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Case Report

The importance of adequate diagnosis of pediatric forearm bowing fractures: A case report

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ABSTRACT

Introduction: Correct diagnosis of pediatric bowing fractures has proven to be challenging. Consequently, these entities are often underdiagnosed both at the initial presentation and at further follow-up. We present a case of an ulnar fracture with subsequent non-union and initially missed associated plastic deformity of the radius to highlight the importance of adequate diagnosis of bowing fractures and obtaining appropriate imaging in pediatric forearm trauma to prevent sequelae.

Case presentation: A 13-year old male sustained a diaphyseal fracture of the left ulna after a fall on the outstretched hand which was treated conservatively. A non-impact incident (push up on outstretched arm) 4.5 months after the initial trauma caused an ulnar fracture at the same location and was initially considered a simple refracture. Operative treatment was decided on due to significant clinical forearm valgus alignment. Intraoperatively however, a mobile non-union of the ulna was found and anatomic reduction was not possible due to radial bowing. Exploration of the radius showed a clear malalignment with periosteal callus reaction, indicative of a mal-union of the radial bone as a result of the initial injury. To correctly restore alignment, a closing wedge osteotomy of the radius was necessitated followed by plate and screw fixation of both the radius and the ulna.

Conclusion: In this patient, failure of recognizing the associated plastic deformity of the radius during the initial presentation led to radial malunion and non-union of the ulna. As a result of this complication, an osteotomy was necessary which probably could have been prevented if an adequate initial diagnosis had been made.

Introduction

Plastic deformities or bowing fractures are incomplete fractures of tubular long bones and occur as a plastic response to longitudinal stress [1]. They predominantly take place in the pediatric population where the radius and ulna are the most frequently described injury sites and often originate from a fall on the outstretched hand. Furthermore, bowing fractures of the forearm can occur either isolated or in conjunction with joint dislocation or a fracture of the accompanying bone [2]. Correct diagnosis has proven to be challenging due to the absence of a clear cortical defect on radiographic images, the possibility of the plastic deformity only being

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visible on a strict anteroposterior (AP) or lateral view and the lack of or late formation of periosteal callus formation [3]. Consequently, these entities are often underdiagnosed both at initial presentation and at further follow-up. Clinical bowing of the forearm can also be subtle and these injures are often treated by junior residents who might lack experience in pediatric trauma and interpreting pediatric radiographic images. In this case report, the importance of correct diagnosis of bowing fractures and of obtaining adequate imaging in pediatric forearm trauma to prevent sequelae is highlighted. We present a case of an ulnar fracture with subsequent non-union and initially missed associated plastic deformity of the radius.

Case presentation

A 13-year old male presented to another trauma-center after a fall on his outstretched left hand and was diagnosed with an isolated, non-displaced diaphyseal fracture of the left ulna (Fig. 1A). Further follow-up was performed at his hometown hospital where at two weeks post-trauma no clinical malalignment of the forearm was noted and only ulnar tenderness was present. Control radiographs were taken at two weeks and at 6 weeks (Fig. 1B; C). Although the initial radiographs were not available at the two-week control visit, the fracture of the ulna was undisplaced and joint congruity was normal. The radial bowing was considered to be physiological at two weeks despite the image not being a strict lateral view. Conservative treatment was continued with an above-elbow cast for a total of 6 weeks after which 70° of pronation and 75° of supination were noted. No tenderness was present immediately after removing the cast and free movement and full activity were allowed despite the minimal callus formation on the volar side of the ulna.

A non-impact incident (push up on outstretched arm) three months after his last follow-up visit caused an ulnar fracture at the same location with noticeable clinical valgus alignment of the forearm (Fig. 2A). At the time, it was considered a simple refracture and operative treatment was decided on due to the significant clinical bowing. Intraoperatively, a mobile non-union of the ulna was found and reduction was challenging. The bone could not accommodate to the LC-DCP (Limited contact dynamic compression plate, Synthes) plate without excessive bending of the plate itself or applying to much stress to the ulna (Fig. 2B). It was assumed that an associated acute radial bowing fracture prevented correct ulnar reduction and the decision was made to explore the radius using the Henry-approach. Remarkably, no radial fracture hematoma or any macroscopic indication of recent trauma was present. However, there was a clear malalignment of the radius with periosteal callus reaction, indicating a mal-union of the radial bone. To correctly restore the alignment, a closing wedge osteotomy of the radius was performed at the point of maximal deformity and consequently optimal accommodation of the ulna to the ulnar plate was possible with full rotational range of motion intraoperatively (Fig. 2C). Additionally, the osteotomy of the radius was fixed with an LC-DCP plate. The procedure was followed by 5 days of cast immobilization and fracture healing with fully unhindered and pain-free mobility was documented at 3 months and 5 years postoperative (Figs. 2D, 3).

Discussion

In this patient, failure of recognizing the associated plastic deformity of the radius during the initial presentation led to radial malunion. A causal relationship with the subsequent non-union of the ulna is probable as this is a very unlikely outcome in a 13-year-old healthy patient. Presumably, the radial bowing altered the complex interrelation between the radius and the ulna which led to an inappropriate mechanical alignment and prevented uneventful healing of the ulna. Refractures are common for pediatric diaphyseal

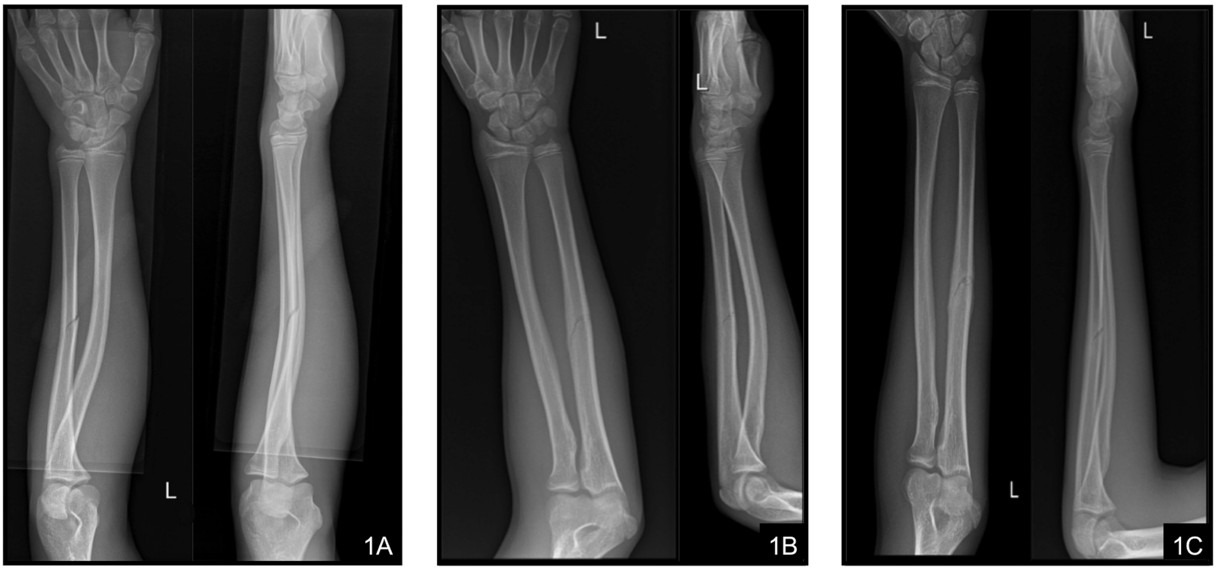

Fig. 1. Radiographic imaging after initial injury. Anteroposterior and lateral radiographs the day of the trauma (A); two weeks post-trauma (B) and at 6 weeks of follow-up (C).

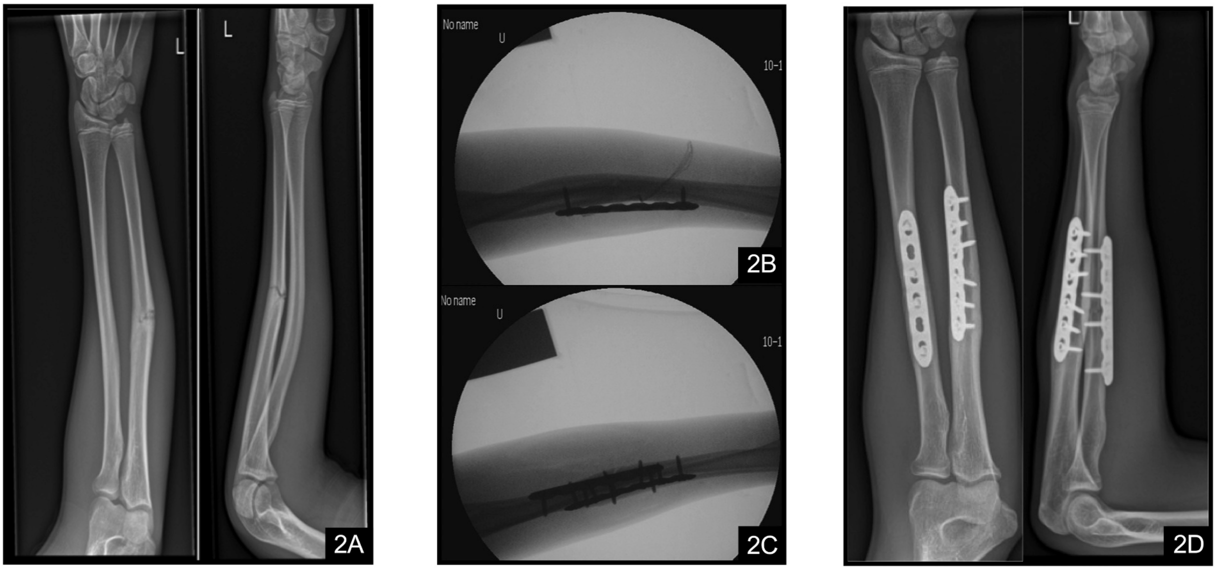

Fig. 2. Radiographic imaging after second injury. Anteroposterior and lateral radiographs after non-impact incident show fracturing of the ulna at the same location of the initial injury (2); intraoperative imaging prior to and after the closing wedge osteotomy (B and C, respectively). Anatomic reduction of the ulna was not possible prior to the radial osteotomy (B); radiographic imaging at 3 months post-op shows healing of the ulna fracture and the osteotomy site (D).

fractures. Intraoperatively however, there was a clear lack of volar callus formation at the initial ulnar fracture site, which makes primary healing unlikely. When considering the absence of impact as well as the timeframe of 18 weeks after the initial injury in this healthy child, this was considered an ulnar non-union rather than a refracture. The occurrence of a radial plastic deformity consolidating in a mal-aligned position and causing delayed union of the ulna has, to the best of our knowledge, not been previously described in the literature. As a result, a more invasive osteotomy was necessary which probably could have been prevented if an adequate initial diagnosis had been made.

In retrospect, noticeable bowing of the radius was visible on the initial and follow-up radiographs. A method described initially by Schemitsch and Richards and modified by Firl et al. uses AP forearm radiographs to estimate both the degree and the site of maximal bowing as percentages of the total length of the radius [4,5]. Based upon 100 children the mean values calculated were 7.2% (95% CI of 7.0 to 7.4) and 60.4% (95% CI 59.7 to 61.1), respectively. When applying this method to the first AP radiograph taken in our patient, the maximal bowing was 9.4% and the site of maximal bowing was found at 54.8% of the length of the radius (Fig. 4). While both these measurements are indicative of a bowing fracture, this method is advised solely for a strict AP view and only considers bowing of the radius found on this incidence, making it less suitable for fractures that are only seen on lateral views. In doubtful cases, we advise on obtaining contralateral radiographs for comparison and emphasize the importance of getting both strict lateral and AP views for proper evaluation of pediatric forearm trauma, even if this means having radiographs retaken.

The therapeutic management of plastic deformities depends on age, the severity of bowing and presence of associated injuries [6]. It can be argued that even if the initial subtle bowing fracture was diagnosed, conservative treatment in the form of an above-elbow cast would still have been appropriate. Spontaneous remodeling of plastic deformities is to be expected in younger children. The remodeling potential however, differs significantly between age groups and Vorlat et al. noted a clear lack of remodeling in children older than ten, thus warranting a closed reduction in our case [6]. This patient denied any pain or other symptoms during activities of daily life in the period between the 6-week follow up and the second incident which is remarkable in the case of nonunion. Due to bony impingement and tensioning of the interosseous membrane in forearm malalignment, reduced rotational mobility is a known complication of radial malunion [7]. Nonetheless, the relatively small clinical rotational deficit at 6 weeks was attributed to stiffness due to prolonged immobilization and could have been compensated for in daily non-strenuous activities by shoulder rotation.

In summary, our take home-messages are (I) to be on guard for associated injuries such as plastic deformities in diaphyseal pediatric forearm fractures; (II) obtain adequate imaging with strict AP and lateral views even in a trauma setting and (III) consider closed reduction of bowing fractures in children >10 years old.

Conclusion

In this patient, failure of recognizing the associated plastic deformity of the radius during the initial presentation led to radial malunion and non-union of the ulna. As a result of this complication, an osteotomy was necessary which probably could have been prevented if an adequate initial diagnosis had been made.

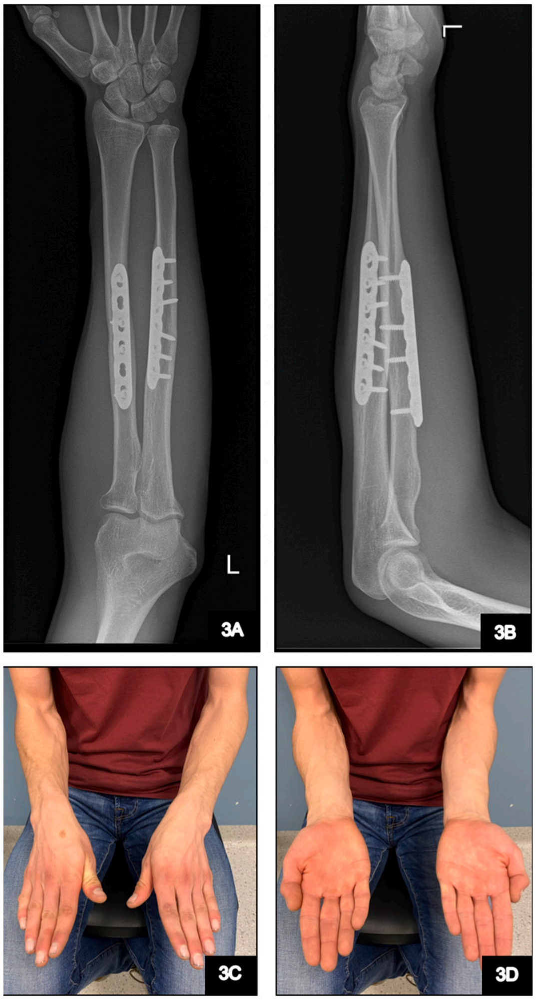

Fig. 3. Radiographic and clinical imaging at 5 years postoperatively. AP and lateral radiographs at final follow-up. Clinical imaging shows symmetrical forearm rotation for both pro- and supination.

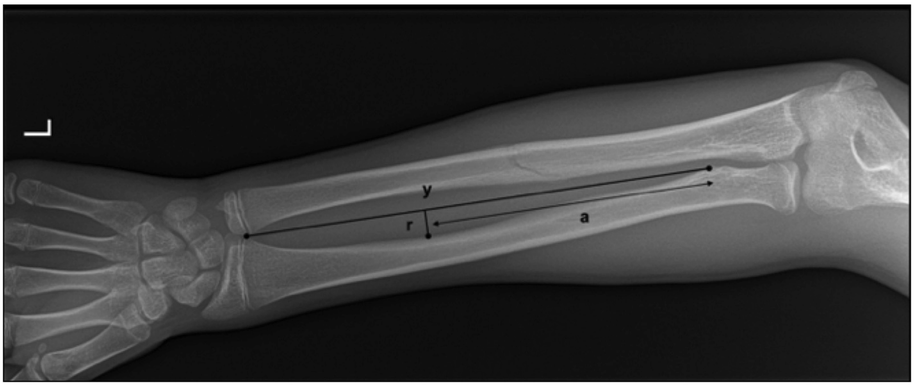

Fig. 4. Radial bowing measurement, method by Schemitsch and Richards on anteroposterior radiographic forearm imaging. (y) Line from bicipital tuberosity to distal radial epiphysis; (r) perpendicular line to the point of maximal radial bowing; (a) distance from point of maximal bowing to bicipital tuberosity. Radial bowing indicated as a percentage of radius length = $r / y \times 100$ (>10% indicative of plastic deformity).

Declaration of competing interest

The authors declare that they have no competing interests.

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