

Refracture of the Pediatric Forearm with Intramedullary Nails in situ

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Learning Point of the Article:

Management of unusual presentation of re-fracture of paediatric fracture with nails in-situ.

Abstract

Introduction: There are few described cases in literature describing the management of refracture of both bone forearm fractures with elastic stable intramedullary nails (ESIN) in situ. We describe our experience and discuss it in the context of existing reports.

Case Report: A 6-year-old girl presented to our unit with a refracture of her forearm with ESIN in situ following a trauma, 5 months post her index injury and ESIN procedure. She was managed with closed reduction under general anesthesia with a good outcome.

Discussion: Treatment of this unusual injury is challenging given the paucity of evidence to inform management. Many existing case series fail to report this complication. We echo those studies that have employed similar strategies and note potential complications associated with this management including altered biomechanics of the ESIN.

Conclusion: Closed reduction of a refracture of pediatric forearm with ESIN in situ is an acceptable approach to this unusual injury. Caution must be taken intraoperatively and postoperatively to account for any biomechanical deficiencies in the ESIN resulting from the forces applied to cause the refracture and forces applied to the in situ nails to achieve correction intraoperatively.

Keywords: Both bone fracture forearm, Elastic nails in situ, Elastic nails, Flexible nails, Forearm fractures, Intramedullary nails, Radial shaft fracture, Refracture, Orthopedics, Pediatrics, Titanium elastics nailing system nails, Ulnar shaft fracture.

Introduction

Elastic stable intramedullary nailing (ESIN) is a well-accepted method of fracture fixation in the pediatric population with minimal complications [1, 2, 3]. The biomechanical principles underlying that this fixation is based on the symmetrical bracing action of two elastic intramedullary nails at the inner cortex [4]. This relative stability construct is suitable for fractures of bones with a narrow medullary canal and where flexibility is required, for example, pediatric forearm fractures. Refracture with ESIN in situ is a relatively uncommon complication of ESIN, with some literature reporting a 1.2% incidence [5]. There are few described cases in literature describing the management of refracture of both bone forearm

fractures with intramedullary nails in situ. Theoretically, the management could include removal of the nails, with or without subsequent nail exchange, open reduction internal fixation, or molded cast. We describe our experience of employing an alternative approach to this unusual injury.

Case Report

A 6-year-old girl presented to our unit following a fall at school onto an outstretched hand. She was known to our unit having had sustained a mid-shaft both bone forearm fracture (Fig. 1a) which was subsequently treated with flexible IM titanium elastics nailing system (TENS) (IM, intramedullary; TENS DePuy Synthes) nails 5 months prior (Fig. 1b). ESIN nails are

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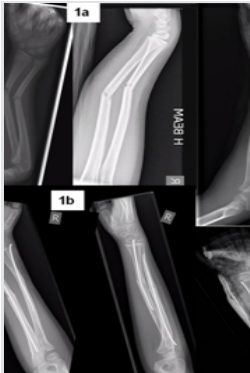


Figure 1: (a) X-ray of the right forearm at initial presentation $t=0$. (b) X-rays at planned follow-up 4 months later, $t=4/12$.



Figure 2: Clinical presentation after a second fall, 5 months post-initial fracture and elastic stable intramedullary nails (ESIN), corresponding to X-ray seen in Figure 2a, refracture with ESIN.

composed of titanium (Ti-6Al-4V), with a modulus of elasticity closer to the bone than stainless steel. On presentation to ED, she had an obvious right upper limb deformity (Fig. 2) but denied pain. This was an isolated injury, she was clinically stable and her distal neurovascular status was intact. X-rays revealed a fracture through her previous fracture site (Fig. 3a). She was brought to theater and managed through a closed reduction under general anesthesia, correcting the angle of the IM nails until acceptable reduction was achieved (Fig. 3b). Our patient was discharged well the following day. She went onto have an excellent recovery, routine follow-up in clinic allowing for confirmation of radiological and clinical fracture union (Fig. 4a). The IM nails were then removed 6 months following her refracture (11 months total in situ, Fig. 4b) and she has been since discharged well from our service.

Discussion

ESIN is a well-established method of fracture fixation in the



Figure 3: (a) X-rays following second fall and representation 5 months after initial trauma, $t=5/12$. (b) X-rays showing position following manipulation under anesthesia and casting with elastic stable intramedullary nails in situ.



Figure 4: (a) X-rays showing status of forearm at $t=6/12$ post refracture (and 11 months post-initial fracture). (b) X-rays post removal of elastic stable intramedullary nails, $t=7/12$ post-fracture (and 12 months post-initial fracture).

pediatric population with minimal complications [1, 2, 3]. There is a paucity of research surrounding the management of complications of this well-accepted treatment approach. There is a number of case series reviewing pediatric forearm fractures managed with ESIN including 175 patients in Sweden [1], 120 in the UK [6], 85 in France [7], 202 in Germany [8], 50 in India [3], and 205 in USA [9]. However, these case series do not report the specific complication that we were presented with in this case, i.e., refracture with ESIN in situ. Fernandez et al. in their large case series of 553 pediatric forearm fractures treated with ESIN, describe a 2.5% incidence of refracture with ESIN in situ ($n = 14$) (10). In five of 14 such cases, they describe an early second trauma, i.e., <6 weeks after the first fracture resulting in loss of correction without fracture healing. In eight of the remaining nine cases, the fracture was fully consolidated, and a refracture due to a second trauma then resulted. One of the nine cases where refracture occurred after 6 weeks was found to be a delayed union [10]. The authors do not give details as to how these 14 refractures were subsequently managed. Kelly et al. reported a 1.2% incidence of refracture of the pediatric forearm with ESIN in situ in their series of 485 pediatric forearm fractures. 1.2% presented with refracture with ESIN making this the largest case series with subsequent management approaches published for this presentation ($n = 6$) [5]. In all six patients, fractures resulted from a second traumatic event after radiographic healing but before implant removal at a mean of 13.0 months from the initial procedure [5]. The mean angulation of the refracture was 28.4° (Range 4° – 51°). One patient had an adequately aligned fracture and was treated conservatively with casting without reduction. The remaining five patients were brought to the operating room for treatment under general anesthetic. Two patients underwent ESIN exchange, and two patients were treated with ESIN removal and subsequent open reduction internal fixation with plating without an attempt at closed reduction. The authors explain their rationale for this approach in the latter was due to patient's age (16 years). Only one patient underwent a closed reduction in this case series. The authors report good outcomes in all six cases with the uncomplicated radiographic union at a mean 3.6 months post their refracture. Muensterer and Regauer described their successful outcome of a closed reduction with ESIN in situ of a 13-year-old presenting with refracture 1 month post-initial injury and index ESIN procedure [11]. Van Egmond et al. described a similar case of a 12-year-old boy presenting at 9 weeks after his initial trauma (8 weeks after operative management) with a refracture of the radius, with the intramedullary nail in situ, angulated 29° in the lateral and associated traumatic S-shape bending of the intramedullary nail [12]. These authors also performed a closed reduction with successful outcomes reported at 1 year. Shahid et al. described a

variant to the closed reduction we utilized. Their case involves a 10-year-old girl who sustained a refracture at 3 months following her initial injury and ESIN procedure. The fracture resulted in 20° volar angulation of the radius with ESIN in situ. The authors brought this patient to theater for partial removal of the ESIN so that the deformed ESIN was transferred away from the fracture site and a “straight” section of the ESIN was brought to the fracture site to allow for fracture reduction and stabilization. Thus, they also reduced the fracture with the existing ESIN in situ and describe a good outcome from this approach. Closed reduction of refracture with ESIN is not without potential complications, in particular compromising the nail biomechanical properties rendering it susceptible to implant failure and breakage. Mittal et al. described their experience with attempted closed reduction of a refracture of pediatric forearm fracture with an elastic nail in situ. Closed reduction failed and the elastic nail in the ulna broke during attempted reduction [13]. Muensterer and Regauer also described some disadvantages in their case report and investigations into the proof stress of the nails following a force that resulted in refracture [11]. The authors deduce that physically bending the ESIN would result in compromised proof stress, i.e., that lower forces are required for plastic deformation of the previously bent nails (37% less force required) and an associated difference in the spring constants. The authors maintain that so long as precautions are taken to

avoid excessive strain on the reduced nails intraoperatively and postoperatively, the procedure of (re)fracture reduction with ESIN in situ is safe, effective, and minimally invasive [11]. It is thus paramount that a patient who is treated with closed reduction of a refracture with associated deformed ESIN should be instructed to avoid any excessive forces to the forearm until fracture union has been documented radiologically [11].

Conclusion

This report adds to the growing body of literature that closed reduction of a refracture of the pediatric forearm with ESIN in situ is an acceptable approach to this unusual injury. This approach can be applied in cases where the in situ nails themselves have not fractured. However, caution must be taken intraoperatively and postoperatively to account for any biomechanical deficiencies in the ESIN resulting from the forces applied to cause the refracture and forces applied to the in situ nails to achieve correction intraoperatively.

Clinical Message

Closed reduction of a refracture of the pediatric forearm with ESIN in situ is an acceptable approach to this unusual injury.

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