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ORIGINAL ARTICLE

Effect of ulnar tunnel location on elbow stability in double-strand lateral collateral ligament reconstruction

H. Mike Kim, MD*, Colin R. Andrews, BS, Evan P. Roush, BS, Gregory I. Pace, MD, Gregory S. Lewis, PhD

Department of Orthopaedics and Rehabilitation, Penn State College of Medicine Milton S. Hershey Medical Center, Hershey, PA, USA

Background: Double-strand lateral ulnar collateral ligament (LUCL) reconstruction is an effective treatment for posterolateral rotatory instability (PLRI) of the elbow, but anatomic landmarks for ulnar tunnel placement are often difficult to identify intraoperatively, which potentially can result in a nonanatomic LUCL reconstruction. This study investigated the effect of ulnar tunnel location on joint stability in double-strand LUCL reconstruction.
Methods: PLRI was artificially created in 7 cadaveric elbows, and double-strand LUCL reconstruction was performed. Five different ulnar tunnels were made along the length of the ulna. In each specimen, each possible pair of 2 tunnels (10 total) were used for graft passage. Varus and posterolateral joint gapping was measured after joint loading using a 3-dimensional digitizer system and X-ray image intensifier.
Results: No significant gapping was observed at the posterolateral ulnohumeral joint regardless of the location of the ulnar tunnels ($P > .05$). In contrast, the lateral radiocapitellar joint showed statistically significant varus gapping when both ulnar tunnels were placed proximal to the radial head-neck junction ($P < .05$).
Discussion: This findings of study suggest that the location of the ulnar tunnels may not be as critical as that of the humeral tunnel during double-strand LUCL reconstruction and that posterolateral rotatory elbow stability can be achieved reasonably well as long as at least 1 of the 2 ulnar tunnels is located at or distal to the radial head-neck junction level.
Level of evidence: Basic Science Study; Biomechanics

Keywords: Lateral ulnar collateral ligament reconstruction; ulnar tunnels; elbow stability; posterolateral rotatory instability; double-strand; docking technique

The lateral collateral ligament complex consists of the lateral ulnar collateral ligament (LUCL), radial collateral ligament, and annular ligament.[12-14] Disruption of these ligaments at the humeral attachment site usually occurs in patients with elbow dislocation.[20] Although most patients achieve adequate healing of the ligaments and regain a stable joint, persistent instability in the form of posterolateral rotatory instability (PLRI) does occur in some patients.[17,18,20] The LUCL has been known to be a primary stabilizer of the elbow against PLRI,[15-17,20] and reconstruction of the LUCL has been shown

No Institutional Review Board or Ethical Committee review was needed for this cadaveric biomechanical study.

*Reprint requests: H. Mike Kim, MD, 30 Hope Dr, P.O. Box 859, EC089, Hershey, PA 17033, USA.

E-mail address: hkim2@hmc.psu.edu (H.M. Kim).

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to reliably restore the elbow stability in patients with PLRI.[7,8,16,17,22] A number of studies have reported various LUCL reconstruction techniques with respect to the graft fixation method, the source of the graft, graft configuration, the number of graft strands, and the location of graft attachment sites.[2,5,7,9,10,16,21,22]

Double-strand tendon LUCL reconstruction has been used commonly with successful clinical results.[7,16,17] One of the theoretical advantages of a double-strand LUCL reconstruction technique is that varus and posterolateral rotational stability of the elbow can both be achieved by having 2 separate strands of graft tendon.[8] For successful LUCL reconstruction, identifying the anatomic landmarks and reconstructing the ligament at the anatomic location is critical. Ideal humeral tunnel placement for LUCL reconstruction has been well studied because it is directly related to the isometry of the ligament.[15,16,19,23]

In contrast, the literature is somewhat unclear on the ideal location of the ulnar tunnel, simply suggesting that the tunnel be placed close to the tubercle of the supinator crest of the proximal ulna. The supinator tubercle is often not prominent enough to be identified in many individuals,[1] and the supinator crest extends from a level proximal to the radial head to a level distal to the radial neck.[1,6] This makes it challenging to place the ulnar tunnels at an anatomic location during a LUCL reconstruction, potentially leading to inadvertent nonanatomic placement of the tunnels. This study investigated the effect on elbow joint stability of placing the ulnar tunnels at various locations in double-strand LUCL reconstruction. We hypothesized that ulnar tunnel location would significantly affect elbow stability.

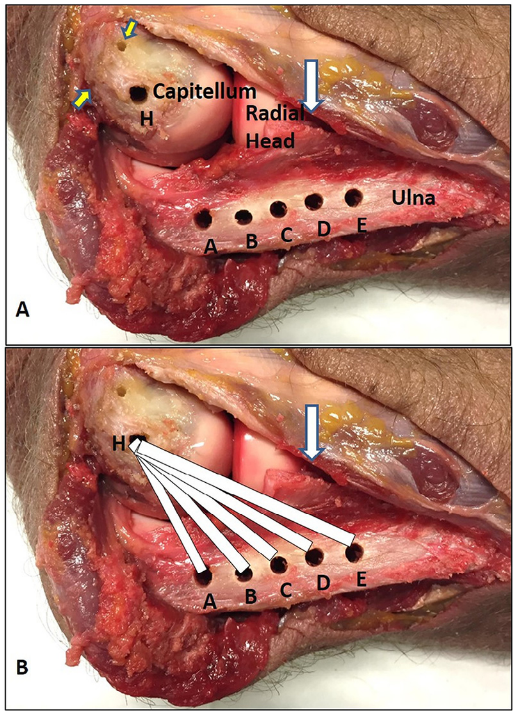

Figure 1 **(A)** Preparation of cadaveric elbow specimen for lateral ulnar collateral ligament reconstruction. A humeral tunnel was made at the isometric point on the lateral epicondyle (*H*). Two suture retrieval tunnels were made on the either side of the supracondylar ridge (*yellow arrows*). Five transosseous ulnar tunnels (*A*, *B*, *C*, *D*, and *E*) were created along the lateral aspect of the proximal ulna. Tunnel D was made at the level of the radial head-neck junction (*large white arrow*), representing the ideal location of the distal ulnar tunnel. The tunnels were separated by a 5-mm bone bridge. **(B)** Depiction of the graft directions for the 5 ulnar tunnels. Two tunnels were randomly chosen for graft passage at a time for a total of 10 combinations of ulnar tunnels. The testing protocol was repeated for each combination of ulnar tunnels

Materials and methods

Specimen preparation and LUCL reconstruction

Seven nonpaired fresh frozen elbow cadaveric specimens from seven donors (5 men; mean age, 50 ± 12; range, 35-63 years) with no evidence of previous surgery, trauma, or arthritis were dissected using the Kocher lateral approach. The lateral collateral ligament complex and anconeus were detached from the proximal and distal attachment sites (Fig. 1, *A*). Part of the extensor origin and part of the flexor digitorum profundus origin were detached from the lateral epicondyle and the medial aspect of the proximal ulna, respectively. The entire lateral aspect of the capitellum, lateral epicondyle, radial head, and the proximal ulna were exposed, resulting in obvious posterolateral rotatory instability of the elbow.

A docking technique, as described by Jones et al,[7] was used for LUCL reconstruction. A 1.5-cm-deep humeral docking tunnel was made at the isometric point of the LUCL on the lateral epicondyle using a 4.5-mm drill bit (tunnel H in Fig. 1). The isometric point was determined at the center of the rotation of the capitellum and usually fell on the base of the lateral epicondyle where the epicondyle flattens onto the lateral aspect of the capitellum, as previously described by Cohen and Hastings.[3] Two suture retrieval tunnels were made on either side of the supracondylar ridge toward the docking tunnel using a 2.0-mm drill bit.

To test the effect of ulnar tunnel locations on the posterolateral rotatory stability of the elbow, 5 transosseous ulnar tunnels were created along the lateral aspect of the proximal ulna using a 3.2-mm drill bit. These tunnels were made along the line bisecting the anteroposterior width of the proximal ulna. The first tunnel was made at the level of the radial head-neck junction (tunnel D), which represented the anatomic location of the distal ulnar tunnel. The tubercle of the supinator crest was not clearly identifiable in 5 of the 7 specimens, so the radial head-neck junction was used as the reference, as previously described in the literature.[1,6,8] The second tunnel (tunnel E) was made distal to tunnel D with a 5-mm bone bridge between the 2 tunnels. The third (tunnel C), fourth (tunnel B), and fifth tunnels (tunnel A) were made proximal to tunnel D with a 5-mm bone bridge between each of them.

Double-strand LUCL reconstruction was simulated using 2 nonabsorbable 2-mm-wide tapes (FiberTape; Arthrex, Naples, FL, USA), instead of using an actual tendon graft, to maintain consistent mechanical properties of the ligament substitute across the testing conditions and specimens (Fig. 1, *B*). This was based on our pilot experiment where the mechanical properties of tendon grafts substantially changed after only a few repetitions of the testing protocol.