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ORIGINAL ARTICLE

Importance of the posterior bundle of the medial ulnar collateral ligament

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Background: There has been a renewed interest in the pathomechanics of elbow dislocation, with recent literature having suggested that the medial ulnar collateral ligament is more often disrupted in dislocations than the lateral ligamentous complex. The purpose of this serial sectioning study was to determine the influence of the posterior bundle of the medial ulnar collateral ligament (pMUCL) as a stabilizer against elbow dislocation.
Methods: An elbow dislocation was simulated in 5 cadaveric elbows by mechanically applying an external rotation moment and valgus force. Medial ulnohumeral joint gapping was measured at 30°, 60°, and 90° of flexion in an intact elbow after sectioning of the medial collateral ligament's anterior bundle (aMUCL) and then after sectioning of the pMUCL as well.
Results: After sectioning of the aMUCL, the pMUCL was able to stabilize the joint against dislocation. After aMUCL sectioning, the proximal joint space significantly increased by 4.2 ± 0.6 mm at 30° of flexion and 2.6 ± 0.3 mm at 60° of flexion, although it did not dislocate. The gapping increase of 0.9 ± 0.6 at 90° of flexion did not reach significance. After sectioning of the pMUCL (after having already sectioned the aMUCL), all of the specimens frankly dislocated at all flexion angles.
Conclusions: An intact pMUCL can prevent elbow dislocation and limited joint subluxation to within 6.6 mm. Our findings indicate that repair or reconstruction may be warranted in certain circumstances (ie, residual instability after operative management of a terrible triad injury or after aMUCL reconstruction).
Level of evidence: Basic Science Study; Biomechanics
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Keywords: Elbow instability; elbow dislocation; medial collateral ligament posterior bundle; posterolateral rotatory instability; elbow trauma; recurrent elbow instability

An elbow dislocation can result from complete disruption of the stabilizing soft tissue structures, particularly in cases in which the osseous stabilizers remain uninjured. Classic teaching has indicated that disruption of the soft tissues originates from the lateral side, progressing anteriorly and then medially,[14-16] described as the circle of Horii. However, there is a lack of consensus agreement on the origin of the

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disruptive forces as other reports have discussed a possible medially originating mechanism.[8,18,19,21]

Of the medial collateral ligamentous complex, the anterior bundle of the medial ulnar collateral ligament (aMUCL) is the primary restraint against valgus instability.[7] The posterior bundle of the medial ulnar collateral ligament (pMUCL) has been described as a minor secondary constraint.[3] Several biomechanical studies have discussed the role of the pMUCL in conferring stability within the context of evaluating other ligaments.[2-4,7,12] Whereas the pMUCL's influence on stabilizing against valgus forces and rotation moments has been studied, the importance of the posterior bundle as a secondary stabilizer against dislocation, which involves several simultaneous forces, has not been quantified.

The purpose of this serial sectioning study was to determine the influence of the pMUCL as a stabilizer against elbow dislocation and medial joint instability and to introduce a novel method of quantifying elbow stability than has been traditionally used.

Methods

Specimen preparation

Five right-sided fresh frozen cadaveric elbows, which had been transected at the mid humerus and the mid forearm, were obtained from a cadaveric donor program. All of the specimens were from female donors, with an average age of 77 (range, 74-79) years. Each specimen was fully thawed at room temperature before dissection.

Specimen preparation

All of the skin and subcutaneous tissues were dissected to the layer of the investing fascia. All of the muscles were sharply excised, except for the common extensors. The joint capsule and medial and lateral ligamentous joint complexes were left intact. The specimens were secured in aluminum pots using polymethyl methacrylate to allow attachment to the fixture within the testing machine. A 10 × 20-mm anterior capsular window was created to assist with proper joint alignment during potting and to ensure congruous articular contact during testing. The humeral shaft was potted into one aluminum pot, and the radius and ulna were separately potted into another aluminum pot. After potting of the radius and ulna, an osteotomy of the radial shaft was performed, always distal to the bicipital tuberosity. This was performed so that a fixed radius would not limit motion and alter the kinematics through pivoting of the elbow about a constrained, rigid radiocapitellar articulation during the simulated dislocation event. During potting, care was taken to ensure that the natural carrying angle of each elbow was taken into account and that the articular surface remained parallel to the base of the pot (ie, horizontal).

Mounting of the specimen

The forearm (ie, radius and ulna pot) was secured into the multiaxis hydraulic actuator, which applied the axial load, valgus force, and external rotation moment.

The humeral pot was mounted on a custom jig that allowed adjustment of the elbow flexion angle, in increments of 15° from 0° to 90° (Fig. 1). The jig was mounted onto a custom-made, low-friction X-Y stage, which itself was mounted into a 6-axis load cell.

Mechanical testing

A dislocation event that originated with disruption of the medial-sided soft tissue stabilizers was mechanically simulated using a servohydraulic materials testing system (MTS) machine (MTS Systems, Eden Prairie, MN, USA), and joint gapping was measured using a 3-dimensional (3D) motion tracking camera system (Vicon, Denver, CO, USA). The MTS machine was equipped with a low-friction X-Y stage, which was mounted on a 6-axis load cell (ATI Industrial Automation, Apex, NC, USA).

The MTS machine was equipped with an actuator that allowed the application of an axial load, a torsional moment (ie, rotation), and bending in the X and Y planes. The forearm pot was mounted into the clamp that was attached to this actuator (ie, top of the machine) and secured with a collar clamp. The humeral pot was secured to the jig at the bottom of the machine (Fig. 1).

Once the specimen was secured within the clamps and before the application of any loads, it was ensured that the joint was congruous and seated in its natural position. This was accomplished by direct visualization of the anterior ulnohumeral articulation 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 0 as possible (always <0.05 N · m of torque). After this step, the specimen was subjected to the cycle of loading.

After application of an axial load of 25 N that was applied to simulate a joint compressive force, the machine placed the elbow into 5° of valgus by bending the forearm pot in the X-plane. An external rotation moment of 2.5 N · m was simultaneously applied. The motion of the ulna was similar to that which would occur in a posterolateral rotatory subluxation event. This meant that the forearm pot was externally rotated until the load cell detected a torsional force of 2.5 N · m. Once 2.5 N · m of torque was reached, the machine stopped torque application and then internally rotated the forearm

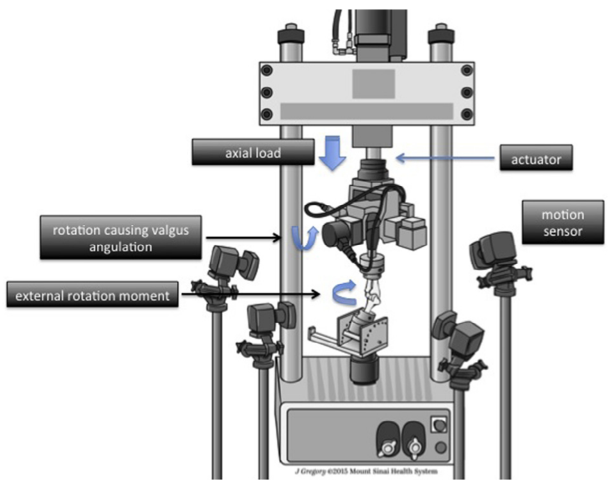

Figure 1 Schematic of the testing apparatus showing the direction of axial load (25 N), rotation of the X-axis motor causing a 5° valgus angulation, and external rotation of the actuator.

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