SCIENTIFIC ARTICLE

Interosseous Ligament and Transverse Forearm Stability: A Biomechanical Cadaver Study

Christina J. Gutowski, MD, MPH,* Kurosh Darvish, PhD,† Asif M. Ilyas, MD,‡ Christopher M. Jones, MD‡

Purpose The interosseous ligament (IOL) is known to be an important longitudinal stabilizer of the forearm. We hypothesize that it may also contribute to transverse stability, with pronosupination tensioning of the radius relative to the ulna. Therefore, when injured, we predict the interosseous space should widen in the transverse plane, enough to be appreciable on plain radiographs. A measurable difference in interosseous space, comparing an injured with an uninjured forearm, can potentially be of diagnostic and clinical value.

Methods Ten fresh-frozen cadaver arms (from 5 individuals) were radiographed in 6 different positions of forearm supination, first in an uninjured state and then with the IOL sectioned, both partially (central band only) and completely. The transverse interosseous distance was measured on radiographs using edge detection software and compared using analysis of variance and contrast analysis. The maximum range of pronosupination was also compared before and after injury, using a paired *t* test.

Results Average maximum supination increased from 84° to 106°, and pronation from 69° to 84°, after the IOL was sectioned completely. Sectioning of the IOL led to a statistically significant increase in the interosseous distance, a minimum of 2 mm, in all but one forearm position.

Conclusions The IOL of the forearm plays an important role in providing transverse stability to the radius and ulna. When the IOL is sectioned, the forearm exhibits increased pronosupination range of motion. Radiographs of bilateral forearms taken in identical rotational position can reliably differentiate between an intact and torn IOL in cadavers.

Clinical relevance The IOL's stabilizing role during forearm rotation suggests a novel strategy for diagnosing forearm IOL injury using comparative radiographic measurements. *(J Hand Surg Am. 2016;■(■):■−■. Copyright © 2016 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Essex-Lopresti, forearm stability, interosseous distance, interosseous ligament.

*From the *Orthopaedic Service, Memorial Sloan Kettering Cancer Center, New York, NY; the †Department of Mechanical Engineering, Temple University; and the ‡Rothman Institute Orthopaedics, Thomas Jefferson University, Philadelphia, PA.*

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The experiments described in this study were performed at the University of Virginia Center of Applied Biomechanics (CAB), with cadaveric specimens provided by CAB.

Corresponding author: Christina J. Gutowski, MD, MPH, Department of Orthopaedic Surgery, Thomas Jefferson University Hospital, 1025 Walnut Street, College Building Suite 516, Philadelphia, PA 19107; e-mail: gutowski1@gmail.com.

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THE FIRST CASE OF CONCURRENT injuries to the proximal radius and distal radioulnar joint (DRUJ) was described in 1946 by Curr and Coe.[1] Several years later, Essex-Lopresti reported on 2 cases, more thoroughly describing the injury mechanism and emphasizing the importance of recognizing the simultaneous disruption of the forearm interosseous ligament (IOL).[2] He proposed the mechanism of injury to be a violent longitudinal compressive force along the long axis of the forearm. He also described the development of longitudinal

TABLE 1. Demographic Data Describing the 10 Cadaveric Forearm Specimens (5 Matched Pairs)

Sample Number	Sex	Age at Time of Death	Weight, kg	Stature, cm	Bone Density *t* Score
1	M	56	79.4	165.0	−1.6
2	F	88	52.2	162.6	−1.4
3	F	65	45.4	152.4	−3.4
4	F	57	31.7	152.0	−2.6
5	M	85	84.5	180.3	−1.6
Average		70	58.6	162.5	−2.1
SD		15	22.6	11.6	0.9
Standard error		7	10.1	5.2	0.4

instability of the radius that results from inappropriate excision of the injured radial head when the ligamentous injury went unrecognized. He drew attention to the clinical significance of this injury, and his name has come to be commonly associated with the combination of proximal radius fracture combined with IOL and DRUJ disruption.

Concurrent ligamentous injury in conjunction with radial head or neck fracture poses a diagnostic challenge in the acute setting. In a series of 106 patients reported by Osterman et al,[3] only 38% had been diagnosed at the time of injury. Physical examination and common imaging modalities such as radiographs, magnetic resonance imaging, and ultrasound are not sensitive nor specific for the Essex-Lopresti injury.[3–6] The importance of prompt identification of this injury has been shown: outcomes are considerably worse in patients treated for elbow fracture without recognition and treatment of their concomitant IOL tear.[4] The development of radiocapitellar impingement and ulnar impaction syndrome are common sequelae of proximal migration of the radius, due to chronic longitudinal instability from an undiagnosed IOL injury or inappropriate surgical treatment.[3] Patients who are properly diagnosed and treated go on to report much higher satisfaction and better wrist and elbow scores.[4,7,8]

The IOL comprises several components, the most important of which is the central band. Its center originates from a point approximately 60% of the radial length from the radial styloid and inserts at approximately 33% of the ulnar length from the ulnar styloid.[9] Although the radial head is the primary stabilizer against longitudinal instability, the central band and the triangular fibrocartilage complex (TFCC) provide important secondary support. In the case of radial head fracture or excision, the TFCC and the central band of the IOL contribute about equally to the longitudinal stabilization of the forearm.[10]

The strain distribution within the IOL is dynamic, as it is dependent on forearm rotation: the highest overall strain is found in neutral position and the strain focus shifts proximally with pronation and distally with supination.[11] In addition to providing longitudinal stability, the IOL also functions to keep the radius and ulna joined in the transverse plane, providing a joint reaction force and thus stability to the proximal joint and DRUJ.[12] We hypothesized that an injured IOL will manifest on plain radiographs as an increased transverse distance between the radius and ulna. This widening may become more pronounced with specific rotational positions of the forearm. The goal of this study was to investigate the transverse interosseous distance with radiographs performed on cadaver forearms in various rotational positions, with the central band and then the entire IOL sectioned.

MATERIALS AND METHODS

The institutional review board's approval was not required as this was a cadaver-based study. Ten fresh-frozen cadaver arms from 5 individuals (2 males and 3 females) were selected. They had been cut at the level of the mid-humerus, and included the elbow joint, forearm, and wrist. The donors' characteristics are summarized in Table 1, which shows that the average age at death was 70 (standard deviation, 15) and the bone density *t* score was −2.12 (0.86). Physical examination and fluoroscopy evaluation were performed to identify any previous injuries; none were found.

Interosseous ligament integrity

Three conditions were simulated for testing: preinjury (Pre-Inj), central band disruption (CB Disrupt), and complete IOL division with DRUJ release (IOL Inj). The standard volar approach to the forearm was used