SCIENTIFIC ARTICLE

The Posterior Bundle's Effect on Posteromedial Elbow Instability After a Transverse Coronoid Fracture: A Biomechanical Study

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Purpose There has been increased interest in the role of the posterior bundle of the medial collateral ligament (pMUCL) in the elbow, particularly its effects on posteromedial rotatory stability. The ligament's effect in the context of an unfixable coronoid fracture has not been the focus of any study. The purposes of this biomechanical study were to evaluate the stabilizing effect of the pMUCL with a transverse coronoid fracture and to assess the effect of graft reconstruction of the ligament.

Methods We simulated a varus and internal rotatory subluxation in 7 cadaveric elbows at 30°, 60°, and 90° elbow flexion. The amount of ulnar rotation and medial ulnohumeral joint gapping were assessed in the intact elbow after we created a transverse coronoid injury, after we divided the pMUCL, and finally, after we performed a graft reconstruction of the pMUCL.

Results At all angles tested, some stability was lost after cutting the pMUCL once the coronoid had been injured, because mean proximal ulnohumeral joint gapping increased afterward by 2.1, 2.2, and 1.3 mm at 90°, 60°, and 30°, respectively. Ulnar internal rotation significantly increased after pMUCL transection at 90°. At 60° and 30° elbow flexion, ulnar rotation increased after resection of the coronoid but not after pMUCL resection.

Conclusions An uninjured pMUCL stabilizes against varus internal rotatory instability in the setting of a transverse coronoid fracture at higher flexion angles. Further research is needed to optimize graft reconstruction of the pMUCL.

Clinical relevance The pMUCL is an important secondary stabilizer against posteromedial instability in the coronoid-deficient elbow. In the setting of an unfixable coronoid fracture, the surgeon should examine for posteromedial instability and consider addressing the pMUCL surgically. *(J Hand Surg Am. 2017;■(■):1.e1-e8. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Coronoid fracture, elbow biomechanics, elbow posteromedial rotatory instability, elbow trauma, posterior bundle medial collateral ligament.

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Fracture-dislocation of the elbow frequently involves fracture of the coronoid.[1] There is general agreement that if the height of the fragment is 50% or more of the total coronoid height, internal fixation should be performed.[2−9] However, fixation of the coronoid is not always possible, particularly in the setting of severe fragment comminution. In circumstances in which the osseous stabilizers of the elbow are compromised, there is an increased role of the soft tissue structures in preventing instability.

The role of the anterior bundle of the medial ulnar collateral ligament (aMUCL) as the primary restraint against valgus instability has been studied and established.[10−12] Several biomechanical studies have discussed the role of the posterior bundle (pMUCL) within the context of evaluating other ligaments[11−15] and it has been described as a minor secondary constraint.[10] However, there have been recent clinical publications suggesting that the entire medial collateral ligamentous complex is more often injured in elbow dislocations than previously appreciated,[16−18] and also a growing number of biomechanical studies that have focused specifically on the pMUCL.[19−21]

As originally described by O'Driscoll et al,[22] varus posteromedial rotatory instability can result in joint incongruity and accelerated early ulnohumeral arthrosis. Recent data suggest that the pMUCL confers some stability against varus and internal rotational instability.[19,20,23]

In this cadaveric biomechanical study, we hypothesized that in the setting of a transverse coronoid fracture that was greater than 2 mm (tip subtype II)[22] and 50% of the coronoid height, the pMUCL would maintain some stability against a posteromedial type of elbow instability. In addition, we hypothesized that graft reconstruction of the pMUCL would restore some stability.

MATERIALS AND METHODS

Specimen preparation

Seven fresh-frozen cadaveric elbows were transected at the mid-diaphyseal humerus and forearm. An a priori a sample size analysis demonstrated that with at least 6 specimens, a difference of 0.7 mm between groups could be detected with 80% power and a statistical significance of $P < .05$ ($\alpha = .05$). We dissected soft tissues by layer, taking care to preserve the medial collateral ligamentous complex, the capsule, and the common extensor origin with the underlying lateral collateral ligamentous complex. Both the humerus and forearm were potted using polymethylmethacrylate into cylindrical aluminum pots. A small anterior capsulotomy was created to ensure appropriate positioning of the specimen within the pot, and so that joint congruity could be confirmed later during the testing stage. Through the capsulotomy, we made sure to account for the natural carrying angle of each elbow and that the articular surface remained horizontal (ie, parallel to the base of the pot). After secure fixation, a radial diaphyseal osteotomy was performed in each specimen at a point just distal to the bicipital tuberosity, so that a rigid radius would not limit motion and change the kinematics during the simulated subluxation event. The entire lateral ulnar collateral ligament (LUCL), including its insertion on the crista supinatoris, remained intact.

Specimen mounting

The forearm pot was secured into a multiple-axis hydraulic actuator that allowed for later force application designed to simulate posteromedial elbow instability.[7]

The humeral pot was secured to a custom-machined jig that enabled the elbow flexion angle to be changed. The jig was designed to allow for a flexion angle of 15° to 90° in 15° increments. This jig was itself secured to a low-friction X−Y stage, which in turn was mounted onto a 6-axis load cell (ATI Industrial Automation, Apex, NC).

Mechanical testing

A previously reported device[19,21] was used to simulate a varus, posteromedial, rotatory type of instability event that was simulated after the specimen was mounted within the materials testing machine (MTS, Eden Prairie, MN). The materials testing machine was equipped with an actuator that applied an axial load, a torsional moment (ie, internal rotation), and bending in the X and Y planes (varus). The forearm pot was mounted into a clamp that was attached to this actuator (ie, on top of the machine); a collar clamp was used to secure it. The humeral pot was secured to the jig at the bottom of the machine (Fig. 1).

Before testing, care was taken to ensure that the joint surfaces were congruous and that the elbow was seated in its natural position. This was achieved by direct visualization of the joint surface through the capsular window and by performing minor adjustments in rotation of both the humeral and forearm pots such that the load cells indicated that the forces across the joint were as close to zero as possible (always less than 0.05 Newton-meters [N-m] of torque).

Initially, a 25-N axial load was applied that acted as a joint compressive force. Then the machine applied a varus bend to 5° at a speed of 2°/s, followed