ANATOMY OF THE CORACO-ACROMIAL ARCH

RELATION TO DEGENERATION OF THE ACROMION

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We examined 200 scapular bones for signs of degenerative changes in the coraco-acromial arch. The slope and length of the acromion and the height of the arch were found to be most closely associated with degenerative change. These anatomical features are not significantly altered by current techniques of subacromial decompression.

Spurs and osteophytes on the anterior margin of the acromion have been associated with humeral impingement (Neer 1972) and with the presence of rotator cuff tears (Petersson and Gentz 1983; Morrison and Bigliani 1987). We have found that these changes correlate with certain anatomical variations in the shape of the coraco-acromial (C-A) arch. Our aim was to relate these variations to the diagnosis, prognosis and treatment of some common shoulder problems.

MATERIALS AND METHODS

We examined 280 scapulae taken from collections in the anthropology department and the Sackler Medical School of Tel Aviv University, Israel. The exact ages of the specimens were not known but 200 were estimated to be from mature individuals aged between 30 and 70 years, the majority (73%) being between 40 and 60 years old. This determination was made according to morphological criteria from accompanying skeletal remains (İşcan and Loth 1986) and is generally accepted by anthropologists to be accurate within $\pm$ ten years (White 1990). These 200 mature specimens were the basis of our study.

The C-A arch comprises the coracoid, the C-A ligament, and the acromion. The ligament was absent in our specimens. The distal clavicle was also excluded from evaluation since it was not present in all specimens. We did include, however, the acromial side of the acromioclavicular joint which reflects variations on the clavicular surface (De Palma 1963).

We examined the specimens for evidence of osteophytic spurring, faceting or other degenerative changes on the acromion and the coracoid. The arch anatomy of the arthritic specimens was then compared with that of specimens in which no degenerative changes had been found. The following measurements were taken to quantify the differences between the specimens (Fig. 1):

Diagram to show the measurements taken: as, acromial slope; ad, coraco-acromial arch distance; h, maximum acromial height; c, coracoid height; L, coracoid length; y_1 , y_2 , scapular angles of root of coracoid and base of acromial spine respectively; cs, coracoid slope.

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- 1) Slope of the acromion (as).
- 2) Slope of the coracoid (cs).
- 3) Coraco-acromial arch distance (ad). The C-A ligament was simulated by a semi-rigid plastic insert and the shortest distance to the supraglenoid tubercle was measured.
- 4) Maximum length, width and thickness of the acromion and height of the coracoid.
- 5) Degree of curvature of the acromion in profile, approximated by the maximum height (h) of the bone above a straight line drawn between its ends.

Fig. 2

Specimen showing typical degenerative changes on the anterolateral third of the acromion.

- 6) The angles y_1 and y_2 , after construction of the 'scapular y' (Rubin, Gray and Green 1974). The glenoid mid-sagittal line was taken as the body of the 'y', the arms being the root of the coracoid and the base of the acromial spine.

RESULTS

Degenerative changes were seen in 18% of the acromions (Fig. 2), generally limited to the anterior third. The middle and posterior areas were usually uninvolved except in one specimen, estimated to be 70 years of age, in which there was extensive cupping of the entire undersurface of the acromion. None of the specimens showed significant degenerative changes in the coracoid pillar.

There were two types of degenerative change. One resembled a traction spur at the anterior edge of the bone (Fig. 3a) and the other an eburnated facet like a pseudo-articular surface for the humeral head (Fig. 3b). Both were present in 23% of affected specimens (Fig. 2).

The slope of the acromion was the measurement most commonly associated with degenerative changes (Fig. 4); the more horizontal the acromion the greater the degeneration. No acromion with a slope angle of more than 41° had degenerative changes and 75% of those with such changes had a slope angle of 35° or less.

Fig. 3a

Fig. 3b

Figure 3a – Spur-type degenerative change seen from above the acromion. Figure 3b – Facet-type degeneration seen from below the acromion.

Fig. 4a

Fig. 4b

Figure 4a – On the left a horizontal-type acromion with a visible spur. On the right a vertical-sloped acromion without degenerative changes. Figure 4b – On the left a vertical acromion without degeneration. On the right a horizontal acromion with a hook-like degenerative spur.

Fig. 5a

Fig. 5b

Fig. 5c

Figure 5a – A 'cobra'-shaped acromion, the position of the articular facet for the clavicle is 5 to 10 mm posterior to the anterior margin in this type of acromion (arrow head). Figure 5b – A 'square tip' acromion. The clavicular articular facet is at the anterior margin of the bone. Figure 5c – An 'intermediate'-shaped acromion with characteristics between those of figures 4a and 4b.

Fig. 6a

Fig. 6b

Variation in the acromion. Figure 6a – Thick. Figure 6b – Thin.

The slope of the acromion was also related to the angle at which the base of the scapular spine jutted out from the scapular blade (y_2 angle; Fig. 1a). The more nearly perpendicular the base of the spine was to the blade, the more vertical was the slope of the acromion.

Increased degenerative changes of both types were associated with increased length of the acromion (L ; Fig. 1a) and length was in turn related to the shape of the acromion. The longest specimens were 'cobra' shaped (Fig. 5a) with a mean length of 6.2 cm (5 to 7.75). These constituted 33% of the specimens of which 26% showed degenerative changes. The shortest specimens (22%) were 'square-tipped' (Fig. 5b) with a mean length of 5.2 cm (4.5 to 6.25). Degenerative changes were found in 11% of these. The remainder (45%) were of an 'intermediate' type (Fig. 5c) with a mean length of 5.8 cm (5 to 7.25). Degenerative changes were found in 19% of these.

There was also considerable variation in the thickness and width of the acromion (Fig. 6). Neither, however, appeared to correlate with degenerative changes.

Fig. 7

Radiograph of a specimen with a high C-A arch, a vertical acromial slope and a vertically oriented coracoid root.

The height of the C-A arch was associated with degenerative changes in the acromion. There was no degeneration in arches crossing more than 15 mm above the supraglenoid tubercle (Fig. 7). It increased in frequency and severity as arch distance decreased; 75% of specimens with degenerative changes had an arch distance of 12 mm or less. On the acromial side the height of the C-A arch was determined mainly by the slope of the acromion and on the coracoid side by the length of the coracoid root and by its angle of ascent from the glenoid (y_1 angle; Fig. 1a). A long, vertically orientated coracoid root raised the height of the arch and was associated with less acromial degeneration. A horizontally orientated root had the opposite effect.

Fig. 8a

Fig. 8b

Figure 8a – A specimen showing a normal coracoid slope. Figure 8b – A sharply downward orientation of the coracoid effectively lowers the coraco-acromial arch distance.

Fig. 9a

Fig. 9b

Figure 9a – The acromial facet of an A-C joint extending inferiorly and projecting down on the under surface of the acromion. Figure 9b – A high-riding A-C facet without inferior projection.

Fig. 10

Extensive degenerative changes on the acromial facet of the A-C joint (larger arrow) seen from below. These changes are separated from the facet-type degeneration on the anterolateral aspect of the acromion itself (small arrow).

Fig. 11

Os acromiale seen from above. There are degenerative changes on both the proximal and distal sides of the ununited apophysis.

An increased slope of the coracoid (cs; Fig. 1b) also lowered the C-A arch. Most coracoids sloped gently inferiorly but some turned down acutely (Fig. 8) thereby lowering the C-A arch distance.

The size and slope of the acromial facet of the acromioclavicular joint are very variable (De Palma 1983). In our specimens 58% of the facets projected inferiorly as a hard edge on to the undersurface of the acromion (Fig. 9); this was enhanced by degenerative changes in 38% (Fig. 10). Acromioclavicular degeneration was usually a separate process from spur formation or faceting on the rest of the acromion.

Three of our specimens had an os acromiale. In two there were severe degenerative changes at the site of the nonunited apophysis (Fig. 11).

DISCUSSION

Few animals, not even the monkey, have a well-developed acromion. Only in the chimpanzee and in man is the process sufficiently large to have its own bursae (Inman, Saunders and Abbott 1944). A large overarching acromion provides the origin for the important deltoid muscle but limits overhead brachiation through trees and predisposes to the degenerative processes arising from the more mundane overhead activities of man.

Bigliani, Morrison and April (1986) noted the relationship between the profile shape of the acromion and degenerative changes in the bone and underlying rotator cuff. They characterised acromions as flat (17%), curved (43%), and hooked (40%); our comparable figures are 22%, 62% and 16%. The concept of a 'hooked' acromion, although easily translated into a schematic drawing, is difficult to measure in practice. Secondary degenerative anterior spurs may be mislabelled as such. We believe that true hooks occur rarely and represent an unusually large development of the pre-acromial epiphysis (Liberson 1937b). The influence of the hook on degenerative processes is determined mainly by the slope of the acromion to which it is attached.

Neer (1990) and Aoki, Ishii and Usui (1986) mentioned the importance of the slope of the acromion, as distinct from its hooked shape in profile, but did not discuss this in detail. We have elaborated on this association. A horizontal acromion together with increased acromial length gives more bone cover over the humeral head. Diminished C-A arch height applies this cover more closely to the underlying head which results in increased degenerative changes in the acromion.

The development of an anterior spur on the acromion, a process termed enthesopathy, takes place within the substance of the C-A ligament and probably results from the transmission of tensile forces through the ligament (Ogata and Uhthoff 1990). It might be anticipated that similar changes would also develop on the coracoid pillar of the C-A arch but these did not occur in our specimens. We believe that this is due to the triangular shape of the C-A ligament which has a wide base attached to the coracoid. Tensile forces are thus distributed over a broad area and enthesopathic changes do not occur. Nor was facet degeneration found on the coracoid. The degenerative changes seen on the acromion presumably arise from long-standing impingement by the humeral head. Clinical 'coracoid impingement' (Gerber, Terrier and Ganz 1985) appears to be a more transitory phenomenon and, except when produced iatrogenically, it does not cause bone changes on the coracoid (Gerber, Ganz and Vinh 1987).

Os acromiale has been associated with degenerative acromial changes and with rotator cuff tears (Mudge, Wood and Frykman 1984) and we confirmed this in two of our three specimens.

Measurements similar to those on dry bone specimens can be made also from radiographs. A lateral scapular (Norris 1985) or outlet view (Neer 1990) is recommended. Positioning for these views is often difficult, but even with imperfect positioning a clinically useful impression of the slope of the acromion can usually be obtained. Similarly, the scapular y angles and the C-A arch height can be estimated. An additional axillary

Fig. 12a

Fig. 12b

Fig. 12c

Figure 12a – An axillary radiograph of a patient with a 'cobra'-shaped acromion. Note the position of the clavicle and the A-C joint. Figure 12b – A modified axillary oblique view of a 'square tip' acromion. The clavicle sits proud in an anterior position. Figure 12c – Modified axillary view of an 'intermediate' shaped acromion.

or modified axillary oblique (Liberson 1937a) view should be obtained to evaluate the size and shape of the acromion (Fig. 12). The axillary view will also show the status of the acromioclavicular joint and the possibility of an os acromiale.

Tears of the substance of the rotator cuff can occur from trauma or attrition independently of the shape of the overlying C-A arch (Fukuda, Hamada and Yamanaka 1990; Ogata and Uhthoff 1990). A closely applied arch will, however, eventually be affected by these changes and exacerbate them (Bigliani, Morrison and April 1986). Acromioplasty for decompression of the rotator cuff is necessary in all operations for the relief of impingement or cuff-tear pain. Most current techniques of decompression, however, do not significantly alter the slope of the acromion, the height of the C-A arch, or the length of the acromion. A guarded prognosis should be given to patients with a horizontal acromion and a low-lying arch, particularly if they intend to resume vigorous unrestricted overhead activities after surgery (Tibone et al 1985).

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