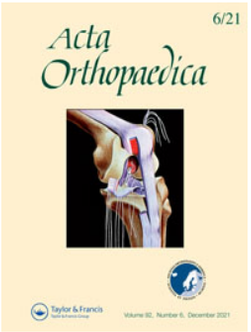

Acta Orthopaedica Scandinavica

ISSN: 0001-6470 (Print) (Online) Journal homepage: informahealthcare.com/journals/iort19

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To cite this article: Nirav Shah & Panos Diamantopoulos (2004) Position of the humeral head and rotator cuff tearAn anatomical observation in cadavers , Acta Orthopaedica Scandinavica, 75:6, 746-749, DOI: 10.1080/00016470410004139

To link to this article: https://doi.org/10.1080/00016470410004139

Published online: 08 Jul 2009.

Position of the humeral head and rotator cuff tear

An anatomical observation in cadavers

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Submitted 03-11-12. Accepted 04-03-31

Background **The relationship between the humeral head position and rotator cuff tears is not well described.**

Material and methods **We performed an anatomical study of 22 cadaveric shoulders to find out the relationship between the normal anatomical position of the humeral head and tears of the rotator cuff. After dissection, the rotator cuff pathology was documented. The position of the humeral head was noted in relation to the acromion. The humeral head with intact acromion and articulated shoulder joint was photographed from the superior aspect of the joint and the area of the humeral head outside the acromion was measured, i.e. the part of the humeral head lateral to the lateral border of the acromion process. The relationship between rotator cuff pathology and uncovering of the humeral head was determined.**

Results **9 specimens had a partial cuff tear, while 4 had a complete tear. Those specimens with a rotator cuff tear had a mean area of 83% of the humeral head under the acromion. The specimens that did not show a rotator cuff tear had a mean area of 61% of the humeral head under the acromion.**

Interpretation **We suggest that there is individual variation in anatomical position of the humeral head in relation to the acromion and that this position correlates with the occurrence of rotator cuff pathology.**

Irregularity in the shape of the coracoid and the acromion was first reported by Goldwaite in 1909 (Meyer 1931). In 1986, Bigliani et al. (1986) described three shapes of the acromion process (flat, curved and hooked). They also correlated occurrence of cuff tear with the shape of the acromion process. Most of the studies have concentrated on the acromion or the rotator cuff itself to find out the cause of cuff tear and pathology. The relationship between the anatomical position of the humeral head and rotator cuff pathology appears not to have been studied.

Zuckerman (1992) studied the influence of coracoacromial arch anatomy on rotator cuff tears. By using a series of measured and calculated parameters, he characterized the spatial anatomy of the coracoacromial arch and its relationship with the humeral head. Saidani and Gagey (1997) showed the relationship between the coracoacromial arch and the humeral head by 3D reconstruction of MRI. They suggested that each person has an individual anatomy of the humeral head and its relationship with the acromion. In their mechanical study of contact geometry of acromion and rotator cuff, Lee et al. (2001) have suggested that factors other than the shape of the acromion, such as anteroposterior and mediolateral dimensions of the acromion, play a role in rotator cuff pathology.

We carried out an anatomical study of cadaveric shoulder joints to find out whether there is any relationship between the anatomical position of the humeral head under the acromion and rotator cuff pathology.

Material and methods

The study included 22 randomly selected shoulder

DOI 10.1080/00016470410004139

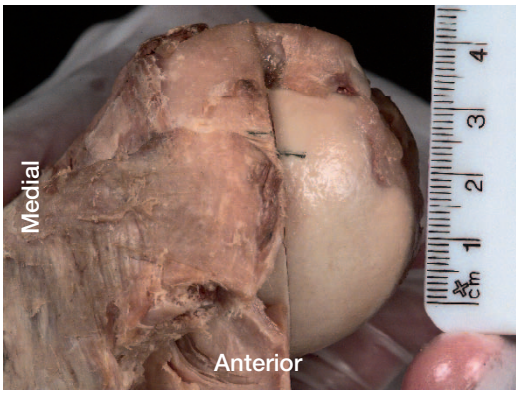

Figure 1. Photograph of a specimen captured from above.

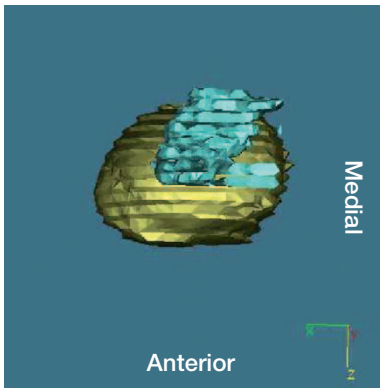

Figure 2. Computerized model of specimen with 3D reconstruction.

joints from the cadavers obtained from the anatomy department of the Medical School. Of 22 shoulder joints, 12 specimens from 6 cadavers were paired and 10 were unpaired. All cadavers had been preserved in a standard embalming fluid (a mixture of formalin, phenol, glycerine, alcohol and water) in an anatomical position. All of them died of medical problems such as pulmonary or cardiac conditions. From the medical notes of these specimens, we could not find any history of trauma or fractures involving upper limbs, nor of systemic diseases such as sickle cell anaemia, Gaucher's disease, Caisson's disease, rheumatoid arthritis or gout. Degenerative changes and avascular necrosis of the humeral head were not present. None of the patients had had any upper limb deformity. Their mean age at death was 82 (69–93) years. Of the 22 specimens, 14 were males.

The entire shoulder joint was harvested, including the whole scapula and mid-humerus, along with all soft tissues around the shoulder. The skin was removed. The deltoid muscle was dissected from its origin off the clavicle and the acromion and reflected carefully down to its insertion on the humerus. The coracoacromial ligament was identified and detached from the coracoid and the acromion. As these specimens were embalmed, removal of the soft tissues did not affect the positioning of bones and hence the true relationship of the scapula with the humeral head was maintained very well. The rotator cuff was examined carefully and degenerative changes were noted and graded as follows (Hijioka et al. 1993): grade 1, loss of bursa on the cuff; grade 2, surface degeneration of the tendon (DG); grade 3, clear ulcer formation on the cuff—so-called "bursal side" incomplete tear (PT); and grade 4, full thickness cuff tear (CT).

We identified the acromioclavicular joint and cut its capsule and ligament superiorly. All the acromion processes were examined macroscopically for their shape according to Bigliani et al. (1986). Due to the poor interobserver reliability of type II and type III shapes of the acromion process morphologically and radiologically (Bathel et al. 1993) and our small sample size, we divided the shape of the acromion processes into two groups (Shah et al. 2001): group 1, acromion process having totally flat undersurface—type I as in Bigliani et al. (1986); group 2, acromion process with shape other than flat undersurface – type II and type III.

We compared the relationship of the shape of the acromion process with the rotator cuff pathology. The rotator cuff was removed. All the specimens, fixed in a special holder, were photographed above the shoulder joint. The camera was fixed on a tripod 1 meter away from the specimen, with a standard scale placed by the side of the specimen (Figure 1). This standardized fixed method of capture avoided variation in the orientation of the photograph.

These images were computerized and a model of the specimen was created (Figure 2). A line running parallel to the lateral border of the acromion, perpendicular to the head of the humerus was drawn. This line divided the humeral head into two parts (Figure 3): (1) the part of the humeral head lateral to the lateral border of the acromion (X), and (2) the part of the humeral head medial to the lateral border of the acromion (Y).

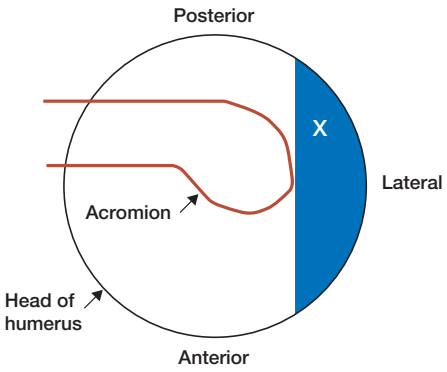

Figure 3. Schematic representation of a specimen with blue-colored area representing part of the humeral head outside the lateral border of the acromion process.

Thus, the area X of the humeral head represents lateral uncovering of the humeral head under the acromion, and area Y is the part of the humeral head under the cover of the acromion process. Though the area X represents lateral uncovering of the head, it also includes an area of the humeral head anterior to the acromion process.

With the help of the Sonic Digitizer Analyzing System (Horng-Chaung et al. 2003), we calculated the part of the humeral head that was situated lateral to the lateral border of the acromion (Figure 3), and correlated this with rotator cuff pathology. Since our aim was to ascertain the relationship between uncovering of the humeral head under the acromion and rotator cuff tear, we ignored other confounding factors such as the shape of the acromion.

Statistics

Statistical analysis of the effect of uncovering of the humeral head under the acromion on the rotator cuff was done by independent samples t-test, using both equal variance assumed and not assumed.

Results

22 cadaveric shoulder joints were studied for this project. 3 of 15 male specimens and 2 of 7 female specimens had a flat acromion (group I).

9 specimens had partial cuff tear and 4 specimens had complete cuff tear. All of these specimens had an acromion that was not flat (Table 1). We also noted that the shape of the acromion had bilateral symmetry in only 3 specimens.

Table 1. Relationship between shape of acromion process and cuff tear

Rotator cuff pathology	Shape of the acromion process	
	Flat	Not flat
Grade 1 (loss of bursa)	3	19
Grade 2 (degeneration)	3	9
Grade 3 (partial tear)	0	9
Grade 4 (complete tear)	0	4

Table 2. Lateral uncovering of humerus head under the acromion process

Specimen No.	Lateral uncovering of humerus head (mm)	% of humerus head outside the acromion	Rotator cuff pathology grade
1	25	29	PT
2	14	16	CT
3	25	39	DG
4	30	47	DG
5	15	39	DG
6	14	15	CT
7	25	35	DG
8	16	14	PT
9	19	14	CT
10	31	39	DG
11	26	31	DG
12	14	15	PT
13	21	40	DG
14	15	38	DG
15	18	50	DG
16	12	14	PT
17	14	13	PT
18	14	15	PT
19	15	29	PT
20	20	16	PT
21	14	15	CT
22	18	16	PT

DG degeneration
PT partial tear
CT complete tear

The area of the humeral head outside the lateral border of the acromion process varied between 14% and 50% of the size of the humeral head. Of the 22 specimens, 13 had more than 70% of the humeral head under the cover of the acromion process (mean 17%, SD 5.3). 9 specimens had more than 30% of the humeral head outside the acromion process (mean 40%, SD 5.5, Table 2).

Of the 22 specimens, 13 had either a partial or a complete rotator cuff tear. Those specimens with a rotator cuff tear, whether partial or complete,

had 70% or more of the humeral head under the cover of the acromion (independent samples t-test, $p < 0.001$, with 95% CI of the difference equal to 27 at lower limit and 18 at upper limit, when equal variance was assumed or not assumed). The 9 specimens that did not show a rotator cuff tear had ≤ 60% of the humeral head under the acromion process (independent samples t-test, $p < 0.001$).

Discussion

On the basis of our measurements, the relationship of the humeral head and the acromion should be divided into two groups: group A, small head in relation to the acromion with more than 70% of the humeral head under the acromion process; and group B, large head in relation to the acromion with more than 30% of the humeral head outside the acromion process.

We observed that specimens in group A had either partial or complete rotator cuff tears. It seems that if the humeral head is more under the cover of the acromion or is small in relation to the acromion process, then there is a higher risk of developing rotator cuff pathology. In this group, with each movement of the shoulder joint, the tendinous part of the rotator cuff comes into contact with the antero-inferior surface of the acromion. This may result in a rotator cuff dysfunction that eventually leads to tears in the rotator cuff.

In the specimens in group B, 30% or more of the humeral head is outside the acromion, or large in relation to a small acromion. The specimens in this group only had surface degeneration of the cuff, but no partial or complete tearing of the rotator cuff. We believe that, with movements of the shoulder joint, the muscular part of the rotator cuff comes into contact with the acromion. Thus, there is less irritation of the cuff and less risk of a tear.

We thank Mr. J. Stothard, Mr. S. C. Deshmukh, Mr. R Turner, Carol Cresswell, Mrs. C. E. Harkness, Dr. D. Shanahan, and also Liz Crago for help in preparation of the manuscript.

No competing interests declared.

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Appendix

Example of a calculation (Figure 3)

The circle represents the humeral head when seen from above. The area of a circle is $A = \pi \times R2$ where R = radius. Therefore, area of humeral head $A = \pi \times R2 = 3.14 \times 212 = 1384.74$ mm^2. The blue line represents the line parallel to the lateral border of the acromion process. The area on either side of this line is represented by an ellipse. The area of an ellipse $A = \pi \times$ Radius 1 $\times$ Radius 2. Assuming that the part of this ellipse on one side is X and this is one-quarter of the ellipse, then the formula for its calculation is $X = (\pi \times AB \times AC) / 4 = (3.14 \times 20 \times 14) / 4 = 220$ mm^2. This represents 19% of the total area of the humeral head.