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ORIGINAL ARTICLE

Study on the anatomic relationship between the clavicle and the coracoid process using computed tomography scans of the shoulder

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Background: The current trend in the treatment of acromioclavicular dislocations is to reconstruct the coracoclavicular ligaments by using transosseous tunnels in the coracoid process or in the clavicle, yet there is no definition as to the location of these. To study the anatomic relationship between the coracoid process and the clavicle, we made measurements to find a convergence point (cP) between them that has intraoperative applicability for creating transosseous tunnels.

Methods: We analyzed 74 computed tomography scans (40 female and 34 male patients). Measurements were taken in the axial and sagittal planes and obtained from a cP, as determined by the intersection of the cortical surface of the clavicle and the coracoid process, with various relationships having been established.

Results: On average, the cP was determined to be about 2.9 cm and 2.5 cm distant from the coracoid process apex for male and female patients, respectively, whereas the width at this position was determined to be 2.1 cm and 1.9 cm. In the clavicle, this point is on average 2.9 cm and 2.5 cm distant from the acromioclavicular joint in male and female patients, respectively, and its anteroposterior width at this point is on average 1.9 cm and 1.6 cm.

Conclusion: The cP of the clavicle and the coracoid process was determined with the aim of preparing bone tunnels in operations for treating acromioclavicular dislocations.

Levels of evidence: Basic Science; Anatomy Study; Imaging

Keywords: Acromioclavicular joint/injuries; adult; anatomy; clavicle; multidetector computed tomography; shoulder

Treatment of acromioclavicular dislocations is surgical for types IV, V, and VI, and although there are >60 techniques described, none of them is considered standard.[5] The Weaver-Dunn[21] technique, which transfers the coracoacromial ligament to the clavicle, has been the most frequently used procedure in treating chronic dislocations.[14] However, biomechanical studies have proved that this ligament transfer maintains only 25% of the coracoclavicular fixation force and <50% of its resistance in comparison to the intact coracoclavicular ligaments, which postoperatively leads to subluxation or dislocation in as many as 30% of the cases.[8,11]

The study was submitted to the Research Ethics Committee of the institution and approved in accordance with the CAAE (Certificate of Application for Ethical Review): 41856315.0.0000.5479.

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New ligament reconstruction methods have emerged, using either autologous[9,10,14] or homologous[12,16] grafts or synthetic material, such as anchors, SutureTape (Arthrex, Naples, FL, USA),[11] or TightRope (Arthrex).[20] These options can be used by threading them beneath the coracoid process[11,16] or drilling transosseous tunnels in the coracoid process and in the clavicle, which has been the current trend.[2,3,5-7,13,15,20] However, there is no consensus on the definition of an exact point on which the drilling of the bone is to be conducted before the passage of biologic or synthetic implants through the tunnel thus created in the coracoid process or in the clavicle.

Several authors diverge with respect to the exact point where the transosseous tunnel should be drilled in the coracoid process. Mazzocca et al,[13] Costic et al,[5] and Grutter and Petersen[7] drilled the bone tunnel at its base, without specifying its exact placement; the diameter of the drilling ranged from 3.5 to 8 mm. Walz et al,[20] in turn, used two TightRope-type devices for reconstructing the conoid and trapezoid ligaments, both 3.5 mm in diameter. Coale et al[3] studied 3 possibilities for making transosseous tunnels, taking into account the midpoint from the origin of the coracoclavicular ligaments in the coracoid process, the clavicle, and an ideal point where the same bone distances could be obtained between the tunnel and the lateral and medial edges of the base of the coracoid process. They concluded that it is not possible to create transosseous tunnels capable of mimicking the anatomic position of the coracoclavicular ligaments without the risk of fracture of the coracoid process.[3]

With regard to creating transosseous tunnels in the clavicle, there is also a discussion in the literature about where, how many, and what diameter to drill.[4,19] Cook et al[4] stated that tunnels in the clavicle that are more medial stand a higher chance of early failure than do more lateral tunnels, whereas Voss et al[19] found that lateral holes 25 mm from the acromial end of the clavicle sustain early failure.

Accordingly, to date, there is no consensus in the literature on where and how to drill a transosseous tunnel either in the coracoid process or in the clavicle. With the loss of vertical stabilization of the acromioclavicular joint, which occurs in complete lesions of the coracoclavicular ligaments, ligament reconstruction surgery must interconnect the coracoid process to the clavicle in such a way as to prevent its superior dislocation. Thus, a bone tunnel in the central region of the coracoid process positioned at its base, just beneath where the reduced clavicle would be, allows the biologic or synthetic material used to pull the clavicle in the inferior direction, thereby preventing its superior dislocation. Bone tunnels drilled in unsuitable sites may lead to poor reduction of the acromioclavicular joint, causing fixed anterior subluxation[15] or contributing to fractures.[2,6,12] The correct location for creating a transosseous tunnel in the coracoid process is known to be at its base; still, its precise numerical definition has not yet been determined. The objective of this work was to study the anatomic relationship between the coracoid process and the clavicle and to make measurements by using computed tomography (CT) imaging for determining the convergence point (cP) between them. Our hypothesis was that the cP between the coracoid process and the clavicle must be located in the central region of the base of the coracoid process, and in the clavicle, it must be located in the central region and above the coracoid process.

Methods

A total of 74 CT scans of the shoulders of patients, whose test results were stored in the database of the Diagnostic Imaging Service System at the hospital at which the test was conducted between 2011 and 2013, were analyzed. Of these, 40 patients were female and 34 were male. We have used the IMPAX Results Viewer 1.0 software (Agfa HealthCare NV, Mortsel, Belgium) for viewing the images. As inclusion criteria, only the scans of patients who had no changes in the scapula or clavicle, regardless of whether there were any changes in the humerus, were analyzed. All those shoulder CT scans showing changes in the scapula or clavicle were excluded. Whether the shoulder examined was the dominant one or not was not taken into consideration.

For conducting the tomographic study of the relationship between the clavicle and the coracoid process, we have used the helical technique coupled to a 6- and 64-channel multidetector CT scanner (Philips Healthcare, Eindhoven, The Netherlands), with axial slices of 1 mm in thickness, additional reformatting in the sagittal planes, and image overlapping with the aid of a workstation (Philips).

Initially, scans for showing the relationship between the clavicle and the coracoid process were performed in the axial plane using the overlapping technique. Images in the axial plane were selected, including the image with the portion of the clavicle with a larger anteroposterior diameter at the level of the coracoid process (Fig. 1, *A*) and another running through the base of the coracoid process (defined as the greatest distance in the laterolateral direction) that contained the apex of this structure (Fig. 1, *B*). For the assessment of measurements, the acromioclavicular joint and the distal end of the coracoid process had necessarily to be included.

In this plane, the relationships between the clavicle and the coracoid process were obtained from a cP, which is the midpoint of a line AB, where A was determined at the intersection of the anterior cortical surface of the clavicle and the lateral cortical surface of the coracoid process and B was determined at the intersection of the posterior cortical surface of the clavicle and the medial cortical surface of the coracoid process (Fig. 1, *C*). From the cP, many relationships have been established. In the clavicle, they were measured from the cP to the articular surface of the acromial end of the clavicle (cP-ac) (Fig. 2, *A*); the anteroposterior distance of the clavicle, running through the coracoid process (Ap-clav) (Fig. 2, *B*); from the cP to the most distal apex of the coracoid process (cP-cor) (Fig. 2, *C*); and the lateral distance from the coracoid process running through the cP (Lat lat-cor) (Fig. 2, *D*).

Subsequently, measurements were taken of the relationship between the clavicle and the coracoid process in the sagittal plane, with the sagittal image necessarily having to pass through the cP (Fig. 3) as well. The relationships assessed and measured were the craniocaudal distance between the upper and lower cortical surfaces of the clavicle (cc-clav) (Fig. 4, *A*) and the craniocaudal distance between the upper and lower cortical surfaces of the coracoid process (cc-cor) (Fig. 4, *B*).