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No difference in torque load to failure between split anconeus fascia transfer and autograft palmaris longus tendon for reconstruction of the lateral ulnar collateral ligament

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A R T I C L E I N F O

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Background: The split anconeus fascia transfer (SAFT) is an option for reconstruction of the lateral ulnar collateral ligament (LUCL) in chronic posterolateral rotatory instability (PLRI) of the elbow with potential advantages of using only local tissue within the surgical exposure and not requiring ulnar fixation. This study aimed to assess SAFT strength compared to a traditional free graft reconstruction in a PLRI biomechanical model.

Methods: To measure biomechanical strength, eight cadaveric upper extremity pairs were utilized. Within each pair, one specimen was randomly assigned to LUCL reconstruction with autograft palmaris longus and the other to SAFT reconstruction. Torque load to failure was assessed on a load frame with the elbow in 30 degrees of flexion, 5 degrees of valgus, and 25 N axial load as the elbow was brought into external rotation. Torque load to failure was compared between the two reconstruction techniques.

Results: No difference was found in the torque load to failure between SAFT specimens compared to palmaris longus autograft specimens (mean 14.6 ± 4.4 Nm vs. mean 11.3 ± 3.9 Nm; $P = .16$).

Discussion: In this biomechanical study, the SAFT LUCL reconstruction provided torque load to failure similar to that of the traditional technique. These findings suggest that the SAFT technique warrants continued study as a biomechanically sound option for LUCL reconstruction in the setting of elbow PLRI.

Posterolateral rotatory instability (PLRI) of the elbow is a common sequela of elbow trauma that typically occurs with elbow dislocation after a fall onto an outstretched arm or in rarer cases with iatrogenic injury from injections or prior elbow surgery. The mechanism of injury is a valgus, supination, and axial force at the joint. Treatment requires restoration of lateral elbow stability provided by the lateral collateral ligament complex, including the lateral ulnar collateral ligament (LUCL) and radial collateral ligament (RCL).[16] In the setting of an acute injury, this may be accomplished by simple repair or reinsertion of the avulsed structures.[8,21] However, the native ligament tissue may be inadequate for repair because of chronic or recurrent instability, multiple steroid injections, cubitus varus, chronic lateral epicondylitis, or tissue loss.[1,12,15,17,18] In these situations, reconstruction of the LUCL is indicated.

Since the introduction of LUCL reconstruction techniques, advances have been made to improve fixation methods and achieve maximally isometric tunnel placement.[5,9,14,19] Results are good to excellent in 85%-90% of patients in studies of LUCL reconstruction.[2,7] However, these reconstruction techniques require a free graft, either allograft or autograft, and the techniques require fixation on both the humeral and ulnar sides. Furthermore, these reconstructions typically reconstruct only the LUCL and not the RCL, resulting in a nonanatomic reconstruction. Hackl et al described the importance of the RCL in stabilizing the elbow to rotatory forces,[10] and small case series involving dual reconstruction of the RCL and LUCL have reported clinical success.[11,20] The use of autograft also typically requires additional incisions with the risk of donor site morbidity, except in cases where triceps tendon autograft is used. The use of allograft increases the cost of the procedure, which is

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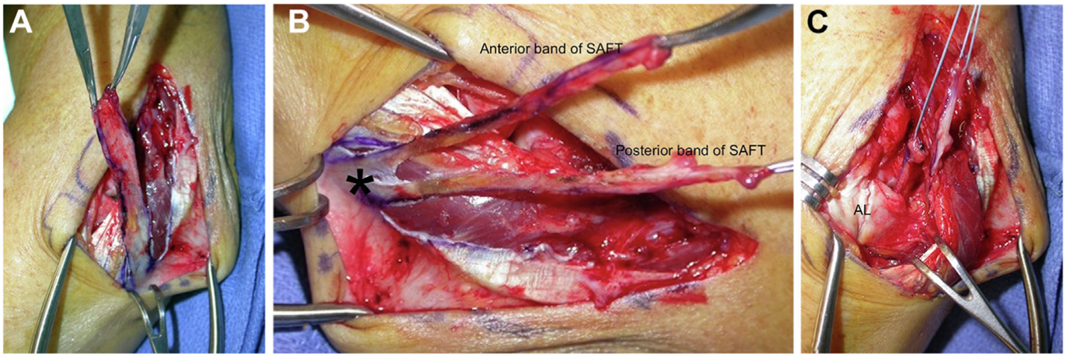

Figure 1 (**A**) The anconeus fascia graft is elevated proximally. (**B**) The fascia is split, allowing for independent tensioning of the graft (SAFT) limbs and (**C**) passage of the anterior band through the annular ligament reconstructing the radial collateral ligament. *, ulnar insertion site of the anconeus fascia, left intact during graft harvest and transfer; *SAFT*, split anconeus fascia transfer; *AL*, annular ligament.

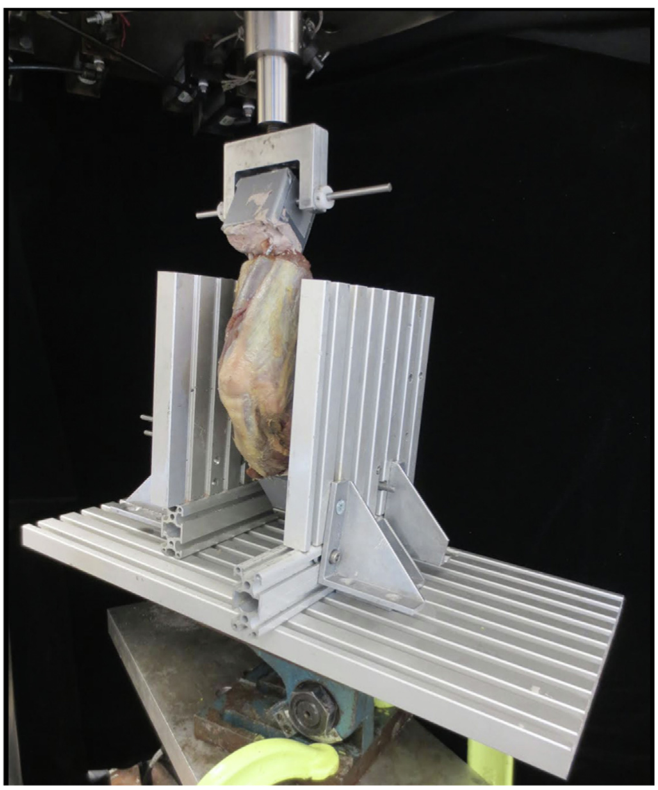

Figure 2 Photograph shows a specimen mounted in the biomechanical testing apparatus.

further increased with the use of suture anchors for the ulnar and/or humeral fixation.[3,22]

The split anconeus fascia transfer (SAFT) was developed in an effort to avoid these drawbacks of a free graft LUCL reconstruction. In this technique, a 1-cm wide strip of the antebrachial fascia overlying the anconeus fascia is elevated from the underlying muscle starting just proximal to the lateral epicondyle.[4] The ulnar insertion is maintained distally. The fascial graft is then split into two 5-mm bands that are passed deep to the anconeus muscle, with one limb passed deep to the annular ligament to reconstruct the RCL and the more posterior band used to reconstruct the LUCL. These bands are then inserted into the humerus with a docking technique with the arm flexed to 60 degrees, fully pronated, and with a valgus load.[11,20] Local harvest of the anconeus fascia supplies a sizeable graft that parallels the orientation of the native RCL and LUCL, maintains an anatomic origin and blood supply, and requires no instrumentation on the ulna (Fig. 1, *A*-*C*).

The potential utility of the SAFT as an alternative procedure for LUCL reconstruction warrants biomechanical investigation of the technique. No clinical or biomechanical data on the procedure have been reported. The goal of this study was therefore to determine the torque load to failure of the SAFT technique in comparison to a conventional free graft LUCL reconstruction in a model of PLRI.

Methods

Specimens

Nine pairs of fresh-frozen cadaveric upper extremities were obtained. One pair was excluded because of previous open reduction internal fixation in one specimen, leaving eight pairs for study. The specimens in each pair were randomly assigned to SAFT or autogenous palmaris longus (PL) LUCL reconstruction via coin toss.

LUCL reconstruction

Specimens were dissected of skin and subcutaneous tissues. The lateral ligamentous complex was sectioned on each specimen, and PLRI was confirmed with manual stress testing demonstrating radiocapitellar and ulnohumeral subluxation under direct observation and fluoroscopy. For SAFT, the anconeus fascia was elevated from the underlying muscle, working proximally to distally. The ulnar insertion was maintained distally. The fascia was split into anterior and posterior bands and passed deep to the annular ligament and inserted into the humerus at the lateral condyle center of rotation with a docking technique. A #2 Ethibond nonabsorbable suture (Ethicon, Cincinnati, OH, USA) was passed in a locked running fashion through both limbs of the fascia proximally and secured into the humerus using a docking technique. For PL autograft reconstruction, the PL was harvested from the specimen forearm utilizing multiple small stab incisions along the length of the tendon. A yoke technique was used for secure fixation on the ulnar side.[15] On the humeral side, the same docking technique described in the SAFT technique was used, with #2 Ethibond (Ethicon, Cincinnati, Ohio, USA) used in a locked running fashion to secure the graft. At time zero, each specimen demonstrated no gapping on stress examination under fluoroscopy.

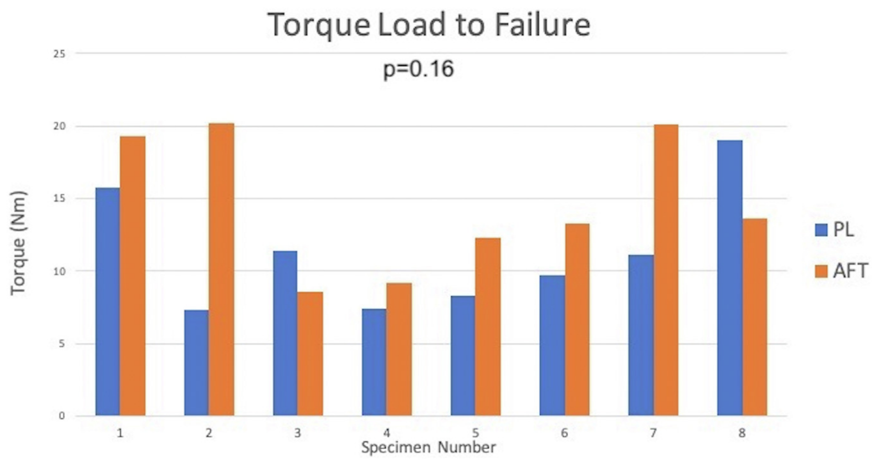

Figure 3 Graph shows load to failure of all reconstructed specimens ($P = .16$). *PL*, palmaris longus; *AFT*, anconeus fascia transfer.

Load testing

The specimens were then potted in cement and mounted to a biomechanical testing apparatus (MTS Mini-Bionix load frame, Eden Prairie, MN, USA) in 30 degrees of flexion (Fig. 2). The specimens were subjected to 5 degrees of valgus bending and 25 N of axial load. Torque was applied at a constant displacement rate of 10 degrees/sec in external rotation. Angle vs torque data were recorded at 100 Hz, and the maximal torque preceding a sudden drop in torque was determined to be the torque load to failure.

Statistical analysis

A priori power analysis was based on a study comparing LUCL repair and reconstruction methods,[13] with an effect size of 1.34. Based on these data, 8 specimens were needed in each group for 0.9 power to detect a significant difference in torque load to failure with a significance level of 0.05. Data distribution was assessed by the Shapiro-Wilk test, and normally distributed results were compared by a two-sided, two-sample *t*-test. A P value <.05 was considered statistically significant.

Results

Eight paired elbow specimens were utilized in the study, with an average age of 88 years (range, 83-95 years). Two pairs were male, and six were female. Five right-sided specimens and three left-sided specimens were assigned to the SAFT group. Three right-sided specimens and five left-sided specimens were assigned to the PL group.

The torque load to failure ranged from 7.4 to 19.0 Nm for the PL group and from 8.5 to 20.2 Nm for the SAFT group (Fig. 3). The mean torque load to failure in the SAFT group was 14.6 ± 4.4 Nm compared to 11.3 ± 3.9 Nm in the PL graft group, with no significant difference in torque load to failure between the two groups ($P = .16$).

Discussion

The torque load to failure at time zero of the SAFT group was not significantly different from that in the PL free graft group, indicating similar time zero biomechanical strength of the SAFT to a traditional free graft LUCL reconstruction technique. Our failure data for both the SAFT and the PL techniques are consistent with previous studies of LUCL graft reconstruction. Ellwein et al[6] reported a mean torque load to failure for LUCL graft reconstruction of 8.1 ± 2.7 Nm, and Melbourne et al[13] found a mean torque load to failure for LUCL graft reconstruction of 12 ± 4 Nm. The finding of torque load to failure similar to that for other well-established methods supports further consideration of the SAFT technique in LUCL reconstruction.

Splitting the SAFT graft to pass the anterior limb under the annular ligament produces a reconstruction of the RCL in addition to the LUCL.[4] A traditional free graft LUCL reconstruction does not provide any mechanism for RCL reconstruction. Clinical success has been reported in small case series using reconstruction techniques aimed at dual reconstruction of the RCL and LUCL.[11,20] This more anatomic aspect of the SAFT reconstruction technique may provide biomechanical and clinical benefits in addition to those associated with load to failure.

In addition to providing an option for RCL reconstruction, the SAFT technique has other potential benefits. The SAFT technique avoids a separate autograft harvest site without adding the expense of allograft tissue. No ulnar fixation is needed when the SAFT is used, potentially reducing cost and preventing the risk of ulnar fracture that can accompany anchor or tunnel placement.[23]

This study has limitations. It is a cadaveric biomechanical study and as such the tissues behave differently compared with what may be seen in patients. Additionally, this is a time zero analysis. Repeated loads may change the strength of the graft options. Split anconeus fascia tissue may respond differently than tendon graft tissue to cyclical loading. However, fascia has many biologic similarities to the native capsuloligamentous tissue that makes up the LUCL complex, and this time zero study demonstrates no difference in torque to failure between the two tissue types. The study focused on one key biomechanical property, torque load to failure, and did not compare other biomechanical properties between the LUCL reconstruction techniques. Finally, only one technique, the docking technique, was used for both grafts on the humeral side, and the yoke technique was used for the free graft on the ulna. Fixation technique could impact results.

Conclusion

In this biomechanical study, the SAFT LUCL reconstruction provided torque load to failure similar to that of the traditional reconstruction technique. These findings suggest that the SAFT technique warrants continued study as a biomechanically sound option for LUCL reconstruction in the setting of elbow PLRI.

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