Posttraumatic distal ulnar physeal arrest: a case report and review of the literature

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Abstract We report the case of a 12-year-old male who sustained a Salter–Harris (SH) type IV physeal fracture of the distal ulna and a SH type II fracture of the distal radius. At 34 months later, he presented with activity-related wrist pain and ulnar variance of -17 mm. He successfully underwent ulnar distraction osteogenesis with radial closing wedge osteotomy. At 16-month follow-up, the patient denied wrist pain with activity, and imaging demonstrated ulnar variance of -3 mm. Epiphyseal fracture separations of the distal radius and ulna have the potential to cause early growth arrest and may become symptomatic as a result. High-energy mechanism, open fracture, number of reduction attempts, and age at injury can all increase the risk of premature closure. Therefore, we recommend longitudinal follow-up of patients with these injuries as earlier intervention may improve outcomes. When premature physeal closure is discovered early, treatment may include resection of the physeal bar, osteotomy with or without epiphysiodesis, and distraction osteogenesis.

Introduction

Pediatric forearm fractures account for approximately 45 % of all childhood fractures. Fortunately, injuries to the distal ulnar physis are not common [9, 10], but when the physis is involved, there is a substantial risk of premature physeal closure (PPC) or arrest, reported as 55 % by Golz et al. [3]. Evidence suggests that these injuries may be increasing in

incidence, highlighting the importance of understanding the natural history and complications that may result from an injury commonly encountered in orthopedic practice. We present a clinical case and our treatment and discuss the literature concerning distal ulnar physeal arrest. We suggest that distal forearm fractures in patients with open physes be followed for evidence of PPC as early intervention may improve clinical outcome.

Case Report

A 12-year-old left-hand-dominant male sustained a right distal both bones forearm fracture following a fall while snowboarding at the age of 10 (Fig. 1). He was treated with closed reduction and discharged from care following healing of the fracture. The patient was first seen in our clinic 34 months later after a repeat fall on the wrist which prompted his pediatrician to order radiographs of his wrist (Fig. 2). He subsequently had an MRI (Fig. 3) and was referred for treatment. His primary complaint was activity-related wrist pain, but his activities, including sports, were not limited. Clinical exam revealed laxity of the distal radio-ulnar joint (DRUJ) in both pronation and supination, but no gross instability and no specific tenderness to palpation. Wrist, forearm, and elbow ranges of motion are documented in Table 1.

Due to the patient's symptoms, the increased radial inclination secondary to tether from the triangular fibrocartilage complex (TFCC), and the potential for ulnar translocation of the carpus, a decision was made with the patient and family to proceed with operative treatment. At 37 months post-injury, he underwent a closing wedge osteotomy (Hand Innovations, DePuy Orthopaedics, Warsaw, IN) of the radius with epiphysiodesis as well as osteotomy of the ulna and

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Fig. 1 **a, b** Anteroposterior (AP) and lateral radiographs of the right wrist at the time of injury demonstrate a Salter–Harris type IV physeal fracture of the distal ulna and a SH type II fracture of the distal radius

application of a uniplanar external fixator (Stryker, Kalamazoo, MI) for distraction osteogenesis to improve the ulnar variance.

Postoperative imaging demonstrated improvement in radial inclination and good alignment of the ulna with an initial distraction gap of 1 mm (Fig. 4a, b). Distraction was begun on postoperative day 6 at a rate of 1 mm/day. At 1 month, distraction was discontinued, and films revealed a distraction gap of 2 cm and neutral ulnar variance at the DRUJ (Fig. 4c). At 3 months, the patient noted some discharge from the proximal pin site and was placed on a 5-day course of antibiotics for a pin-tract infection that was resolved without further treatment. At 16 weeks, bony consolidation of the regenerate was apparent on all radiographic views (Fig. 4d), and the external fixator was removed. Follow-up radiographs revealed maintained alignment of

Fig. 2 **a, b, and c** AP, lateral, and oblique radiographs of the right wrist at 34 months after injury. Ulnar variance measures -17 mm with 45° of radial inclination

Fig. 3 **a, b** Sagittal and coronal T1-weighted MRIs through the distal ulna, demonstrating a bony bridge centrally within the ulnar physis. The TFCC is intact but elongated

the radius and ulna. At 16 months postoperatively, the patient was satisfied with his outcome and denied complaints of wrist pain with activity, including sports. Clinical examination showed the DRUJ to be stable in both pronation and supination, and the patient denied pain with stressing of the dorsal and palmar radioulnar ligaments. Imaging revealed complete healing of the ulnar osteotomy site with improvement in ulnar variance to -3 mm and radial inclination of 15° (Fig. 4e, f). Postoperative range of motion values are listed in Table 1 and illustrated in Fig. 5.

Discussion

Fractures involving the physis are seen in 20–30 % of all pediatric fractures with those involving the distal radius accounting for 28 %, second in frequency only to phalanx fractures [9, 10]. By contrast, distal ulnar physeal fractures are far less common, estimated at 2–5 % of all physeal injuries [9, 14]. Although injury to the ulnar styloid and the TFCC occurs commonly in association with a distal radial metaphyseal fracture, up to 34 % in one series [1], the injury is rarely propagated into the ulnar physis, possibly due to a protective cushioning effect of the TFCC [3].

Interestingly, while epiphyseal fracture separations involving the distal radius are common, PPC and associated sequelae of pain, limitation of range of motion, and deformity are relatively uncommon. Cannata examined 163 physeal fractures of the distal forearm treated nonoperatively and reported that 29 % progressed to develop growth disturbance at long-term follow-up; however, more than 90 % of these patients were asymptomatic. Only 5 % had radiographic radial shortening of more than 1 cm and were symptomatic as a result [1].

Table 1 Range of motion preoperatively and at the time of most recent follow-up at 16 months postoperatively

	Elbow		Wrist		Deviation		Forearm rotation	
	Flexion	Extension	Dorsiflexion	Palmarflexion	Radial	Ulnar	Pronation	Supination
Preop	145/145	0/0	80/75	65/60	15/20	35/40	85/85	85/85
Postop	145/145	0/0	75/80	70/70	25/20	30/40	85/85	85/85

Values listed as right/left, in degrees of movement

In contrast to this relatively low risk of symptomatic radial growth arrest, the risk of growth disturbance of the ulna following physeal fracture has been reported as 55 % [3]. In this series, most of the patients remained asymptomatic and primarily had complaints of cosmetic deformity and slight limitation of radial deviation. Zimmerman and colleagues retrospectively reviewed more than 200 distal forearm fractures with average follow-up of 21 years. In their series, they reported a 4 % incidence of distal ulnar physeal fractures, which is consistent with other reports. Ten percent of their cases had negative ulnar variance, and only one case complained of pain at the DRUJ with activity [17]. Therefore, while the incidence of PPC following distal ulnar injury may be high, long-term complications seem to be less frequent.

Although the Salter–Harris (SH) classification is commonly used to classify physeal fractures, this seems to be of less prognostic importance than other factors, including age at injury, amount of growth remaining, high-energy mechanism, presence of open fracture, and number of

attempted reduction maneuvers, in predicting risk of progressing to PPC [1, 3, 8]. The distal ulnar physis contributes 70–80 % of longitudinal growth to the ulna, which means that PPC can result in significant deformity if injury occurs at an age when substantial growth potential remains. Lee and colleagues reviewed 100 cases of distal forearm physeal injury and reported that eight of ten patients with premature radial growth plate closure sustained SH type II injuries. The authors concluded that mechanism of injury and repeated reduction attempts were more important than fracture pattern itself in predicting PPC [8].

Our patient presented after sustaining a sports-related, closed, SH type IV physeal fracture of the ulna that only underwent one reduction attempt. Despite not presenting with risk factors identified in the literature, this patient still went on to develop PPC. Other authors have previously reported this particular combination of a SH II fracture of the radius with SH IV fracture of the ulna progressing to premature ulnar arrest [2, 12]. Our case therefore reinforces the importance of close follow-up in this type of injury.

Fig. 4 **a, b** Postoperative AP and lateral radiographs and **c** AP radiograph at 4 weeks showing distraction gap of 2 cm. **d** AP radiograph at 16 weeks showing consolidation of the regenerate and neutral ulnar variance. **e, f** AP and lateral radiographs at final 16-month follow-up

Fig. 5 **a, b, c, and d** Clinical photographs demonstrating **a** wrist extension, **b** wrist flexion, **c** pronation, and **d** supination at 16 months following surgery

Surgical indications include cosmetic deformity, progressive carpal subluxation, and decreased wrist range of motion. Treatment options need to be individualized to each patient and depend on the amount of remaining growth expected. Options for patients with open physes include resection of the epiphyseal bar, epiphysiodesis of the distal radial epiphysis, and ulnar lengthening. Once maturity is reached, options include a closing wedge osteotomy of the radius or ulnar lengthening. Yamamoto and colleagues reported the case of a 13-year-old male who sustained a pronation injury to the wrist and developed an ulnar minus wrist from a SH type I injury to the distal ulnar physis. At 11 months post-injury, the patient had a negative ulnar variance of 8 mm and underwent ulnar lengthening osteotomy. These authors placed their osteotomy 9 cm distal to the olecranon and performed their lengthening at 0.5 mm/day. At 1 year postoperatively, the patient demonstrated an ulnar variance of −4 mm and had no complaints of pain [16].

Outcomes following surgical intervention for PPC are generally good. Page and colleagues described four patients treated with distraction osteogenesis for symptomatic premature radial arrest of >5 mm. At 112 months, all patients were nearly pain free, and the authors report two fair, one good, and one excellent outcome as measured by the Mayo wrist score. Complications included pin-tract infections in three patients [13]. Waters reported on 30 patients with posttraumatic distal radial growth arrest treated with a variety of interventions including ulnar shortening osteotomy, ulnar epiphysiodesis, radial osteotomy, or a combination thereof. Outcomes at 21 months showed improvement in functional wrist scores in all patients, with 100 % reporting good to excellent results. Complications included one fracture through the radial osteotomy and two unplanned reoperations for continued ulnar overgrowth [15].

Physeal bridge resection is indicated in patients with 2 years of skeletal growth remaining, if the bridge involves

less than 50 % of the physis, and in the absence of existing growth disturbances such as increased radial inclination, radial bow, or a substantial length difference between the ulna and radius. Outcomes are improved with earlier time from injury to resection; moreover, the smaller area of the physis involved the better the outcome [4]. Bridge resection was not performed in our patient as he had a preexisting ulnar variance of −2 cm, and physeal bar excision was felt to yield unpredictable results.

Preoperative clinical laxity of the DRUJ in this patient can be correlated with the MRI findings shown in Fig. 3, which demonstrates elongation with likely incompetence of the primary or intrinsic stabilizers of this joint, namely, the dorsal and palmar radioulnar ligaments (DRUL/PRUL). The lack of gross instability preoperatively is hypothesized to result from the secondary stabilizers including dynamic support from the extensor carpi ulnaris tendon, the superficial and deep heads of the pronator quadratus, and the interosseous membrane (IOM) [7]. This view is supported by biomechanical data from Kihara and colleagues demonstrating relative stability of the DRUJ following isolated sectioning of the DRUL and PRUL, but instability to stress testing after additional disruption of the pronator quadratus and distal portion of the IOM [5]. More recently, anatomic studies have identified a thick band within the distal IOM that runs from the distal 10–15 % of the ulna to insert on the sigmoid notch of the radius [11]. This distal oblique bundle (DOB), when present, provides additional stability to the DRUJ [6]. As lengthening in this patient was performed through an osteotomy proximal to the origin of this ligament, it is possible that the DOB contributed significantly to the clinical observation of DRUJ stability postoperatively.

In summary, pediatric forearm fractures are common, and although growth arrest is not common, we recommend longitudinal follow-up of patients with forearm fractures involving the radial or ulnar physis to evaluate for premature

physeal closure. When premature physeal closure is discovered early, treatment may include resection of the physeal bar, osteotomy with or without epiphysiodesis, and distraction osteogenesis, with the potential to allow continued growth of the extremity.

Conflict of interest None.

References

1. Cannata G, De Maio F, Mancini F, et al. Physeal fractures of the distal radius and ulna: long-term prognosis. *J Orthop Trauma*. 2003;17:172–9. discussion 179–80.
2. Carbonell PG, Rey EF, Vicente-Franqueira JR, et al. Infrequent physeal wrist injury of the ulna and radius: a case report. *Strategies Trauma Limb Reconstr*. 2008;3:123–5.
3. Golz RJ, Grogan DP, Greene TL, et al. Distal ulnar physeal injury. *J Pediatr Orthop*. 1991;11:318–6.
4. Khoshhal KI, Kiefer GN. Physeal bridge resection. *J Am Acad Orthop. Surg*. 2005;13:47–8.
5. Kihara H, Short WH, Werner FW, et al. The stabilizing mechanism of the distal radioulnar joint during pronation and supination. *J Hand Surg Am*. 1995;20:930–6.
6. Kitamura T, Moritomo H, Arimitsu S, et al. The biomechanical effect of the distal interosseous membrane on distal radioulnar joint stability: a preliminary anatomic study. *J Hand Surg Am*. 2011;36:1626–30.
7. Kleinman WB. Stability of the distal radioulnar joint: biomechanics, pathophysiology, physical diagnosis, and restoration of function what we have learned in 25 years. *J Hand Surg Am*. 2007;32:1086–106.
8. Lee BS, Esterhai Jr JL, Das M. Fracture of the distal radial epiphysis. Characteristics and surgical treatment of premature, post-traumatic epiphyseal closure. *Clin Orthop Relat Res*. 1984;185:90–6.
9. Mann DC, Rajmaira S. Distribution of physeal and nonphyseal fractures in 2,650 long-bone fractures in children aged 0–16 years. *J Pediatr Orthop*. 1990;10:713–6.
10. Mizuta T, Benson WM, Foster BK, et al. Statistical analysis of the incidence of physeal injuries. *J Pediatr Orthop*. 1987;7:518–23.
11. Noda K, Goto A, Murase T, et al. Interosseous membrane of the forearm: an anatomical study of ligament attachment locations. *J Hand Surg Am*. 2009;34:415–22.
12. O'Hagan T, Reddy D, Hussain WM, et al. A complex injury of the distal ulnar physis: a case report and brief review of the literature. *Am J Orthop (Belle Mead NJ)*. 2012;41:E1–3.
13. Page WT, Szabo RM. Distraction osteogenesis for correction of distal radius deformity after physeal arrest. *J Hand Surg Am*. 2009;34:617–26.
14. Peterson CA, Peterson HA. Analysis of the incidence of injuries to the epiphyseal growth plate. *J Trauma*. 1972;12:275–81.
15. Waters PM, Bae DS, Montgomery KD. Surgical management of posttraumatic distal radial growth arrest in adolescents. *J Pediatr Orthop*. 2002;22:717–24.
16. Yamamoto K, Tateiwa T, Takaaki S, et al. Treatment of epiphyseal injury of the distal ulna without associated radial fracture. *Orthopedics*. 2006;29:157–9.
17. Zimmermann R, Gschwentner M, Kralinger F, et al. Long-term results following pediatric distal forearm fractures. *Arch Orthop Trauma Surg*. 2004;124:179–86.