The influence of the acromial coverage index in rotator cuff tears

Carlos Torrens, MD, Joan-Miquel López, MD, Isabel Puente, MD, and Enrique Cáceres, MD, Barcelona, Spain

Several intrinsic and extrinsic factors have been advocated in the pathogenesis of rotator cuff tears, but it is still unclear whether the origin of the tear is related to tendon degeneration itself or induced by several morphologic changes. The purpose of this study is to determine the relationship between the acromial coverage of the humeral head and the presence of a cuff tear. We evaluated 148 shoulders, including 45 that underwent surgical rotator cuff repair (group I), 26 with documented rotator cuff tears treated conservatively (group II), and 77 with no cuff pathology as a control group (group III). The mean acromial coverage index was 0.68 in group I, 0.72 in group II, and 0.59 in group III, giving a highly significant difference (P < .0001) between the control group and both cuff tear groups. Patients with a cuff tear have a significantly higher acromial coverage index than the control group. (J Shoulder Elbow Surg 2007;16:347-351.)

Controversy still remains about the pathogenesis of rotator cuff tears. In 1972, Neer21 stated that impingement on the tendinous portion of the rotator cuff by the coracoacromial ligament and the anterior third of the acromion was responsible for the development of the chronic impingement syndrome. Since that statement, numerous studies have supported the extrinsic origin of cuff tears. Bigliani et al3 defined 3 distinct types of acromions and the relationship between acromial morphology and the incidence of rotator cuff tears in cadavers. Their classification has been corroborated by different studies3,12,16,23,30,34,35 and has also been the subject of discussion by several authors who believe that the type III acromion is not an anatomic variant but results from ossification in the attachment of the coracoacromial ligament or is age-related.2,28,33 Other authors support the extrinsic mechanism by defining different patterns of contact that may lead to cuff compromise, such as the anterior slope of the acromion,1 the coracoid process as another possible site of soft-tissue impingement,10 the relationship between the lateral acromion angle and rotator cuff disease,2,13,17,31 impingement of the deep surface of the rotator cuff on the posterosuperior border of the glenoid,32 the anterosuperior impingement of the deep surface of the subscapularis,11 and the influence of glenoid version on rotator cuff tears.29 Some studies are focused on glenohumeral and scapular kinematics and the combined dynamic and static contributions to subacromial impingement.20,24,27 On the other hand, the intrinsic origin of cuff pathology was proposed by Codman and Akerson,5 who concluded that rotator cuff tears were degenerative in nature. Ozaki et al,25 based on their study with specimens that had a partial tear of the rotator cuff on the articular side with the undersurface of the acromion intact, also declared that most of the tears of the cuff were caused by degenerative changes related to age. Other authors believe that impingement is a dynamic process resulting from intrinsic failure of the tendon that results in reactive osseous changes, causing the radiologic changes seen with impingement syndrome.8,26 Finally, Panni et al26 proposed that partial tears on the articular side were in no case associated with acromial changes whereas tears originating on the bursal side were related to acromial morphology and more frequent in the presence of a type II or III acromion. Because the treatment proposed by Neer,21 for the chronic impingement syndrome includes anteroinferior acromioplasty, the association of this surgical procedure with the cuff repair is under suspicion for those who believe in the intrinsical origin of the cuff degeneration.2

On standard true anteroposterior radiologic views, a grossly different relationship between the lateral end of the acromion and the humeral head is commonly seen (Figures 1 and 2). The objective of this study is to analyze the influence of the different coverages that the acromion provides to the cuff and the humeral head and the presence of a rotator cuff tear.

MATERIALS AND METHODS

One hundred forty-eight shoulders were evaluated in the study and divided into 3 groups. Group I (n = 45) included subjects operated on because of a rotator cuff tear, group II

From the Orthopaedic Department, Hospitals del Mar i l’Esperança, Barcelona, Spain.
Reprint requests: Carlos Torrens, MD C/ Montseny 49, Baixos 3ª, 08012 Barcelona, Spain.
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(n = 26) included subjects with rotator cuff rupture identified by magnetic resonance imaging or arthrosceon with good conservative management with a minimum follow-up of 2 years, and group III (n = 77) included subjects with post-traumatic subacromial syndrome and no rotator cuff rupture documented either by Arthrosceon or by ultrasonography (control group).

The whole population of the study was composed of 92 women and 56 men, with a mean age of 49.84 years. All 3 groups were comparable in age and gender. A true anteroposterior view was obtained under fluoroscopic control for each subject. To measure the acromial coverage of the humeral head, a line tangential to the articular surface of the glenoid was drawn, so that the perpendicular to this line to the lateral end of the acromion was designated as the acromial distance. The humeral head was considered as a circle, and the diameter perpendicular to the tangential glenoid line was identified as the humeral distance. The ratio between the acromial distance and the humeral distance was called the acromial coverage index (Figure 3). Being an index, it was independent of the focal distance on which the radiologic examination was obtained. To avoid the influence of rotation of the scapula in the measures obtained, only true anteroposterior views were included. To avoid the variability of the shape and width of the greater tuberosity observed in chronic rotator cuff tears, the humeral measure was obtained considering the humeral head as a circle. The cranio-caudal tilt of the true anteroposterior radiographic examination did not affect the acromial distance, because the lateral end of the acromion does not change when varying the cranio-caudal tilt. To ensure that different rotations of the arm did not affect the humeral distance, several radiographs were obtained and measured in different rotations of the arm, but by considering the humeral head as a circle, all the measures were equal. For statistics, Pearson correlation analysis was performed.

RESULTS

The mean value of the acromial coverage index in the group of subjects operated on because of rotator cuff tears (group I) was 0.687 (ranging from 0.490 to 0.890). The mean value of the acromial coverage index in the group of subjects with a rotator cuff tear treated conservatively (group II) was 0.724 (ranging from 0.600 to 0.900). The mean value of the acromial coverage index in the control group (group III) was 0.590 (ranging from 0.340 to 0.730) (Table I). Significant statistical differences were noted between the group of subjects operated on and the control group (P < .0001) and between the group of subjects conservatively treated and the control group (P < .0001). Conversely, no significant statistical differences were noted between the group of subjects operated on and the group treated conservatively (P < .219).

No significant statistical differences were noted between right or left shoulders (P < .471), but highly significant differences were noted between men and
women ($P < .0001$), with the female acromial coverage index being higher than that in men in both rotator cuff tear groups.

DISCUSSION

Since Neer\textsuperscript{21,22} concluded that 95% of rotator cuff tears were caused by impingement, numerous acromial morphologic changes have been implicated in cuff pathology. It is still unclear whether Bigliani acromial type III can be considered as a morphologic condition or an age-related adaptation, but it is clear that the morphologic or age-induced hooked acromion is present more frequently in cuff tears. The anterior slope of the acromion\textsuperscript{1} and the lateral acromial angle\textsuperscript{4} also seem to contribute to rotator cuff disease. On the other hand, glenoid version also seems to affect the cuff in the sense that injury to the anterior part of the cuff is associated with retroversion of the glenoid. Meanwhile, injury to the posterior part of the cuff is associated with anteversion of the glenoid.\textsuperscript{29}

There are anatomic studies of the scapula giving the measurements and relationships of different scapular prominences but without taking into consideration its relationship with the humerus.\textsuperscript{6,19} The glenohumeral relationships were described by Iannotti et al,\textsuperscript{15} but the measurements were done in cadavers without signs of arthritis of the shoulder or through imaging studies in patients without a rotator cuff tear.

Commonly seen in routine radiographic analysis of the glenohumeral joint, are grossly different coverages that the acromion provides to the humeral head. To study this phenomena, several considerations must be made. Direct measuring on radiographs of the differences observed between the most lateral parts of the acromion and the humeral head is subject to noncomparable values because of different focal distances on radiographs. If the measurement taken to assess the humeral head includes the greater tuberosity, it is also in error because of the nature of cuff disease itself, which erodes the greater tuberosity. To avoid these errors, an acromial coverage index was developed to be independent of the focal distance, and the humeral head was considered as a circle, which is consistent with the report of Iannotti et al\textsuperscript{15} of direct measurement of the acromiohumeral lateral distance differences that are related to different humeral head diameters, eliminating the effect of the erosion of the greater tuberosity. To prevent the distortion effect of rotation of the scapula, only true anteroposterior views were obtained under fluoroscopic control. The rotation of the humerus did not affect the humeral distance measured because it was taken as the diameter of the circle.

Significant differences of the acromial coverage index were obtained between the control group and both groups of rotator cuff tears, meaning that patients with a rotator cuff tear presented a higher coverage of the acromion to the humeral head. To explain these results, two hypotheses can be proposed. The first is to consider that, if an in balance of the cuff is present and eccentric forces of the different muscles are acting, the acromion of the shoulders with a higher coverage index may impinge on the insertion site of the cuff, leading to an insertion tear. This is supported by the observation that, when the acromial index is high, the cuff tear is located at the insertion site (Figure 4), whereas in the rare cases where the acromial index is low, the tear is located in a more medial position (Figure 5). No conclusions can be drawn because this is being evaluated in an ongoing study. The second hypothesis is that if the acromial coverage index is determined by differences in humeral head diameters, this effect can change the lever arm of the cuff muscles, reducing it as the index increases. Liu et al\textsuperscript{18} demonstrated that 17 mm of medial advancement on the reinsertion of the tendon significantly reduces the moment arm of the muscle, compromising the repair. In the same way, Gagey, and Hue\textsuperscript{9} hypothesize the mechanics of the deltoid muscle relays in humeral head size, as well as the shape of the acromion.

No conclusions can be drawn from this study that give support to the extrinsic for the intrinsic pathogenesis of cuff tears, because both can be still be explained through the hypotheses enunciated.

Finally, significant sex differences were found demonstrating that women present a higher acromial coverage index. Sex-specific differences of the subacromial space width at 30° of elevation with no muscle activity have been published,\textsuperscript{14} so it seems reasonable to believe that sex-morphologic differences may influence rotator cuff tears. The differences found in this study may contribute to understanding rotator cuff tear pathogenesis better.

In conclusion, in patients with a rotator cuff tear, a significantly high coverage of the acromion to the humeral head is observed when compared with a control group, and significative sex-morphologic dif-

<table>
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</table>

ACI, Acromial coverage index.
ferences are present, meaning there is a higher acromial coverage index in women.\textsuperscript{13,16,17,31}

REFERENCES


Figure 4 Patient with high coverage of acromion and rotator cuff tear at insertion site: radiograph with high coverage (A) and magnetic resonance image showing rotator cuff tear at insertion (B).

Figure 5 Patient with low coverage of acromion and rotator cuff tear medial to insertion site: radiograph with low coverage (A), and magnetic resonance image showing medial rotator cuff tear (B).