

Original Article**TITANIUM ELASTIC NAILING (TEN) FOR PEDIATRIC LONG BONE FRACTURES: A RETROSPECTIVE INSTITUTIONAL EXPERIENCE***Jay Raj Sharma¹, Mandir Khatri¹, Sundar Karki¹, Dipendra Singh Chhetri¹, Shaju Aryal², Ruban Raj Joshi³^{1,3}Department of Orthopedic, ²Department of Paediatric, ^{1,2}Devdaha Medical College and Research Institute, Rupandehi, Nepal, ³Lumbini Medical College and Teaching Hospital, Palpa, Nepal

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DOI: <https://doi.org/10.3126/mjen.v1i02.51161>**ABSTRACT****Background**

Titanium Elastic Nail (TEN) is used for fixation of diaphyseal fractures of paediatric long bone, where the medullary canal is thin or flexibility of the implant is a chief concern. These are used for biologically and minimally invasive fracture treatment that delivers accurate reduction and stabilization in appropriate paediatric age group

Methods

A hospital based 18 months (from December 2020 to July 2022), retrospective study was conducted at Devdaha Medical College and Research Institute, Rupandehi, Nepal with the patients of paediatric long bone fractures who were operated with an elastic titanium intramedullary nail for diaphyseal fractures. Records of the surgical procedure and the follow-up outcomes were all recorded and the data was collected and tabulated in excel sheet for statistical analysis. The total number of patients in the study were 25 wherein, 20 were male and 5 were female.


Results

Children ranging from age 4 to 15 years of age were included with mean age of 9.44 years. Average hospital stay was 4 days having standard deviation of 1.68. Statistical analysis yielded z value of 2.97 and p-value of 0.003 which was significant. Most of the patients reported injury in the left side 17(68%) than right side 8(32%). Majority of the injury was sustained in forearm 18(72%) followed by femur 4(16%) and tibia 3(12%). Fall on the ground 14(56%) was commonest mode of injury followed by road traffic accident (RTA) 5(20%), fall from tree 3(12%), fall from bicycle 2(8%) and sports injury 1(4%) respectively. The average time to fracture union was 9.84 ± 2.93 weeks. Only 4 patients had complication, in which 2 had superficial surgical site infection and no patient had Limb Length Discrepancy or non-union.

Conclusion

TENS for diaphyseal fracture is not only a safe, minimally invasive technique with shorter operating time but also helps in preservation of accurate bone alignment and encourages quicker bone healing.

Keywords: Bone remodeling, Diaphyseal fractures, Titanium elastic nail (TEN)

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INTRODUCTION

The most common aetiologies of fracture include domestic fall, sports injury, road traffic accident (RTA) and child abuse, which are usually seen in the upper limbs as compared to the lower ones that has a great impact on an individual's daily normal life thus representing an imperative topic of public health. The prevalence is seen more in the males than the females.^{1,4} In children, such fracture cases are seen to be more common, (one in every four children per year), with long-term risk of fracture accounting approximately 40% for girls and 64% for boys. There are several researches that deals with paediatric long bone fractures and discuss about its incidence and the healthcare resources needed for the treatment. Such literature work also gives a vivid overview of the indications for surgical intervention thus minimizing the risk of surgical failure with the use of new implant techniques and diminishing the time and extent of post-injury disability.^{3,4} Hence, a holistic approach by the treating Orthopaedic surgeon is essential for the treatment of such paediatric diaphyseal long bone fractures with appropriate knowledge about the surgical anatomy, indications, techniques and implants usage. Due to the development of novel surgical implants, the traditional concept of splinting the long bone fractures have been replaced by internal fixation and early mobilization. Surgical management helps to avert complications including rotational mal- alignment, non-union, malunion etc.^{5,6}

Surgical treatment of paediatric long bones fractures is considered for its excellent results with non- operative care and reported union rates of more than 90%, and full functional recovery of 100%.⁷ However, sometimes reduction cannot be preserved owing to excessive shortening, angulation, or malrotation at the fracture site thus, ensuing operative intervention. Thus, for the past few years, elastic stable intra-medullary nails have been used that has intensely amplified along with the use of various types of nails.⁸ The Titanium Elastic Nail (TEN) for Elastic Stable Intramedullary Nailing (ESIN) is envisioned to be used for fixation of diaphyseal fractures in pediatric cases, where the medullary canal is thin or flexibility of the implant is a chief concern. Due to the flexibility of the TENs it can be implanted in such a manner that the injury to the growth plate is avoided that such intra- medullary devices are indicated for open fractures, unstable fractures or irreducible fractures. These devices are used for biologically, minimally invasive fracture treatment that renders accurate level of reduction and stabilization that is appropriate for the age of the child. The major biomechanical principle of this procedure depends upon the symmetrical bracing action of two elastic nails incorporated into the

metaphysis, bearing against the inner bone at 3 points thus, providing optimal results pertaining to flexural, axial, translational and rotational stability.^{9,10} The ESIN has the benefits of early immediate stability to the involved bone segment, which permits early mobilization and return to the normal activities of the patients, with very low complication rate.¹¹

Hence, the present study was conducted with the primary aim to evaluate the outcome of operative treatment of pediatric diaphyseal fractures in the age group between 4 to 15 years using titanium elastic nails (TENs). The study also was aimed to evaluate the stabilization and union of fracture and to identify complications like limb length discrepancy, mal alignment and infections after performing surgery of pediatric long bone fracture (Humerus, Forearm both bone, Femur and Tibia) by TENS.

METHODS

A hospital based 18 months (from December 2020 to July 2022), retrospective study was conducted at Devdaha Medical College and Research Institute, Nepal with the patients of paediatric long bone fractures who were operated with an elastic titanium intramedullary nail for diaphyseal fractures. Convenient sampling method was applied to include the subjects of the study.

Children of age group between 4-15 years with diaphyseal fractures of long bones are included in this study whereas children with long bone diaphyseal fracture from congenital disorder, neuromuscular diseases like Cerebral Palsy, medical contraindication to surgery are excluded from study. Ethical approval was received from IRC- Devdaha Medical College and Research Institute.

Records of Operating room, records of OPD when patient came for follow up. Some patient's guardian were called upon by telephone to evaluate the condition and asked to come for follow up.

Procedure: Surgery was performed under either general anaesthesia or regional block according to the age of patients. Aseptic preparation and precautions were followed. Under C-arm image- entry hole was made with an awl and the fracture was reduced manually and with the help of F-tool. We chose nail diameter of not more than 40% of the width of the canal or one third of the isthmus of the canal. Two nails with same diameter were selected to balance the opposing bending forces and to avoid malalignment and both nails were contoured into the concave side of the bowed nail.

In femur, humerus and radius a retrograde insertion of the nail was done and in ulna and tibia antegrade insertion was preferred. After crossing the fracture, the nails were passed up to the metaphyseal zone. Then

nails were cut within 2 cm long and bent along the cortex of the bone to prevent soft tissue impingement. Insertion site wound was sutured with polypropylene and dressing done and posterior slab was applied. Patient were kept in post-operative ward for 1 day and general ward for 2 days then they were sent home in 3rd post-operative day. The assessment was done at 6, 12 and 24 weeks.

RESULTS

The collected data were tabulated in Microsoft excel sheet and were subjected to statistical analysis using SPSS vs 26.0.0.0. Z-test and chi-square tests were applied to obtain the results of the study.

The total number of patients in the study were 25, in which 20 (80%) were male and 5(20%) were female. Children ranging from age 4 years to 15 years were reported, having mean age of 9.44 years and median age of 10 years. 88% of children were 12 or below 12 years in the study (Table 1).

Average hospital stay was 4 days having standard deviation of 1.68.

Most of the patients reported injury in the left side 17(68%) than right side 8(32%). Majority of the injury was sustained in forearm 18(72%) followed by femur 4(16%) and tibia 3(12%). In case of forearm, radius fracture was seen in 2, ulna fracture in 1 and both bone fracture in 15 patients. Running chi-square test on occurrence of forearm in relation to other long bones yielded p-value of 0.002 which was significant. (Figure 2).

Fall on the ground 14(56%) was the commonest mode of injury followed by road traffic accident (RTA) 5(20%), fall from tree 3(12%), fall from bicycle 2(8%) and sports injury 1(4%) respectively. (Figure 3). Total of 3 (12%) fracture occurred in proximal third of long bone, 16 (64%) in middle third, 5 (20%) in distal third and in 1 forearm radius

fracture occurred in proximal third and ulna in distal third. Mean Hospital stay was 4 ± 1.6 days. The case of forearm both bone fracture along with supracondylar fracture of humerus had longer hospital stay of 10 days.

Total of 4 (16%) cases presented with complication; 1 nerve injury (ulnar nerve injury due to wrong site insertion of nail) which was recovered in 6 weeks, 2 pin site infections and 1 Extensor pollicis longus (EPL) rupture. Superficial surgical site infection was treated with intravenous antibiotics for 7 days and regular dressings. EPL rupture which was encountered in 10 month post-operative time was repaired. Limb Length Discrepancy was not noted in any case. None of the case showed non-union, mal union or any implant related complications like implant failure.

Table 1: Age wise distribution of children and reported fracture in the study

Age (In years)	Frequency	Percentage (%)	Cumulative Percent
4	1	4.0	4.0
5	2	8.0	12.0
6	4	16.0	28.0
7	1	4.0	32.0
9	2	8.0	40.0
10	4	16.0	56.0
11	5	20.0	76.0
12	3	12.0	88.0
13	1	4.0	92.0
14	1	4.0	96.0
15	1	4.0	100.0
Total	25	100.0	

Table 2: Average time to Union of fracture

Femur	12.76 \pm 3.2 weeks
Forearm bone	10.25 \pm 1.8 weeks
Tibia	11.33 \pm 3 weeks
Overall	9.84 \pm 2.93 weeks

Table 3: Surgery Time

Femur	65 \pm 12.9 minutes
Forearm	45 \pm 17.22 minutes
Tibia	61.66 \pm 7.6 minutes
Overall	50.65 \pm 17.53 minutes

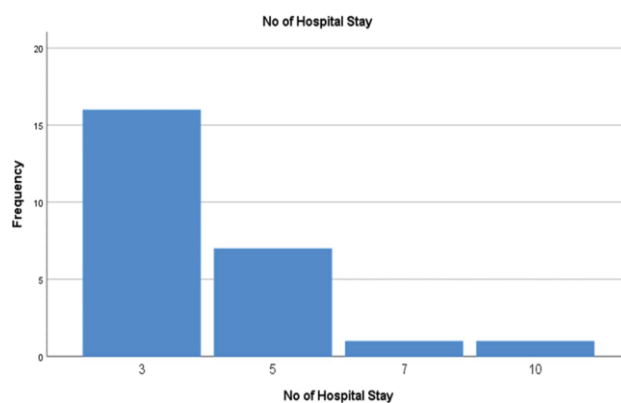


Figure 1: Hospital stays of children in days

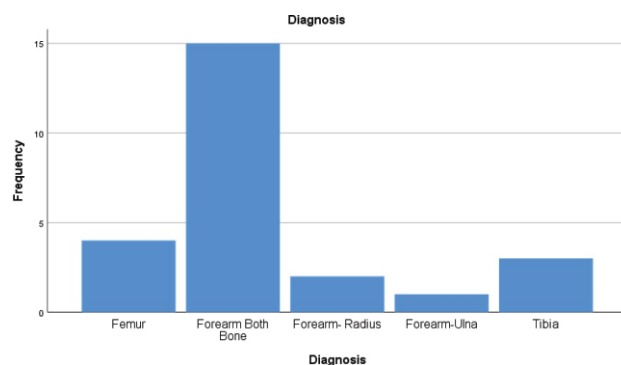


Figure 2: Distribution of long bones fractured in the study

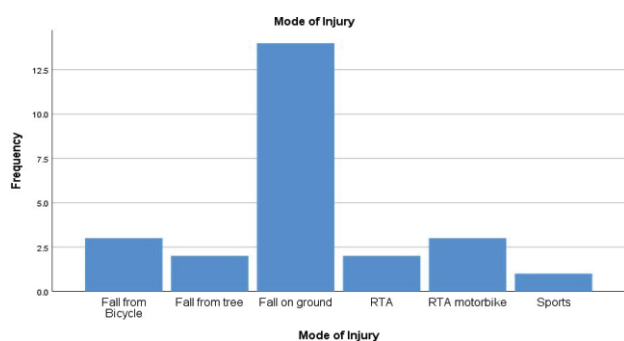


Figure 3: Mode of injury reported in the study

DISCUSSION

The management of diaphyseal femoral fractures in the paediatric age group is still a topic of debate. However, conservative treatment modalities are still considered to be the primary approach in paediatric patients bearing in mind the good healing capacity, the high remodelling power and the extensive range of acceptance in this group of patients. Such conventional treatments have proven to be safe, produce good clinical outcomes, are less invasive and virtually devoid of soft tissues risk or growth plate injuries. However, none of these has revealed any good results over other methods.¹² Few limitations of such treatment includes prolonged skin traction with prolonged hospitalization, patient discomfort and long weight-bearing limitations.¹³ Furthermore, casting is required in surgical procedures, and there is radiation exposure for closed reductions with the use of specific invasive device.^{14,15}

Hence, the present study was conducted with the primary aim to evaluate the results of operative treatment of pediatric diaphyseal fractures in the age group between 5 to 12 years using titanium elastic nails (TENs).

The children in the present study were all treated with TENs for diaphyseal fractures of the limbs. These results were supported by other study²⁰ who indicated TENs as the standard treatment for patients of approximately 3 years old. It has been documented that external fixation could be a well-thought-out treatment option in patients less than 6 years of age, however, it is less comfortable and accepted by the patients and their parents. They also take a longer time to achieve optimal healing.^{21, 22} In other studies it has been observed that TENs proved to be a safe and useful treatment option for diaphyseal fractures of the limbs that permits easy nursing care and evades conditions like pressure ulcers. In a study⁶, the most common mode of injury was due to fall injuries which is similar to our study (Graph 3). The complications encountered using TENS nailing were found to be minimalistic with good rate of recovery during follow-up period. In our study only 4 cases presented complication, out of which 2 were superficial pin site infection and there were no cases of limb length discrepancy (LLD), No non Union or any malunion which is analogue with another study²⁶. Unlike other study, our study had presented one case of nerve injury

(Ulnar nerve) which was recovered in 6 weeks. The mean operative time was 50.65 ± 17.53 ³¹. TEN has suggestively reduced the duration of hospital stay ensuing early discharge of the patients. In our study patient had hospital stay of 4 ± 1.6 days⁴.

It should be recommended as the physiological method of surgical treatment for paediatric diaphyseal long bone fractures owing to its comparatively simple, marginally invasive technique with good biological healing process including callus formation.⁶ There has been excellent results among the 49 patients with a mean age group of 7.5 years, using TENs for diaphyseal fractures of the long bones.⁴ In our study the average time to healing was 9.844 ± 2.9 weeks [Femur (12.76 ± 3.2 weeks), Forearm (10.25 ± 1.8 weeks) and Tibia (11.33 ± 3 weeks)]. Our study was analogous to other studies^{11, 15, 23, 24, 25} who showed the effective and excellent clinical results of the TENs procedure used for long bone diaphyseal fractures in which the average time to healing was 12-14 weeks.

A retrospective study²⁶ of 130 cases suggested that TEN could be considered as the first method of management of paediatric long bone fractures to achieve good results with minimal or no clinical complications. However, certain authors have reported about the expensive treatment method involving TENs as compared to K-wire stabilization or non-surgical treatment options,²⁷ whereas in other studies it was documented as a safe, effective treatment option with excellent clinical outcomes and also an economically well-accepted procedure by the patients.⁴

Hence, considering and analysing the decent and good outcomes, TEN has developed to be the first choice of treatment even in isolated femoral fractures in children above six years of age.²⁸ Surgical management of such long bone fractures is being progressively applied to guarantee ideal arrangement and alignment, permit early movement and enable easy and early weight bearing capacity for the patients.²⁹ Intramedullary nailing with TEN hence renders a steady fixation, thus regulating the rotational deformity (according to the known basic surgical rule) for the patients.³⁰

CONCLUSION

Titanium elastic intramedullary nailing thus can be described as an effective and safe treatment option for paediatric long bone diaphyseal fractures which cannot be managed by closed manipulation. This is simple, minimally invasive technique with short operating time and it preserves accurate bone alignment and promotes quicker bone healing and brilliant aesthetic results. Hence, this technique should be accepted and followed by the orthopedic surgeons after appropriate training to deliver good satisfactory clinical results to the patients. There is minimal soft tissue dissection and no neuromuscular injury that produce good cosmetic results too. TEN with specific indications serves to be a valuable and efficient treatment option for the

diaphyseal femoral fractures even in patients younger than six years of age with the surgeons possessing good surgical skills. One of the short-comings of the present study was the small sample size to validate our findings on a larger scale, hence, further studies are recommended necessarily to evaluate if this technique has

any noteworthy advantages over other conservative treatments.

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Conflict of interest: None

Ethical approval: Yes

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