# Superior excursion of the humeral head: A diagnostic tool in rotator cuff tear surgery

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*Superior excursion of the humeral head on the face of the glenoid was investigated to determine whether a relationship exists between the degree of humeral head excursion and the identity of the injured tendon in a shoulder with a torn rotator cuff. Twenty-seven patients with unilateral full-thickness rotator cuff tears diagnosed by either positive arthrogram or magnetic resonance imaging were included in this study. Three groups were formed based on intraoperative findings: 10 patients had isolated supraspinatus tendon tears (group 1), 11 patients had supraspinatus and infraspinatus tears (group 2), and 6 patients had supraspinatus, infraspinatus, and subscapularis tendon tears (group 3). There was no statistically significant difference between the degree of humeral head excursion in groups 1 and 2. However, patients in group 3 had a statistically significantly higher degree of excursion of the humeral head ($P < .05$) when compared with groups 1 and 2. In addition, an inverse relationship between the degree of humeral head excursion and preoperative Constant scores was found. Superior excursion of the humeral head on the glenoid had a significantly higher incidence in patients with subscapularis tears, and a larger amount of excursion was present in patients who had lower preoperative Constant scores. (J Shoulder Elbow Surg 2005;14: 375-379.)*

One of the keys to proper functioning of the shoulder is an intact rotator cuff. The function of the rotator cuff has 3 effects on the shoulder. It compresses the humeral head into the glenoid fossa, increases joint contact pressure, and centers the humeral head on the glenoid. The deltoid muscle works in conjunction with the supraspinatus and infraspinatus muscles to abduct the arm.[2,4] At the beginning of abduction, the deltoid causes superior displacement of the humeral head due to its vector. To prevent complete superior excursion of the humeral head by the deltoid, the rotator cuff compresses the humeral head against the glenoid, fixing the head of the humerus to the glenoid, thereby providing a fulcrum for the deltoid.[5,19] Thus, the rotator cuff, specifically the supraspinatus, acts as a synergist to deltoid function. In the case of rotator cuff tear or failure, the humeral head is displaced superiorly during abduction as a result of the unopposed action of deltoid.

Narrowing of the acromiohumeral interval (AHI) was first defined by Golding[9] as a characteristic of rotator cuff tears on plain radiographs. Golding reported that the AHI ranged from 7 to 13 mm in normal subjects. Cotton and Rideout[4] included Golding's finding in the 5-group classification of radiologic features of rotator cuff tears, and several other studies have supported Golding's findings. Cotton and Rideout reported a range of 6 to 14 mm, and Weiner and Macnab[20] reported an AHI of 7 to 14 mm in patients with intact rotator cuffs whereas an interval of 5 mm or less was considered as a tear of the rotator cuff. Recently, Deutsch et al[5] studied the effect of rotator cuff function on the humeral head position, but instead of AHI, they used the superior excursion of the humeral head for both the impingement syndrome and rotator cuff tear.

None of the studies mentioned gave direct information about the severity and location of the cuff tear in considering the AHI or superior excursion of the humeral head. This study aims to use the plain radiograph to determine the location and size of the cuff tear preoperatively by measuring the superior excursion of the humeral head.

## MATERIALS AND METHODS

We studied 30 consecutive patients (17 women and 13 men) presenting between 1990 and 2000 with unilateral full-thickness rotator cuff tears diagnosed by positive arthrogram or magnetic resonance imaging (MRI). Patients having any history, symptom, or physical finding suggesting a

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rotator cuff condition in the opposite shoulder were excluded from the study. The size of the tear and the affected tendons were noted during surgery. Patients with intact supraspinatus tendons (3 shoulders) were excluded from the study because of the small size of this population for statistical comparison. The remaining 27 patients with unilateral full-thickness rotator cuff tears of medium to large size (1-5 cm) were included in the study. The long head of the biceps was intact in all cases. Three patient groups were formed based on the location of the tear. Group 1 included 10 patients with isolated supraspinatus tendon tears, group 2 included 11 patients with supraspinatus and infraspinatus tears, and group 3 included 6 patients with supraspinatus, infraspinatus, and subscapularis tendon tears.

Anteroposterior views of the glenohumeral joint of both shoulders were taken before surgery. Plain radiographs were taken with the arm actively elevated 30° in the plane of the scapula with the patient in the upright position. The x-ray beam was parallel to the plane of the glenoid and perpendicular to the plane of the scapula. On the anteroposterior view, a y-axis that was parallel to the glenoid and tangent to both the inferior and superior rims was selected as a reference line. Lines passing through the geometric center of the humeral head ($O_h$) and the center of the glenoid face ($O_g$) that were perpendicular to the y-axis were drawn. The distance between the $O_h$ and $O_g$ was measured[5] (Figure 1). The center of the glenoid face was used as a point of reference. When the geometric center of the humeral head was located inferior to the center of the glenoid face, a negative excursion value was recorded. Similarly, a positive value was assigned when the humeral head was located superior to the center of the glenoid face. The distance between $O_h$ and $O_g$, referred to as e, was measured in both shoulders. The difference between the e value of the injured shoulder and the e value of the uninjured shoulder was recorded. This number was defined as the degree of excursion (Δe) of the injured shoulder. Statistical analysis was done to determine a correlation between the degree of excursion of the humeral head and the rotator cuff tendon involved.

The relevance of humeral head excursion with regard to preoperative Constant scores was also investigated. Patients were divided according to Δe: group A included patients with excursion ranging from 0 to 3 mm, whereas group B included patients with excursion ranging from 4 to 5 mm. One-way analysis of variance, Tukey-Kramer multiple comparisons test, and unpaired *t* tests were used to determine a statistically significant relationship.

## RESULTS

The mean age of the patients was 56 years (range, 32-71 years). It was determined intraoperatively that tears of the supraspinatus, infraspinatus, and subscapularis tendons were present in 27 patients (100%), 11 patients (40.7%), and 6 patients (22.2%), respectively. Tears of the teres minor were not reported. The mean excursion of the humeral head in injured shoulders was +0.03 mm, whereas the mean excursion in uninjured shoulders was −2.00 mm (inferior excursion). The difference was statistically significant ($P < .0001$).

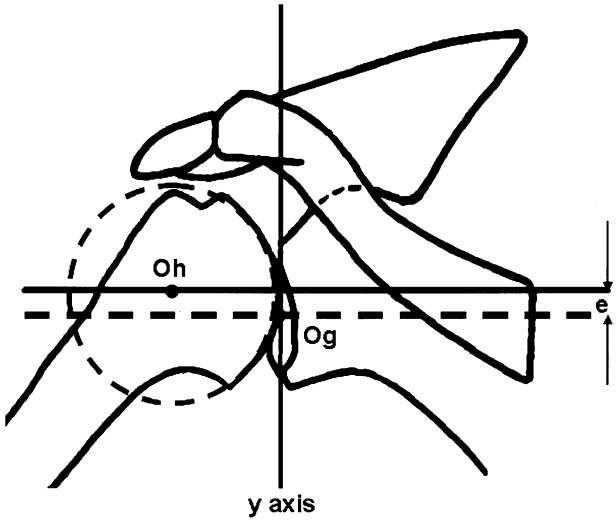


**Figure 1** The parameters used for the measurement of excursion of the humeral head on the face of glenoid (e) on preoperative plain radiographs. *Oh*, Geometric center of humeral head; *Og*, center of glenoid face.

Comparison of the Δe among the 3 groups revealed that patients with isolated supraspinatus tears (group 1) had a mean Δe of 1.4 mm whereas patients in group 2 (supraspinatus and infraspinatus tears) had a mean Δe of 2.0 mm. The difference between the two groups was statistically insignificant. The mean Δe increased to 4.5 mm in patients in group 3, resulting in a statistically significant difference when compared with groups 1 and 2 ($P < .05$) (95% CI, 3.925-5.075) (Table I).

The Δe was 0 to 3 mm in 19 patients (group A) and 4 to 5 mm in 8 patients (group B). The mean preoperative Constant score was 48.6 in group A and 21.5 in group B. The difference was statistically significant ($P < .001$) (Figure 2). A negative correlation was present between the Δe and the preoperative Constant scores.

There was no direct relationship between the size of the tear and the extent of humeral head excursion.

## DISCUSSION

Elevation of the arm is accomplished by the deltoid working in conjunction with the rotator cuff.[1,4,5,11,13] The pull of the deltoid, which tends to displace the humeral head from the glenoid, is counteracted by the rotator cuff, which fixes the humeral head in the glenoid. This force couple applies the force necessary to abduct the humerus.[2] When a large tear of the rotator cuff exists, the upward pull of the deltoid is unopposed, leading to superior displacement of the humeral head.[5]

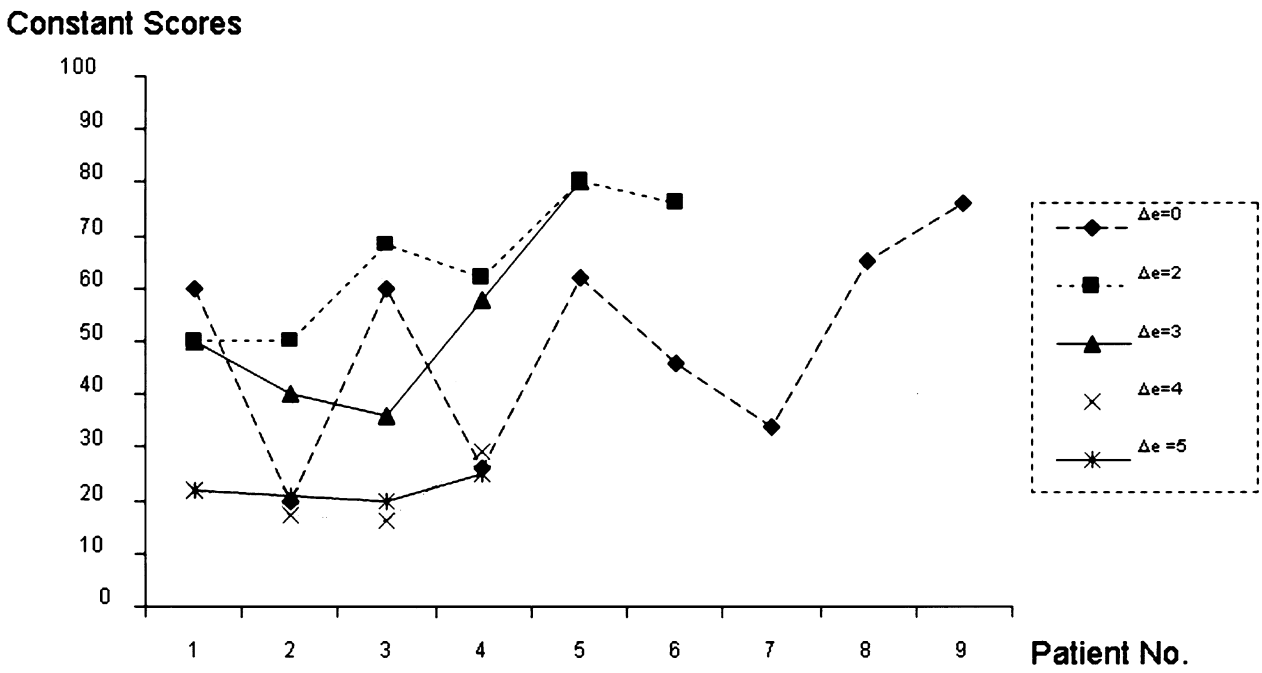


**Figure 2** The distribution of Δe values and preoperative Constant scores in patients with torn rotator cuffs.

**Table I** Distribution of Δe in three rotator cuff tear groups

| | Isolated supraspinatus tear (group 1) | Supraspinatus and infraspinatus tear (group 2) | Supraspinatus, infraspinatus, and subscapularis tear (group 3) |
|---|---|---|---|
| No. of Cases | 10 | 11 | 6 |
| Mean Δe (mm) | 1.4 | 2.0 | 4.5 |
| Minimum (mm) | 0 | 0 | 4 |
| Maximum (mm) | 3 | 5 | 5 |
| SD | 1.2 | 1.7 | 0.5 |
| 95% CI limits (lower-upper) | 0.5–2.3 | 0.8–3.2 | 3.9–5 |

The importance of the AHI for diagnosing rotator cuff tears on plain radiographs has been discussed by many authors.[4,9,10,20] Golding[9] first studied the AHI as a diagnostic tool by measuring the interval in the injured and uninjured shoulders of 150 patients. He reported that the AHI in uninjured shoulders generally ranged from 7 to 13 mm. Cotton and Rideout[4] combined radiologic and pathologic surveys of shoulder joints at necropsy to confirm changes associated with rotator cuff tears. They also reported on the AHI. They clarified the methodology for measuring the AHI by defining their margins of measurement from the inferior aspect of the acromion directly above the head of the humerus to the articular cortex of the humeral head. They found that the AHI ranged from 6 to 14 mm in subjects with intact rotator cuffs based on plain radiographs. Patients with full-thickness rotator cuff tears were reported to have an AHI ranging from 1 to 4 mm. However, they concluded that narrowing of the AHI was not a reliable sign for diagnosis of a full-thickness tear of the rotator cuff and further reported that changes seen on plain radiographs gave little indication of the severity of the tear.

In 1970 Weiner and Macnab[20] radiologically evaluated the superior migration of the humeral head. Standard anteroposterior views of the shoulder with the arm at the side in neutral rotation were reviewed. They reported that a normal AHI ranged from 7 to 14 mm, and they considered an interval of 5 mm or less to be compatible with a tear of the rotator cuff. They proposed that narrowing of the AHI was a result of a decrease in the amount of substance normally located within the AHI combined with the pull of the deltoid that shifts the humeral head proximally as a result of ineffective supraspinatus function.

Hamada et al[10] reported AHI measurements in

patients with massive infraspinatus and supraspinatus tears verified by arthrography. In their study the mean AHI was 4.4 mm (range, 0-9 mm). Anteroposterior radiographs were taken with the arm in a neutral position without active abduction.

Deutsch et al[5] performed a radiologic study of superior displacement of the humeral head in impingement and rotator cuff tear patients. Rather than measure the AHI, the authors measured the humeral head position with respect to the glenoid face as patients held their arms in different positions, based on the previous work of Poppen and Walker.[15] Although there was no significant difference in position of the humeral head at the beginning of abduction in the cuff tear, impingement, and normal shoulder groups during the initial 40° of abduction, there was a significant superior excursion of the humeral head in the tear and the impingement groups compared with the normal control group. The shoulder muscles cause a significant rise of the humeral head during the initial 30° to 60° of abduction in rotator cuff–injured shoulders.[5,16] In our study humeral head excursion was measured on radiographs taken with the arm actively abducted to 30° to promote activity in the rotator cuff muscles.

Poppen and Walker[15,16] were the first investigators to study and define the excursion of the humeral head on the face of the glenoid. This description was used by Chen[3] and Deutsch et al.[5] During abduction, the glenoid face moves medially and tilts upward with the movement of the humeral head[15] so that, in our opinion, measurement of superior excursion of the humeral head on the glenoid face reflects glenohumeral congruity better than the AHI. In this study, measurement of excursion of the humeral head on the glenoid face was preferred, unlike the previous studies that used the AHI as a diagnostic criterion for rotator cuff tears.[4,9,10,20]

Our findings suggest that there is no significant difference in humeral head excursion between patients with isolated supraspinatus tears (group 1) and patients with supraspinatus and infraspinatus tears (group 2). However, patients with supraspinatus, infraspinatus, and subscapularis tears (group 3) showed a statistically significant increase in superior displacement of the humeral head on the glenoid. These findings are supported by the physiologic characteristics of the rotator cuff muscles. The subscapularis is the strongest of the rotator cuff muscles.[6] It maintains the stability of the humeral head by pulling it downward and posteriorly during abduction of the arm.[16,18] The loss of this strong muscle function allows the humeral head to subluxate anterosuperiorly as a result of the remaining force of the deltoid, which causes a large amount of superior excursion (group 3). The infraspinatus is relatively weaker and contributes 22% of the cuff moment, which is less than the subscapularis, which generates 53% of the total moment.[14] A tear of this muscle together with the supraspinatus was found to cause a small amount of humeral head excursion.

The relationships between superior excursion of the humeral head and the preoperative Constant scores were also investigated. We found an inverse relationship between humeral head excursion and preoperative Constant scores (ie, preoperative Constant scores were lower in patients in whom superior excursion of the humeral head in the injured shoulder relative to the normal one was $>3$ mm).

The uninjured shoulders of the patients included in this study were used as controls because there is wide variability in the size of the humeral head between patients of different heights.[12] Therefore, uninjured shoulders were compared with injured ones in the same patient to prevent errors that might result from patient variability.

Three patient groups were defined to include 1, 2, or 3 types of tears. This classification enabled the investigators to include a sufficient population of patients for evaluation, as isolated infraspinatus tears and isolated subscapularis tears are rare.[7,8,17] Further investigation of excursion in patients with isolated infraspinatus or isolated subscapularis tears will define more clearly the interaction between the tendons involved and the excursion of the humeral head.

Although ultrasound and MRI are likely to demonstrate cuff rupture more than superior excursion of the head on radiographs, the refinement of the findings from the ultrasound requires special skills. MRI is important for the diagnosis of rotator cuff tears; however, it is an expensive tool and may not be found everywhere. On the contrary, radiography is a cheap and feasible diagnostic tool that may aid in the diagnosis of a tear based on the finding of superior excursion of the humeral head.

In conclusion, measurement of superior excursion of the humeral head of both shoulders in patients with a suspected 1-sided full-thickness rotator cuff tear is important for determining the tendons' involvement. In this study, 3.9 mm of superior excursion of the humeral head was found to be the lower limit for subscapularis tears presenting together with supraspinatus and infraspinatus tears. Superior excursion of more than 3 mm was found to be adversely influential on the preoperative Constant scores.

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