Pediatric both Bone Forearm Fractures Fixed with Titanium Elastic Nails (TENs)

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ABSTRACT

BACKGROUND: Pediatric forearm fractures are usually managed by conservative methods, however, non-operative treatment is not suitable for displaced unstable diaphyseal fractures which require surgical intervention. Non-operative treatment may lead to significant angular and rotational deformity which is rarely corrected if the children ≥ 8years. Different surgical techniques are available including plating and intramedullary nailing. Among these titanium elastic nailing is one of the best options because of its several advantages over other techniques.

MATERIALS AND METHODS: This is a prospective study which included 73 patients of age 4 to 14 years treated with titanium elastic nailing (TENs) following closed reduction or mini-open method if required. All the demographic profiles, techniques, indications of surgery, union time, functional outcomes and complications were evaluated during follow up examination. Final results were documented at the time of union of fracture.

RESULTS: This study included 73 patients with unstable both bone forearm fractures with mean age of 9.90±2.28 years. There were 43 (58.9%) male, 30 (41.1%) female, forty-four (60.3%) of patients sustained fracture in middle shaft of forearm, 7 (9.6%) patients needed open reduction for nail fixation, 69 (94.5%) patients had excellent results according to Price et al criteria. Average time to unite the fracture was 9.10±1.81 weeks and 13.7% of patients had irritation and bursa formation over entry site, 6.8% had superficial radial nerve neuropraxia, 8.2% had delayed union and one patient had osteomyelitis.

CONCLUSION: Titanium elastic intramedullary nailing is an appropriate, effective and safe operation for unstable diaphyseal fractures of the forearm in children who cannot be treated by closed manipulation.

KEY WORDS: Functional outcomes, Forearm fracture, Pediatric, Titanium elastic nail

INTRODUCTION

Diaphyseal fractures of forearm are common in children and comprise 6 to 10% of all pediatric fractures[1,2]. More than 90% of these fractures are successfully treated with closed reduction and long arm cast application while few require surgical intervention for unacceptable alignment of fracture[2,3]. Indications for surgical treatment include displaced fracture with unacceptable alignment, unstable fractures, compound fractures, failure of conservative treatment[1]. Successful treatment of pediatric forearm fractures indicates restoration of alignment and full recovery of forearm motion. Limitation of forearm motion is directly related to the angular deformity because useful remodeling of bone rarely occurs in children ≥ 8 years if significant deformity is left untreated[4]. Angular deformity of 10 degree or more leads to limited motion of forearm and hence conservative treatment is not useful[5]. Several surgical techniques have been described to achieve near normal anatomical reduction such as plating, intramedullary nailing or external fixators[6,7,8,9]. Out of the different methods, intramedullary nailing is gaining popularity in recent years.

This technique is simple, minimally invasive, shorter operating time, maintains accurate bone alignment, promotes faster bone healing, excellent cosmesis and implant removal is relatively safer, however, numerous complications have been noted especially when improper surgical technique is used[7,10,11,12]. The purpose of this study was to investigate the indications, techniques, clinical results, functional outcomes, possible complications and means of avoiding them in unstable forearm fractures in children treated with titanium elastic nails (TENs).

MATERIALS AND METHODS:

This was a prospective descriptive analytical study performed in Civil Service Hospital, Kathmandu from 2011 to 2015. We reviewed 73 diaphyseal forearm fractures in children treated with titanium elastic nail (TEN) during that period. To simplify the study the patients with age 4 to 14 years, closed displaced or type I compound displaced both bone fractures and the cases with failed closed reduction were included in the study. The patients with type II or III compound fractures, Monteggia fracture dislocations, Galeazzi fracture dislocations, multiple fractures, fractures beyond metaphyseo-diaphyeal junction and those with multiple injuries were excluded from the study. Demographic data, mechanism of injury, type of fracture, site of fracture, time to unite the fracture, any complications noted during and after surgery, range of mobilization of elbow and wrist, functional outcomes of limb were evaluated in each patient. All the patients underwent surgery within 48 hours of admission in hospital. We used nails with diameters varying from 1.5 mm to 3 mm depending upon the size of medullary canal of bone. The tip of nail was bent 30 degrees to facilitate passing of nail through the fracture site under image guidance after closed reduction. Because of flexible nature of nail, it did not require the pre-bending of nail as it maintained three point fixation spontaneously inside the medullary cavity of bone. We usually preferred to fix the less displaced bone first to avoid the further displacement while passing the nail. Usually radius bone was fixed first with ascending technique. Under fluoroscopy distal radial physis was identified and entry point was made in the radius either in lateral or dorsal side 2 cm proximal to the physis. The size of the nail was calculated by measuring the minimal diameter of the diaphysis in mm and multiplying it by 0.4. The appropriate size titanium nail with curved tip was introduced through the entry point and passed upto the fracture site. Once the nail tip was near the fracture site, fracture was reduced by traction and manipulation. Nail was passed through the fracture site by appropriately rotating the tip of nail with a T handle. Similarly ulna was fixed with descending technique with entry point 2 cm distal to proximal ulnar physis as described for the radius fracture. The nail was cut in appropriate length and final impaction with impactor was done only after confirmation of suitable length of nail inside the medullary canal and proper reduction of fracture. To avoid the skin irritation, which is one of most frequent complications of intramedullary nail, cut end of nail should not protrude not more than 5 to 6 mm from the bone. After final impaction, elbow was gently mobilized to ensure adequate stability of fracture site.

If fracture was not reduced by three attempts of closed reduction, an artery forceps was used to manipulate the fracture by giving a stab incision over the fracture site and if still did not reduce a small mini incision was given to reduce the fracture by open method. The forearm was rested in an arm pouch sling after surgery. The patient was advised for finger mobilization and grip strengthening exercises of hand next day after surgery. Once the pain had subsided, patient was discharged from the hospital and asked to follow up in OPD every 2 weeks until fracture was united. In 2 weeks stitches were removed, active and passive mobilization of both elbow and wrist was started however weight lifting and other resistant type of activities were prohibited at least for 6 to 8 weeks after surgery.

RESULTS:

All the final results obtained in our study were documented in Table 1, 2 and 3. Even though there were some complications noted in our study 94.5% of patients had excellent functional outcomes according to Price criteria

Parameters	**Mean± standard Deviation/ Numbers**
Age (years)	9.90±2.28
Patients with age <10 years	31 (42.5%)
Patients with age ≥ 10 years	42 (57.5%)
Sex	
Male	43 (58.9%)
Female	30 (41.1%)
Mechanism of injury	
Fall from height	32 (43.8%)
RTA	18 (24.7%)
Sports related injuries	23 (31.5%)
Side	
Right	34 (46.6%)
Left	39 (53.4%)
Site of Fracture	
Proximal third	12 (16.4%)
Middle third	44 (60.3%)
Distal third	17 (23.3%)
Diameter of nail (mm)	2.27±0.46
Artery forceps used for reduction of fracture	13 (17.8%)
Mini-open incision for reduction of fracture	7 (9.6%)
Time to unite thefracture (weeks)	9.10±1.81
< 10 years (weeks)	7.67±1.25
≥ 10 years (weeks)	10.17±1.25

Table.1 Demographic profile of patients, treatment methods and time to unite the fractures

Complications	**Numbers/Percentage**
Irritation and Bursa formation at entry site	10 (13.7%)
Perforation of opposite cortex of bone during surgery	3 (4.1%)
Fracture of bone due to nail at entry site	1 (1.4%)
Osteomyelitis	1 (1.4%)
Transient loss of sensation over thumb	5 (6.8%)
Delayed Union	6 (8.2%)
Malunion	1 (1.4%)
Non union	0
Neurovascular injury	0

Table.2 Showing the complications after the titanium elastic nailing.

Functional Outcome of forearm according to Price criteria	
Parameters	**Numbers/Percentage**
Excellent	69 (94.5%)
Good	3 (4.1%)
Fair	1 (1.4%)
Poor	0

Table.3 Showing the functional outcomes after TENs in children.

DISCUSSION

Many studies have indicated that conservative treatment of completely displaced and unstable pediatric forearm fractures result in poor functional outcomes[13]. Acceptable alignment and restoration of normal function of forearm is the indication of successful treatment. Even though there is wide variation in the literature regarding the acceptable angular and rotational alignment in case of pediatric forearm fractures, many reports confirm that angular deformity≥ 10 degree and rotational deformity≥ 30 degree and completely displaced overlapped fractures are unacceptable[14]. Vitro study of Tarr et al shows that angular and rotational deformities of 10 degree or more give rise to functional limitation of supination and pronation[15]. If surgical treatment is mandatory, compression plating and intramedullary nailing are two most common methods for unstable forearm fractures. Intramedullary nailing includes titanium elastic nails (TENs), Enders nails, elastic stable intramedullary nailing like intramedullary K wires, Rush nails, Steinmann pins, Lottes forearm medullary nail[16]. Intramedullary nailing with TENs has number of advantages over other techniques. It preserves both periosteal and endosteal blood supply so that bone healing will be quicker. This is a cosmetically acceptable procedure with minimal surgical scar. Angular deformity is very minimal with strong fixation so that patients return to the normal activities earlier than with the casting techniques. Because of micro-movement at fracture site there will be early bridging callus formation and quicker bone healing. This procedure is simple, takes minimal time for completion of surgery and the implant removal is easier compared to plate removal[1]. Open reduction and plate fixation is associated with higher rates of complications like ugly scars, infection, longer operative time and duration of hospitalization, synostosis, refracture and risk of nerve injury while removal of plate[7,17].

The average age of patients in our study was 9.90±2.28 years with 42.5% of patients were less than 10 years old and 57.5% of patients were more than or equal to 10 years. So majority of patients were more than 10 years old in our study which made them ideal for surgical intervention than the patients less than 10 years. In our study around 58.9% of patients were male, 53.4% of patients sustained fractures in left side around 60.3% of them had fractures in middle third of forearm. These results were also similar to the study of Kapil Mani KC et al[18] in study of fracture shaft of humerus treated with a functional brace. According to his study, male children are more aggressive and involved in outdoor activities. So they are prone to sustain more fractures than female children. Left hand is usually non-dominant and is used for the protective function at the time of impact on the ground. The reason for increased incidence of middle shaft of long bone fracture is due to the angulatory force which comes in action at the time of accident. The average time to unite the fracture in our study was 9.10±1.81 weeks while time taken to unite the fractures for children less than 10 years was 7.67±1.25 weeks and that for ≥ 10 years was 10.17±1.25 weeks. Time taken to heal the fractures reduced by open methods was slightly longer as compared to the fractures reduced by closed methods. Study of Pugh et al[19] showed that patients older than 10 years had approximately 2 weeks longer union time than that for less than 10 years with union time 8.4 and 6.4 weeks respectively. Similarly study of Murat Altay2 showed that union occurred in 7.8 and 6.3 weeks in respective age groups. Longer union time in our study may be due to the significantly higher number of cases with age more than 10 years and in certain number of cases fixation was performed with open reduction technique.

Some authors prefer for single bone fixation instead of double bone because single bone fixation is technically easier, less traumatic and involves less operating time. Stabilization of ulna prevents cosmetically unacceptable bow and provides a stable fulcrum against which radius can be manipulated and maintained in position, however re-displacement and loss of reduction of non-fixed bone is a frequent complication[7]. In our series, we did not apply the posterior slab after surgery and there was not a single case of re-displacement and angulation without immobilization. In our experience patients without plaster feel more comfortable, start early mobilization of limb and it will be more cost effective. Luhmann et al[20] and shoemaker et al[10] have recommended the supplemental posterior slab after intramedullary fixation while Qidwai[21] did not advise a supplemental cast to allow the early mobilization of limb. Around 10% of patients in our study required open reduction and fixation with TENs while 17.8% of patients require manipulation with the help of artery forceps at fracture site. We should avoid repeated attempts of closed reduction in order to avoid the secondary complications because of interosseous scarring, synostosis and compartment syndrome associated with repeated attempts of reduction maneuvers. We believe that small incision is much less traumatic than multiple reduction maneuvers[2]. Many studies[19] mention that children younger than 10 years have potential of remodeling the significant amount of malunion while Kay et al[5] reported that non-operative treatment resulting in greater than 10 degree mal-alignment will probably result in significant loss of forearm rotation and be avoided in children more than 10 years.

In our study, 16.4% of fractures are in proximal shaft, 60.3% are in middle shaft and 23.3% in the distal shaft of forearm bones. The location of fracture affects the outcome. It will be more difficult to achieve and maintain the fracture reduction in more proximal fractures and these types of fracture shows less remodeling potential[22]. In addition to this closed reduction will be more difficult when the radius fracture is more proximal to ulnar one. Based on Price et al[23] for functional outcome of forearm 94.5% of patients in our study have excellent results, 4.1% have good results, 1.4% have good results while there was not a single case of poor results. Many authors reported excellent and good results after fixation of forearm fractures with intramedullary nailing. Although functional results after nailing are good, complications are not uncommon. In our study, 13.7% of patients had irritation and formation of bursa over the entry point on ulna, 4.1% of patients sustained perforation of opposite cortex of bone by nail during surgery, one patient had fracture due to nail at entry site, one patient developed the osteomyelitis, 8.2% of patients had transient loss of sensation over the base of thumb and dorsolateral side of hand, 8.2% suffered delayed union and one case developed malunion. Study of Cumming et al[24] showed that complications were as high as 16%. Patient who developed osteomyelitis was managed with removal of nail, debridement and intravenous antibiotics. All cases of perforation occurred in radius fracture during surgery where entry portal was change from lateral to dorsal site near the Lister's tubercle. To avoid the bursa formation, nail should be cut at appropriate length before final impaction and protruding portion of nail should not be more than 5 to 6mm from bone.

CONCLUSION

Titanium elastic intramedullary nailing is an appropriate, effective and safe operation for unstable diaphyseal fractures of the forearm in children who cannot be treated by closed manipulation. This technique is simple, minimally invasive, has a shorter operating time, maintains accurate bone alignment, promotes faster bone healing, excellent cosmesis and implant removal is relatively safer.

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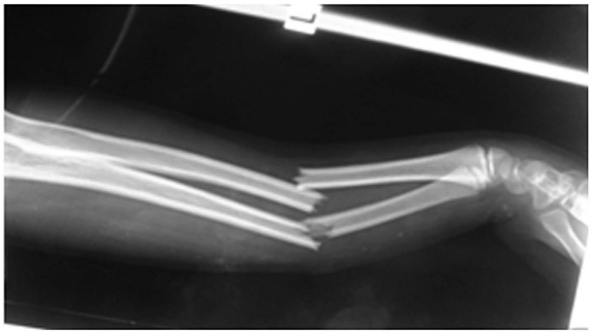
FIGURES



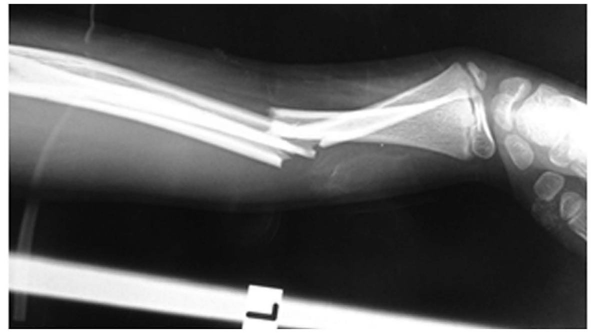


Fig. 1 and 2 AP and lateral view of forearm displaced fracture of both bones.

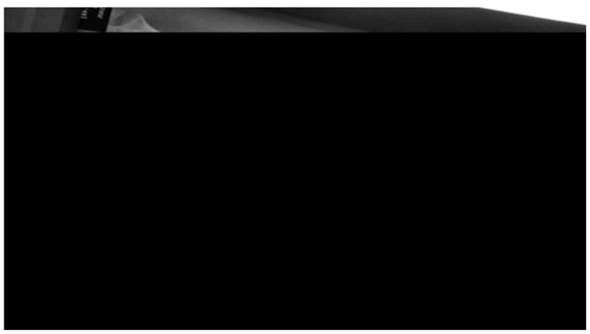


Fig. 3 Ap and Lateral views of forearm showing fixation of both radius and ulna with titanium elastic nail (TENs)

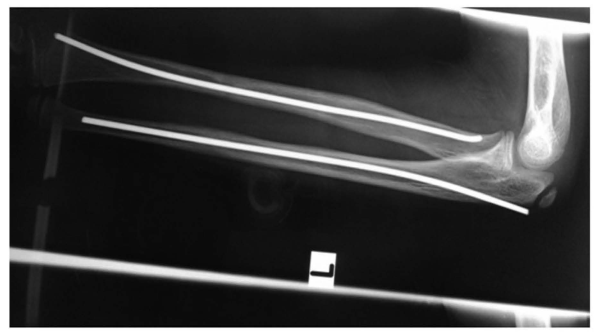


Fig. 4 United fracture both radius and ulna fixed with TENs 5 month after surgery

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