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A Novel Suture-Button Construct for Interosseous Ligament Reconstruction in Longitudinal Radioulnar Dissociations: A Biomechanical Study

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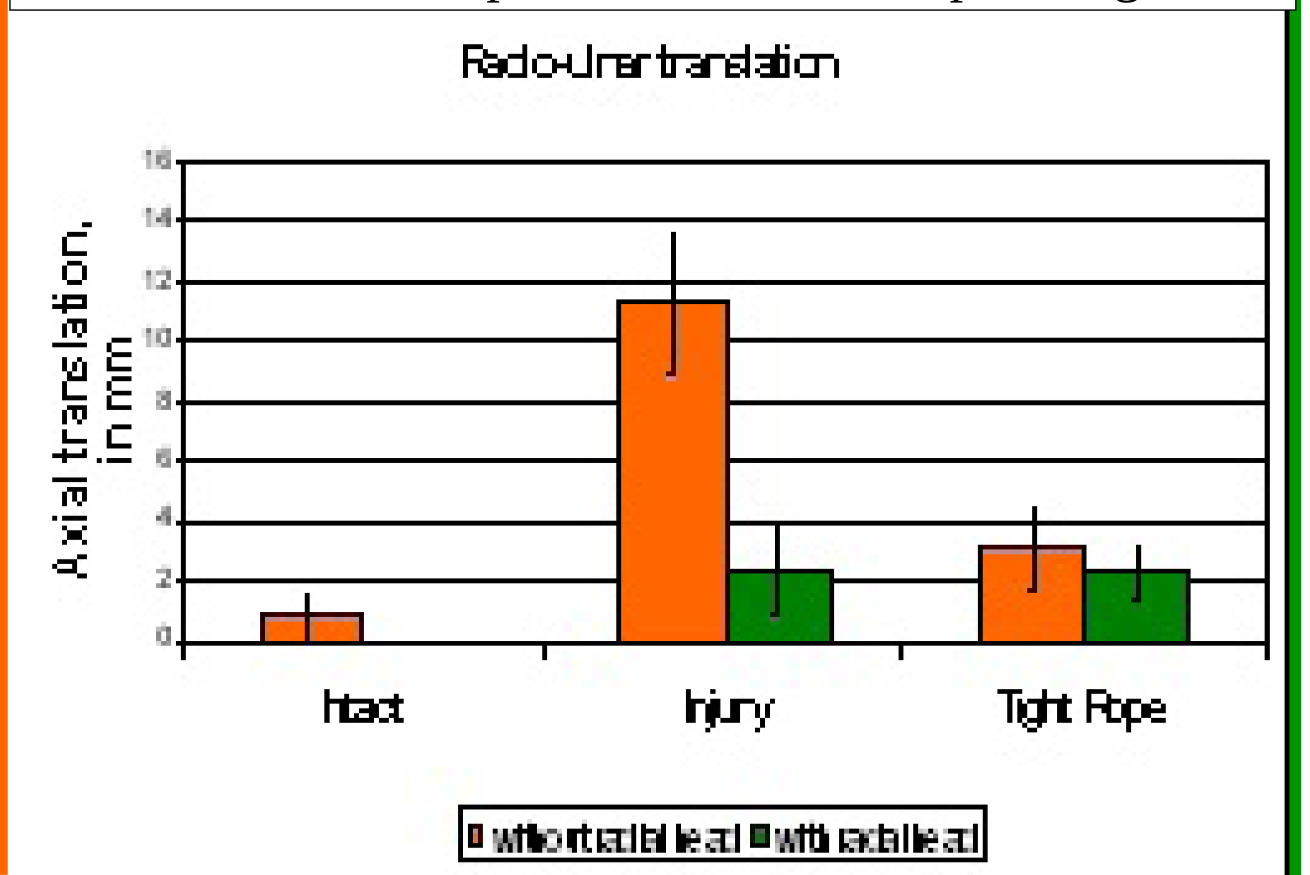
INTRODUCTION

Longitudinal radioulnar dissociation (LRUD) injuries occur when a violent compressive load to the wrist results in a triad of injuries consisting of a distal radioulnar joint (DRUJ) disruption, an interosseous ligament complex (IOLC) tear, and a radial head fracture. The forearm is rendered unstable causing progressive proximal migration of the radius with resultant decreased motion, weakness, and chronic wrist pain. Essex-Lopresti emphasized the importance of either reconstructing or replacing the radial head in these patients and for his contributions his name is now commonly associated with this injury pattern.

Radial head replacement alone has been shown to be effective at restoring 89% of forearm stiffness. Previous studies on IOLC reconstruction material for LRUD injuries included bone-patella tendon-bone graft, flexor carpi radialis, palmaris longus tendon, Achilles tendon allograft, pronator teres transfer, and use of a nylon suture. Though some studies have been promising there is still a paucity of clinical and biomechanical evidence to validate any specific recommendation for the treatment of this challenging problem. The goal of this study is to investigate a new technique for the reconstruction of the IOLC using a FiberWire (Arthrex, Naples, Florida) button construct, the Mini-TightRope (Arthrex, Naples, Florida). This study investigated the use of the Mini-TightRope as a minimally invasive reconstruction of the central band of the IOLC that biomechanically resembles the anatomic position and stiffness of the native central band. Ultimately this may provide stability to allow early rehabilitation while restoring the load distribution at both the elbow and wrist.

Figure 2- Relative axial translation of the ulna to the radius in the coronal plane from fluoroscopic images.



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METHODS

Eight fresh frozen cadaver arms were sectioned mid-humerus and mounted for testing with the elbow at 90º, the forearm in neutral rotation and the wrist in 20º dorsiflexion and the hand was positioned to a plumb line from the elbow to align the forearm vertically. Two transducers were mounted on the distal ulna to measure ulna-carpal impaction force. 1.6 mm SS beads were inserted into the distal radius, ulna, triquetrum and lunate using a bone biopsy needle to measure the relative motion of the bones in the fluoroscopic images. Cyclic axial load was applied along the forearm from +13N distraction to -130 N compression at a rate of 0.25 Hz . Bead motion was recorded fluoroscopically in the coronal plane and analyzed using Image Pro Express (Silver Spring, MD) software. Resolution of the fluoroscopic images was 0.38 mm. The positioning of each arm and the loading procedure was repeated for the intact condition, after creation of the lesion, after applying a radial head implant to the arm with the lesion and after each repair procedure.

While the arm was mounted on the MTS machine, a radial head implant was inserted and the soft tissues closed. The arms were re-tested. Using the previous volar incision, IOLC reconstruction was completed using the Mini-TightRope, Figure 1. The origin and insertion of the central band was estimated based on the percentage of measured length of the radius and ulna. Bone tunnels were then made in both the ulna and radius. The Mini-TightRope was then passed carefully along the IOLC using a suture passer. Once the buttons were securely engaged onto the cortex the Mini-TightRope was gradually tightened by hand with the forearm in supination until the DRUJ was reduced by fluoroscopy, then axially cycled by hand and re-imaged to assure correct reduction.

The arms were re-tested with and without a radial head implant using the previously described technique. Measurements of the beads on the fluoroscopic images, the loads and displacements of the MTS machine and the estimated forces on the ulna from the strain gages were analyzed by multiple comparison ANOVA with Tukey’s HSD of paired samples. The values for each arm in the intact state were used as control values, to which all other measures were compared.

Figure 1-The TightRope was applied along the direction of the ILOC fibers.

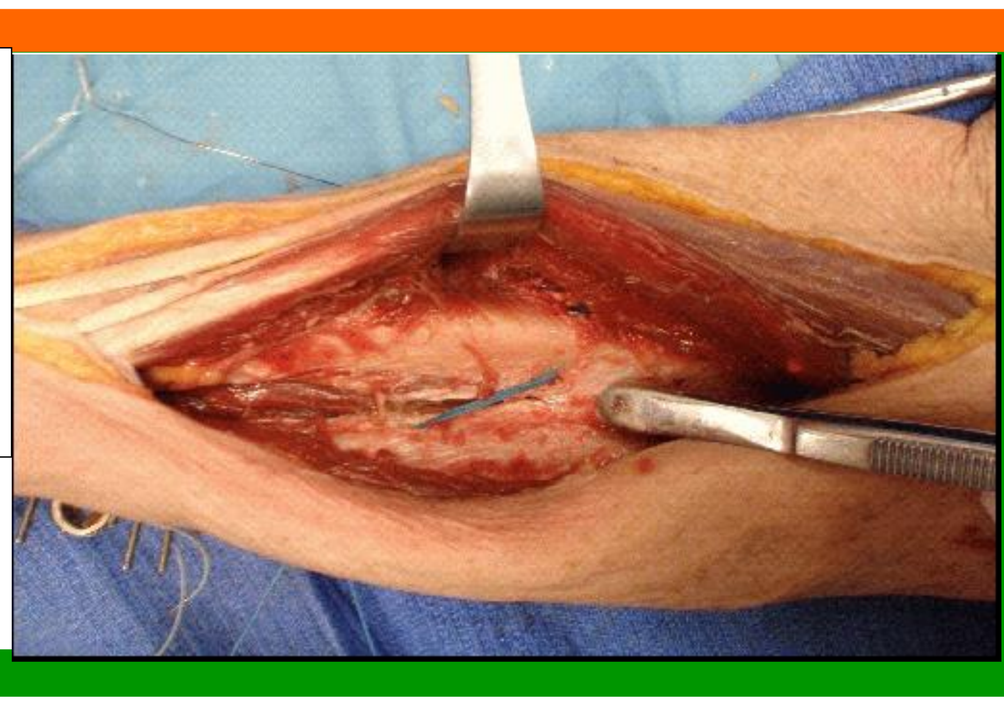
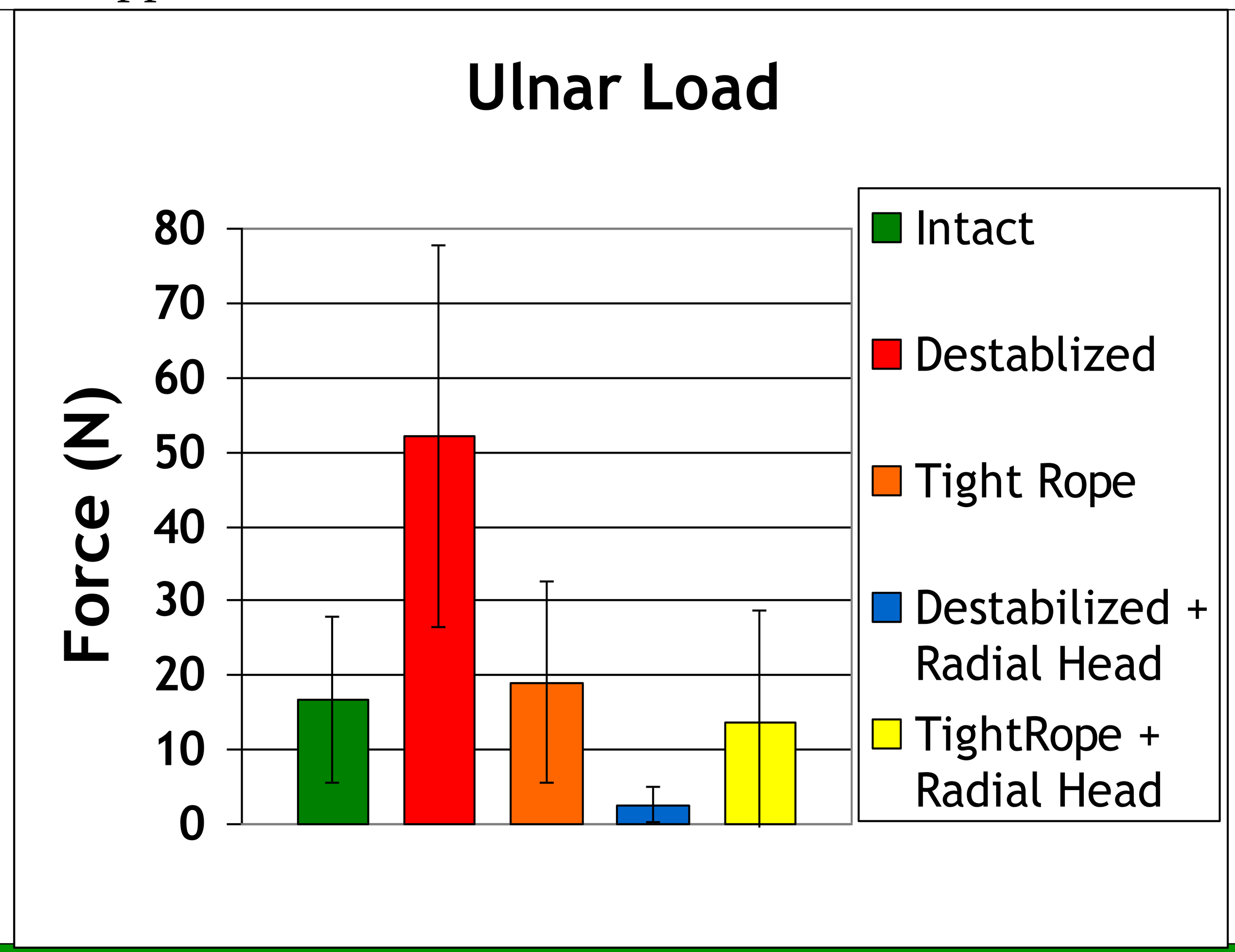


Figure 3- Ulnar load at the distal end per 100N of axial load applied to forearm.



RESULTS

The intact arms all demonstrated minimal radio-ulnar axial displacement (average 0.7 ± 0.8 mm). After destabilization, the radio-ulnar displacement increased significantly to 10.7 ± 3.9 mm ($p<.0001$), for the same load cycle, [Figure 2]. Longitudinal displacement was significantly reduced from 10.7 mm to 2.7 ± 3.11 mm following radial head replacement ($p=0.003$). After reconstruction of the central band using the Mini-TightRope the average displacement was 2.2 ± 0.9 mm and with the addition of a radial head replacement displacement improved to 1.7 ± 1.0 mm. The Mini-TightRope repair with a radial head replacement improved stability significantly ($p<0.0001$) compared to the destabilized state, and was not statistically different from the intact state.

The load on the ulna increased significantly with the simulated injury and was restored to normal levels with the application of the Tight Rope. With the replacement of the radial head alone, the load on the ulna was reduced to almost zero. But the addition of the radial head with the Tight Rope reconstruction did not significantly reduce the ulnar load. A check on the lateral movement of the ulna from the radius on the fluoroscopic images showed that with the radial head alone, the ulna drifted away from the radius and the carpal row. But with the Tight Rope, the ulna was pulled toward the radius with axial load, so the distal ulna articulated with the carpal row ($P <0.06$).

CONCLUSION: Tight Rope reconstruction of the IOLC restored the axial and lateral stability to the forearm after disruption of the DRUJ, IOLC and radial head. Replacement of the radial head alone, restored only the axial stability.