Reconstruction of the Interosseous Ligament Unloads Metallic Radial Head Arthroplasty and the Distal Ulna in Cadavers

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Purpose: Longitudinal radioulnar dissociation may result when a compressive load to the hand results in excessive proximal migration of the radius with interosseous ligament (IOL) disruption and radial head fracture. Interosseous ligament reconstruction has been proposed to restore more normal forearm mechanics. The objective of this study was to evaluate the effect of IOL reconstruction on compressive load transfer through the forearm after excision and metallic replacement of the radial head in cadavers.

Methods: In 8 cadaveric forearms, 138 N of compressive load was applied to the hand in neutral forearm rotation and neutral elbow varus–valgus alignment. We measured proximal radial migration and 3-dimensional force vectors acting on the distal radius, distal ulna, IOL, proximal radius, and proximal ulna. The experiment was repeated in order for 5 conditions: (1) with the IOL intact, (2) with the IOL reconstructed with a double-bundle flexor carpi radialis construct, (3) with the radial head excised, (4) after metallic radial head arthroplasty, and (5) after cutting the IOL reconstruction. Analysis of variance was used for statistical comparisons.

Results: With the IOL intact the resultant load in the distal radius was 94% ± 3% of hand load, with 75% ± 2% transmitted to the proximal radius. Double-bundle flexor carpi radialis reconstruction effectively restored this relationship. After radial head excision the resultant distal radius load decreased whereas great increases were seen in the resultant distal ulna load, the resultant load in the IOL reconstruction, the resultant load in the proximal ulna, and proximal radial migration. Force continued to transfer through the proximal radius transversely, with a 400% increase in transverse force, a consequence of abutment of the radial stump caused by proximal radioulnar convergence (there was no contact at the capitellum). After radial head arthroplasty loads transferred across the wrist remained closer to intact but the resultant load on the distal ulna and proximal radius remained increased. With cutting of the IOL reconstruction transverse forces in the forearm became negligible, the resultant distal ulna load increased by 50%, and the resultant radial head load increased by 25%. Proximal migration of the radius was small and was increased by 4.6 mm with radial head excision and by 1 mm after radial head replacement compared with the IOL-reconstructed, radial head–intact state.

Conclusions: Interosseous ligament reconstruction may help improve treatment of longitudinal radioulnar dissociation but remains an experimental procedure. (J Hand Surg 2006; 31A:269–278. Copyright © 2006 by the American Society for Surgery of the Hand.)

Key words: Interosseous ligament, interosseous membrane, Essex-Lopresti lesion, reconstruction, radial head fracture, radial head arthroplasty.

The interosseous ligament (IOL), or central band of the interosseous membrane, connects the radius and ulna in the central forearm. Accessory bands and the proximal interosseous band cord often are present.[1] Backlighting of the interosseous membrane shows the prominent IOL[2] (Fig. 1).

Studies show that the IOL is loaded in tension with forearm compression,[3,4] resulting in a complex 3-dimensional (3D) state of forearm forces[5] (Fig. 2). Compressive load applied to the hand causes the radius to migrate proximally[6,7] and causes the radius and ulna to bend in a bowing fashion.[8] Our past research has shown that this motion of the radius and ulna loads the IOL in tension, which causes the IOL to exert force on the radius both longitudinally in a distal direction (relieving load on the proximal radius) and transversely toward the ulna. Similarly the IOL exerts force on the ulna both longitudinally in a proximal direction (transferring load to the proximal ulna) and transversely toward the radius. Transverse forces acting in the distal and proximal radius and ulna balance the transverse force that develops in the IOL. The transverse force exerted by the IOL on the radius and ulna likely helps limit radioulnar bowing and results in compressive forces across the distal radioulnar joint (DRUJ) and the proximal radioulnar joint (PRUJ).[5,6,9]

Previous forearm load transfer studies[5–7,9,10–13] have quantified the forces acting in the radius and ulna proximal and distal to the DRUJ and PRUJ, respectively. The forces acting in the bones at these points are a complex interplay of forces transferred across the wrist/elbow joint, forces in the DRUJ and PRUJ, and force exerted by the IOL on the radius and ulna.

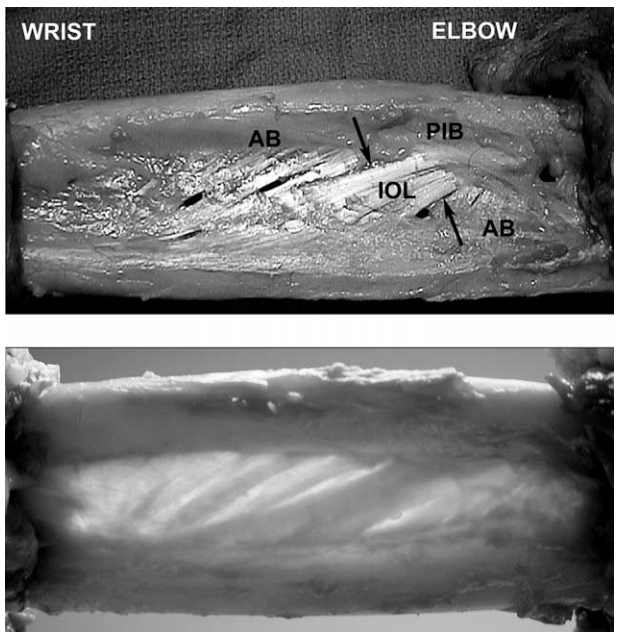

Figure 1. Dorsal view of a dissected cadaveric forearm. (A) Arrows delineate extent of the IOL. Accessory bands (AB) are seen proximal and distal to the IOL and the proximal interosseous band (PIB) is seen overlying the IOL coursing from the radius distally to the ulna proximally. (B) Backlit view of the forearm shows how much thicker the IOL is compared with the rest of the interosseous membrane.

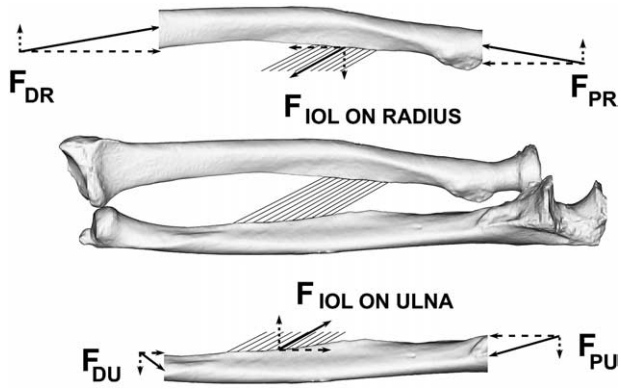

Figure 2. Forces in the forearm when compressive load is applied to the hand (neutral rotation). (A) Free body diagram of the radius showing the force that the IOL exerts on the radius and the forces acting in the distal radius (F_{DR}) and proximal radius (F_{PR}). (B) Free body diagram of the ulna showing the force that the IOL exerts on the ulna and the force acting in the distal ulna and proximal ulna. Solid lines indicate the resultant vector, dashed lines denote each vector's longitudinal (proximal–distal) component, and dotted lines denote each vector's transverse (radioulnar) component. For each free body longitudinal and transverse forces balance each other.

The IOL is important clinically in the setting of longitudinal radioulnar dissociation, which occurs when the radial head is incompetent and the forearm is exposed to compressive loading. This may occur acutely as the Essex-Lopresti fracture–dislocation, in which a violent compressive force across the wrist drives the radius proximally, resulting in a comminuted radial head fracture and tearing of the IOL.[14,15]

Although metallic radial head arthroplasty successfully restores longitudinal stability this solution does not address injury to the IOL.[16,17] Cutting the IOL after metallic radial head replacement has been shown to increase load on the distal ulna.[11] In the setting of longitudinal radioulnar dissociation reconstruction of the IOL may help normalize forearm mechanics. Interosseous ligament reconstruction has been reported clinically[17] and studied in the laboratory.[6,18–24] We recently reported that IOL reconstruction using a double-bundle flexor carpi radialis (FCR) construct restores normal forearm load transfer with an intact radial head.[6] The objective of this study was to evaluate the effect of IOL reconstruction on compressive load transfer through the forearm after excision and metallic replacement of the radial head in cadavers. We focused on the recon-