represents the LAA (Fig. 1 b).

According to Nyffeler et al. [27], two distances were measured. First from the glenoid plane to the acromion (GA) and second from the glenoid plane to the lateral aspect of the humeral head (GA). GA divided by GH represents the acromion index (Fig. 1c).

According to Moor et al. [24], the CSA is formed by two lines. The first connects the most lateral point of the superior and the most lateral point of the inferior glenoid and represents the glenoid plane. The second connects the same most lateral point of the inferior glenoid and the most lateral point of the inferior acromion (Fig. 1d).

All radiographs were digitally acquired. The distances and angles were measured by use of a DICOM viewer. An experienced fellowship-trained orthopaedic surgeon specialized in shoulder surgery (first author) and unaware of the underlying diagnosis evaluated the appropriateness of the radiographs and made the respective measurements.

This study was reviewed and approved by the ethics committee of the University of Witten/Herdecke, Germany (ID number: 133/2013).

Statistical analysis

Statistical analyses were calculated using PRISM 5 for MAC OS X (GraphPad Software, Inc.). The percentaged distribution of the Bigliani type was calculated, and means of age, slope, AH distance, LAA, AI, and CSA were compared using the *t* test. Significance level was set at $p < 0.05$. A post hoc power analysis revealed a power of 67.2 % for "age", 35 % for "slope", 98.6 % for "AH distance", 100 % for "LAA", 84.9 % for "AI", and 76.7 % for "CSA".

Results

Fifty-three per cent of patients with degenerative tears were female, whereas 77 % of traumatic cases were male (Table 1). Time from first symptoms or from trauma until surgery was significantly ($p < 0.001$) longer in degenerative than in traumatic cases (Table 1). Patients with degenerative supraspinatus tendon tears were significantly

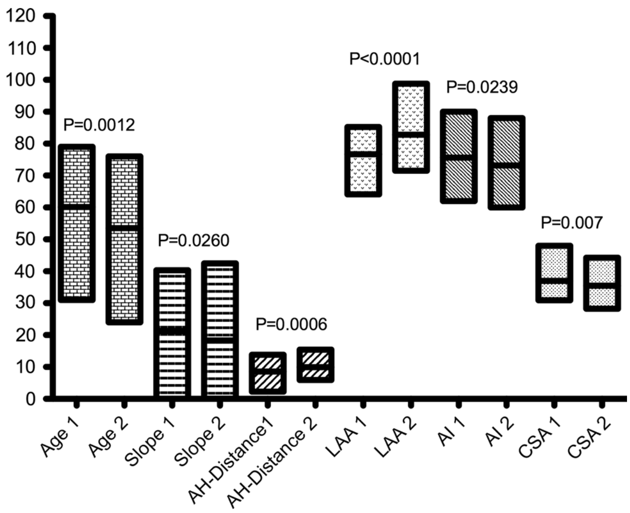

Fig. 2 Statistic evaluation of parameters of acromial morphology means, range and statistically significant differences between degenerative (1) and traumatic (2) rotator cuff tears for age, slope, acromiohumeral (AH) distance, lateral acromial angle (LAA), acromion index (AI), and critical shoulder angle (CSA). For better visualization in this graph, the AI was multiplied by 100

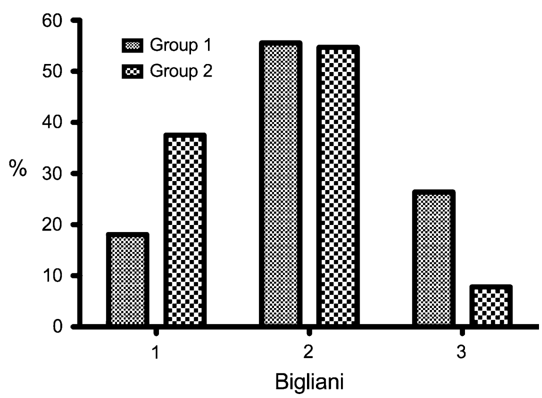

Fig. 3 Percentaged distribution of Bigliani shape distribution of Bigliani shape 1–3 for degenerative (*group 1*) and traumatic (*group 2*) rotator cuff tears

($p = 0.0012$) older (mean 60 years) than patients with traumatic tears (mean 54 years; Table 2; Fig. 2).

The type II acromion was equally distributed between degenerative and traumatic cases (56 vs. 55 %), whereas the type I was more common in traumatic cases (18 vs. 38 %) and the type III in degenerative cases (26 vs. 8 %) (Fig. 3).

The acromial slope angle of degenerative cases (group 1) was significantly ($p = 0.026$) larger than of traumatic cases (group 2); the acromiohumeral distance was significantly smaller. Degenerative cases had a significantly smaller LAA ($p < 0.0001$), a larger AI ($p = 0.0239$), and a larger CSA ($p = 0.007$) than traumatic cases. An LAA of <70° and an AH distance of <5 mm were only present in five (LAA) and four (AH) patients with degenerative cuff tears. For exact data, see Table 2 and Fig. 2.

Because time until surgery and age were significantly different between groups the degenerative tear cases were additionally analyzed. One group with age <60 years ($n = 32$) was compared to a group with age ≥60 ($n = 40$). There were no significant differences for any of the morphological parameters. Patients with degenerative tears and mean time until surgery of 86 days ($n = 36$) were compared to patients with mean time to surgery of 629 days ($n = 36$). Again, there were no significant differences. Also there were no significant differences in male ($n = 34$) and female ($n = 38$) patients or partial ($n = 25$) and complete ($n = 47$) degenerative tears. Degenerative SST tears with additionally torn infraspinatus tendons (IST) had a significantly (slope: $p = 0.0015$, AH distance: $p = 0.0062$) higher slope angle and shorter AH distance ($n = 15$/26.5°/7.2 mm) than cases with intact IST ($n = 57$/19.8°/9 mm). Patients with degenerative SST tears and intact subscapularis tendons ($n = 36$) were significantly ($p = 0.0045$) younger (57 years) than patients with a torn subscapularis ($n = 36$, 66 years).

Discussion

The most important findings of the present study were that the acromial morphology in patients with degenerative supraspinatus tendon tears differs from the acromial morphology in patients with traumatic tears. The rate of a Bigliani type III acromion, the acromial slope angle, acromion index, and critical shoulder angle was higher, and the acromiohumeral distance and lateral acromial angle were smaller in shoulders with degenerative tears.

The literature does not provide other studies on acromial morphology in traumatic rotator cuff tears. If there were a correlation of characteristic morphological changes with the development of degenerative tendon tears, it would seem logical that traumatic tears do not present these changes.

Balke et al. [2] recently published that only 2 % of controls but 20 % of patients with a subacromial pathology had a type III acromion according to Bigliani et al. [5]. The traumatic cases in the present series also had less type III acromia compared to degenerative cases (8 vs. 26 %). Thus, the Bigliani shape in traumatic SST tears seems to be "normal" compared to degenerative tears. According the acromial slope angle, Bigliani et al. [5], Kitay et al. [17], and Tuite et al. [36] published a higher angle in patients with RC tears compared to subjects with intact cuffs (Tuite et al. [36]: 28.9° vs. 23.6°). These findings have been confirmed by Balke et al. [2] who found a slope of 21° for controls and 25° for RC tears. Although the slope angles of the present study were generally lower, degenerative tears presented a significantly higher slope than traumatic tears (21.2° vs. 18.2°). The reasons for the lower angles remain unclear, but might be explained by slight differences in radiographic image acquisition between institutes.

According to Goutallier et al. [14], an AH distance of <6 mm is associated with a higher incidence of degenerative RC tears, mainly long standing supra- and infraspinatus tendon tears. The mean AH distance in shoulders with degenerative tears was significantly smaller than with traumatic tears (8.6 vs. 9.9 mm). Although all four patients with an AH distance of <5 mm were in the degenerative tear group, the mean distance in this group was not <6 mm. This might be explained by the fact that only repairable rotator cuff tears were included in this study. It could be assumed that the smaller AH distance in degenerative tears is caused by the significantly longer time interval until measurements compared to traumatic tears and that the humeral head migrated superiorly over time. But the comparison of degenerative tears with a long interval to treatment and measurements to degenerative tears with a short interval did not show any significant differences, disproving the theory of cranial migration. The findings that degenerative RC tears with additional affection of the infraspinatus tendon have a smaller AH distance than degenerative RC tears with an intact infraspinatus are in accordance with Goutallier et al. [14]. The LAA was introduced by Banas et al. [3] who found an association of a low angle with rotator cuff disease. His findings were confirmed by Tetreault et al. [34] who published that a smaller angle results in a decreased subacromial volume and thus might be responsible for higher pressure on the rotator cuff. In the study by Balke et al. [2, 3], patients with RC tears had a mean LAA of 77.0°, whereas control subjects had an angle of 84.1°. An angle of <70° only occurred in patients with RC tears. In the present study, the LAA of patients with degenerative tears was significantly smaller than of patients with traumatic tears (77.0° vs. 82.5°). An LAA of <70° was only found in degenerative cases. This also supports the theory of external mechanical compression causing degenerative RC disease. In patients with traumatic RC tears, a very low LAA would be at least unusual. Nyfeller et al. [27] Torrens et al. [35], and recently Balke et al. [2] found a correlation of a high AI and rotator cuff tears. In the original study by Nyfeller et al. [27], controls had a mean AI of 0.6, whereas patients with cuff tears had a mean AI of 0.73. Although the difference in the present study of 0.73 in traumatic and 0.77 in degenerative tears was lower, the tendency towards a higher AI in degenerative cuff disease can be supported. Recently, Moor et al. [24] introduced the CSA, describing the lateral extension of the acromion in relation to the orientation of the glenoid joint plane (a combination of the LAA and AI). He found an association with a high CSA and rotator cuff tears. Based on biomechanical observations, Gerber et al. [12] stated that a high CSA can induce a SST overload causing rotator cuff tears. In the study by Moor et al. [24], the mean CSA in the control group was 33.1° compared to 38.0° in the RC tear group which is comparable to the results of the present study with traumatic (35.3°) and degenerative 36.8°) cases.

Although patients with degenerative tears were significantly older than with traumatic tears, no significant differences in morphological parameters were found comparing "younger" to "older" degenerative cases. This supports the findings by Vahakari et al. [38] who did not find significant differences on routine outlet view radiographs of different age groups.

This study has several limitations. Although only patients with an adequate trauma followed by an instant onset of symptoms were included in the traumatic group there might still be some cases that were grouped incorrectly. Additionally, the measured parameters are dependent on the quality of the radiographs, which also might have caused a bias. Moreover, the number of patients in each group was relatively small.

The lack of the distinctive morphological characteristics of degenerative rotator cuff tears in traumatic cases at least supports the theory of external mechanical impingement as a major cause of degenerative rotator cuff disease.

Conclusions

The hypothesis that the acromial morphology of patients with degenerative supraspinatus tendon tears differs from patients with traumatic tears was confirmed. Shoulders with degenerative tears show a narrower subacromial space and a larger lateral extension as well as a steeper angulation of the acromion than with traumatic tears. These findings may be of importance in worker's compensation cases or other cases when the differentiation between traumatic and degenerative rotator cuff tears is of relevance.

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