

Diaphyseal Forearm Fractures in Children Treated with Titanium Elastic Nail System

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ABSTRACT

BACKGROUND: The common injuries in the pediatric population is the forearm fracture around the diaphyseal region. These fractures can result in functional disability, especially in older children due to angular or rotational deformity, which can be minimized by restoration of normal alignment. Titanium Elastic Nailing system is a minimally invasive procedure that spares physis, provides three-point fixation allowing early mobilization.

METHODS: The study included total of 35 children with the aim of assessing the bony union and functional outcome according to Price CT et al criteria of titanium elastic nail in diaphyseal forearm fractures.

RESULTS: In this study, there were 21 boys and 14 girls with a mean age of 9.8 years. Twenty-four children had right forearm fracture and 11 had left forearm fracture. Close reduction was achieved in all cases except in 6 cases where open reduction with mini incision was performed. All of the fractures clinically healed within an average of 6 weeks and radiological union was by the end of 14 weeks. The results according to Price CT et al were excellent in most of the cases. There were no patients with a poor outcome.

CONCLUSION: Titanium Elastic Nailing system is a safe, effective and minimally invasive method of fixation of diaphyseal forearm fractures in children with excellent results in terms of union and functional outcomes in the majority of patients with minimal complication.

KEYWORDS: Pediatric forearm diaphyseal fracture, Titanium Elastic Nailing system (TENS)

INTRODUCTION

The common injuries in the pediatric population is forearm fractures, which represent approximately 3 to 6 % of all children's fractures.¹ The forearm fracture around the diaphyseal region comprises 15 to 18 %² in 6 to 16 years old children, with higher incidence seen in older children.³ The diaphyseal forearm fracture can result in functional disability, especially in older children due to angular or rotational deformity, which can be minimized by restoration of normal alignment.^{4,5} The

spontaneous correction in the diaphysis is less and decreases with the increasing age as well as distance from the physis.⁶ The majority of these fractures can be treated with closed reduction and cast immobilization but it become more difficult in older children due to more chances of re-displacement even after a successful closed reduction.⁷ The most common indication for the surgical intervention is unstable fracture and failure of closed reduction.^{8,9} The ideal fixation for diaphyseal forearm fracture in children, with open physis and growth still remaining, is

intramedullary fixation devices. They maintain the alignment with minimal soft tissue dissection and less complications. Titanium Elastic Nailing system (TENS) is a minimally invasive procedure that spares physis, provides three-point fixation allowing early mobilization.¹⁰⁻¹³ The aim of this study is to assess the bony union and functional outcome of diaphyseal forearm fracture in children using TENS.

MATERIALS AND METHODOLOGY

It is a prospective study. The total of 35 children admitted in Nepal Medical College Teaching hospital from September 2016 to January 2018 were included in study with the aim of assessing the outcome of titanium elastic nail in diaphyseal forearm fractures in children. The children between 6 to 12 years of age having traumatic fracture of diaphysis of the forearm and no other associated injuries, were included. All fracture pattern of diaphysis of forearm were included. The open, pathological, Monteggia and Galeazzi fractures were excluded from the study.

Operative Technique

Under general anesthesia, close reduction was performed under image intensifier, if reduction was not achieved even after the three attempts. Then open reduction with mini incision was performed. After achieving satisfactory reduction TENS was placed in a retrograde fashion through radius and in an antegrade fashion through the ulna respectively.

The radial bone is approached through dorsal aspect of distal radius with the insertion point

proximal to the distal epiphyseal plate. The injury to extensor tendon and superficial radial cutaneous nerve was taken special care.

The appropriate nail size was determined by measuring the diameter of the bones in radiographs. The nail with diameter of about two thirds of the narrowest medullary canal was used. The tip of the nail was prebent to 30 degree with additional bending, so that the apex of bend overlaps with the fracture site to obtained three-point fixation. The nail is inserted proximally upto the proximal metaphysis of radius and end of the nail is bent and cut flush to the bone leaving enough length for the removal of nail later on and buried under the skin. Same procedure is performed for the ulna through antegrade approach through dorsoradial side, sparing the olecranon apophysis with the insertion point distal to the apophyseal plate.

All children were immobilized postoperatively in an above elbow plaster slab for 2 weeks. The flexion and extension of elbow and wrist was allowed after 2 weeks but supination and pronation were allowed only after six weeks postoperatively. The children were followed up to 2, 6, 9, 12, 24 and 36 weeks for evaluation of bony union and functional outcome.

Bony union was assessed clinically by the absence of pain and tenderness at the fracture site and radiological assessment included the presence of a bridging callus with obliteration of the fracture line on both AP and Lateral views.

The functional outcome was evaluated according to the Price CT et al criteria,¹⁴ consisting of Range of motion (Pronation and Supination) and pain. (Table 1)

Table 1: Functional Outcome criteria – Price CT et al

Outcomes	Symptoms	Loss of Forearm rotation
Excellent	No complaints with strenuous activity	<15°
Good	Mild complaints with strenuous activity	15°–30°
Fair	Mild complaints with daily activities	31°–90°
Poor	All other results	>90°

Data were analyzed using Statistical Package for Social Sciences (SPSS version 23).

RESULTS

The diaphyseal forearm fracture included in this study, there were 21 boys and 14 girls with a mean age of 9.8 years. Twenty-four children had right forearm fracture and 11 had left forearm fracture. Closed reduction was achieved in all cases except in 6 cases where open reduction

with mini incision was performed. Soft tissue interposition might be the reason for failure of closed reduction. All of the fractures clinically healed within an average of 6 weeks and radiological union was by the end of 14 weeks. (Fig. 1-5)



Fig. 1: Preoperative (Diaphyseal fracture of radius and Ulna)



Fig.2: Immediate Postoperative (Fracture reduction done and fixed with TENS)



Fig.3: Follow up (Alignment maintained, union in progress)



Fig. 4: Bony Union



Fig.5: Implant (TENS) Removal

All the results were clinically evaluated using price CT et al scoring criteria (Fig. 6-9). The 27 patients had an excellent result followed by

good in 6 patients and fair in 2 cases. There were no patients with a poor outcome. (Table 2)



Fig. 6: Plantarflexion



Fig.7: Dorsiflexion



Fig.8: Supination



Fig.9: Pronation

Nepal Orthopaedic Association Journal (NOAJ) infection and avoids the soft tissue trauma due to less surgical dissection.²⁰

The mean age of the patients in our study was 9.8 years (range 6-12), similar observation was seen in study by Shivanna et al²¹ who found it to be 9 years (range 5-15), Makki D et al²² observed an average age of 9 Years (range 7-14).

In our present study 82.85 % (n=29) of the fractures were treated with close reduction and 17.15% (n=6) needed mini open reduction to insert the nails across the fracture site. This is comparable to studies by Jubel et al²³ in which 90.70% (n=39) were managed with close reduction, whereas 9.3%(n=4) required mini open reduction, Vishwanath C et al²⁴ study shows 76% (n=38) were managed with close reduction and 24% (n-12) required mini open reduction.

In this study the average union time was 6 weeks clinically and radiologically was by the end of 14 weeks which was comparable to the studies done by Makki D et al²² have 12 weeks of union rate in their study(n=102) and Garg NK et al²⁰ have 12.8 weeks of union rate in their study (n=21).

The functional results in our study were based on Price et al¹⁴ scoring system, which consists of range of movements and complaints on daily activities. There were 27 (77.15%) patients with excellent results and 6 (17.15%) with good and 2 (5.70%) with fair results. No poor results were observed in our study. Our results are comparable with Vishwanath C et al²⁴ study who had 36 (72%) patients with excellent results, 9 (18%) with good results and 4 (8%) with fair results. Manjappa CN et al²⁵ observed 15 (75%) patients with excellent results, 3 (15%) with good results and 2 (10%) with fair results in their study. Richter et al²⁶ observed 24 (80%) patients with excellent results, 5 (16.6%) with good results and 1 (3.3%) with fair results in their study.

In our study, all the implants were cut short and buried under the skin. However, 5 patients (14.30%) had nail irritation due to long nail ends outside the cortex. No other complications such as infection, refracture, neurapraxia, nonunion

Table 2: Functional Outcome

Outcome	Patients	Percentage
Excellent	27	77.15%
Good	6	17.15%
Fair	2	5.70%
Poor	0	-
Total	35	100%

The nail irritation was present in 5 children due to longer nail ends outside the cortex. There were no post-operative complications like infection, refracture, back out of nail and neuropraxia of sensory branch of radial nerve.

The average time for removal of the implants was 9 months. After removal no complications was seen in our patients.

DISCUSSION

The treatment options for the diaphyseal fracture of forearm in children ranges from conservative to surgical methods. Conservative treatment includes closed reduction and casting. Surgical intervention is required if the fracture is unstable or redisplacement occurs, specially in older children.¹⁵ When surgical stabilization is needed, the choice is between closed reduction and internal fixation with elastic intramedullary nail or open reduction and internal fixation with plates.

The diaphyseal forearm fracture treated with plate fixation had restricted forearm rotation in five out of ten patients with poor functional outcome due to excessive soft tissue handling reported by Vainionpaa et al study.¹⁶ During plate removal, there may be neurovascular complications and rarely radio-ulna synostosis can occur.¹⁷

The intramedullary nailing provides stable fixation without disturbing the biology around the fracture site, which contributes to fracture healing.¹⁸ Intramedullary nail act as an internal splint, maintains bony alignment due to the three-point fixation provided by a nail.¹⁹ Intramedullary nail fixation reduces the risk of

or malunion were encountered in our study. Our results were comparable to other various studies, Flynn JM et al⁸ studies showed the overall complication rate was 14.6%, whereas Chapman et al²⁷ studies found 24% complication rate. The complication occurring in their series were skin irritation, infection, nonunion and implant migration. All implants were routinely removed after 9 months of surgery, there was no complication observed after the removal. Similarly, in Shivanna et al²¹ study implant was removed at an average of 8 months (range 6-10).

CONCLUSION

TENS is a safe, effective and minimally invasive method of fixation of diaphyseal forearm fractures in children's with excellent results in terms of union and functional outcomes in the majority of patients with minimal complication

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