Fracture of the Radial Styloid and Concomitant First Dorsal Compartment Musculotendinous Injuries

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Abstract

In the absence of preexisting inflammatory conditions, pure traumatic rupture of the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) tendons are rare injuries. We present a report of 2 cases of extensor tendon ruptures at the musculotendinous junction occurring after concomitant fractures of the radial styloid in patients who were involved in high-energy trauma. The presence of a radial styloid fracture should raise suspicion for a greater spectrum of injury that can contribute to multidirectional instability. The spectrum might even include proximal damage to the EPB and APL tendons. Although the associated tendon injuries might or might not contribute to functional loss, their presence should be noted when evaluating a patient with this injury pattern.

Tendon rupture of the extensor pollicis longus (EPL) is a well-described phenomenon that has been frequently reported in association with fractures of the distal radius or with predisposing conditions, including chronic tendonitis.[1-3] Unlike ruptures of the EPL tendon, ruptures of the extensor tendons in the first dorsal compartment, including the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) tendons, have not been commonly described in the literature. In the absence of predisposing conditions, such as rheumatoid arthritis or other pathological states,[4-6] pure traumatic EPB tendon rupture has been reported only a handful of times. Although intrasubstance tears are common with chronic inflammatory conditions, traumatic rupture typically occurs at the bony insertion, musculotendinous junction (MTJ), muscle substance, or muscle origin.[7,8] Failla[9] presented a case series of 3 patients with athletic injuries who suffered ruptures of the EPB tendon at its distal insertion, with tearing of the dorsoradial capsule and concomitant rupture of the radial collateral ligament of the thumb. Additional reports have noted damage to the tendon distal to the extensor retinaculum.[10-12] We present a report of 2 cases with injuries to the extensor tendons of the first dorsal compartment, proximal to the extensor retinaculum at the MTJ, with concomitant fractures of the radial styloid after high-energy trauma.

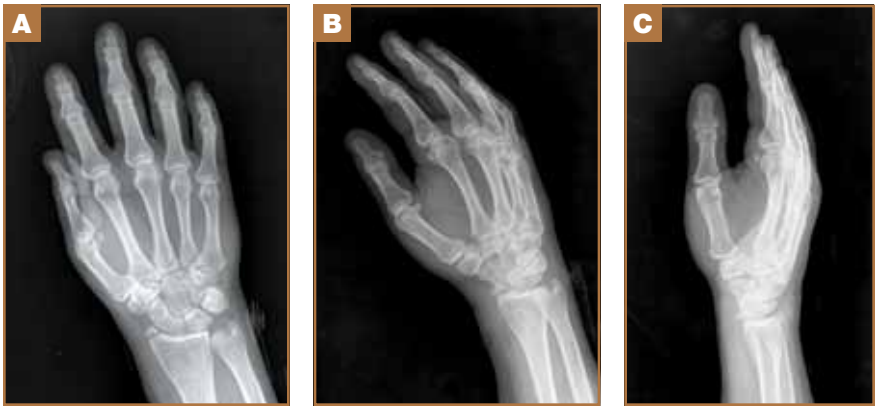
The patients provided written informed consent for print and electronic publication of this case report.

Case Series

Case 1

A 55-year-old woman was transported to the emergency dapartment for evaluation of bilateral upper extremity injuries after being involved in a motor vehicle collision. The findings of an initial examination were significant for swelling and tenderness over the right distal radius, without gross deformity or obvious dislocation. In addition, swelling and ecchymosis were present over the left elbow, with minimal deformity. Except for chronic sensory deficits from bilateral carpal tunnel syndrome, the patient had preserved motor and sensory function distal to her injuries.

Figure 1. Posteroanterior (A), oblique (B), and lateral (C) view radiographs of the distal radius showing a minimally displaced avulsion fracture of the radial styloid.



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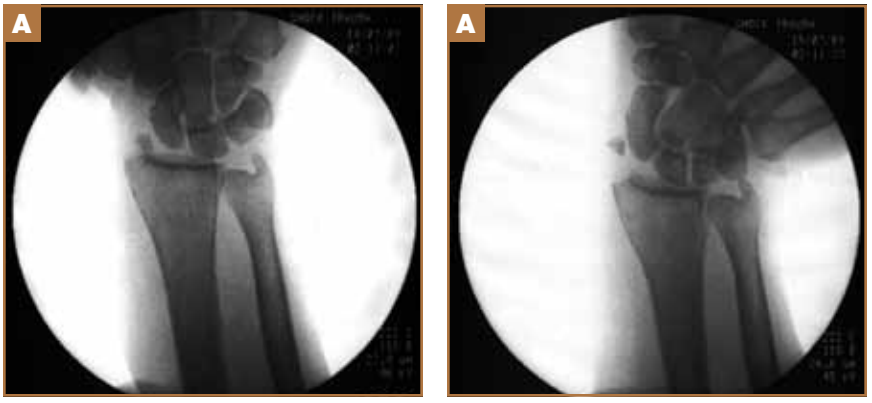

Figure 2. Stress (ulnar deviation) fluoroscopic views of the distal radius showing substantial ulnar translation (A) and displacement (B).

Figure 3. Intraoperative anteroposterior (A) and lateral (B) view radiographs showing tension band wiring.

Radiographs were obtained and showed an isolated radial styloid avulsion fracture of the right wrist (**Figures 1A-1C**) and comminuted fractures of the left olecranon and coronoid process. Displacement of the styloid seen on static and traction films raised concern for a possible radiocarpal fracture-dislocation with associated ligamentous injury. The patient was optimized for the operating room, and after anesthetic induction, stress radiographs with intraoperative fluoroscopy were obtained to evaluate the stability of the radiocarpal joint. Concern for a self-reduced radiocarpal dislocation was initially dispelled after the wrist was shown to have stability with palmar and dorsal-directed force. However, with ulnar deviation, extensive gapping and translation occurred (**Figures 2A, 2B**).

The decision was made to proceed with open reduction and internal fixation of the avulsed radial styloid fragment, ligamentous repair, and carpal tunnel release for the preexisting condition. A standard palmar carpal tunnel incision was used to release the transverse carpal ligament. A dorsal incision was then made and a W-shaped release of the first dorsal compartment performed. Tendons of the APL and EPB were identified, with laxity of the EPB tendon being noted. With ulnar deviation, the radial styloid fracture was easily identified and injuries to the palmar ligamentous structures were noted. The majority of the damage was isolated to the long radiolunate ligament (LRL), and additional injury to a portion of the radioscaphocapitate (RSC) ligament was observed. The palmar incision was extended proximally into the forearm to access the transverse ligamentous injuries.

Fixation of the radial styloid was performed first, with a tension band technique.[13-16] A 2.0-mm drill bit was used to create a transverse hole in the proximal bone, and a 24-gauge wire was inserted. After appropriate reduction, two 0.045-inch Kirschner wires (K-wires) were passed from distal to proximal, to secure the avulsed portion of styloid, and the 24-gauge wire was passed around the K-wires (**Figures 3A, 3B**). Repair of the transverse ligamentous injuries and first dorsal compartment was performed with 2-0 polydioxanone suture (PDS; Ethicon, Somerville, NJ). During closure of the first dorsal compartment, laxity of the EPB tendon was further explored. With slight traction, the proximal portion of the tendon with muscle attached was delivered through the retinaculum. The musculotendinous injury was irreparable, and appropriate debridement of the tendon was performed. Intraoperative imaging revealed preserved anatomic relationships; however, the repair was not stressed. Injuries to the left upper extremity were addressed simultaneously by a second surgical team. At the conclusion of the operation, a palm-based, thumb spica splint was applied with the wrist in slight extension.

Four weeks postoperatively, the patient was allowed full range of motion and was weaned out of her splints. By 6 weeks after surgery, the patient was allowed full activity with both upper extremities. She did require hardware removal from her left elbow. Four months after the original surgery, the patient was discharged from our care because she was fully functional, had no limitations or complaints, specifically regarding her right hand or her right thumb.

Case 2

A 57-year-old woman sustained an injury to her left wrist. At the time of presentation to the emergency department, she

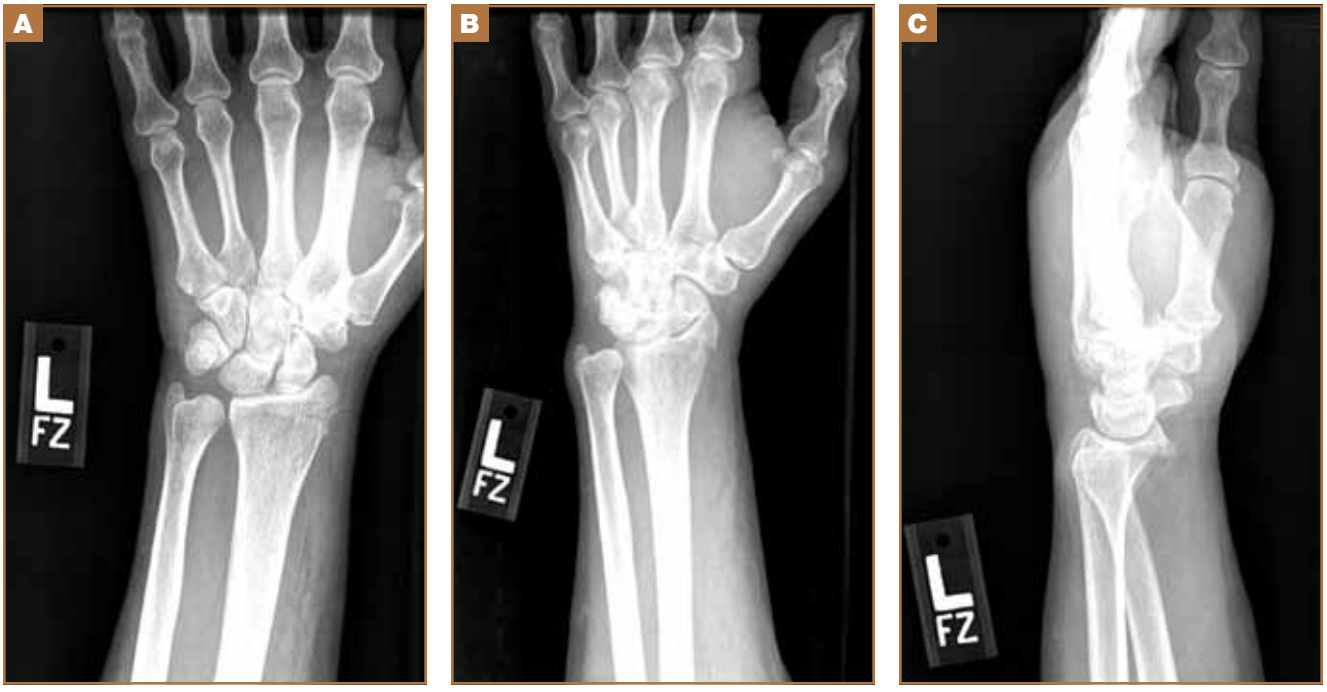

Figure 4. Posteroanterior (A), oblique (B), and lateral (C) view radiographs of the distal radius showing scaphoid fossa displacement and palmar displacement.

had significant swelling and angular deformity. Radiographs showed a left radial styloid fracture with involvement of almost the entire scaphoid fossa and anterior translation of the carpus (**Figures 4A-C**). Closed reduction was performed with the patient under a hematoma block, and operative fixation was indicated. A dorsal approach was used over the first compartment, and a W-shaped release of the extensor retinaculum was performed. No tendons were identified within the compartment. With additional subcutaneous dissection, the APL tendon was found in the fracture and had a proximal stump with its muscle belly still attached. With gentle traction on the APL, a second tendon was visualized and identified to be EPB. This tendon was also avulsed proximally and was observed to have a portion of muscle belly attached to the stump. The musculotendinous nature of the avulsions deemed the injuries irreparable.

After confirmation of extensor carpi radialis longus, extensor carpi radialis brevis, and EPL tendon continuity, the stumps were excised at the level of the styloid in the first compartment. Fixation of the styloid fragment was achieved by using a combination of a 4-hole 1.5-mm T-plate and a 2.7-mm lag screw (**Figures 5A, 5B**). Anatomic reduction, without ulnar translocation, was confirmed with fluoroscopy. The retinaculum was repaired with 4-0 Vicryl suture (Ethicon), and the wrist was placed into a plaster sugar tong splint in slight supination.

Despite a rigorous therapy program that began immediately after her surgery, the patient developed complex regional pain syndrome. Two months after her initial surgery, she underwent Bier block and stellate ganglion block anesthesia with manipulation of the fingers and her wrist because of limited

Figure 5. Posteroanterior (A) and lateral (B) view radiographs obtained 9.5 months after ORIF of a radial styloid fracture.

range of motion. She continued to have problems with stiffness and pain in her finger. She underwent metacarpophalangeal (MCP) joint capsulectomies of her index, long, ring, and small fingers with proximal interphalangeal (PIP) joint contracture

release of her long, ring, and small fingers. The procedures were performed approximately 10 months after the initial surgery. Function did improve; however, the patient continued to experience limitations referable to her left hand, more so in her fingers than in her thumb. She had achieved successful bone healing, and when last seen 2 years after injury, she noted she still had not returned to driving the school bus in which she was initially injured. The ulnar deviation and contractures of her PIP joints continued to limit use of her left hand. A physical examination revealed a hand that was maintained at approximately 15° to 20° of ulnar deviation. The patient was unable to abduct her thumb unless pre-positioned, which she would then hold with her EPL. Contractures of the small finger PIP joint were approximately 70°. The MCP joint arc motion was only approximately 45° in the small finger. Mild contractures of the long finger and ring finger PIP joints were also present. The patient declined any further surgical intervention and was discharged with instructions to return as needed.

Discussion

Fractures of the distal portion of the radius that involve the radial side of the metaphysis and extend to the articular radial surface of the radiocarpal joint have been referred to as "chauffeur's fractures." The origin of the name stems from the mechanism of injury involving car-starting handles. As a result, these injuries have also been referred to as "backfire fractures," in the orthopedic literature. Initially, it was thought that these fractures followed a benign course;[17] however, a review presented by Helm and Tonkin[18] of 14 surgically treated patients suggests a more complex pattern of injury that can be likened to the work presented by Mayfield and colleagues[19,20] on perilunar instability. The pattern is highly dependent on the degree and duration of the force applied to the wrist, with the hand in a position of extension and ulnar deviation, with "intercarpal supination."[19,20] Wrist extension and ulnar deviation create tension on the palmar radiocarpal ligaments, the precise anatomic relationships of which have been accurately mapped using cadaveric and 3-dimensional computed tomography models.[21,22] With rotational, shear, and angulatory deforming forces, the carpus peels from the distal radius and ulna in a reproducible and predictable fashion. The work presented by Helm and Tonkin[18] suggests that a chauffer's fracture is the first stage in a sequence leading to fracture-dislocation and subsequent radiocarpal instability.

Failure to recognize the potential pattern, especially in cases with a radial styloid fracture without frank radiocarpal dislocation, can lead to persistent ulnar and/or palmar radiocarpal translocation and multidirectional instability.[23] The early work presented by Moneim and colleagues[24] provided a framework within which to classify these injuries in hopes of guiding an appropriate treatment regimen. Moneim and colleagues[24] reported that fracture-dislocations, accompanied by intercarpal dissociation (type II injuries), responded poorly to conservative management. The authors supported open reduction, internal fixation, and repair of all torn ligaments in cases with these injuries. Dumontier and colleagues[25] reclassified these injuries into group I versus group II injuries. Group I, representing pure radiocarpal dislocations with or without avulsion fracture of the radial styloid, commonly suffered from instability, including ulnar translocation of the carpus. Support was provided for operative management with a palmar based approach to repair the ligamentous structures, primarily the RSC and LRL. The importance of the RSC ligament in the prevention of ulnar translocation has been known for some time.[26] However, in a cadaveric model, Viegas and colleagues[27] showed that preservation of only the RSC is not adequate to stabilize the wrist; stability requires the preservation of both the RSC and LRL ligaments.[27,28]

Distal ruptures of the EPB tendon are rare; however, they have been reported in the literature.[9-12] Even rarer are reports of failure of the extensor tendons of the hand at the MTJ.[8,29-33] Injuries that have produced failure of the myotendinous unit at the MTJ have been purely torquing mechanisms and have not been associated with fracture.[8,33] To our knowledge, failure of APL or EPB at the MTJ has never been reported in the literature. In addition, these injuries have not been reported in combination with fractures of the radial styloid, with or without radiocarpal dislocation.

Pertinent to the discussion of tendon function and rupture is the anatomy of the EPB, which is best summarized by Dawson and Barton,[34] who stated that the EPB shows anatomic variation to the extent that deviation from the standard anatomic description is the rule rather than the exception. The classic anatomic description of the EPB places the origin at the dorsal aspect of the radius, distal to the origin of the APL, and from the adjacent interosseous membrane. It inserts distally to the base of the proximal phalanx of the thumb to aid in extension of the MCP joint of the thumb and with abduction of the thumb and carpus.[35] Numerous studies have evaluated the anatomic variations.[9,34-37] Kulshreshtha and colleagues[36] studied 44 cadaveric hands from 23 donors. EPB was present in all specimens; however, absence has been noted in up to 9.2% of cadavers sampled.[37] A number of specimens lacked a distinct EPB muscle belly from the APL because the EPB is a phylogenetically young structure that is separated from the APL only in gorillas and humans.[34] Only 25% of the specimens maintained a traditional insertion point, with variations including the following: (1) complete insertion into the extensor hood, (2) proximal phalanx base and extensor hood, (3) proximal phalanx base and extensor hood with extensions with the EPL tendon to the base of the distal phalanx, and (4) extensor hood with EPL to the base of the distal phalanx.[36] Wide variation has even been noted between cadaveric hands from the same donor.[34-36] Multiple tendon slips have also been observed as has an osteofibrous septum separating EPB from APL in the first dorsal compartment.[37]

This variability in anatomy may contribute to the variations observed in the function of the EPB. Insertions into the base of the proximal phalanx would reasonably contribute to extension at the MCP joint of the thumb and abduction of the thumb and carpus. Brunelli and Brunelli[35] suggest that insertions completely to the extensor hood may serve only a

stabilizing function at the MCP joint. In 10 cadaveric hands, this insertion point was noted and tension on the EPB tendon failed to elicit action at the MCP joint or interphalangeal joint of the thumb.

A reasonable question then arises regarding the functional consequences of our observations. Failla[9] reported 3 cases of avulsion of the EPB tendon insertion into the MCP joint capsule of the thumb and concomitant rupture of the radial collateral ligament. Two of the cases presented subacutely with palmar subluxation of the MCP joint and substantial extensor lag associated with the injuries. These were not isolated injuries; they involved damage to the dorsoradial joint capsule and the RCL of the thumb. In addition, they were distal as opposed to proximal injuries of the EPB. Fujimoto and colleagues[12] reported patient inability to actively extend at the MCP joint in a case of mid-substance EPB tendon rupture. That finding was also supported by Batra and colleagues[11] who found an inability to extend the MCP against resistance with the interphalangeal joint of the thumb flexed. EPB has also been found to be instrumental in its phasic role in hand opening, the release phase of opposition, and key pinch.[38] This idea has been challenged by Johanson and colleagues[39] who looked at the contributions of the first dorsal compartment to key and opposition pinch postures between stable and unstable tasks. They found that the most critical muscles involved included APB and EPL, with the lowest activity levels being recorded from the EPB muscle. Numerous other studies have also countered these findings, citing no functional consequences after loss of EPB.[39-42]

Britto and Elliot[42] presented a complicated case requiring multiple operations and ultimately complete debridement of the EPB and APL because of keloid infiltration of the muscles and tendons. The authors reported only a minor loss of radial and dorsal extension of the thumb at the 1-year follow-up examination, with no loss of function regarding thumb tip, key pinch, or circumduction. They emphasized the ability of EPL, APB, and the first dorsal interosseous muscle to salvage motor function to the thumb in a case of complete loss of APL and EPB action.

Although the clinical effects of loss of contributions from the first dorsal compartment are not well delineated, options exist for proximal or distal injuries. The extensor indicis proprius (EIP) tendon transfer is most commonly cited in the literature for EPB rupture[11,12,38] because of its proximity and, more importantly, because it displays the same amplitude of movement and oblique ulnarward pull as those of the EPB.[38] Results during short-term follow-up have been reported to be excellent with this technique.[11,12] In cases in which EIP is not available, flexor carpi radialis has also been described as achieving some success for tendon transfer.[33]

The presence of a radial styloid fracture should raise suspicions for a greater spectrum of injuries that can contribute to multi-direction radiocarpal instability. Reduction and fixation of the styloid fragment addressed the potential radiocarpal instability. We report that the spectrum of injuries may even extend to include proximal damage to the extensor tendons of the first dorsal compartment. Although this damage may or may not contribute to functional loss with respect to thumb extension and abduction, the potential for its presence should be noted. In addition, it should also be noted that surgical options do exist if the tendon injury contributes to significant functional loss. It is difficult to hypothesize about the undetected injuries pertinent to the loss of the APL and EPB. Defining a pathological event can help to explain functional deficits. If avulsions were undetected, patients could experience decreased range of motion and decreased strength. Scarring and contracture of the avulsed tendons could result in tenodesis and associated functional deficit. Acknowledging the pathological condition can facilitate patient care by assisting in focused postoperative care.

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