



## Outcome of Both Bone Forearm Fracture Fixation in Children by Rush Nails

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### ABSTRACT

**Introduction:** Forearm fractures are common upper limb injuries among children and usually treated non-operatively. Failure of non-operative treatment, open injuries and multiple fractures are the indications for surgery in paediatric both bone forearm fractures. Intramedullary nailing is considered as minimally invasive procedure with excellent to fair outcomes but it is not free of complications. We reviewed the results and evaluated the outcomes of IM fixation of forearm fractures in children by Rush nails to understand the risks and complications associated with these procedures.

**Methods:** A retrospective crosssectional study of all paediatric patients treated for diaphyseal forearm fractures for period of five years in a tertiary care setup. Complications were classified according to modified Clavien-Dindo complication classification system. Outcomes were graded depending upon complication grade along with range of motion of forearm.

**Results:** A total of 25 patients were included in the study. Mean time for fracture union was 10.56 weeks. Outcomes were excellent in 16 (64%), good in 7 (28%), fair in 2 (8%) patients and no poor outcome was noted. Ten minor complications were seen.

**Conclusion:** Fixation of paediatric forearm fractures by intramedullary Rush nail is minimally invasive procedure and outcomes are excellent to fair with acceptable complication rates.

**Keywords:** complication; forearm fractures; intramedullary nailing; outcome; paediatrics; Rush nail.

### INTRODUCTION

Diaphyseal forearm fractures are common upper limb injuries among children. Non-operative treatment in the form of close reduction and cast application is the standard method for treating most of these fractures, as most of the children with displaced forearm fractures achieve satisfactory results with this treatment.<sup>1</sup> Operative treatment of paediatric forearm fractures is indicated for patients in whom satisfactory alignment cannot be achieved by close reduction and cast application, in multiple bone fractures and in compound

fractures. Results of nonoperative treatment of paediatric diaphyseal forearm fractures are favourable in the majority of cases, despite of that surgical treatment for such injuries are increasing nowadays. A study showed an increase in the rate of surgical treatment of paediatric forearm fractures in the form of intramedullary (IM) nailing from 1.8% to 22% over

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a 10-year period.<sup>2</sup> Increasing trend towards operative treatment of paediatric forearm fractures may be due to technologic advances and its accessibility, awareness of parents, and liability concerns of surgeons and may be due to medical economics.

Various types of implants can be used for IM fixation of forearm fracture like k-wires, Rush nails and titanium elastic nails. Several studies have shown excellent to good results of IM nailing of paediatric forearm fractures, leading to increase in practice of IM fixation of such injuries.<sup>3,4</sup> There are several minor and major complications associated with IM Fixation including delayed union, nonunion, need to frequently expose the fracture site, compartment syndrome (CS), and wound problems.<sup>4</sup>

The purpose of this study was to review the results and evaluate the outcomes of IM fixation of paediatric forearm fractures by Rush nails, to better understand the risks and complications associated with these procedures.

## METHODS

This retrospective study was conducted in the Department of Orthopaedics, Lumbini Medical College and Teaching Hospital, Palpa, Nepal after approval from the Institutional review board. We performed a retrospective review of all paediatric patients treated for diaphyseal forearm fractures between January 2011 to December 2015. We collected data entered in computer, reviewed the clinic notes, operative summaries, and radiographic films for this selected group of patients to get the following information: age and gender of patients, date of injury, date of surgery, fracture location, injured limb, indications for surgery, type of implant used, duration of follow-up, time to radiographic union, final range of forearm motion, and postoperative complications. Any patient with a pathologic fracture, radial head fracture, Monteggia or Galeazzi fractures, isolated single bone fracture and compound (open) fractures were not included in this study. Both bone fractures where single bone fixation was done, fractures those were fixed with other type of implants like k-wires; titanium elastic nails were also excluded from study. Fracture union beyond 3 months was defined as a "delayed union" and failure of fracture union beyond 6 months was defined as a "nonunion."<sup>5</sup> Clinical outcomes were graded from the records available at final follow up according to classification system proposed by Jeffrey E. Martus et al.<sup>6</sup> This classification system include range of motion (ROM) of forearm and post operative surgical complications classified according to the Clavien-Dindo complication classification system as shown in table 1.<sup>7</sup> Normal forearm rotation was considered to be 70

degrees of pronation and 85 degrees of supination. An outcome was judged excellent if the forearm rotation was normal (full) and no complications greater than grade 1 occurred.

**Table 1. Modified Clavien-Dindo Classification of Surgical Complications.**

Complication grade	Definition	Examples
1	Deviation from a routine postoperative course without the need for intervention	Asymptomatic delayed union Prominent implant
2	Resolution after outpatient management, pharmacologic therapy, or close observation	Superficial infection Transient nerve palsy
3	Requiring inpatient management or reoperation	Deep infection Implant migration requiring early Removal
4	Complication that is limb threatening, life threatening, or resulting in a permanent deficit	Compartment syndrome Permanent nerve palsy Radioulnar synostosis Tendon rupture
5	Death of patient	Postoperative mortality secondary to anesthetic reaction

**Table 2. Outcome Grading System.**

Outcome grade	Range of Motion	Complication Grade
Excellent	Full	Grade 1 or none
Good	Loss of <10 degrees pronation and/or supination	Grade 2 or less
Fair	Loss of 10 -30 degrees pronation and/or supination	Grade 3 or less
Poor	Loss of >30 degrees pronation and/or supination	Up to grade 5

A good result was based upon mild loss of forearm rotation ( $<10$  degrees) with complications up to grade 2. A fair result was reported if loss of rotation was more significant (10 to 30 degrees) and complications were grade 3 or less in severity. A poor result was given if there was a significant loss of rotation ( $>30$  degrees) and/ or there were complications of grade 4 or 5 in severity as shown in Table 2.

## RESULTS

Twenty five patients, 15 males and 10 females met the inclusion criteria. Mean age was 10.31 years (range, 5–15 years). Fifteen patients (60%) of them got fractured due to fall while playing. Indication for surgery was unacceptable reduction following close reduction and cast application in 15 (60%) patients, floating elbow in 1 (4%) patient and in 9 (36%) patients surgery was selected as a primary method of treatment. Side involved, location of fracture and type of reduction are shown in table 3.

Table 3. Fracture pattern and type of reduction.		
Forearm	Right	15
Fractured	Left	10
Fracture location	Proximal third	4
	Middle third	16
	Distal third	5
Mini Open reduction required	Radius	2 (8%)
	Ulna	4 (16%)
	Radius and ulna both	3 (12%)

The average time interval from injury to surgery was 2.4 days (range, 2 to 6 days). Reduction of fracture was achieved in 16 (64%) patients by closed method and 9 (36%) patients (radius in 2 (8%), ulna in 4 (16%) and radius and ulna both in 3 (12%) patients) required open reduction. Patients were immobilized postoperatively in long arm cast or in above elbow posterior slab with an average duration of 4.88 weeks (4 to 8 weeks).

Mean time to fracture union was (10.56 weeks; range, 6 to 16 weeks). Out of 25 patients 20 (80%) patients had normal forearm rotation and normal flexion and extension of elbow and wrist.

Loss of forearm rotation less than 30 degree was noted in 5 (20%) patients. As per classification system proposed by Jeffrey E. Martus et al. <sup>6</sup> outcomes were

excellent in 16 (64%), good in 7 (28%), fair in 2 (8%) patients and no poor outcome was noted.

Postoperative complications occurred in 10 (40%) patient. Out of 10 complications 6 were asymptomatic delayed union that united without intervention within the 16 weeks. Remaining 4 complications were grade 2. One patient developed superficial radial nerve palsy, which resolved spontaneously without treatment. One had superficial wound infection that resolved with oral antibiotics and dressing. Two patients developed a pin site irritation one on radial and one on ulnar site that resolved after implant removal.

Table 4. Complications and outcomes.

	Total cases (25)
Grade 1 complications	6
Asymptomatic delayed union	
Grade 2 complications	1
Superficial infection	
Postoperative neuropraxia (transient)	1
Symptomatic Prominent implant	2
Grade 3 complications	0
Grade 4 complications	0
Grade 5 complications	0
Overall complications	10
ROM	
1. Full	
2. Loss of $<10$ degrees pronation and/or supination	3
3. Loss of 10-30 degrees pronation and/or supination	2
4. Loss of $>30$ degrees pronation and/or supination	0
Outcomes	16
Excellent	
Good	7
Fair	2
Poor	0

Latest follow up available was 28.72 weeks (16 to 54 weeks) and only 12 (48 %) patients followed for implant removal. Indication of implant removal was solid union in all cases with complete obliteration of fracture line. Mean time at which implant was removed was 30.66 (16 to 52) weeks from the time of index surgery.

**Table 5. Comparison of literature for similar studies.**

	Study period Years	Total patients (n)	Sex	Mean age	Type of implant used	Average time to radiological union	Functional outcome assessment Criteria	Functional outcome	Complications
Flynn JM et al 3	11 yrs	103	Not mentioned	10.6	Titanium nails, Kirschner wire	6.9 - 8.6 weeks	Children hospital of Philadelphia forearm fracture fixation outcome classification	Excellent = 77.7% Fair = 14.6% Poor = 7.8%	Major = 4 (3.8%) Minor = 11 (10.6%)
Richter D et al 13	2 yrs	30	M = 18 F = 12	Not mentioned	Titanium Nails	13 weeks	Tscherne score	Excellent = 80% Good = 16.6% Fair = 3.3%	Minor = 4 (13.3%)
Shoemaker SD et al 14	8 yrs	32	M = 22 F = 10	8.8	Kirschner wire	12 weeks	Price criteria	Excellent = 96.8% Good = 3.2%	Major = 2 (6.2%) Minor = 7 (21.8%)
Yalcinkaya M et. al 15	8 yrs	45	M = 35 F = 10	10	Rush pins, Kirschner wire	6 - 10 weeks	Price criteria	Excellent = 82.2% Good = 17.8%	Major = 2 (4.44%) Minor = 15 (33.3%)
S.-N. Kang et al 16	10yrs	90		8.4(2-15)	Elastic nails	2.9 months (1.1 to 8.7)	Daruwalla criteria	Excellent 59 Good 17 Fair 5 Poor 9	Superficial radial nerve palsy 2 Compartment syndrome Delayed union 1 Malunion 1 Remodelled Wound-related problems 7 Failure to remove implant 1
Parajuli NP et al 17	3 yrs	50	M = 38 F = 12	10.4	Rush pins	8 weeks	Price criteria	Excellent = 94% Good = 6%	Minor = 8 (16%)
Jeffrey E. Martus et al 6	11yrs	203	Male = 65% Female = 35%	9.7	TENs 97% 3% k = wires or Steinman pins	Not available	Clavien-Dindo classification with modifications	Excellent 163 Good 24 Fair 5 Poor 13	Overall complication 21% 17% were grade 2 or greater
Our study	5yrs	25	M = 15 F = 10	10.31	Rush nails	Rush nails 10.56 wks	New classification as used by Jeffrey E. Martus et al	Excellent 16 Good 7 Fair 2 Poor 0	10 Minor complications

## DISCUSSION

Diaphyseal forearm fractures are common fractures among children. Closed reduction and cast immobilization is the standard method of treatment for most of these fractures.<sup>1</sup> Malreduction can lead to restriction

in forearm rotation and function. There is variable opinion regarding acceptable degree of angulation and acceptable range of forearm rotation. A study by Daruwalla<sup>8</sup> followed the long-term clinical outcomes

of 53 forearm fractures treated with closed reduction and cast immobilization. He found that although 28 patients demonstrated notable limitations of supination, pronation, or both upon clinical examination, none of these patients complained of difficulties related to forearm motion. Morrey et al.<sup>9</sup> determined that the majority of daily activities can be performed with 100 degree of forearm rotation equally divided between pronation and supination. These two studies suggest that the residual angulation after nonoperative treatment may be well tolerated by children.

Several other investigators found that fracture angulation between 5 to 10 degrees at the level of mid-shaft of the forearm can lead to pronation deficits of 10% to 83% of normal and supination deficits of 5% to 27% of normal.<sup>10</sup> Remodeling capacity of bone decreases with increasing age. Study has shown children ten years or older do not predictably remodel to a significant degree.<sup>11</sup> Incidence of poor results of closed treatment of fractures in children older than ten years old remains widely under reported.<sup>12</sup> Considering this functional limitation due to malreduction of fracture and unpredictable remodeling capacity in older children there is increase in trend towards operative treatment of pediatric forearm fractures. There are situations, however, in which operative management is beneficial to avoid repeated reductions, additional corrective surgical procedures, and functional limitations. Plating is considered as standard method of fixation in adults whereas intramedullary nailing by Rush Nails, TENs or K wires are considered as standard methods of fixation of forearm fractures in children.

Various studies have shown that IM nailing can provide precise fracture reduction, maintain the reduction for fracture healing, results in minimal cosmetic deformity, and facilitates easy removal of implants after treatment.<sup>3</sup> However; IM nailing is not free of complications. Documented complications of this technique include infections at nail insertion site, skin irritation at nail insertion sites, fracture displacement after implant removal, migration or failure of implants (bent or broken nails), loss of reduction, refracture, nerve and tendon injury, decreased range of motion, delayed union and nonunion, and compartment syndrome(CS).<sup>3,4</sup>

In our study mean age of patients was 10.31 years similar to previous other studies and this is the age around which fixation is required for better radiological and functional outcome due to decreasing remodeling capacity. Reduction of fracture was achieved in 16 (64%) patients by closed method and in 9 (36%) patients open reduction was required. The frequency of open reduction during IM fixation in previously closed fractures has been reported to be as high as 38% to 74.4% in the literature.<sup>13-16</sup> We have not compared

the outcome of closed with open nailing in our study. Merter Yalcinkaya et al.<sup>15</sup> concluded closed reduction or open reduction with a mini incision for intramedullary nailing yield similar functional results, with a similar complications rate in the treatment of pediatric unstable diaphyseal forearm fractures.

In this study post operative complications were evaluated with the modified Clavien-Dindo classification system. This classification system provides uniformity in the reporting of complications because this system uses objective criteria for the severity scale. An advantage of this classification is the elimination of the potential subjective bias that is associated with the grouping of complications in grades as minor/major or mild/moderate/severe.<sup>7</sup>

Outcomes and complications in the present study are comparable to other various studies as shown in (table no 5).<sup>3, 4,13-17</sup> Yalcinkaya M et al.<sup>15</sup> reported complications rate range from 4-38% in patients treated with intramedullary nailing and results were excellent in 82.2% and good in 17.8% of patients. Flynn JM et al.<sup>3</sup> reported 77.7% excellent, 14.6% fair and 7.8% poor results and showed that the overall complication rate in patients undergoing intramedullary nailing was 14.6%.<sup>3</sup> The most common complication occurring in their series were infection, skin irritation by hard ware, pin back out, delayed union and compartment syndrome.

In our series, 10 minor complications were noted. Among which 6 were asymptomatic delayed union. We considered delayed union as minor complication which united without any interventions. No nonunion or malunion occurred in our series. There were no deep infections noted. Flynn noted compartment syndrome (CS) in those patients those were operated within first 24 hours. However, in our study no case was operated in first 24 hours, which may be the reason of not getting any complication in the form of CS in our study. Parajuli NP et al reported excellent outcomes in 94% and good in 6% of patients. There were only 8 (16%) minor complications.<sup>14</sup>

## CONCLUSIONS

Intramedullary fixation of forearm fractures in children by Rush nail is minimally invasive procedure and outcomes are excellent to fair with acceptable poor results. Overall outcomes in this study are comparable to various other studies, with reasonable complication rate. Since Rush nails are easily available and affordable in developing countries like ours, we can prefer Rush nails for intramedullary fixation of paediatric forearm fractures. Retrospective and non comparative nature were limitations of this study.

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