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ORIGINAL ARTICLE

The anterior borders of the clavicle and the acromion are not always aligned in the intact acromioclavicular joint: a cadaveric study

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Background: The aim of this study was to find reliable anatomic landmarks of the normal acromioclavicular joint (ACJ) that could enable the precise evaluation of the horizontal displacement of the clavicle after dislocation. The hypothesis was that the anterior borders of the acromion and the clavicle are always aligned in intact ACJs.

Materials and methods: In 30 cadaveric specimens, the anterior and posterior borders of the ACJ's articular facets and the most prominent anterior and posterior bony landmarks of the acromion and the clavicle were identified. The anterior and posterior overhang of the acromion and the clavicle was measured in relation to the borders of the articular facets. Therefore, the possible anterior and posterior alignment of the ACJ was evaluated.

Results: Anteriorly, only 18 ACJs (60%) were aligned whereas 7 (24%) had major overhang of the acromion and 3 (10%) had major overhang of the clavicle. Similarly, 18 cases (60%) were posteriorly aligned, whereas 6 (20%) had major clavicular overhang and 4 (14%) had major overhang of the acromion. In 78% of these cases, the ACJ was aligned as well anteriorly as posteriorly ($P < .001$). Finally, the larger the width of the acromion ($P = .032$) or the clavicle ($P = .049$), the better the posterior joint alignment.

Conclusion: Our hypothesis was not verified. The acromion and clavicle are not perfectly aligned in a significant number of specimens with intact ACJs (40% of cases). The most reliable landmarks remain their articular facets.

Because the data do not contain personal identifiers (anonymous biological material), Institutional Review Board approval was not required (Human Research Act 810.30).

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Level of evidence: Basic Science; Anatomy Study; Cadaver Dissection

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Numerous studies have reported on newer surgical techniques and functional outcomes of acromioclavicular (AC) injuries, with promising postoperative results.^{2,3,5,8,15,18,20} However, controversy still exists regarding the initial treatment algorithm¹ and the postoperative reduction results, especially in the axial plane.²⁰

For several decades, the Rockwood classification has served as the reference not only for describing AC joint dislocations but also as a treatment guideline.¹² Although there is a paucity of high-quality evidence, conservative treatment is recommended for type I and II injuries whereas surgical intervention is preferred for types IV, V, and VI, and the treatment of type III injuries is highly debated.¹ The Rockwood classification relies on distinguishing vertical and horizontal displacement. Vertical displacement is evaluated by measuring the coracoclavicular distance on comparative Zanca views,²¹ which is between 25% and 100% for type III injuries and over 100% for type V. However, there are no firm guidelines for the radiographic evaluation of the posterior displacement characteristic of type IV injuries.

Furthermore, there are limited data on the anatomic variations of AC joint alignment on axillary radiographs. For the most part, the anterior border of the acromion is taken as the reference point compared with the anterior clavicle.¹³ Therefore, the diagnosis of a type IV injury is dependent on the clinical evaluation of whether the clavicle is truly locked posteriorly in the trapezius. Although Rockwood reported only 4 type IV cases out of 520 AC joint dislocations (0.8%), some authors have suggested that this type might be underdiagnosed.^{10,14,19} Finally, during AC joint reconstruction, no clear bony landmarks or reference points have been described; therefore, surgeons unofficially aim to align the anterior border of the acromion with the anterior border of the clavicle.

The aim of this study was to evaluate the intact AC joint and find reliable anatomic landmarks and possible normal variations that could further enable the precise estimation of the horizontal displacement of the clavicle after dislocation. The hypothesis was that the anterior border of the acromion and anterior border of the clavicle are always aligned in intact AC joints.

Materials and methods

Specimens

We evaluated 35 (20 right and 15 left) fresh-frozen cadaveric specimens with an intact scapula and clavicle articulation. One cadaver was excluded for possible previous AC joint surgery, and 4 were excluded because of hypertrophic arthritic changes that limited iden-

tification of bony landmarks. This left 30 shoulders (12 male and 18 female cadavers with a mean age of 70 years [range, 44-97 years]) for the final analysis.

Surgical dissection: measurement methods

The specimens were secured with a clamp on the medial scapula and mounted onto an aluminum frame simulating the beach-chair position. The skin, subcutaneous tissue, and overlying trapezius and deltoid muscle were completely removed to skeletonize the clavicle and the acromion. The superior capsule of the AC joint was excised with the disk if present. The anterior (A) and posterior (P) borders of the capsule were preserved, marked, and connected with a straight line (AP line). Then, 2 parallel lines perpendicular to the AP line were created that passed through points A and P (Fig. 1).

Thereafter, the most anterior extra-articular edges of the acromion and the clavicle were recognized and marked. Next, 2 anterior parallel lines perpendicular to the AP line were drawn: one passing at the most anterior edge of the acromion (acromion anteriorly [ACA]) to define the anterior oversizing of the acromion and the other passing at the most anterior edge of the clavicle (clavicle anteriorly [CLA]) to define the anterior oversizing of the clavicle (Fig. 1). After the aforementioned lines were created and the anterior bony landmarks defined, the following distances were measured: (1) the ACA-A distance between the anterior edge of the acromion (ACA) and the anterior capsule (A) and (2) the CLA-A distance between the anterior edge of the clavicle (CLA) and the anterior capsule (A). Finally, the difference between ACA-A and CLA-A gave the anterior alignment of the AC joint (AAL).

The same procedure was followed for the posterior part of the AC joint. The most posterior edge of the acromion and the clavicle were marked, and 2 posterior parallel lines perpendicular to the AP line were drawn: one passing at the most posterior edge of the acromion (acromion posteriorly [ACP]) to define the posterior oversizing of the acromion and the other passing at the most posterior edge of the clavicle (clavicle posteriorly [CLP]) to define the posterior oversizing of the clavicle (Fig. 1). Again, the following distances were measured: (1) the ACP-P distance between the posterior edge of the acromion (ACP) and the posterior capsule (P) and (2) the CLP-P distance between the posterior edge of the clavicle (CLP) and the posterior capsule (P). Finally, the difference between ACP-P and CLP-P gave the posterior alignment of the AC joint (PAL).

On the basis of the aforementioned measurements, the anterior and posterior alignment of the AC joint was classified as aligned, as having minor overhang, or as having major overhang. Overhang was independently classified as due to the clavicle or the acromion. Overhang of the clavicle or acromion of less than 1 mm was considered aligned. Overhang of between 1 and 2 mm was considered minor. Overhang greater than 2 mm was considered major. According to this classification, 5 possible anatomic variations were found anteriorly or posteriorly: aligned joint, minor acromial overhang, minor clavicular overhang, major acromial overhang, and major clavicular overhang. After the aforementioned measurements were taken, the AC joint

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