Review Article

Radial axial interosseous load (RAIL) test for essex lopresti type injuries

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ABSTRACT

Background: When approaching radial head and neck fractures, the decision for ORIF, resection, or arthroplasty is often performed intraoperatively. Factors that contribute include ligamentous and bony stability, cartilage injury, mechanical alignment as well as patient factors. Recent data has suggested conventional methods may not be sufficiently sensitive in detecting Essex Lopresti injuries. Here we describe an intraoperative technique that could objectively assess proximal radio-ulnar stability with subsequent disruption of the ligamentous structures.

Methods: Eight cadaveric specimens were used to evaluate amount of radial proximal migration between three groups of forearms. After radial head resection, proximal migration of the radial shaft was measured in three distinct groups. Group A included intact forearms, Group B included forearms with resected interosseous membranes (IOM), and Group C included forearms with resected interosseous membranes and distal radioulnar joint (DRUJ) disruptions.

Results: As compared to group A, group B averaged 4 mm of proximal radial migration ($p < 0.01$), while Group C demonstrated > 6 mm of migration ($p < 0.01$).

Conclusion: In the setting of a non-repairable radial head, the RAIL test may provide a more objective means of assessing for Essex-Lopresti injuries.

1. Introduction

Essex Lopresti injuries (ELI) were initially described in 1951, by Peter Essex-Lopresti.¹ The mechanism usually resulted from a fall on the outstretched hand, causing a force to travel through the forearm. If the force is great enough, the radial head will fracture and dislocate, the interosseous membrane (IOM) will rupture, and the distal radial ulnar joint (DRUJ) becomes disrupted and the radius migrates proximally, resulting in a complex forearm instability pattern.^{2,3}

This subtle pattern was frequently missed as the clinician simply treated the injury as an isolated radial head fracture. Failure to recognize the injury can result in ulnocarpal pain accompanied by decreased forearm range of motion due to progressive and repetitive radial shortening.^{4,5} Other variants include proximal migration of the radius which may occur in an untreated setting. Other forearm injuries with disruption to the interosseous membrane may also be seen in Monteggia fractures, triangular fibrocartilage complex injuries with radial head fractures or Galeazzi fractures.^{6,7–11}

The current techniques to evaluate integrity of the interosseous membrane have been met with moderate success.^{14,15} Smith et al. described longitudinal traction to the radial shaft to evaluate proximal radial migration in ELI forearms. Soubeyrand et al. reported lateral

translation of the radial shaft as a confirmation of IOM and DRUJ incompetence. Recent data has suggested conventional methods may not be sufficient in detecting Essex Lopresti injuries.¹⁷ Intraoperative testing on cadavers using the push-pull and lateral pull test had only fair results in one study.¹⁷

The current study attempts to objectively assess the incremental differences in proximal radial shaft migration after sequential resection of distal radial-ulnar stabilizers in the setting of an incompetent radial head.

2. Methods

Eight fresh frozen cadaver arms were thawed at room temperature 24 h before testing. Cadavers were prepared using a lateral kocher approach to the elbow, between the anconeus and extensor carpi ulnaris. After exposure to the radial head, approximately a 10 mm resection of the radial head was performed with a mini sagittal saw. These specimens consisted of Group A. In Group B, the interosseous membrane was exposed and resected using an ulnar approach between the extensor carpi ulnaris and ulna, elevating the extensor compartment until reaching the central band, distal and oblique bundles of the interosseous membrane. In Group C, the distal radioulnar joint (DRUJ) was

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Fig. 1. Testing of the Interosseous Membrane Stability.

exposed using the dorsal approach to the wrist between the fourth and fifth extensor compartments. After retraction of the tendon sheaths, the distal radioulnar ligaments were isolated and resected.

3. Technique

A description of the RAIL test is depicted below (Fig. 1). After exposure of the proximal radius via the surgeon’s exposure of choice, the radial head was removed and the elbow is flexed 90° and elevated so the forearm is perpendicular to the arm table. The surgeon then transmits a 20 lb force through the palm into the wrist while measuring the amount of proximal radial migration. A sterile caliper or ruler may be used. This compression is performed in supination and pronation.

Statistical analysis was performed using Student’s *t*-test for comparisons between two continuous variables while ANOVA analysis was utilized to evaluate a detect a difference between all 3 groups.

4. Results

The results of the eight cadaveric specimens are presented in Table 1. There was no proximal migration of the radius in Group A (range 9–16 mm). After resection of the IOM, RAIL testing demonstrated statistically significant proximal migration of 2.75–4.06 mm on average compared to normal (range 4–14 mm, *p* < 0.0001 in pronation and *p* = 0.0005 in supination) (Fig. 2). In group C, radius proximal

Table 1
Results.

	Normal (Group A)	P value	IOM disrupted (Group B)	P value	IOM + DRUJ disrupted (Group C)	ANOVA
Pro	10.375	0.0000678	7.625	0.00352	4.1875	< 0.0001
Sup	10.75	0.000577	6.6875	0.00299	4.5	< 0.0001

Pro = Pronation, Sup = Supination, Nml = normal, IOM = Interosseous membrane. DRUJ = distal radio-ulnar joint.

Fig. 2. Interosseous membrane disruption, demonstrating narrowing of the radio-capitellar area.

Fig. 3. RAIL test with complete disruption of interosseous membrane and distal radio-ulnar joint.

migration was > 6 mm (range 1–6 mm). This was also statistically significant when compared to group B (*p* = 0.003 in pronation and *p* = 0.003 in supination) (Fig. 3).

5. Discussion

Here, we have provided the first description of a dynamic test of the IOM in the full range of motion of the forearm. The results show proximal migration of the radius consistent with other tests previously published.^{14,15}

Smith et al¹⁴ described performing the radial pull test in neutral rotation with 20 pound of force. They recommended more than 2 mm of

migration may suggest interosseous membrane disruption and longitudinal instability, and in all cadavers, more than 5 mm of proximal migration indicated both interosseous membrane and TFCC rupture. Soubeyrand et al.¹⁵ described another way to evaluate the interosseous membrane stability. The joystick test is performed by applying lateral translation of the pronated forearm with a clamp around the radial neck. Lateral translation indicates the membranous structures have been compromised.

Although these tests are described well, the interosseous membrane is of variable anatomy.¹⁷ In addition, the maximum tension generated by the interosseous membrane may be variable and a dynamic test would produce a more accurate and functional evaluation of the competence of the ligamentous structures. Additionally, the interosseous membrane is most taut in supination and pronation, thus we recommend for the arm to be in these positions prior to transmitting the axial force. Ring et al. demonstrated the insufficiencies of the current push-pull test and lateral pull test for Essex-Lopresti injuries.¹⁸ Their study demonstrated only a fair interobserver reliability and moderate intraobserver reliability. In addition, the level of hand surgery experience had not proven to contribute to correct identification of IOM injuries.¹⁸

Benefits of the current test include its simplicity as clamp instrumentation is not required. Application of clamps around the radial neck may place the posterior interosseous nerve (PIN) at risk. Tornetta et al. demonstrated that the PIN lies 1.2 mm to the radial head on average.¹⁶ Additionally, in the setting of a radial neck fracture, cortical comminution may prohibit the ability to utilize a clamp around the radial neck.

In the setting of an unreparable radial head fracture with an intact interosseous membrane, resection has been proven to be a successful technique.¹² Ifitimie et al. performed 51 radial head resections with mean follow up of 17 years. 96% of patients had good or excellent results with Mayo Elbow Performance scores of greater than 96.¹³ This may suggest that elbows with proximal migration less than 4 mm with RAIL testing may have good functional outcomes.

Limitations to this study include the low sample size of cadaveric specimens, the lack of interobserver or intraobserver testing, lack of standardization of force applied and the lack of clinical correlation in vivo. Although our sample size is low, findings were significant between all 3 groups with even distributions. Forces applied may be difficult to estimate at 20 lb precisely, however, minimal proximal radial migration occurred with significantly greater force during practice testing phases.

The current study demonstrates the potential use of the RAIL test in distinguishing the severity of radio-ulnar instability. Additionally, the

RAIL test is a quick and easy test that can be performed intraoperatively to determine interosseous membrane stability and potentially necessity of radial height maintenance. Future research is needed to determine in vivo clinical application.

Disclosures

The authors have no disclosures.

Each author certifies that his institution approved or waived approval for the use of human subjects for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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