



Radius-only intramedullary nailing for both-bones diaphyseal forearm fractures in children

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Both-bones diaphyseal forearm fractures are common injuries in the paediatric age group and are potentially unstable. Both-bones intramedullary nailing for these fractures is a minimally invasive procedure that maintains alignment, and promotes rapid bony healing. Good results have also been shown with single-bone fixation. We report our experience in treating these common injuries with radius-only intramedullary nailing in 29 children. The clinical notes and radiographs were reviewed retrospectively. There were 9 girls and 20 boys ; the mean age at the time of operation was 9 years (range : 5 to 17 years). Closed reduction was achieved in 21 patients, while eight patients required open reduction. Mean duration of follow-up was 6.8 months (range : 4 to 12 months). All fractures achieved clinical and radiological union at 6-8 weeks. Radius-only intramedullary nailing is a sufficient and effective option in treating both bones paediatric forearm displaced unstable type AO 22-A3 fractures, with excellent functional outcome and union rates.

Keywords : paediatric forearm fractures ; radius-only ; intramedullary nailing.

INTRODUCTION

Diaphyseal forearm fractures are common injuries in the paediatric age group (3). Various modalities of treatment have been described in the literature for these injuries including conservative management with application of plaster cast, with or without manipulation, surgical fixation using

plates and screws or intramedullary nailing. The latter option has been popular as a minimally invasive procedure that maintains alignment, and promotes rapid bony healing (14,23). It has also been shown to produce results comparable to plate fixation, with fewer complications (14,23).

Both-bones paediatric diaphyseal forearm fractures are potentially unstable (5,9), and when intramedullary nailing is the chosen treatment option, both bones are fixed in most cases (9,13,15,22). However, single bone fixation for these injuries has also shown good results (6,7,14,15), providing a biomechanically stable construct (8). We report our experience in treating these common injuries with radius-only intramedullary nailing (IMN).

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Fig. 1. — Preoperative radiograph

PATIENTS AND METHODS

Between August 2004 and August 2008, 64 children presented to our unit with diaphyseal both-bones forearm fractures (Fig. 1). Of those, 29 children fulfilled all the criteria that made them suitable for treatment with radius-only IMN using TEN (Titanium Elastic Nail, SYNTHES, UK), in accordance with the department practice : displaced unstable Type 22-A3 fractures in the AO/Müller Classification (simple diaphyseal fractures of both the radius and ulna), without epiphyseal involvement.

Clinical notes and radiographs of those 29 children were reviewed retrospectively. The following clinical and radiological information was extracted : sex, age, side, type of fracture in the AO classification, mode of reduction, complications, time to consolidation, follow-up duration. The other 35 children did not satisfy the criteria and were treated with plaster application without manipulation (undisplaced, non-angulated : $n = 22$) or following manipulation under anaesthesia (undisplaced, angulated : $n = 10$) or, both-bones IMN (22.B3 type with ulna wedge fracture : $n = 2$) or plating (comminuted : $n = 1$).

Surgical Technique

Successful reduction of the radius was achieved with or without opening the fracture site. If the ulnar fracture was not reduced spontaneously with the radius, no attempt was made to reduce the ulna. Radius-only IMN was done using the technique described by Lascombes *et al* (13). A tourniquet was applied in all cases and only inflated where open reduction was necessary. A small incision measuring up to 2 cm was made on the lateral aspect of the radius proximal to the distal growth plate. Careful blunt dissection was carried out to avoid

damaging the neurovascular structures. An oblique hole was drilled in the lateral cortex of the metaphysis angled at 45 degrees relative to the elbow. A pre-bent nail was inserted and pushed in rotatory fashion and when the nail tip was close to the fracture site, a further manipulation of the fracture was performed to negotiate the nail into the proximal fragment up to the proximal epiphysis. To attain the optimal reduction of the fracture, the nail was rotated inside the medullary canal. The size of the nail used was approximately 50% the diameter of the thinnest part of the diaphysis. To facilitate easy removal of the nail, care was taken not to cut the distal end too short and 5-6 mm length of the nail was left outside the lateral cortex (Fig. 2). The wound was closed over the distal end of the nail.

RESULTS

Table I shows the results of this study. Twenty seven out of the 29 children who underwent radius-only IMN had closed and 2 had open (Grade I Gustilo and Anderson) injuries. There were 9 girls and 20 boys and the mean age at the time of operation was 9 years (range : 5 to 17 years). There was a 17-year old girl in this series who was skeletally immature with open physes, the decision was made to treat her injury as a paediatric rather than an adult forearm fracture. Eleven patients had left forearm injuries and 18 had right forearm injuries. Closed reduction was achieved in 21 patients, while eight patients required open reduction. All patients had radius-only IMN. All patients were reviewed regularly at 2 weeks, 6 weeks and 4 months. The forearm was immobilised until the fracture had demonstrated clinical and radiological signs of union (Fig. 3). Mean duration of final follow up was 6.8 months (range : 4 to 12 months).

As per the recommendations by Myers *et al* (15), all patients were immobilised in a plaster cast following surgery for 4 to 6 weeks except one patient who had plaster cast immobilisation for 8 weeks due to loosening of the initial plaster at week 3, and an extended period of immobilisation was recommended by the senior author. All fractures achieved clinical and radiological union at 6-8 weeks, with full supination and pronation at the final follow up. A planned removal of the nail was performed for all children at 10-12 weeks.

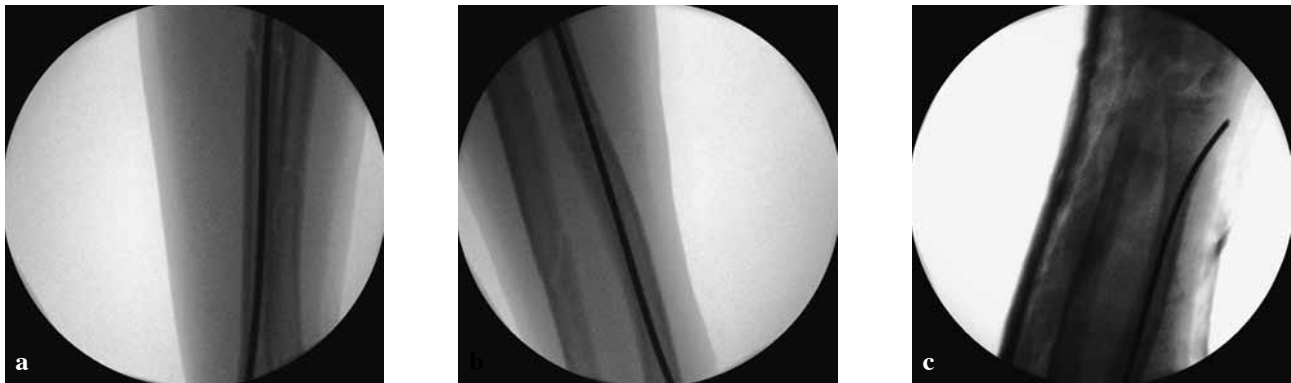


Fig. 2. — Intraoperative radiographs

Table I. — Demographics, results and follow-up

N	Gender	Age (years)	Side	Procedure	Period of immobilisation (weeks)	Complications	Total Follow-up (months)
1	M	8	L	CRIF	5		4
2	M	6	L	ORIF	6	Infection (ORAL AB)	4
3	M	4	R	CRIF	5		5
4	M	5	R	ORIF	6		5
5	M	10	L	CRIF	6		5
6	F	5	L	CRIF	5	Re-fracture (3 months post removal)	8
7	M	11	L	CRIF	8		5
8	F	6	R	CRIF	6		5
9	F	17	R	ORIF	6		5
10	F	5	R	CRIF	6		5
11	M	11	R	CRIF	6		5
12	M	12	R	CRIF	6		5
13	M	6	L	ORIF	5	Infection (ORAL AB)	5
14	M	8	R	CRIF	4		6
15	M	11	R	ORIF	6		6
16	M	5	L	CRIF	6	Re-fracture (4 months post removal)	10
17	F	11	L	CRIF	6		6
18	F	4	R	CRIF	6		7
19	M	8	L	CRIF	6		7
20	F	11	L	CRIF	6	reduced supination	12
21	M	11	R	ORIF	6		7
22	M	13	R	ORIF	5	reduced supination	10
23	M	13	R	ORIF	5		8
24	M	8	R	CRIF	6		8
25	F	11	R	CRIF	6		8
26	F	11	R	CRIF	6		8
27	M	9	R	CRIF	6		9
28	M	13	R	ORIF	6		9
29	M	8	L	CRIF	6		9

CRIF = closed reduction and internal fixation ; ORIF = open reduction and internal fixation ; ORAL AB = oral antibiotics.

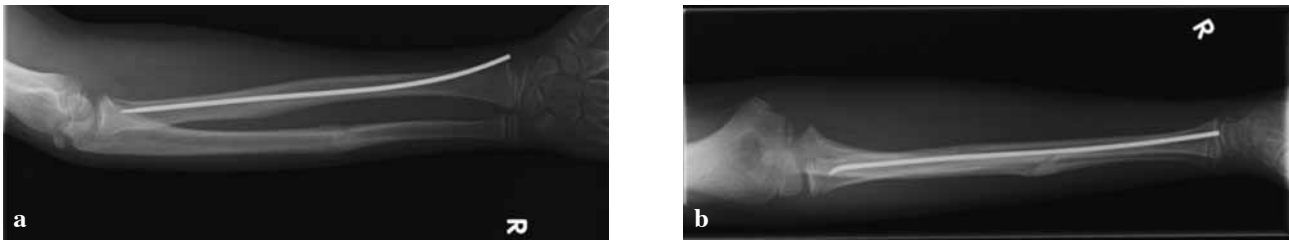


Fig. 3. — 4 months post operative radiographs

Two children had nail entry site infections which resolved completely with one week course of oral antibiotics. There were two re-fractures in the study group following removal of the nail, due to re-injury after falling from a height sustained at 3 and 4 months respectively. Both patients underwent closed reduction and cast immobilisation. Two patients had limitation of supination after the initial immobilisation period (6 and 5 weeks), which resolved completely after physiotherapy. Their final follow-up reviews were at 10 and 12 months respectively.

DISCUSSION

Despite the thick periosteal envelope and the high potential to remodel (7,10), closed manipulation and cast immobilisation for paediatric forearm fractures has a recognised failure rate as high as 31%, requiring repeat manipulation and casting (10,13,18,19). This level of failure rate has prompted the need for surgical intervention, which consists of plate fixation or intramedullary nailing.

Over the last two decades, closed intramedullary nailing for forearm fractures has been a popular technique (1,2,7,9,11,13-15,18). The earliest published series in the literature was by Schöne in 1913 (16), when he used pure silver flexible pins for fixation of seven forearm fractures with no reported complications. Amit *et al* have published a series of 20 children with unstable diaphyseal forearm fractures treated with closed intramedullary nailing using Rush pins, with excellent results (1). Elastic stable intramedullary nailing (ESIN) was first introduced by Lascombes *et al* in a series of 85 patients treated with ESIN of radius and ulna, with good

functional outcome and no reported non-union or limitation of movement (13).

ESIN has advantages over the plate fixation for being minimally invasive in primary fixation and also at the time of removal. There are fewer complications when compared to plate and screw fixation such as minimal soft tissue dissection and scarring, and reduced risk of nerve injury, infection and growth arrest (5,12,17,21). However, plate fixation provides a more anatomical and stable construct in comparison to ESIN (8,21).

Single bone IMN for both-bones forearm fractures has been reported previously (6,7,14,15), with results comparable to those of both-bones fixation, especially in radius-only IMN, in addition to a shorter operative time and reduced cost. We believe that our series is the largest in the literature for radius-only IMN for diaphyseal both-bones forearm fractures in children. Myers *et al* (15) and Houshian *et al* (7) also reported excellent results in single bone IMN, with the radius fixed in 18 and 17 patients, respectively.

The first reported series of diaphyseal both-bone forearm fractures treated with single-bone fixation was that by Flynn and Waters (6). This series included 17 children successfully treated by fixation of either the radius or ulna with plate and screws or an intramedullary nail. The rationale of treatment was to stabilize one bone while the other rotated into reduction.

Kirkos *et al* believe that the radius has the more complicated function and so if this bone is reduced and fixed then the function of the forearm will be secured and the alignment of the ulnar fracture is improved (11). In a biomechanical study, Jones *et al* have concluded that the use of an intramedullary

rod to stabilize a fracture of the radius produces a significantly more stable construct than it does if used to fix a fractured ulna (8). Moreover, single-bone ulnar intramedullary nailing and closed reduction of the radius has been associated with re-angulation of the radial fracture during the first 2-3 weeks following fixation (14), failure of removal of the ulnar nail (15), and elbow pain at the ulnar nail entry site (18).

In this series, the indication of treating both bones paediatric forearm fractures with radius-only IMN was based on the biomechanical concepts explained by Kirkos *et al* and Jones *et al* (8,11) and the good clinical outcome reported by various authors (6,7,14,15), avoiding the possible complications associated with ulna-only IMN (14,15,18), in addition to the shorter operating time and reduced cost in single bone IMN.

Post-operative cast immobilisation has been used following single and both-bones IMN (2,4,7,9,13-15). Calder *et al* have found that there was increased parental anxiety following early mobilisation post-operatively with no clear advantage when compared to cast splintage (2). The indication to immobilise the forearm in this series of children was to minimise the risk of further injury prior to fracture union.

In this study, all fractures achieved union, and there were no cases of deep infections, paraesthesia, complications of nail removal or loss of motion at the final follow-up. We reported a complication rate of 20.7% (six children), where two children had nail entry site infections (resolved completely with oral antibiotics), two children had re-fractures (treated with closed reduction and cast immobilisation with full recovery) and two children who had limitation of supination that resolved completely after physiotherapy. However, both-bones ESIN has also been associated with complication rates of 19%-26% (4,9,20).

The period of follow-up in this study has been arguably short. We believe that there was no indication for further follow-up following nail removal when clinical and radiological union was achieved with no evidence of infection, and full supination and pronation were present at the final follow-up.

We acknowledge the fact that single-bone IMN has been reported before with successful results,

however, we intend to support the existing evidence and encourage the use of this technique, and from our experience, radius-only IMN is a sufficient and effective option in treating both bones forearm displaced unstable type AO 22-A3 fractures in the paediatric age group, with excellent functional outcome and union rates and without any failures.

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