Europasian Journal of Medical Sciences
https://doi.org/10.46405/ejms.v3i1.251
Original Article

Functional Outcomes of Pediatric Both Bone Fractures Fixed with Titanium Elastic Nails: A Hospital Based Study

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ABSTRACT

Background: Successful treatment of both bone fractures depends on the restoration of normal alignment and full recovery of range of motion that can be achieved by either closed reduction and casting or surgical intervention. Number of surgical treatment modalities have been mentioned for unstable pediatric both bone fractures that includes Kirschner wire fixation, plating, external fixation and elastic intramedullary nailing.

Methods: This was descriptive cross-sectional study performed from January 2016 to December 2019. A total of 85 diaphyseal pediatric forearm fractures were treated surgically with titanium elastic nails(TENs) during this period. Functional outcomes and complications were analysed 6 months after surgery.

Results: The mean age of patients in our study was 10.67±1.88. There were 50 (64.1%) male and 28 (35.9%) female. Incidence of fracture is higher in left side 47 (60.2%) in comparison to right side 31 (39.8%). Fifty (64.1%) fractures were in middle third, thirteen (16.7%) fractures were in proximal third and 15 (19.2%) in distal third of both bone forearm. There were excellent outcomes in 91%, good outcomes in 6.4% and fair results in only 2.6% of patients.Seven different types of complications were noted including skin irritation 8 (10.2%), cortex perforation in 2 (2.5%) and iatrogenic fracture in 1 (1.3%) case.

Conclusions: Titanium elastic nailing is excellent treatment option for displaced unstable pediatric both bone fractures especially in elderly children. This is technically easy, minimally invasive procedure with relatively faster bone healing, easy implant removal with excellent cosmesis of skin without long ugly scar.

Keywords: Both bone fractures; Closed reduction and casting; Functional outcomes; Surgical treatment; TENs

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Received: 23 December 2020; **Accepted:** 23 April 2021; **Published Online:** 24 April 2021

How to cite this article in Vancouver Style?

KC KM, RC DR, Acharya P, Sigdel A, Lamsal DK, Dahal sudip C. Functional Outcomes of Pediatric Both Bone Fractures Fixed with Titanium Elastic Nails: A Hospital Based Study. Europasian J Med Sci. 2021; 3(1): 53-59. https://doi.org/10.46405/ejms.v3i1.251

Disclaimer

Conflict of Interest: None Declared; **Source of Support:** Nil

Crossref 10.46405/ejms
https://doi.org/10.46405/ejms.v3i1.251

INTRODUCTION

Most of the pediatric both bone fractures heal well with closed reduction and casting, however some cases require operative intervention.[1,2] Successful treatment of both bone fractures depends on the restoration of normal alignment and full recovery of range of motion. Appropriate remodeling rarely occurs in children ≥8 years if large angulation is left untreated that causes significant limitation of range of motion especially supination and pronation.[3] Conservative treatment is rarely suggested for angulation more than 10 degree since it causes limited forearm motion.[4]

Surgical intervention is advised for displaced both bone fracture with unacceptable alignment, compound fractures, unstable fractures and failure of conservative treatment.[5] Number of surgical treatment modalities have been mentioned for pediatric both bone fractures that includes Kirschner wire fixation, plating, external fixation and elastic intramedullary nailing.[6-8] Among different surgical methods, flexible intramedullary nailing is relatively better choice because it is minimally invasive, simple, shorter surgical time, promotes quicker bone healing, maintains accurate alignment of bone, gives excellent cosmesis because of lack of long skin incision and finally implant removal is also less invasive.[9-11] Even though this technique is also not free from complications like implant prominence, skin impingement, bursa formation of skin and migration of implant.

The purpose of this study was to find out functional outcomes, possible complications and possible techniques of avoiding them in unstable forearm fractures in children treated with titanium elastic nails (TENs).

MATERIALS AND METHODS

This was a descriptive cross-sectional study performed in Civil Service Hospital, Kathmandu, Nepal from January 2016 to December 2019. A total of 85 diaphyseal pediatric forearm fractures were treated surgically with TENs during this period, however 7 patients were lost during the follow up and finally included 78 patients in this study. Ethical clearance was taken from the institutional review board of Civil Service Hospital. Written consent from was taken before participating in the study. Patients with age 5 to 13 years, displaced either closed or type I compound fractures and those with failed closed reduction were included in the study while the patients with type II or III compound fractures, fractures associated with polytrauma, galeazzi fractures, monteggia fractures, fractures proximal to metaphyseo-diaphyeal junction in distal end and those involving the radial head olecranon in proximal end of both bone were excluded from the study.

Operative intervention was done under general anesthesia in all patients within 12 to 72 hours after admission. Appropriate nail diameter of TENs was calculated by using the Flynn's formula. This means nail diameter = 0.4 x lowest intramedullary width of bone. Tip of nail was pre-bent to about 30 degree for easy passage through the fracture site, however whole length of nail was not bent because of flexible nature of TENs which was automatically bent after passage into the intramedullary cavity. Regarding the fixation of bone, less comminuted or less displaced bone was fixed first to prevent the further displacement of less displaced bone. Small incision was given at the region of distal radius either radially or dorsally and with the help of owl under floroscopy, entry portal was made 1to 2 cm proximal to physis. Appropriate diameter of nail with its bent tip was passed through the portal and reached up to fracture site. At this stage, fracture was reduced by giving traction, counter-traction and suitable manipulation. Once the fracture was reduced, nail was advanced forwards up to neck of radius which was confirmed under fluoroscopy. Likewise, ulna was fixed with entry portal on the dorsal surface of olecranon. Nail was cut at 5 to 10 mm protruding from the bone after adequately giving the axial force to reduce the fracture and checking good range of elbow and wrist motion. If the fracture was not reduced with several attempts of closed reduction, a stab incision was given over the fracture site and an artery forceps or blunt tip instrument was put to reduce the fracture. If still fracture was not reduced, then mini-incision was given to manipulate and reduce the fracture.

Patients were discharged from hospital 48 hours after surgery after doing dressing in case of open reduction and fixation otherwise dressing was done after one week and suture was removed at 2 weeks. After that patients were followed up in OPD every month to assess the fracture union until the fracture union had been completed (figure 2 and 3). Functional outcomes of forearm were assessed after completion of fracture union according to the price criteria as shown in figure 1.

Statistical analyses were performed using the SPSS software . Quantitative variables were documented as mean ± standard deviation. Qualitative variables were assessed using Chi Square test or Fisher's Exact test. P values < 0.05 were considered statistically

significant.

RESULTS

The average age of patients in our study was 10.67±1.88 years with 50 (64.1%) male and 28 (35.9%) female. There were 47 (60.2%) fractures in left side and 31 (39.8%) fractures in right side. Regarding the mechanism of injury, fall from height is most important cause 29 (37.2%) followed by sports related injury 25 (32%) and Road Traffic Accident 24 (30.8%). Fifty fractures (64.1%) were in middle third, 13 fractures (16.7%) in proximal third and 15 (19.2%) in distal third as shown in table 1. Average size of nail used to fix the bone was 2.37±0.39 mm in diameter. Twelve cases (15.4%) needed artery forceps while further 8 (10.2%) cases needed mini-incision for reduction of fractures during surgery. Time to unite the fracture 10.27±1.77 weeks.

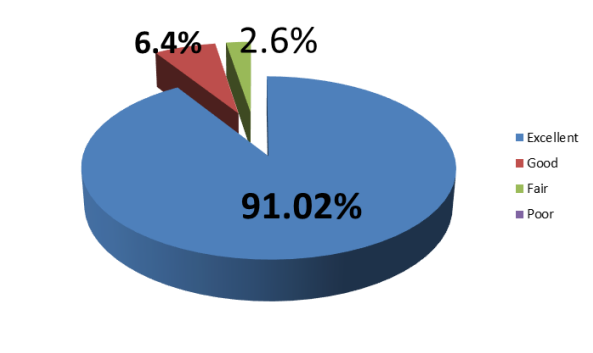

Figure 1: Functional outcomes of patients after fixation with TENs.

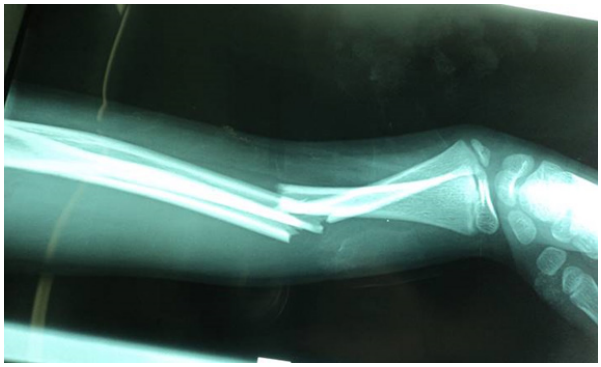

Figure 2: Displaced both bone fracture of forearm

Regarding the complications, skin irritation was most common 8 (10.2%) followed by paresthesia 5 (6.4%) and delayed union 4 (5.1%). There were 2 cases of malunion, one case of cortex perforation, one case of iatrogenic fracture at the time of surgery, one case of deep infection as shown in table 2. However, there was no single case of nonunion and neurovascular injury in our study.

Functional outcomes were assessed based on Price

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

Parameters	Mean ± SD / Numbers
Age (years)	10.67±1.88
<10 years	30 (38.5%)
≥10 years	48 (61.5%)
Sex	
Male	50 (64.1%)
Female	28 (35.9%)
Mechanism of injury	
Fall from height	29 (37.2%)
RTA	24 (30.8%)
Sports related injuries	25 (32%)
Side	
Right	31 (39.8%)
Left	47 (60.2%)
Site of Fracture	
Proximal third	13 (16.7%)
Middle third	50 (64.1%)
Distal third	15 (19.2%)
Average size of nail (mm)	2.37±0.39
Patients requireing Artery forceps	12 (15.4%)
Cases requireing mini-open incision	8 (10.2%)
Time to unite the fracture (weeks)	10.27±1.77

Table 2: Showing the complications after the titanium elastic nailing

Complications	Numbers/ Percentage
Skin irritation	8 (10.2%)
Cortex perforation	2 (2.5%)
Iatrogenic fracture	1 (1.3%)
Deep infection	1 (1.3%)
Paresthesia	4 (5.1%)
Delayed Union	5 (6.4%)
Malunion	2 (2.5%)
Non union	0
Neurovascular injury	0

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https://doi.org/10.46405/ejms.v3i1.251

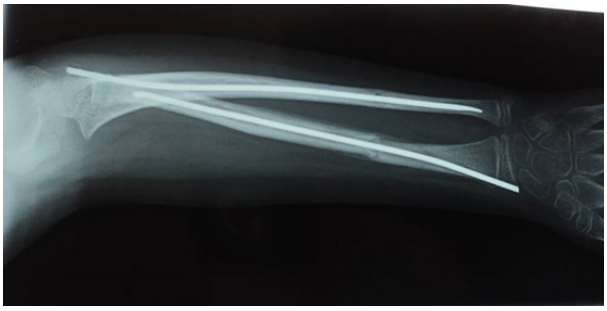

Figure 3: United both bone fractures six months after TEN

criteria. Around 91.02% patients had excellent outcomes, 6.4% patients had good outcomes and 2.6% patients had fair outcomes as shown in figure 1.

DISCUSSION

Most of the pediatric diaphyseal fractures can be treated with closed reduction and cast application even though there is tendency to redisplace the fracture in older children and in case of proximally located fractures. Based on Price criteria, angulation ≥ 10 degree, rotational deformity ≥ 30 degree and complete displacement is considered unstable fracture.[12] Similarly children younger than 9 years tolerate higher angulation because of higher remodeling power in these age group.[13,14] Franklin et al mentioned that painless and free from the complications including normal flexion extension and supination pronation of elbow after surgical fixation of fracture indicates the successful treatment.[14] Angulation of more than 15 to 20 degree in middle third both bone fracture in children significantly reduce the supination pronation motion. Loss of reduction of fracture, elbow stiffness, disuse osteopenia, skin breakdown, muscle atrophy and re-fractures are some of the common complications after conservative treatment out of which loss of reduction accounts between 10 to 60%.[15.16]

Considering these factors, surgical treatment is recommended for unstable fractures. Open reduction with plating and intramedullary nailing are most commonly used surgical procedures. Intramedullary nailing techniques include Titanium elastic nails (TENs), rush nails, enders nails, Kirschner wires, Steinmann pins and Lottes forearm medullary nail.[17]

Flexible intramedullary nail has number of advantages.1) It maintains the periosteal cover of bone and do not hamper the blood supply 2) provides acceptable cosmetic appearance because of mini-incision 3) prevents malunion and thus no loss of supination pronation 4) Implant is strong enough to provide angular stability so that patients return to normal activities early 5) because of flexible nature it provides the micromotion at fracture site that will help to early callus formation 6) it is easier to remove once the fracture union has completed.[18] Open reduction and internal fixation with plating is associated with increased blood supply, large surgical scar which is cosmetically unacceptable, increased incidence of infection, prolonged hospital stay, chance of synostosis, refracture after implant removal and increased incidence of neurovascular injury.[19,20]

The mean age of patients in our study was 10.67±1.88 years with 61.5% of patients were more than or equal to 10 years and 38.5% of patients were less than 10 years. Therefore majority of patient were more than 10 years who need surgical intervention more frequently than those less than 10 years. In our study majority of patients were male 50 (64.1%) as compared to female 28 (35.9%) while incidence of fracture is higher in left side 47 (60.2%) in comparison to right side 31 (39.8%). Kapil Mani KC et al in European journal of surgery and traumatology (2013) has mentioned that incidence of fracture is higher in left upper limb as compared to right side because left hand is usually non-dominant and used as protective function while patients fall on the ground.[21] Likewise male children are more aggressive and frequently engaged in the outdoor sports activities. So they sustain fracture more frequently than the female children. In our study, incidence of fracture is higher (64.1%) in midshaft region of forearm. It is because of more angulatory force that comes in action while patient falls on the ground. The average time to unite the fracture in our study was 10.27±1.77 weeks. It is generally accepted that time take to heal fracture is higher in open reduction compared to closed reduction. Pugh et al mentioned that fracture union time is longer in children more than 10 years by 2 weeks or more as compared to children less than 10years with 8.4 and 6.4 weeks respectively.[22] Similarly Altay M et al demonstrated the union time 7.8 and 6.3 weeks in children more than or less than 10 years respectively.[1] In our study there were higher number of children with more than 10 years and we performed quite significant number of cases by open reduction technique that may probably lengthened the union time.

In our study we did not treat any case with single bone fixation, however some authors believe to fix the single bone because of shorter operating time, less traumatic and technically more easier to

fix the single bone. Cullen et al demonstrated that stabilization of ulna only with intramedullary nail provides the stable fulcrum against which radius can be manipulated and maintained however redisplacent is common.[19] In the current series, we did not apply the posterior slab after the surgical procedure. However, there are conflicting reports regarding the use of posterior slab in the literature. Shoemaker et al[9] and Luhmann et al[23] in their respective series recommended the need of posterior slab whereas Qidwai et al[24] did not advise the use of posterior slab for early mobilization. In our opinion without the use of posterior slab gives the opportunity of early mobilization as well as patients feels more comfortable and it is cost effective as well. Around 15.4% of cases in our study required manipulation of fracture by blunt tipped instrument like artery forceps while 10.2% of those needed the mini-incision for reduction of fracture. We do not recommend the repeated failed closed reduction but rather to do with small mini-incision technique to reduce soft tissue insult.

In the current series, there were 13 (16.7%) of fractures in proximal third, 50 (64.1%) in middle third and 15 (19.2%) in distal third of both bone fractures. Location of fractures in both bone affects the difficulty in reduction and functional outcomes. It is assumed that fractures in distal and proximal third are difficult to reduce and incidence of malunion is increased while proximal third fractures have tendency to have slow remodeling potential.[25]

There are seven different types of complications that we encountered in our study. We have got skin irritation and bursa formation over the site of insertion in 8 cases (10.2%), cortex perforation by nail during insertion in 2 cases (2.5%), iatrogenic fracture during surgery in one case (1.3%), deep infection in one case (1.3%), paresthesia over the dorsal surface of thumb in 4 cases (5.1%), delayed union in 5 (6.4%), malunion in 2 cases (2.5%), however we did not get any nonunion and neurovascular injury. Study of Yalcinkaya M et[26] al demonstrated the complications range from 4 to 38% while Flynn JM et al[27] mentioned the 14.6% of complications after fixation with intramedullary flexible nailing. In the series of Flynn et al the most common complication noted were delayed union, compartment syndrome, infection, skin irritation by hard ware and pin back out, however nonunion and deep infection were not noted. Similarly, Cumming et al[28] demonstrated 16% complications in their series. In our study, deep infection in one case was managed by removal of nail, thorough debridement and intravenous antibiotics for 10 days followed by oral antibiotics. Perforation occurred intra-operatively in our patients was managed by change of entry portal lateral to dorsal surface and vice-versa.

In our study, there were excellent outcomes in 91%, good outcomes in 6.4% and fair results in only 2.6% of patients based on Prince criteria.[29] Likewise, study of Goyal D et al[30] demonstrated that TENs has overall good to excellent results in adolescent forearm fractures provided the principle of three point fixation was followed and soft tissue injury was minimal.

The lack of control group in this study is major limiting factor otherwise we can compare the functional outcomes and complications of treatment group with control to get the logical results

CONCLUSION

Intramedullary nailing with titanium is excellent treatment option for displaced unstable pediatric both bone fractures especially in elderly children who cannot maintain the reduction in plaster casting. This is technically easy, minimally invasive procedure where bone healing is relatively fast, implant removal is easy with excellent cosmesis of skin without long ugly scar in forearm.

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