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Concomitant injury of the annular ligament in fractures of the coronoid process and the supinator crest

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Background: Fractures of the coronoid process or the supinator crest, as well as arthroscopic resection of osteophytes around the coronoid process, can endanger the attachment of the annular ligament (AL) to the proximal ulna. The purpose of this study was to investigate the corresponding insertional areas of the AL within this context.
Methods: In 30 embalmed human cadaveric elbow specimens, the insertional area of the AL at the anterior and posterior margin of the sigmoid notch was characterized. The distances and relations of the AL insertion anteriorly to the coronoid surface, the coronoid tip, and the depth of the coronoid process, as well as posteriorly to the supinator crest, were evaluated macroscopically.
Results: The mean distance of the anterior insertion area was 1.9 ± 0.6 mm (range, 1.0-3.1 mm) to the coronoid articular surface and 6.2 ± 1.7 mm (range, 2.9-10.2 mm) to the tip of the coronoid. The distance of the anterior insertion in relation to the depth of the coronoid process was 44% ± 11% (range, 30%-69%). The distance of the posterior insertion area to the level of the sigmoid notch measured from 3.5 ± 1.5 mm (range, 0.5-6.5 mm) to 17.7 ± 2.9 mm (range, 13.1-25.4 mm).
Conclusions: Coronoid fractures involving 44% or more of the coronoid process and anterolaterally oriented fractures where one-third of the anterolateral facet is affected are accompanied by a complete anterior bony disruption of the AL. Arthroscopic resection of the coronoid tip should be limited to 1 mm distal to the coronoid articular surface to avoid injury to the AL. Fractures of the upper half of the supinator crest place the AL at risk at its posterior insertion.
Level of evidence: Basic Science Study; Anatomy; Cadaver Dissection

Keywords: Annular ligament; coronoid fracture; supinator crest; iatrogenic injury; concomitant injury; insertion areas; sigmoid notch

Along with the lateral ulnar collateral ligament, the radial collateral ligament, and the accessory lateral collateral ligament, the annular ligament forms the lateral collateral ligament complex of the elbow.[5,12] Various studies have described the

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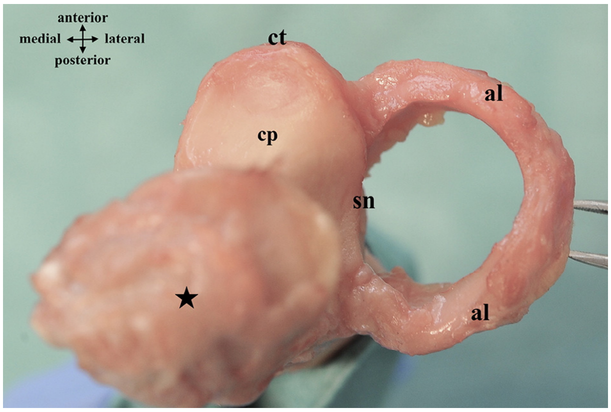

Figure 1 Axial view of the annular ligament (al), a fibrous ring that entangles and stabilizes the radial head (which is exarticulated in the image) from the anterior margin at the sigmoid notch (sn) of the coronoid process (cp) to the posterior margin of the sigmoid notch. The *star* indicates the olecranon. ct, coronoid tip.

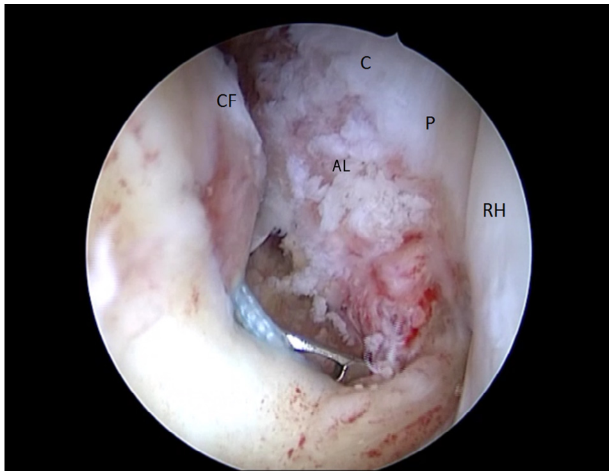

Figure 2 Arthroscopic view of a ruptured annular ligament (AL) as a concomitant injury to a coronoid fracture during arthroscopic repair by suture fixation. C, coronoid; CF, coronoid tip fragment; P, proximal radioulnar joint; RH, radial head.

annular ligament as a fibrous ring, which entangles and stabilizes the proximal radius from the anterior margin at the sigmoid notch of the coronoid process to the posterior margin of the sigmoid notch at the supinator crest, respectively[5,11] (Fig. 1). Whereas most studies have uniformly described the anterior insertion as a single band, different authors have observed a "fenestrated" posterior insertion with an inferior and superior oblique band and attributed it with a stabilizing force regarding the radial head.[5,11,20]

The lateral collateral ligament complex stabilizes the elbow joint against varus stress and ensures the stabilization of the humeroradial and proximal radioulnar joint, especially during stress load in supination.[3,13,17] The lateral ulnar collateral ligament is often regarded as the major stabilizer of the lateral elbow; however, the importance of the annular ligament also has been emphasized in many studies. Insufficiency of the annular ligament leads to an instability of the proximal radioulnar joint with increased mediolateral and anteroposterior movement of the radial head.[7,10,11,22] Such increase in movement results in higher interface pressure and wear between the radial head and the contacting capitellum, thus significantly increasing the risk of osteochondral injuries and posttraumatic osteoarthritis at the radiocapitellar joint.[7,10,11] As a result, an injury of the annular ligament may potentially cause persisting disability and will have substantial implications on treatment procedures and prognosis.

Ruptures of the annular ligament are frequently present as part of broader injuries of the lateral ligament complex and rarely occur on their own, but damage may also emerge because of fractures related to the insertion points of the annular ligament as bony avulsions with an attached ligament. Injuries of the ligament are observable in fractures of the coronoid process (anterior insertion) (Fig. 2) and the supinator crest of the proximal part of the ulna (posterior insertion).[4,21] At present, no anatomic tabulation and description of the origin and insertion of the annular ligament in relation to fracture size and classification methods of these patterns of injuries exist. The first aim of this study was therefore to compile such standard reference values. In addition, especially the arthroscopic resection of osteophytes around the coronoid process seems to place the integrity of the attachments of the annular ligament at risk. The second objective was therefore to measure the most proximal anterior insertion of the annular ligament at the coronoid in terms of a potential risk of iatrogenic injury during arthroscopic arthrolysis of the elbow.

Methods

Thirty embalmed human cadaveric elbow specimens were used in this study. These were composed of 17 right and 13 left elbows from a total of 23 body donors (13 female and 10 male donors) with an average age of 82 ± 9 years (range, 59-94 years). The same approach was used in each specimen and included the removal of the soft-tissue envelope of the elbow and the extensor muscles from their origin at the lateral epicondyle. The extensor carpi radialis brevis muscle is in proximity to the annular ligament and was thus removed only with great care. The annular ligament was incised transversely, and the radius was exarticulated to expose the ligamentous insertions of the annular ligament as presented in Figure 3. The insertions of the annular ligament were marked, and pins were fixed at the anterior insertion area—at the anterior margin of the sigmoid notch—in the nearest distance (most proximal anterior insertion point) and furthest distance (most distal anterior insertion point) of the insertion area to the coronoid articular surface. Other pins were tagged at the most proximal and most distal posterior insertion point at the insertion area at the supinator crest. The procedure was repeated and photographed for each specimen in a standardized fashion, frontal and lateral, with a scale next to each sample to ensure exact digital measurements. The photographs were saved as TIFF files and evaluated by use of a digital image analysis software (Image-Pro Plus; Media Cybernetics, Rockville, MD, USA). The software was adjusted to the scale in use to match real distances with the digitally created image calculation. The intraobserver and interobserver