Correlation between rotator cuff tear and gleno-humeral degeneration

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ABSTRACT – We studied the occurrence and correlation between a rotator cuff tear and glenohumeral degeneration. 44 cadaveric shoulders (22 right) were obtained from 32 subjects (18 females), mean age 73 (62–86) years and without a history of systemic diseases. Rotator cuffs were exposed and tear size (14 shoulders) was measured after removal of soft tissue and deltoid. Articular cartilage damage of the glenoid and humeral head was recorded by photography. A grading system of 1 (intact), 2 (mild) and 3 (severe) was used to determine the severity of cartilage damage. The area of articular cartilage damage was calculated using the Sonic Digitizer Analyzing System.

The area of articular cartilage damage to the glenoid and the humeral head in the rotator cuff tear group was 32% and 36%, respectively. It was greater than that in the groups without a tear, which was 6% in the glenoid and 7% in the humeral head. However, it was not correlated with the size of the tear. Most of the articular cartilage damage in massive and large rotator cuff tears was located in the anterior-inferior portion of the glenoid and in the posterior portion of the humeral head. The articular cartilage damage area of the glenoid was correlated with that of the humeral head. In conclusion, the area of glenohumeral degeneration was greater in the rotator cuff tear group and was located in a specific site.

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Tearing of the rotator cuff and glenohumeral arthrosis are two common pathologies of the shoulder, but their relationship is rarely mentioned in the literature. The glenohumeral joint is not a weight-bearing articulation, so considerable changes related either to glenohumeral arthritis or rotator cuff degeneration may exist in the absence of significant clinical disability. An association between glenohumeral joint arthrosis and tear or atrophy of the rotator cuff has been suggested by several investigators (Kerwein 1965, Petersson 1983, Radke et al. 2001, Umans et al. 2001). Neer (1974) proposed that osteoarthrosis of the glenohumeral joint begins as a defect in the articular cartilage, which is followed by slowly progressive deterioration resulting in articular surface incongruity. Neer et al. (1983) discussed in more detail a condition they called cuff-tear arthropathy, which includes collapse of the humeral head and is also related to tearing of the rotator cuff. Chronic cuff deficiency of the shoulder is accompanied by loss of the articular cartilage and softening of the subchondral bone of the humeral head and glenoid (Neer et al. 1983). Petersson (1983) found that three quarters of the shoulders with cartilage degeneration were also afflicted with rotator cuff degeneration or full-thickness rupture.

The mechanical basis for normal glenohumeral function depends on the balance of muscle force couples in coronal and transverse planes. Loss of quantitative muscle forces can be expected with a musculotendinous cuff tear. We hypothesized that loss of the balance of muscle force couples in patients with chronic rotator cuff tears may lead to glenohumeral instability and result in articular cartilage damage. We studied the correlation between rotator cuff tears with glenohumeral degeneration.

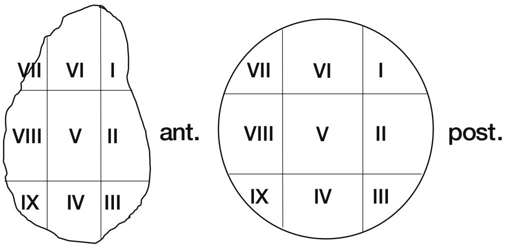

Figure 1. Areas of articular cartilage damage were recorded in 9 zones of the glenoid and humeral head.

Material and methods

44 cadaveric shoulders (22 right) were obtained from 32 subjects (18 women) with mean age 73 (62–86) years. None of the patients had a history of systemic diseases such as sickle cell anemia, Gaucher's disease, Caisson's disease, rheumatoid arthritis, ochronosis or gout. Degenerative changes and avascular necrosis of the humeral head that might be associated with complications following these abnormalities of the bone or cartilage were not present. The glenohumeral joint was harvested including the whole scapula and mid-humerus, along with all soft tissue around the shoulder. The rotator cuff was exposed after removal of skin, subcutaneous tissue and deltoid muscle, and the size of the rotator cuff tear, if one existed, was measured. The condition of articular cartilage was recorded using pictorial photography of the specimens with the center of the glenoid and humeral head facing perpendicularly to the camera shutter after arthrotomy. Recorded areas of articular cartilage damage were divided into 9 zones of the glenoid and humeral head (Figure 1). Severity of the articular cartilage damage was graded into three categories: grade I (intact), sound cartilage without gross changes or destruction; grade II (moderate), fibrillation with discoloration of the cartilage without subchondral bone exposure; and grade III (severe), loss of the cartilage with subchondral bone exposure. The area of each grade of articular cartilage damage on the glenoid and humeral head was calculated using the Sonic Digitizer Analyzing System.

Statistics

Owing to the small sample size in each category, nonparametric methods including Mann-Whitney's test, the Kruskal-Wallis' test, Friedman's test and Spearman's rank correlation test were used. Hypotheses were formulated and analyzed. Hypothesis 1: The area of articular cartilage damage on the glenoid (or humeral head) depends on the integrity of the rotator cuff. Hypothesis 2: The area of articular cartilage damage on the glenoid (or humeral head) depends on the extent of the tear. Hypothesis 3: The location of articular cartilage damage on the glenoid (or humeral head) also depends on the extent of the tear. Hypothesis 4: The damaged area of the articular cartilage on the glenoid is correlated with the area of articular cartilage damage of the humeral head.

Results

We found 14 rotator cuff tears, of which 2 were partial and 12 full thickness (1 small, 5 medium, 3 large, and 3 massive). Grossly, the changes were comprised of thinning, fibrillation, pitting, and erosion of the articular cartilage. Along the periphery, the findings consisted of pitting and erosion of cartilage and formation of bony spurs and excrescences. Osteophytes were found most frequently in the vicinity of the tubercles and the sulcus of the humeral head and sometimes along the borders of the glenoid cavity. The average involved area of articular cartilage damage on the glenoid and humeral head in the rotator cuff tear group was 32% and 36%, respectively. It was statistically significantly greater than that of the group without a rotator cuff tear (n = 30), which was 5.8% in the glenoid and 7.0% in the humeral head. On the basis of Mann-Whitney's test, the results showed that the area of articular cartilage damage on the glenoid (or humeral head) depended on the integrity of the rotator cuff (hypothesis 1). Using the Kruskal-Wallis' test, we found no evidence to support our hypothesis 2 that the area of articular cartilage damage on the glenoid (or humeral head) would increase with the size of the rotator cuff tear (Table). Thus, the areas of articular cartilage damage of the glenoid and humeral head differed statistically between the groups with or without

Area of articular cartilage damage and size of the rotator cuff tear

		Glenoid (%)	Humeral head (%)
Small	(n = 1)	26	26
Medium	(n = 5)	33	31
Large	(n = 3)	37	49
Massive	(n = 3)	32	35

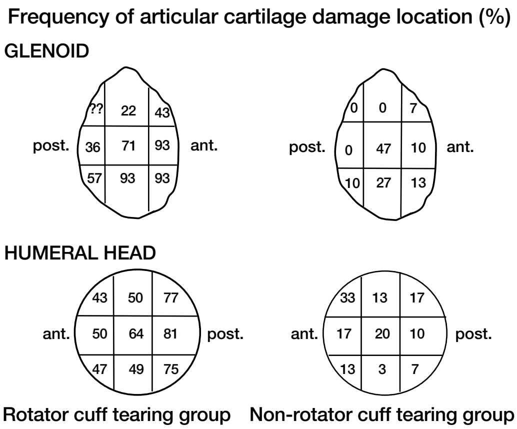

Figure 2. Articular cartilage damage occurred with high frequency in the anterior-inferior portion (zones II, III, IV) of the glenoid and in the posterior portion (zones I, II, III) of the humeral head in the rotator cuff tear group.

a rotator cuff tear, but not correlated with the size of the tear. We analyzed hypothesis 3 with Friedman's test. Atrophy of the articular cartilage and alterations due to subacromial impingement such as rounding of the greater tuberosity, erosion or wear of cartilage in the superior region of the humeral head were found in massive tears. In addition, high frequency of articular cartilage damage in massive and large rotator cuff tears occurred in the anterior-inferior portion (zones II, III, IV) of the glenoid and in the posterior portion (zones I, II, III) of the humeral head (Figures 1 and 2). In both the groups with and without rotator cuff tears, we found a nonspecific central erosion area on the glenoid (zone V). This was evident in 10/14 and 14/30 of specimens of the groups with and without a tear, respectively (Figure 3). The articular cartilage damage area of the glenoid was correlated with the articular cartilage damaged area of the humeral head, using Spearman's rank correlation test (Hypothesis 4).

Discussion

No strong association has been found between the changes in osteoarthrosis and those related to integrity of the rotator cuff. In an autopsy study, Petersson (1983) found that 26 of 34 shoulders with cartilage degeneration had degeneration or rupture of the rotator cuff. In an arthrographic study, Kerwein (1965) observed that 32 of 35 shoulders with glenohumeral osteoarthrosis had a lesion in the rotator cuff. At variance with these data are the results of Neer (1974), who performed hemiarthroplasty on 48 shoulders with glenohumeral joint osteoarthrosis and reported that only 1 shoulder had a full-thickness tear of the rotator cuff. This may be due to the use of different surgical and cadaveric dissection techniques. The most

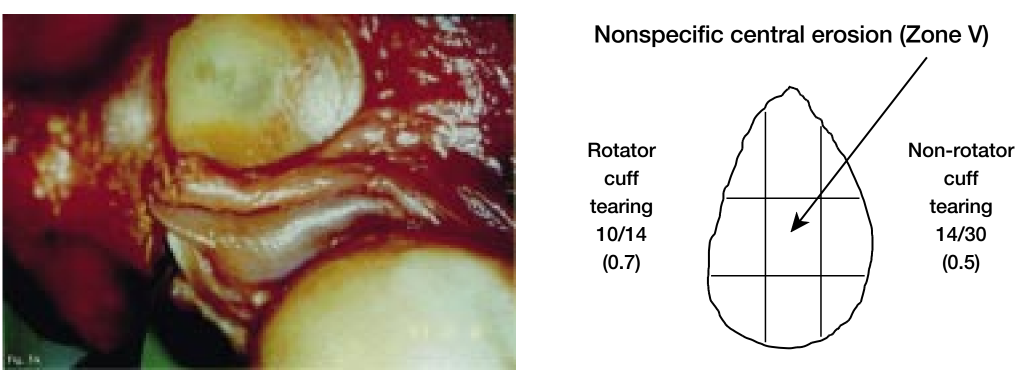

Figure 3. In the groups both with and without a rotator cuff tear, we found an area of nonspecific central erosion on the glenoid (zone V).

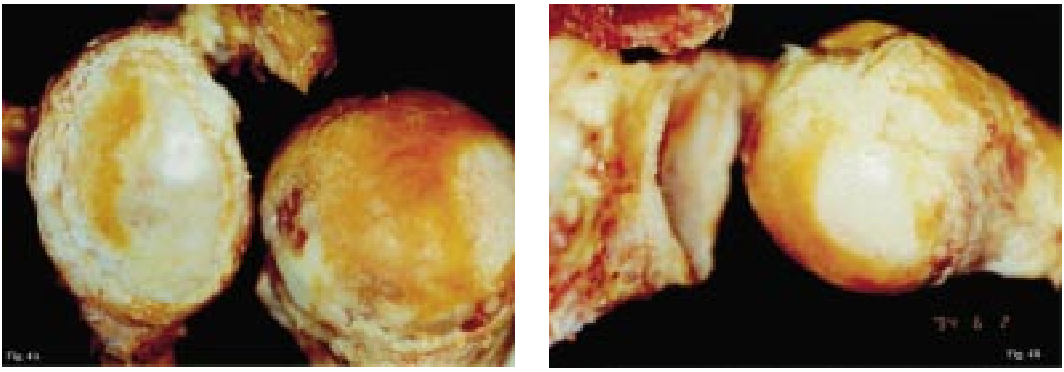

Figure 4. No kissing image was seen when the arm was in a hanging position (left) and at 90° of abduction (right).

frequent degenerative abnormality was the formation of osteophytes along the articular margin of the humeral head and the line of attachment of the labrum to the glenoid. These marginal osteophytes are thought to result from functional stress provided by capsular traction (Kerwein 1965, De Palma 1983). They predominate in the anterior and inferior aspects of the humeral articular margin and along the lower two-thirds of the circumference of the glenoid fossa. We found that the area of articular cartilage damage on the glenoid (or humeral head) dependend on the integrity of the rotator cuff. However, there was no statistical evidence to support our hypothesis that the area of articular cartilage damage on the glenoid (or humeral head) would increase as the size of the tear increased. This may have been partly due to deformation changes of a realistic 3-dimensional subject into a 2-dimensional photographic picture. In addition to the nonspecific area of central erosion on the glenoid in both groups with or without a rotator cuff tear, which was also consistent with findings in a pathoanatomic study of Kerr et al. (1985), in which most of the articular cartilage damage in massive and large rotator cuff tears occurred in the anterior-inferior portion of the glenoid and posterior portion of the humeral head. We found no kissing image when the arm was in a hanging position and at 90 degrees of abduction (Figure 4). Conversely, the kissing image matched well in 90-degree flexion, and 90-degree abduction with external rotation and maximal elevation (Figure 5). This means that patients with rotator cuff tears should be reminded that infrequent high stress activity or positions such as high angle abduction with external rotation and maximal elevation can cause cartilage damage if the instability is serious. This contrasts with the lesion caused by excessive load, where the cartilage defects are mirrored on the opposed articular surfaces. No cases of central erosion of the glenoid fossa were reported by Kerr et al. (1985) in 15 of 92 specimens. The percentage of central area erosion in our study was higher in both groups with (71%) or without a rotator cuff tear (47%). We noted that the hyaline cartilage lining the glenoid fossa was thinner in the center of the comma head than in the tail, which led us to assume that the thin area is the area of greater contact with the humeral head. This concept clearly explains why the center of the glenoid fossa is thinner than the surrounding surfaces: it bears constant and greater stress during movements of the arm (De Palma 1983). Another degenerative-like finding in the glenohumeral joint documented by Kerr et al. (1985) is focal or global eburnation of the articular surface of the humeral head, manifested radiographically as subchondral sclerosis. This abnormality was most evident in the middle and superior parts of the humeral head, areas in contact with the glenoid fossa when the arm is abducted between 60 and 100 degrees. This finding is consistent with that of Neer (1974), who demonstrated severe thinning of the articular cartilage of the humeral head in this region in patients with osteoarthrosis of the glenohumeral joint. In our study, zones V and VII were the areas of the most frequently occurring articular cartilage damage of the humeral head in the group without a rotator cuff tear (Figure 2).

Assessment of the articular surface contact area in normal and abnormal shoulders during joint

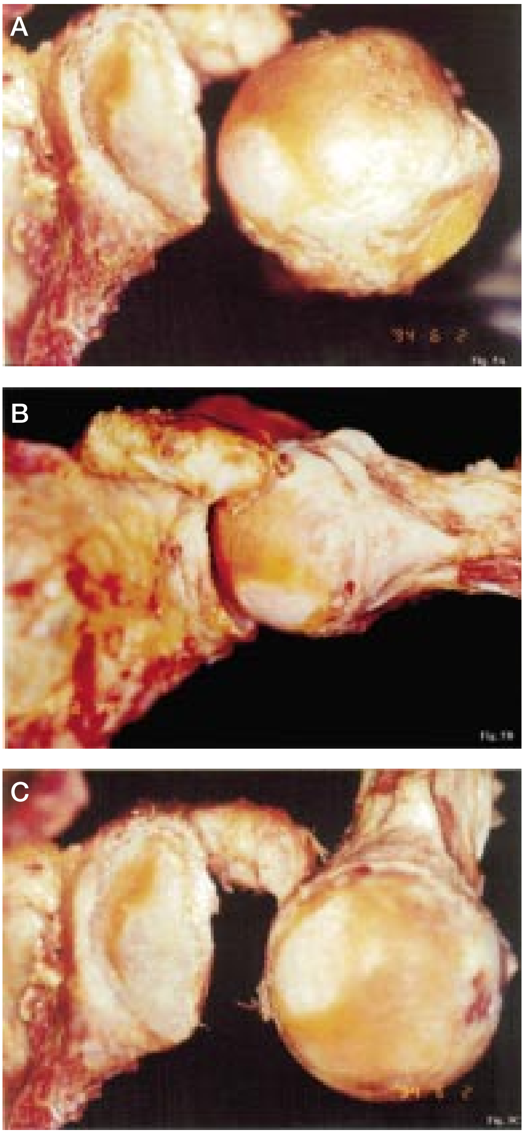

Figure 5. The kissing image matched well at 90 degrees of flexion (A), 90 degrees of abduction with external rotation (B) and maximal elevation (C).

motion has clinical significance in understanding joint degeneration and stability. Excessive compression or shearing load on a particular articular surface caused by a rotator cuff tear will lead to articular cartilage damage and result in glenohumeral arthrosis. The electromyographic pattern of a muscle is altered in a diseased or pathologic state (Peat and Grahame 1977). In studies on rotator cuff disease and anterior instability, not only is the shoulder unable to compensate for the injured area, it also seems to develop a deleterious dyskinetic pattern that exacerbates the ongoing clinical problem (Glousman et al. 1988, Jobe and Bradley 1988, Altcheck et al. 1990, Bradley 1991, Kronberg, et al. 1991). Once cuff-tear arthropathy occurs, it may be difficult to treat without replacing the joint. Although many tears of the rotator cuff do not enlarge sufficiently to allow this condition to develop, it is certainly a factor to be considered when deciding whether or not a documented tear of the rotator cuff should be surgically repaired. Dealing with the mechanical adverse effect of dynamic stabilizer in patients with a rotator cuff tear, we should pay attention to the possible associated lesions and the importance of the effect on glenohumeral degeneration.

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