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Biomechanical Evaluation of Ulnar Collateral Ligament Reconstruction of the Elbow Using the Docking Technique: An In Vitro Study Comparing the Intact UCL to Reconstructions Performed at 30 and 90 Degrees of Elbow Flexion

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Summary:
This study suggests that surgical reconstruction performed at 30 degrees of elbow flexion provides improved functional results than similar reconstruction performed at 90 degrees of elbow flexion.

Abstract:
Background:
Ulnar Collateral Ligament (UCL) injuries are common among throwing athletes. Surgical reconstruction of the UCL is frequently performed using the Docking technique and has achieved successful results. Reconstruction has been suggested at 30 degrees of elbow flexion as well as at greater degrees of elbow flexion (90 degrees) approximating the elbow flexion position during throwing. No quantitative biomechanical data exists to provide guidelines for the appropriate elbow flexion angle at which surgical reconstruction should be performed.

Hypothesis:
Biomechanical characteristics of the reconstructed elbow, including valgus laxity, load to failure and kinematic coupling, are significantly affected by the elbow flexion angle at which the Docking surgical reconstruction procedure is performed.

Methods:
Testing was conducted on 10 matched pairs of cadaver elbows using a 4 degrees of freedom loading system described in previous studies. Sub-failure valgus loads were applied to the native elbows at specific, fixed flexion angles (30, 60, 90 and 100). During load application, valgus rotation, forearm rotation, initial length and elongation under load of the proximal and distal portions of the anterior bundle of the UCL were simultaneously recorded. The elbows were then loaded to failure in valgus at 90 degrees of flexion. Docking technique was then performed using palmaris longus autograft. For each matched pair, one of the elbows was reconstructed at 30 degrees of elbow flexion, while the contralateral elbow was reconstructed at 90 degrees of elbow flexion. Biomechanical testing consisting of the sub-failure valgus loading followed by loading to failure was then repeated.

Results:
The load to failure of the native UCL averaged 20.1 N-m (range: 6-34 N-m) while the load to failure after UCL reconstruction using the Docking technique averaged 4.6 N-m (range: 2-10 N-m). There was no statistical difference in load to failure of the UCL reconstructions performed at 30 degrees of elbow flexion (avg. = 4.86 N-m; range: 3-6.1 N-m) compared to those performed at 90 degrees of elbow flexion (avg. = 4.35 N-m; range: 1.8-10 N-m). Analysis of kinematic coupling for the native UCL found that as the elbow moved from extension (30 degrees) to flexion (90 degrees), coupling of forearm rotation with valgus motion progressed from pronation to supination. This coupling

pattern is consistently seen in the throwing motion. Elbows reconstructed at 30 and 90 degrees of elbow flexion produced similar kinematic coupling as compared to each other and to the intact elbow at low flexion angles (30 degrees). However the elbows reconstructed at 30 degrees of flexion more closely resembled the kinematic coupling pattern of the intact elbow at 90 degrees. The valgus laxity of the elbows reconstructed at 30 degrees of elbow flexion were closer to the intact elbow at both 30 and 90 degrees of elbow flexion than the elbows reconstructed at 90 degrees of elbow flexion. The results also indicate that as the elbow moved from extension into flexion the anterior band of the UCL shortens while the posterior band lengthens for the intact elbow. Similarly during this motion, the anterior portion of the surgical reconstruction shortens while the posterior portion lengthens.

Conclusion:
Biomechanical characteristics of elbows which underwent Docking surgical reconstructions at 30 degrees of elbow flexion, appear to more closely approximate those of the intact elbow than reconstructions performed at 90 degrees of elbow flexion.

Clinical Relevance:
Surgical UCL reconstruction using the Docking technique does not restore, immediately post-surgically, the biomechanical characteristics of the elbow to the pre-injury levels. However, it improves valgus stability, load-to-failure and kinematic coupling as compared to the UCL deficient elbow. This study suggests that surgical reconstruction performed at 30 degrees of elbow flexion provides improved functional results than similar reconstruction performed at 90 degrees of elbow flexion.