OSTEOSYNTHESIS WITH TITANIUM ELASTIC NAILS IN PAEDIATRIC LONG BONE FRACTURES- A STUDY

Naveen Raj K[1], Venkateswarlu Kurukunda[2], Nagaraju Madiga[3], Shyamdhar Tirumuru[4], Mahesh Sagar Athinarapu[5], Srikar Jakkala[6]

[1]Junior Resident, Department of Orthopaedics, Kurnool Medical College, Kurnool, Andhra Pradesh.
[2]Professor, Department of Orthopaedics, Kurnool Medical College, Kurnool, Andhra Pradesh.
[3]Assistant Professor, Department of Orthopaedics, Kurnool Medical College, Kurnool, Andhra Pradesh.
[4]Assistant Professor, Department of Orthopaedics, Kurnool Medical College, Kurnool, Andhra Pradesh.
[5]Junior Resident, Department of Orthopaedics, Kurnool Medical College, Kurnool, Andhra Pradesh.
[6]Junior Resident, Department of Orthopaedics, Kurnool Medical College, Kurnool, Andhra Pradesh.

ABSTRACT

BACKGROUND

The technique of titanium elastic nailing system was developed by Metaizeu and the team from Nancy in 1982 which brought a major change in the treatment of paediatric long bone fractures. A lot of interest has been generated over the surgical treatment of paediatric long bone fractures. But there has been a lot of debate over operative indications in the children less than 6 years and adolescents greater than 16 years. Several treatment methods such as traction followed by hip spica, external fixation, flexible, stable intramedullary nails, plate fixation, and locked intramedullary nailing are available for the age group between 6 to 16 years. Any treatment method can be chosen, but the ultimate goal should be to stabilize the fracture, to control length and alignment, to promote bone healing, and to minimise the morbidity and complications for the child and his/her family. Initially titanium elastic nail (TEN) fixation was used as an ideal treatment method for femoral fractures; later, this technique was gradually applied to other long bone fractures in children, as it represents a compromise between conservative and surgical therapeutic approaches with satisfactory results and fewer complications.

MATERIALS AND METHODS

Study was conducted in 30 children from October 2016 to April 2018 who underwent fixation with titanium intramedullary nails for long bone fractures. The age group of children was 6 to 12 years. Mean age group was 10.33 years. There were 16 femoral, 10 tibial, 2 forearm and 2 humeral fractures. Majority of patients were operated with in first week. Average operating time was 45 minutes. Average blood loss was 55 ml. Mean duration of hospital stay was 5 days. Follow up was done for a period of 6 months.

RESULTS

Patients were evaluated using Flynn's criteria. All patients achieved complete healing at a mean duration of 10 weeks. Good to excellent results were obtained in 90% of patients and 10% of patients had fair results. Knee stiffness was seen in 4 cases, shortening was seen in 1 case, malunion was seen in 1 case. No cases of non-union were seen.

CONCLUSION

Titanium elastic nailing is the method of choice for paediatric patients, because it is minimally invasive, less traumatic and simple method. It shows very good functional and cosmetic results. Early ambulation of patient is an advantage

KEYWORDS

Titanium Elastic Nails, Paediatric Long Bone Fractures, Elastic Stable Intra Medullary Nailing.

HOW TO CITE THIS ARTICLE: Naveen Raj K, Kurukunda V, Madiga N, et al. Osteosynthesis with titanium elastic nails in paediatric long bone fractures- a study. J. Evid. Based Med. Healthc. 2019; 6(8), 595-600. DOI: 10.18410/jebmh/2019/123

BACKGROUND

The technique of titanium elastic nailing system was developed by metaizeu and the team from Nancy in 1982 which brought a major change in the treatment of paediatric long bone fractures a lot of interest had been gained over the surgical treatment of paediatric long bone fractures. But there has been a lot of debate over operative indications in the children less than 6 years and adolescents greater than 16 years. several treatment methods such as traction followed by hip spica, external fixation, flexible, stable intramedullary nails, plate fixation, and locked intramedullary nailing are available for the age group between 6 to 16 years. Any treatment method can be chosen, but the ultimate goal should be to stabilize the fracture, to control length and alignment, to promote bone healing, and to minimise the morbidity and complications for the child and his/her family. Initially titanium elastic nail (TEN) fixation was used as an ideal treatment method for femoral fractures, later, this technique was gradually applied

Financial or Other, Competing Interest: None.
Submission 09-02-2019, Peer Review 12-02-2019,
Acceptance 21-02-2019, Published 25-02-2019.
Corresponding Author:
Dr. K. Venkateswarlu,
H. No. 50-760a, 127,23-24,
Gayatri Estates, Kurnool- 518002,
Andhra Pradesh.
E-mail: kvenkee66@gmail.com
DOI: 10.18410/jebmh/2019/123

to other long bone fractures in children, as it represents a compromise between conservative and surgical therapeutic approaches with satisfactory results and fewer complications.

Aims and Objectives

1. To study the type of injury and clinical profile of various long bone diaphyseal fractures in children.
2. To study the merits and demerits of Titanium Elastic nails in the management of various long bone diaphyseal fractures in children about intraoperative and postoperative clinical and radiological characteristics (i.e., functional status, union of the fracture and postoperative complications.)

Objectives of Using Titanium Elastic Nailing System

1. To undertake the procedure that is effective and least time consuming for the most common type of fractures seen in children (6-12 yrs. age groups), i.e., diaphyseal fractures long bones (closed & compound type I &, II).
2. To eliminate the problems of pin traction and prolonged bed rest like bed sores, Urinary tract infection, thromboembolic diseases, pulmonary embolism, the stiffness of adjacent joints and pin tract infection.
3. To overcome the problems of non-operative treatment and plate fixation, i.e. implant failure, osteomyelitis, and loosening of screws, etc.
4. To decrease postoperative psychological morbidity and mortality of patient.

Biomechanics of Titanium Elastic Nailing System (TENS) Nails / Elastic stable intramedullary nailing (ESIN).

It was first tried and practised by Rush and Enders. They tried this procedure to stabilize a long bone fracture in the femoral shaft and trochanteric fractures. It works on the basic principle of - three-point fixation - provided by symmetrical bracing action of two elastic nails inserted into the metaphysis, each of which bears against the inner bone at three points. This produces the following four properties: flexural, axial, translational and rotational stability. All four are essential for achieving an optimal result.

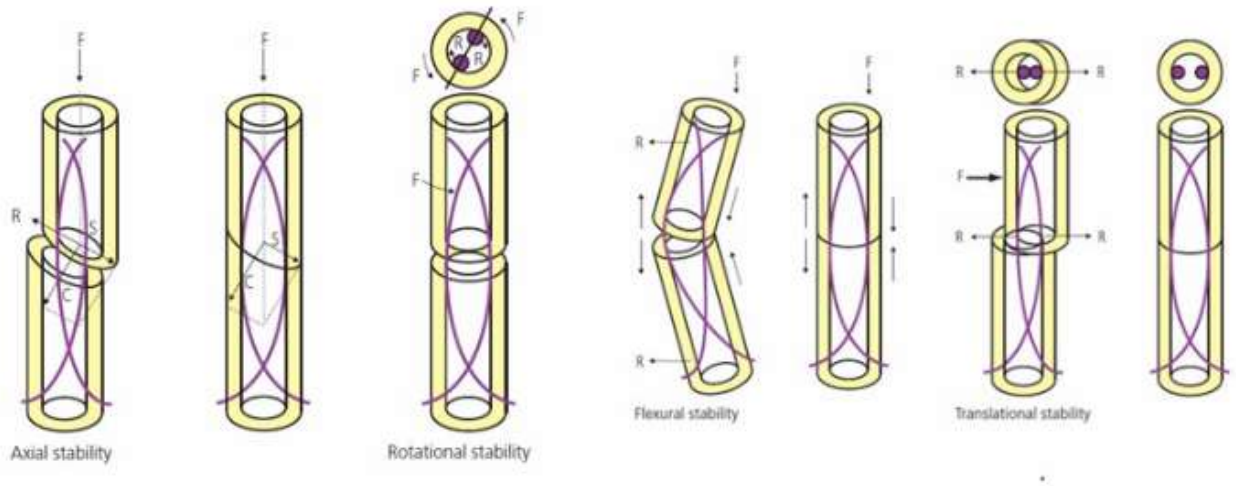

Figure 1

F- Force Acting, R- Restoring Force of The Nail, S- Shear Force, C- Compressive Force

The ends of nails are anchored firstly in their entry points, secondly in the metaphysis at the other end of the bone. The curvature of the nail is achieved by bending it beyond its elastic limit from this new position of stability; it resists the tendency to be straightened out (thus creating some tension within intramedullary canal) as well as a tendency to be further bent, thus minimizing the risk of deformation. Once introduced into the medullary canal, the nail resists angular, compressive and rotational forces by virtue of the elastic quality of material and balanced insertional construct. Titanium alloy has a modular elasticity and handling characteristic very suitable to a child's diaphysis. It allows the stable reduction, maintenance of reduction and early mobilization. It aims to develop early bridging callus and contributes to rapid restoration of bone continuity.

Titanium elastic nails are available in 6 diameters: 1.5 mm, 2 mm, 2.5 mm, 3.0 mm, 3.5 mm and 4.0 mm. The 1.5 mm diameter nail is 300 mm long. The 2.0 mm through 4.0 mm nails are 440 mm long. The nails are colour coded for easy identification.

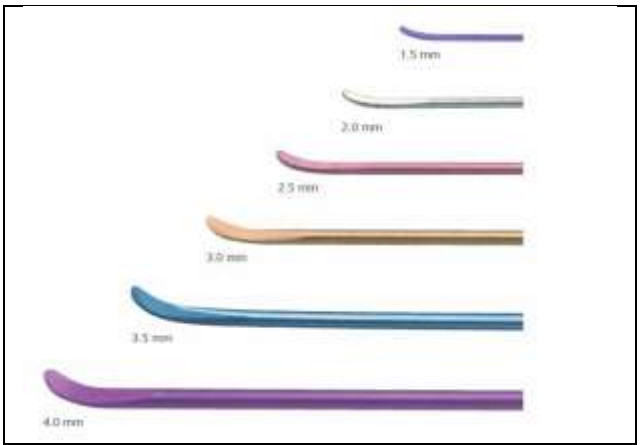

Figure 2

1.5 mm- dark blue, 2 mm- green, 2.5 mm- pink, 3 mm- gold, 3.5 mm – blue, 4 mm - purple

The following sizes are typically used for children of average stature:

6 - 8 years	3.0 mm nails
9 - 11 years	3.5 mm nails
12 - 14 years	4.0 mm nails

MATERIALS AND METHODS

The study was conducted in 30 paediatric patients with various long bone fractures who got admitted from OPD and Causality of Government General Hospital, Kurnool, between November 2016 to April 2018 patients were treated with titanium elastic nails and followed for period of 12 months.

Inclusion Criteria

1. Femoral diaphyseal fractures
2. Tibial diaphyseal fractures
3. Diaphyseal fractures of the humerus
4. Diaphyseal fracture both bones forearm
5. Comminuted fractures.

Exclusion Criteria

1. Epiphyseal and metaphyseal fractures,
2. Unmotivated patients
3. Compound fractures
4. Greenstick fractures

Sample Size

30

Sample Procedure

A prospective study. Patients are followed up periodically post operatively.

Patients Assessed By

Flynn's criteria after the treatment.

Methodology

After clinical examination all patients' radiography was taken. The surgery was performed, and the details of surgical procedure are as follows the patients is anaesthetized by General Anaesthesia for upper limb long bone fractures and by spinal anaesthesia for lower limb long bone fractures. Patients was kept in supine position for femoral shaft fractures entry point was made 2 cm proximal to distal epiphyseal plate and internal fixation done with two titanium nails. For tibial fractures entry point was made 2 cm distal to proximal epiphyseal plate and internal fixation done with two titanium nails. For humerus fractures entry point was made 2 cm proximal to distal epiphyseal plate and internal fixation done with two titanium nails. For radial fractures entry point was made just proximal to radial styoid process.For ulnar fractures antegrade entry point was made at posterior aspect of olecranon. Radius and ulnar fractures each bone fixation was done with single titanium nail. All the surgeries were done under fluoroscopic C arm guidance.

Post-Operative Regime

Patients were kept nil orally 4 to 6 hours postoperatively, IV fluids/blood transfusions were given as needed Analgesics were given according to the needs of the patient The limb was kept elevated over a pillow. IV antibiotics were continued for five days and switched over to oral antibiotics on the 5th day and continued till the 12th day.

Sutures were removed on the 12th postoperative day, and patients were discharged.

Post-operatively, patients are immobilized with long leg cast with a pelvic band for femur fracture or above knee POP cast for tibia fracture for six weeks, and such immobilization was continued for another 2-3 weeks based on the radiological assessment. The period of immobilization was followed by active hip and knee/knee and ankle mobilization with non-weight bearing crutch walking Full weight bearing is started by 8 - 12 weeks depending on the fracture configuration and callus response.

Plaster of Paris immobilization was given for a period of 3 or more weeks in unstable fractures. Immobilization with the brace was given for stable fractures of humerus For humerus fractures patients were allowed to take shoulder and elbow mobilization exercises after two weeks. For radius and ulna fractures above elbow pop cast was applied for a period of 1 month.

RESULTS

During the period 2016-2018, 30 patients of age between 6-12 years of age group with various diaphyseal long bone fractures in children were treated by closed /open reduction and Titanium Elastic nail fixation. In our study:

Age in Years	No. of Cases	Percentage
6 – 9	12	40
10 – 12	18	60
Total	30	100

Table 1. Age Distribution

Sex	No. of Cases	Percentage
Males	15	50
Females	15	50
Total	30	100

Table 2. Sex Incidence

Side Involved	No. of Cases	Percentage
Right	18	60
Left	12	40
Total	30	100

Table 3. Side Involved

Mode of Injury	No. of Cases	Percentage
Road Traffic Accidents	18	60
Fall	12	40
Total	30	100

Table 4. Mode of Injury

Duration	No. of Cases	Percentage
On the Day of Injury	15	50
Up To 3rd Day	12	40
3-5 Days	3	10
Total	30	100

Table 5. Duration of Injury on Admission

Interval	No. of Cases	Percentage
1-3 Days	27	90
3-5 Days	3	10
Total	30	100

Table 6. Interval between Injury and Operation

Duration of Operation	No. of Cases	Percentage
< 30 Min	9	30
31 – 40 Min	15	50
41 – 50 Min	6	20
Total	30	100

Table 7. Duration of Operation

Blood Loss	No. of Cases	Percentage
< 50 ml	21	70
50 – 100 ml	9	30
Total	30	100

Table 8. Blood Loss During Operation

Ambulatory Status	No. of Cases	Percentage
By the End of 6 Weeks	9	30
By the End of 9 Weeks	15	50
By the End of 12 Weeks	6	20
Total	30	100

Table 9. Ambulatory Status (Full Weight Bearing)

Duration	No. of Cases	Percentage
0-8 Weeks	9	30
9-16 Weeks	21	70
Total	30	100

Table 10. Fracture Union

Functional Results	No. of Cases	Percentage
Excellent	21	70
Good	6	20
Fair	3	10
Poor	0	0
Total	30	100

Table 11. Functional Results

Complications	No. of Cases	Percentage
1. Migration of Nails	1	3.3
2. Infection		
a) Superficial	0	0
b) Deep	0	0
3. Bed Sores	0	0
4. Implant Failure	1	3.3
5. Shortening < 2 cms	1	3.3
6. Mal Union with Rotational Deformity	1	3.3
7. Limitation of Joint Movements (Total)	4	13.3
a) Slight (10-20%)	3	10
b) Considerable (20-50%)	1	3.3
c) More Than 50%	0	0
8. Reoperation	1	3.3

Table 12. Complications

DISCUSSION

The present study consisted of 30 cases of various long bone diaphyseal fractures (Femur, Tibia, Both bones forearm & Humerus) in children; treated in the Department of Orthopaedics, Kurnool during the year Oct 2016-Apr 2018. The results obtained have been compared with the results obtained by other works using the same technique

Age Incidence

The mean age group in the present study is 10.33 yrs. 40% of the cases were in 6-9 years of age group, and 60% of cases were 10-12 years of age group. Atul Bhaskar[1] conducted the study in 60 patients with various long bone fractures who underwent operative treatment with elastic intramedullary nailing the mean age was 10 years. D Furlan et al[2] conducted a study in 173 children with various long bone fractures who underwent operative treatment with elastic intramedullary nailing. The mean age group was 11.7 years.

Sex Incidence

In the present study, there were 15 males (50%) and 15 females (50%). In a study conducted by D Furlan et al,[2] 70% were males and 30% were females. In a study conducted by Atul Bhaskar,[1] 54.3% were males, and 45.7% were females.

Mode of Injury

A road traffic accident was responsible for 60% of the patients, and an accidental fall was responsible for 40% of patients. In study conducted JM Flynn et al[3] Road traffic was responsible for 58.1% of patients an accidental fall was responsible for 19.6% patents.

Long Bones Affected

In present study number of long bones affected are 16 femur, 10 tibia, 2 humerus, 2 both bones forearms whereas in Furlan et al[1] study number of long bones affected are 42 femurs, 36 tibias, 55 humeri, 42 both bones forearm. Most common long bone affected in the present study was femur whereas in D Furlan et al[2] study most common long bone affected was humerus.

Associated Injuries

In this series, 6.6% cases of associated fractures were found they are one has distal femur fractures on the opposite side, and other has ipsilateral both bones forearms whereas D Furlan et al[2] reported that in his study 76% of cases had isolated long bone injury and 24% had associated injuries.

Operating Time

The average operating time in the present study was 45min. This is a marked contrast to the other types of fixation like interlocking nailing and plating techniques. In a study conducted by Khurram Barlas et al[4] average operating time was 70 minutes.

Blood Loss During Surgery

In the present study, 70% of the cases had less than 50 ml of blood loss, and 30% of the cases had 50-100 ml of blood loss. No patient in the current study required a blood transfusion. The average blood loss was 55 ml. Pankovich[5] and Tarabishy reported a blood loss of 120 ml. This is also more contrast to other types of fixation devices where blood transfusion is necessary.

Time for Union

In the present study follow up was done clinically and radiologically for a period of 6 months. Average hospital time was 5 days. 30% of the cases had a union in 0-8 weeks, and 70% of the cases had a union in 9-16 weeks. All fractures in our study showed evidence of union on an average of 4 months. The average time for the union was 10 weeks. Roop Singh, SC Sharma et al[6] studied 35 paediatric patients in the age group 6-14 years with diaphyseal femoral fractures were stabilized with two titanium nails. Patients were followed up clinically and radiologically for two years. Overall results observed were excellent in 25, satisfactory in 8 and poor in 2 patients. Hospital time averaged 12.30 days in the series. All the fractures healed with an average time to union of 9.6 (6-14.4) weeks.

Complications

P. Berger, J. S. De Graaf, R. Leemans[7] encountered complications in three hydrops of the knee, four low-grade infections, and one delayed union. Leg length discrepancy was only seen in five patients (18%) and was less than 2 cm. JM. Flynn et al.[3] reported 10 (4.3%) cases of minor angulation out of 234 fractures treated with titanium elastic nails. In our series, complications encountered were knee stiffness in 4 cases (13.3%), no infections or non-union, malunion in 1 case (3.3%), shortening less than 2 cm in 1 case (3.3%). Knee stiffness cases improved on physiotherapy. Shortening was found in 3.3 percent of patients in the current study whereas 10 percent rate reported by Rajesh Govindaswamy et al.[8] Knee stiffness was encountered in 13.3 percent cases in the present study whereas in JM Flynn et al[3] study knee stiffness was encountered in 0.9% of cases out of 234 cases in his study.

Functional Outcomes

Gamal El Adl et al.[9] in their study of 66 children with 48 femoral and 25 tibial shaft fractures reported (75.8%) excellent, 24.2% satisfactory and no poor results. J. M. Flynn et al.[3] treated 234 femoral shaft fractures and the outcome was excellent in 150(65%) cases, satisfactory in 57 (25%) cases and poor in 23 (10%) of the cases. Wudbhav N.Sankar[10] in their study of 19 tibial shaft fractures reported 12 (63.15%) excellent, 6 (31.57%) satisfactory and 1 (5.26%) poor results. KC Saikia et al.[11] in their study of 22 children with femoral diaphyseal fractures reported 13 (59%) excellent, 6 (27.2%) satisfactory and 3(13.6%) poor results. In a study conducted by D Furlan et al,[2] 89% of patients were very satisfied, and 11% were satisfied. In a study conducted by Rajesh Govindasamy et al[8] with femoral diaphyseal fractures reported 83% of patients were excellent and 17% were satisfactory. In our study good to excellent results were obtained in 90% of patients and 10% had fair results.

CONCLUSION

The following conclusions have been arrived at after comparing the overall results of this study with that obtained by other works. Titanium Elastic Nailing is ideally suited not only for the children and younger age groups but also in biologically old, fragile, high anaesthesia risk and osteoporotic patients. Hence, it can aptly be called as "a friendly procedure to paediatric, geriatric and younger age groups." This method is less traumatic, gentle and one of the simplest methods known. This method is based on sound biomechanics. The intramedullary position of the implant, places it more in line with the weight bearing forces, thereby reducing the tendency of the fracture to settle in a deformed position. Excellent biomechanics is reflected by the absence of implant failure. No case of the delayed or non-union were seen in the present study. Early ambulation is one of the advantages of the Titanium Elastic Nailing. This helps to minimize the duration of hospital stay and complications of enforced bed rest like pneumonia, bed sores, UTI, thromboembolic phenomenon, etc. The risk of infection is negligible as the incision is far away from the fracture and it is a closed technique. The high incidence of complications in unstable fractures necessitates a certain degree of caution to be exercised. Few weeks protection often required postoperatively. There is a high incidence of knee stiffness with this procedure which can be minimised by proper placement of the entry portal and rigorous physiotherapy in the postoperative phase. Operative time is also less. This is also very useful in overpopulated countries. Patients are more comfortable from 1st post-operative day

onwards because of it is least traumatic in nature. In segmental fractures, Titanium Elastic Nailing eliminates the torsion of the middle segment, so chances of necrosis of the middle segment are minimised. Titanium Elastic technique can be carried out by an average Orthopaedic surgeon. Finally, we were convinced by the versatility of the Titanium Elastic Nailing as it provides a solution to many fractures that would have been difficult for internal fixation by any other methods including polytrauma cases, with less operative time, less infection rate, less bleeding and improved rehabilitation programme.

REFERENCES

[1] Bhaskar A. Treatment of long bone fractures in children by flexible titanium elastic nails. IJO 2005;39(3):166-168.
[2] Furlan D, Pogorelic Z, Biocic M, et al. Elastic stable-intramedullary nailing for pediatric long bone fractures: experience with 175 fractures. Scandinavian Journal of Surgery 2011;100:208-215.
[3] Flynn JM, Hresko T, Reynolds RA, et al. Titanium elastic nails for pediatric femur fractures: a multicenter study of early results with analysis of complications. J Pediatr Orthop 2001;21(1):4-8.
[4] Barlas K, Beg H. Flexible intramedullary nailing versus external fixation of paediatric femoral fractures. Acta Orthop Belg 2006;72(2):159-163.
[5] Pankovich AM. Flexible intramedullary nailing of long bone fractures: a review. J Orthop Trauma 1987;1(1):78-95.
[6] Singh R, Sharma SC, Magu NK. Titanium elastic nailing in pediatric femoral diaphyseal fractures. IJO 2006;40(1):29-34.
[7] Berger P, De Graaf JS, Leemans R. The use of elastic intramedullary nailing in the stabilization of paediatric fractures. Injury 2005;36(10):1217-1220.
[8] Govindasamy R, Gnanasundaram R, Kasirajan S, et al. Elastic stable intramedullary nailing of femoral shaft fracture-experience in 48 children. Arch Bone Jt Surg 2018;6(1):39-46.
[9] El-Adl G, Mostafa MF, Khalil MA, et al. Titanium elastic nail fixation for paediatric femoral and tibial fractures. Acta Orthop Belg 2009;75(4):512-520.
[10] Sankar WN, Jones KJ, David Horn B, et al. Titanium elastic nails for pediatric tibial shaft fractures. J Child Orthop 2007;1(5):281-286.
[11] Saikia K, Bhuyan S, Bhattacharya T, et al. Titanium elastic nailing in femoral diaphyseal fractures of children in 6-16 years of age. Indian J Orthop 2007;41(4):381-385.