MRI Correlation of Radial Head Fractures and Forearm Injuries

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Abstract

Background: Radial head fractures can be associated with soft tissue injuries of the forearm and wrist. The Essex-Lopresti injury can lead to significant morbidity, especially if the diagnosis is not made acutely. Better identification of such injuries is needed to allow optimal surgical treatment and prevent long-term sequelae. We used magnetic resonance imaging (MRI) to correlate the degree of soft tissue injuries with radial head fractures. **Methods:** Sixteen pairs of forearms with an associated radial head fracture in 15 patients prospectively underwent an MRI within 2 weeks of their injury. MRI findings were correlated with fracture type, associated soft tissue injury, and presence of symptomatic wrist pain. **Results:** According to the modified Mason classification, there were 8 type I, 5 type II, and 3 type III radial head fractures. Wrist pain was reported in 8 of 16 extremities, and 2 had associated wrist pathology, including an acute scaphoid fracture in 1 patient and a preexisting stage II scapholunate advanced collapse (SLAC) wrist in another patient. The MRI findings included an elbow effusion in all 16 patients, edema in the proximal third of the radius in 15 extremities, which extended to the middle third in 3 extremities, edema of the interosseous membrane (IOM) in 5 extremities, and edema of the soft tissues including the supinator and/or pronator quadratus in 13 extremities. **Conclusions:** Eighty percent of patients with edema of the IOM had associated wrist pain. Soft tissue injuries of the forearm did not correlate with the severity of the radial head fracture.

Keywords: radial head fracture, MRI, soft tissue injury

Introduction

The Essex-Lopresti injury, or longitudinal radioulnar dissociation (LRUD), is a complex injury resulting from an axial load to the forearm. In the setting of a radial head fracture, attention often is focused on the obvious fracture and elbow injury, and as a result, injury to the forearm and wrist may go unrecognized. Prompt diagnosis becomes extremely important because of the disappointing results of treatment in chronic cases. Treatment in acute cases has shown 80% success rates compared with an 80% failure for chronic cases in some series.^{1,5,13} Early recognition of this injury pattern can thus aid in timely treatment and improved outcomes.

Clinically, determining which radial head fractures may be associated with an Essex-Lopresti lesion can be quite difficult because it often relies on the subjective complaint of pain when assessing the patient's wrist. In addition, a "push-pull test" may be used intraoperatively to assess the longitudinal stability of the radius. However, this also relies on a qualitative assessment by the surgeon. Two to 3 mm of proximal migration of the radius is considered normal following radial head excision. Late proximal migration of the radius has been described and attributed to attrition and progressive incompetence of the interosseous ligament (IOL).¹¹

Because previous studies have all been retrospective, it is uncertain whether the IOL was partially or completely torn during the initial injury with progressive incompetence of other restraints to proximal migration of the radial head, or if the IOL simply weakens over time leading to late proximal migration of the radius.

Magnetic resonance imaging (MRI) and ultrasound have been shown to effectively visualize IOL anatomy and tears. Fester et al performed a cadaveric study to examine the efficacy of MRI and ultrasound for detecting disruptions of the interosseous membrane (IOM). MRI showed a 96% accuracy rate, and ultrasound showed a 94% accuracy rate. They concluded that both MRI and ultrasound could be used to effectively evaluate the integrity of the IOM.³ Although both imaging modalities have proven to be effective in evaluating the integrity of the IOM, the association of radial head fracture severity and possible IOM injury has not been directly

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Table 1. Patient Demographics and MRI Findings.

Patient	Age	Sex	Wrist pain	Fracture type	Edema radius	Edema IOM	Edema soft tissues
1R	28	Male	Yes	II	Prox 1/3	Prox 1/3	Supinator, PQ
1L	28	Male	Yes	I	Prox 2/3	No	Supinator, PQ
2	50	Female	No	I	Prox 1/3	Dist 1/3	PQ
3	29	Male	No	III	Prox 1/3	No	PQ
4	28	Female	No	I	Prox 1/3	No	PQ
5	26	Female	No	III	Prox 1/3	No	PQ
6	24	Male	No	I	Prox 1/3	No	No
7	45	Male	Yes	III	No	Prox and Dist 1/3	Diffuse
8	31	Male	Yes	I	Prox 1/3	Prox 2/3	Supinator
9	67	Male	Yes	II	Prox 1/3	Prox 2/3	Supinator, PQ
10	53	Female	No	II	Prox 1/3	No	Supinator
11	24	Female	No	I	Prox 1/3	No	Supinator
12	26	Male	No	I	Prox 2/3	No	Supinator, PQ
13	64	Female	Yes	II	Prox 2/3	No	AC fossa
14	22	Male	Yes	I	Prox 1/3	No	Supinator, PQ
15	43	Female	Yes	II	Prox 1/3	No	Supinator, PQ

Note. MRI = magnetic resonance imaging; IOM = interosseous membrane; Prox = proximal; Dist = distal; PQ = pronator quadratus; AC = antecubital.

correlated. All studies previously described have only focused on retrospective analysis of failures following radial head excision and subsequent proximal migration of the radius.

To our knowledge, no other study has evaluated MRI findings in acute trauma involving radial head fractures. We hypothesized that MRI may be effectively used to visualize the IOM following radial head fractures and that a correlation exists between radial head fracture severity and forearm soft tissue injury.

Methods

Between February 2003 and May 2007, 15 patients with 16 radial head fractures were prospectively enrolled in this study. Demographic information and the presence or absence of wrist pain were recorded. Plain radiographs were used to classify radial head fractures according to the modified Mason classification. After institutional review board approval, MRI of the fractured and uninjured forearm was performed. T1 and T2 weighted images were made in the axial, sagittal, and coronal planes to evaluate the IOM. The studies were evaluated by a musculoskeletal radiologist to evaluate the extent of soft tissue injury of the forearm with special attention to the IOM and ligament. The forearms were examined with respect to edema of the proximal radius, IOM, soft tissues of the forearm, IOM symmetry, and IOM tearing.

Results

Of the 15 patients in the study, 8 were males and 7 were females, with an average age of 37 years (range, 22-67 years). The right elbow was fractured in 7 extremities, and

6 involved the dominant extremity. Two patients had associated wrist pathology—1 with an acute scaphoid fracture and 1 with a preexisting SLAC wrist. Fourteen extremities were treated nonoperatively, 1 underwent open reduction and internal fixation (ORIF), and 1 had a titanium radial head replacement. Radial head fracture types were classified based on the modified Mason classification. Eight extremities had type I fractures, 5 extremities had type II fractures, and 3 sustained type III fractures. MRI study results varied among patients (Table 1). All patients demonstrated an elbow effusion, and 15 of 16 (94%) showed edema of the proximal third of the radius, which extended to the middle third of the radius in 3 of 16 (19%). The IOM was clearly visualized and best seen on axial images. No patient had a tear of the IOM, but 5 of 16 (31%) showed edema within the IOM. Of these 5 patients, 4 (80%) had wrist pain that was further evaluated with wrist radiographs. None of the patients with wrist pain had preexisting arthritis or wrist pain before the injury. Furthermore, 13 of 16 (81%) patients had edema of the soft tissues, most frequently the pronator quadratus (11 patients). There was no correlation between fracture severity and edema of the IOM or the incidence of wrist pain. Except for the 1 patient with bilateral radial head fractures, the MRI of the contralateral forearm was unremarkable for edema or occult injury of the IOM.

Discussion

Although this injury had been recognized prior to 1951, Peter Gordon Essex-Lopresti made several observations that continue to serve as the foundations of our understanding of it. He described the injury as resulting from a longitudinal

compression force with subsequent injury to the radial head, IOM, and distal radioulnar joint (DRUJ). He also recognized that wrist pain and forearm swelling may not be evident despite injury to the wrist and supporting structures within the forearm. He further recommended performing an open reduction and internal fixation of the fracture if possible. He suggested that in this clinical scenario, the radial head should not be excised under any circumstance and that if comminution precludes fixation, a prosthetic radial head should be used.² These conclusions, made more than half a century ago, remain the principles that guide diagnosis and treatment today. Furthermore, the elbow pain may distract from symptoms which may occur in the wrist or forearm. In 1 series of 106 patients with Essex-Lopresti injuries, the complete diagnosis was made only 38% of the time.⁶ When untreated, the loss of continuity of the IOM can result in proximal migration of the radius and the sequelae of ulnar sided wrist pain and weakness. Alternatively, longitudinal forearm instability may occur after radial head resection in a chronic setting. This may result from the unhealed acute disruption or attenuation of the central band fibers of the IOM over time. In both cases, radiocapitellar impingement as well as ulnar impaction can ensue.⁹

Several studies have looked at the anatomy as well as imaging of the IOM of the forearm (Figures 1 and 2).^{4,8,12} It consists of a membranous portion, a central band, accessory bands, and a proximal interosseous band. In the uninjured forearm, the radial head is the primary restraint to proximal migration of the radius. The IOM (primarily the central band) and triangular fibrocartilage complex (TFCC) are secondary restraints with forearm load. When the radial head is lost, the IOM and TFCC become the primary restraints and resist proximal migration by transferring load to the ulna.¹⁰ Hotchkiss et al theorized that a continuum of injury from simple isolated radial head fracture to the so-called Essex-Lopresti lesion probably exists. Varying degrees of injury to the central band could compromise longitudinal stability and allow proximal migration with activity.⁴ Many patients may not be seen initially with obvious disruption of the DRUJ but may have sufficient injury to the IOM to permit proximal migration.

McGinley et al⁷ also looked at soft tissue injuries associated with radial head fractures. In their study, the IOM was intact in all patients with Mason type I fractures. Two patients had Mason type II fractures with associated partial and complete tearing of the IOM, and all 3 patients with Mason type III fractures had complete tearing of the IOM. They concluded that severity of radial head fracture correlates with longitudinal forearm injury evidenced by presence of IOM tearing.

Several observations can be made based on the results of our findings. First, MRI has shown to be effective in visualizing the IOM of the forearm. Although no patients had

Figure 1. Magnetic resonance imaging based on the Mason

classification system in a study by McGinley et al.⁷
Source. Reprinted with permission from McGinley et al.⁷

Note. The central portion of the interosseous membrane was evaluated in each patient with magnetic resonance imaging (axial T2 fat saturated [AX T2 FS]). In all patients with Mason type I radial head fractures (a), the central IOM was intact (arrow). In a patient with Mason type II fractures (b), partial disruption of the central IOM was identified (arrow). In all patients with Mason type III fractures (c), complete IOM disruption was present (arrow). IOM = interosseous membrane.

frank ruptures of the IOM, the anatomy was well visualized and associated soft tissue injuries were seen, including edema within the IOM and the soft tissues including the

Figure 2. Backlit photograph of interosseous membrane ligaments. Source. Reprinted with permission from Noda et al.⁸

Note. Asterisks indicate the CB as part of the middle ligamentous complex, which originates from the interosseous crest of the radius (white arrow), runs distally and ulnarly, and inserts into the interosseous border of the ulna. Arrows indicate the accessory band, which runs in a similar way to the CB. Arrowheads indicate the distal oblique bundle within the distal membranous portion, which originates from around the distal one-sixth of the ulnar shaft and inserts into the inferior rim of the sigmoid notch of the radius. Broken arrows indicate the dorsal oblique accessory cord on the posterior aspect of the forearm, which originates from around the distal two-thirds of the ulnar shaft and inserts into the interosseous crest of the radius. The proximal oblique cord cannot be distinguished in this photograph because this cord is in contact with the surface of the radial tuberosity (x). R = radius; U = ulna; CB = central band.

pronator quadratus and supinator. In our study, 80% of patients who had edema within the IOM presented with wrist pain. Perhaps these patients who present with wrist pain and edema within the IOM are prone to developing

chronic LRUD over time due to gradual attenuation of the IOM and possible concurrent injury to the TFCC. Conversely, injuries to the IOM may heal without any sequela. Further studies are needed to determine the clinical significance of these associated soft tissue injuries.

The results of our study also indicated that severity of radial head fracture did not correlate with the extent of soft tissue findings and incidence of wrist pain. Only 1 out of 3 patients with a type III fracture complained of wrist pain, compared with 3 out of 8 patients with type I fractures. Soft tissue injuries were consistently seen in all types of radial head fracture. Given these findings, a high index of suspicion for an Essex-Lopresti injury must be maintained even for type I fractures.

An important limitation of our study is the small sample size, which decreased the power of our study. In our series, no patient was found to have a frank tear of the IOM, so no generalizations could be made on clinical findings of patients who had LRUD. With a larger sample size, a better indication of the incidence of Essex-Lopresti injuries could be gained.

Another limitation of our study is the limited information of the status of the TFCC and DRUJ given from MRI of the forearm. An MRI, specifically of the wrist, showing the TFCC and DRUJ ligaments in more detail could also help predict future Essex-Lopresti lesions, given the role of the TFCC as a stabilizer to longitudinal instability of the forearm. In addition, only limited information can be garnered from 1 MRI scan in the acute setting. Follow-up MRI scans at 3 to 6 months would be important to help determine the healing status of the IOM and muscular edema or injuries.

Finally, no patient in our study was found to have an Essex-Lopresti injury. We did find that patients with radial head fractures do sustain soft tissue injuries in the forearm. Given that no Essex-Lopresti injuries were found with a single MRI scan after an initial acute injury, a meaningful correlation between radial head fracture and soft tissue injuries to Essex-Lopresti injuries could not be established in this group of patients. Longitudinal, time sequential MR scans on patients with trauma and diagnosed Essex-Lopresti injuries are required to try to establish the usefulness and clinical relevance of forearm MRI after a radial head fracture.

Identifying which radial head fractures may be more “at risk” for IOL injuries may enhance the clinician’s treatment algorithm when deciding on an appropriate treatment. Data obtained from this study may be used to better understand the Essex-Lopresti lesion and guide the clinician on appropriate initial treatment and whether or not reconstruction or repair of the IOM is clinically indicated.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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