J Shoulder Elbow Surg (2017) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

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ORIGINAL ARTICLE

The annular ligament—revisited

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Background: Studies investigating the annular ligament have presented confusing information about its anatomy and nomenclature. Cadaver elbow dissections were used to clarify the anatomy and terminology of the annular ligament.
Methods: Nineteen elbows were dissected (7 fresh frozen and 12 embalmed). Target structures were identified, photographed, and measured by independent observers.
Results: There are 3 layers to the lateral elbow ligaments: the superficial lateral ulnar collateral and radial collateral ligament; a deeper layer of the superior oblique band (SOB) and inferior oblique band (IOB) of the annular ligament; and the deepest capsular layer. The annular ligament measured 9.5 ± 1.4 mm anteriorly. The SOB (15/19) was 3.9 ± 1.0 mm wide by 10.5 ± 3.8 mm long. The IOB (13/19) was 3.6 ± 1.1 mm wide by 11.4 ± 4.2 mm long. The IOB inserts onto the anterior proximal ulna rather than the supinator crest. The anterior oblique band (8/19) was 3.8 ± 1.7 mm wide.
Conclusion: The SOB and IOB were present in the majority of specimens. The previously described accessory lateral collateral ligament is a localized thickening on the lateral ligament complex arising from the supinator insertion independent of the IOB that attaches to the annular ligament inferiorly and distally and attaches onto the proximal anterior ulna at the bicipital fossa floor, medial to the supinator crest.
Level of evidence: Anatomy Study; Cadaver Dissection
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Keywords: Annular ligament; elbow anatomy; elbow lateral ligament complex; superior oblique band; inferior oblique band; anterior oblique band

The lateral ligament complex is composed of the radial collateral ligament, the lateral ulnar collateral ligament (LUCL), the annular ligament, and the accessory lateral collateral ligament (LCL). The radial collateral ligament extends from the lateral epicondyle of the humerus to merge with the annular ligament fibers just proximal to the head of the radius. With a similar proximal attachment, the LUCL also contributes blending fibers to the annular ligament but continues on to attach distally on the supinator crest of the ulna. There is not much controversy about these portions of the lateral ligament complex.

The first detailed description of the lateral ligament complex was done by Martin.[3] Martin described a 3-layer structure at the proximal radioulnar joint. The deepest layer was the capsule of the joint, the intermediate layer was composed of the annular ligament, and the outermost layer was then named the lateral ligament of the elbow. Martin did not individually name the LUCL and radial collateral ligament but called them collectively the lateral ligament of the elbow. These 3 layers were distinguishable posteriorly; however, anteriorly, the 2 deeper ones were blended. Martin also described anterior and posterior

Institutional Review Board approval is not required for this cadaveric anatomic study.

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https://doi.org/10.1016/j.jse.2017.07.031

fibers running distally to the annular ligament and attaching to the anterior and posterior aspect of the radial notch at the outermost layer. These oblique fiber bundles were initially described as arising above and below the radial notch, hence taking origin from the coronoid process and supinator crest as 2 separate ligaments, distinct from the annular ligament. He stated that these 2 separate ligaments could be referred to as the anterior and posterior accessory ligaments. In addition, he described a deep band of the annular ligament that is formed by localized thickening of the joint capsule distally and described its distal attachment to be more medial and anterior to the supinator crest, toward the floor of the bicipital fossa on the anterior proximal olecranon.

Morrey and An[4] attempted to further clarify the anatomy of the lateral ligament complex. The accessory posterior ligament of Martin was renamed the accessory LCL, and it was seen in 9 of 10 specimens. They also identified and coined the name LUCL in 5 of 10 specimens. The accessory LCL and the LUCL were described to distally attach onto the supinator crest. Morrey and An[4] were not able to further clarify the annular ligament anatomy or had not identified the accessory anterior ligament or deep band of Martin in their dissections.

Bozkurt et al[1] further studied the anatomy of the annular ligament and offered additional terminology to the ligamentous structures of the lateral elbow. They described discrete fibers and tentatively named them the superior oblique band (SOB) and inferior oblique band (IOB) of the annular ligament that attached proximally and distally onto the ulna, thus helping to secure the annular ligament in place. Specifically, they described that fibers of the accessory LCL and the distal fibers of the annular ligament formed the IOB of the annular ligament attaching onto the anterior proximal ulna medial to the supinator crest. Furthermore, they labeled similar fibers going in the opposite direction the SOB. Based on this description, although the accessory LCL formed the IOB, it was attaching medial to where the accessory LCL should have attached on the supinator crest, causing confusion. Furthermore, there is suggestion of these bands traversing among the layers of the ligamentous complex, that is, to originate superficial to the annular ligament and to attach deep to the annular ligament at the deepest layer while going crosswise over the annular ligament, increasing the confusion.

Because of these controversies, a cadaveric dissection study was performed to further the understanding of the exact anatomy—the attachment of the SOB and IOB, the layers of the lateral elbow ligament complex, and the accessory LCL and its attachments—and to clarify the suggested nomenclature of the elbow lateral ligaments.

Materials and methods

Seven fresh frozen cadavers (all male, aged 56-78 years) were used to identify the anatomy initially, and 12 embalmed cadavers (unknown genders and ages) were used to validate our findings and to increase the number of specimens in the study. The fresh frozen specimens were upper extremities commercially purchased with funds from a student research award grant, and embalmed cadavers were donations to the university anatomy program. The cadaveric adult elbows were dissected free of their skin and muscles around the proximal radioulnar joint. They were deidentified, with only age and gender disclosed. Dissections were performed by an upper extremity fellowship-trained surgeon. By use of palpation to identify the discrete bands of the ligaments, a suture needle was passed around the anatomic structures palpated and isolated to better identify them within the photographs. After the ligamentous structures were identified and isolated, an analog ruler was placed as close to the specimen as possible, and a digital photograph was obtained. The photograph was then uploaded onto a picture archiving and communication system (iSite; Philips Electronics, Andover, MA, USA). The analog ruler was used for measurement calibration on each photograph.

The width of each structure (SOB, IOB, anterior oblique band [AOB], and annular ligament) was measured at the midsubstance. Footprints of attachments were measured at the bone-ligament interface and recorded in millimeters. Lengths were measured along the longitudinal axis between the proximal and distal attachments for the ligaments.

Measurements were performed for each structure and recorded by 2 analysts on 2 separate occasions, separated by a week. They were blinded to their previous measurements. Statistical analysis was performed using the software package R (Windows version 3.2.2; The R Project for Statistical Computing, Vienna, Austria) to evaluate for measurement means, standard deviations, and inter-rater and intra-rater reliability.

Results

The ligaments of the elbow were noted to be in 3 layers on the lateral aspect of the elbow: a superficial layer consisting of the LUCL and radial collateral ligament; the second layer consisting of the annular ligament proper and SOB and IOB of the annular ligament (Fig. 1); and the deepest capsular layer.

Anteriorly, we have observed 2 layers; the annular ligament and the newly described AOB compose the superficial layer, and the joint capsule forms the deeper layer. An AOB was observed in 8 of 19 elbows (Fig. 1, *C*), with an average width of 3.8 ± 1.7 mm (Table I). It varied in degree of development among the specimens and was observed as a separate structure that was running distal to the anterior portion of the annular ligament and attaching distally on the lateral aspect of the coronoid process distal to annular ligament insertion. The annular ligament anteriorly was found to be 9.5 ± 1.4 mm (Fig. 1, *C*) .

We have not observed a separately identifiable accessory LCL, but on the basis of our observations, the so-called accessory LCL might in fact be a localized thickening of the origin of the supinator muscle on the lateral side of the elbow. We also observed that the IOB is a separate structure not formed by accessory LCL as previously postulated (Fig. 1, *D*). The IOB was identified in all elbows originating from the fibers of the annular ligament distally and attaching medial and proximal to the LUCL origin on the crista supinatoris, with an average width of 3.6 ± 1.1 mm, an average length of

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