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ORIGINAL ARTICLE

Anterior and posterior bands of the anterior bundle in the elbow ulnar collateral ligament: ultrasound anatomy

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Background: The anterior oblique bundle (AOL) of the ulnar collateral ligament (UCL) is composed of anterior and posterior bands. This study evaluated the anatomy of the anterior and posterior bands in the AOL of the UCL for their separate visualization with ultrasound (US).

Methods: We dissected 18 cadaveric elbow joints and recorded the direction of each band from the lateral view to determine the proper position for the US transducer. To determine the proper inclination of the transducer, we measured the inclinations of each band at the proximal and distal insertions from the transverse view. A paired *t* test was used for comparisons between both bands. Values of $P < .05$ were considered statistically significant.

Results: The mean angles of the directions in the anterior and posterior bands were 10° ± 4° and 24° ± 9°, respectively. At the medial epicondyle, the mean inclination angles of both bands were 61° ± 5° and 67° ± 5°, respectively. At the sublime tubercle, the mean inclination angles of both bands were 14° ± 7° and 44° ± 9°, respectively. The inclination angles at the proximal ulna and the directions in both bands were significantly different ($P < .001$).

Conclusions: This study shows that the directions of both bands and inclination angles of the bony attachments in both bands can assist with correct placement of the US transducer and allow for separate visualization of each band.

Level of evidence: Basic Science; Anatomy Study; Imaging

Keywords: Elbow; ulnar collateral ligament; ultrasound; anterior band; posterior band; throwing

The ulnar collateral ligament (UCL) of the elbow consists of anterior oblique, posterior oblique, and transverse bundles. Among these 3 bundles, the anterior oblique bundle (AOL) of the UCL functions as the primary stabilizer of the joint during valgus stress.[21] During throwing, the AOL is under

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stress,[2,6,12,14] with the accumulation of repetitive forces resulting from throwing potentially leading to injury of the ligament. Partial or complete tears of the AOL are a significant injury that can result in elbow pain, valgus instability, and decreased athletic performance.[1,5]

The AOL is mainly composed of 2 bands: the anterior and posterior bands. Prior anatomic studies have detailed the locations of the insertion and origin of each band at the ulna and humerus, respectively.[9,26] One biomechanical study also examined the role of each band of the AOL in response to a valgus stress throughout different flexion angles. The results demonstrated the anterior band of the AOL is important as a primary stabilizer to valgus stress between 30° and 90° of flexion.[4]

Treatment for patients with UCL injury consists of nonoperative treatment or surgery. UCL reconstruction is a commonly performed procedure for patients with partial tears of the UCL that have failed nonoperative treatment.[13,17,28] Detailed information of partial injury of the AOL, such as the injury of each band, can provide more information to the clinician to make the best decision for treatment.

Several imaging modalities are used to assess the UCL, including magnetic resonance imaging (MRI), magnetic resonance arthrography (MRA), and ultrasonography (US). Previous studies showed MRI is a successful tool in detecting full-thickness tears of the AOL.[3,8,20] MRI has demonstrated 100% sensitivity for diagnosing full-thickness tears.[19] Another study, however, found MRI was able to achieve only 14% sensitivity in diagnosing partial-thickness tears.[34] These findings indicate that MRI may be unreliable for detecting partial-thickness tears.

Previous works suggest MRA as an alternative for providing improved sensitivity for detection of partial-thickness tears.[15,33,34] A prior study indicated that of 79 patients, MRA only found 3 patients with an additional partial tear of the UCL compared with conventional MRI.[19] In addition, MRA is an invasive procedure that requires injection of a contrast agent.

US has been implemented as a reliable imaging modality in evaluating the integrity of the ligament and the medial elbow laxity with an applied valgus stress.[7,24,30,35] Partial tear of the AOL in UCL can be also detected using US.[29]

We believe this study has clinical significance because visualization of the different bands in the AOL of the UCL with US will aid clinicians in diagnosing injury to each band and provide additional information in the treatment of UCL injuries. Therefore, the purpose of this study was to evaluate the direction of the path of each band and the inclination angles of both bands with respect to the origin and insertion of the AOL in the UCL to guide sonographic visualization. In addition, US was used to separately visualize each band using the results of the anatomic data.

We hypothesized that the direction of the path of each band and its inclination angle relative to bony insertions would be significantly different.

Materials and methods

This was an anatomic study of the anterior and posterior bands in the AOL of the UCL in an attempt to visualize them separately with US. This study used 23 cadaveric elbows, and was composed of 2 parts: anatomic and sonographic.

Anatomic study

For preliminary testing, this study used 3 cadaveric elbows to macroscopically confirm separate identification between anterior and posterior bands of the AOL. We dissected 18 cadaveric elbow joints (9 men and 9 women), including 9 right and 9 left shoulders. The deceased donors were a mean age of 87.5 years (range, 66-100 years). The study excluded specimens with elbow scars and severe arthritis confirmed through radiography.

Skin and fat tissues were removed, and the common flexor tendons were detached from their humeral attachment and reflected distally. After exposure of the entire AOL of the UCL, the anterior and posterior bands showed themselves as macroscopically distinguishable in all cases.

The specimen was mounted on the table to simulate a clinical examination by US.[30] The elbow and forearm were positioned at 90° of flexion and supination with a goniometer. We kept the neutral rotation of the humerus to maintain the arm position during the US measurements. We photographed the direction of the path in each band relative to the long axis of the forearm from the medial view.

At the medial epicondyle, a line (line A or B) was drawn along the maximum width of the bony insertion of each band from the distal view. Another line (line C) was added through both epicondyles. The angle between both lines was determined as the inclination angle at the proximal insertion. (Fig. 1, *B*). At the proximal ulna, a line was drawn along the bony insertion of each band (line A or B) from the proximal view. The angle of the line relative to the frontal plane of the forearm (line C) was measured from the proximal view as the distal inclination angle (Fig. 2, *B*).

Finally, we calculated the described measurements using ImageJ software (National Institutes of Health, Bethesda, MD, USA) after recording the digital photographs from each view. Two examiners calculated the inclination angles of both bands at the medial epicondyle to obtain inter-rater reliability data of the angle measurement.

Statistics

The inter-rater reliability of inclination angle measurements was evaluated using interclass correlation coefficients with 95% confidence intervals in a 2-way random model with absolute agreement using single measurements. For the direction of the path and inclination angles, a paired t test was used to test both bands to find comparisons. Values of $P < .05$ were considered statistically significant. All statistical analysis were calculated with the open-source statistical computing software R package (The R Foundation for Statistical Computing, http://www.r-project.org).

Power analysis for detection of differences between anterior and posterior bands in the AOL of the UCL was conducted by use of α value of .05, an effect size of 0.95, which was determined according to the results of the preliminary study, and a power of 0.95. Power analysis suggested that this study needed a total sample size of 16 cadaveric specimens.