SURGICAL MANAGEMENT OF LONG BONE SHAFT FRACTURES IN LOWER LIMB BY ELASTIC NAILING IN PAEDIATRIC AGE GROUP

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ABSTRACT

BACKGROUND

Incidence of paediatric long bone fractures are increasing day-to-day due to high speed vehicle accidents.
The aim of the study is to-

1. Evaluate the surgical and functional outcome of surgical treatment of long bone shaft fractures in children by elastic nailing.
2. Study the union rates.
3. Compare the results with those in literature and study the complications associated with elastic nailing.

MATERIALS AND METHODS

Forty patients in the age group of 5-16 years of age with diaphyseal fractures of femur and/or tibia admitted at SVRRGGH, Tirupati. During the study period of November 2014 to October 2016 at SVRRGGH, Tirupati, patient fulfilling the inclusion and the exclusion criteria (as given below) were the subjects for the study. Finally, after the diagnosis, the children were selected for the study depending on the inclusion and exclusion criteria. Postoperatively, all the cases were followed up to six weekly intervals till the fracture union. Results were analysed both clinically and radiologically.

RESULTS

This study comprises of 25 male and 15 female patients aged from 5 to 15 years. The follow-up ranged upto 24 weeks and union rate is assessed based on clinical and radiological aspect.

CONCLUSION

Based on our experience and results, we conclude that elastic stable intramedullary nailing technique is an ideal method for treatment of paediatric diaphyseal fracture between the ages of 5 to 16 years with good results.

KEYWORDS

Paediatric Long Bone Shaft Fractures, Titanium Elastic Nailing, Fracture Union, Early Mobilisation.

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BACKGROUND

Long bone shaft fractures are the most common paediatric orthopaedic injury that most orthopaedic surgeons will treat routinely and is most common paediatric orthopaedic injury requiring hospital admission. Over the past few years, there is marked increase in use of intramedullary fixation in management of long bone shaft fractures in children. Elastic stable intramedullary nailing for the treatment of paediatric long bone fractures was introduced by Prevot and colleagues in 1979. Stabilisation follows the three-point fixation principle that provides internal elastic support in the presence of cortical contact and an intact soft tissue envelope.[1,2,3,4] The technique offer several advantages including better reduction, dynamicaxial stabilisation, shorter hospitalisation with early rehabilitation and low rate of complications. In children who are five years of age or younger, early closed reduction and application of a spica cast is an ideal treatment for most diaphyseal fractures of femur and tibia. In recent years, fixation with flexible intramedullary nails have become popular technique for stabilising femur and tibial fracture in school-aged children. TENS is a simple, effective and minimally-invasive technique. It gives stable fixation with rapid healing and prompt return of child to normal activity without any limb length discrepancy. This study is intended to assess the results following treatment of fracture shaft of femur and tibia by Titanium Elastic Intramedullary Nailing System (TENS).[5]

Aim of the Study- To study and evaluate the surgical and functional outcome of surgical treatment of long bone shaft fractures in children by elastic nailing.

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MATERIALS AND METHODS

Design- Prospective study.

Subjects- Forty patients in the age group of 5-16 years of age with diaphyseal fractures of femur and/or tibia admitted at SVRRGGH, Tirupati. During the study period of November 2014 to October 2016 at SVRRGGH, Tirupati, patient fulfilling the inclusion and the exclusion criteria (as given below) were the subjects for the study. Finally, after the diagnosis, the children were selected for the study depending on the inclusion and exclusion criteria. Postoperatively, all the cases were followed up to six weekly intervals till the fracture union.[6,7,8] Results were analysed both clinically and radiologically.

Inclusion Criteria

a. Patient guardians who are given informed consent.
b. Children and adolescent patients from 5 to 16 years with diaphyseal fractures of long bones.
c. Both the sexes are included in the study.
d. Patient with simple long bone shaft fractures.

Exclusion Criteria

a. Patients unfit or not willing for surgery.
b. Patient above 16 years.
c. Patient with communited segmental fractures.
d. Patient presenting with pathological fractures.

Preoperative Evaluation- Consists of detailed history, clinical examination and radiological assessment.

- Nail size.
- Nail width.

  The diameter of the individual nail is selected as per-

  1. Flynn et al'sFormula.[9]

     Diameter of nail= width of the narrowest point of the medullary canal on AP and lateral view x 0.4mm.

  2. Intraoperative Assessment.

     Diameter of the nail is chosen so that each nail occupies at least one-third to 40% of the medullary cavity.

- Nail length- Lay one of the selected nails over the thigh/leg and determine that it is of the appropriate length by fluoroscopy. The nail for femur should extend from the level of the distal femoral physis to a point approximately 2 cm distal to the capital femoral physis and 1 cm distal to the greater trochanteric physis, and for tibia, it should extend 2cm from the proximal physis till 5mm proximal to the distal physis.

Figure 1. Titanium Elastic Nail System (TENS)

Instrumentation Set

1. Titanium elastic nails.
2. Bone awl.
3. Inserter.
4. Beveled tamp.
5. Hammer.
6. Steffe cutter.

Procedure for TENS Nailing of Diaphyseal Fracture of Femur Retrograde Fixation- General/spinal anaesthesia is administered and patient is placed in supine position on a radiolucent table. The operative extremity is then prepared and draped free. Identify the physis by fluoroscopy and mark its location on the skin. A 2 to 2.5 cm longitudinal skin incision is made over the medial and lateral surface of the distal femur starting 2 cm proximal to the distal femoral epiphyseal plate. A haemostat is used to split the soft tissue down to the bone following which a 3.2 mm drill bit is used at a point 2.5 cm proximal to the distal femoral growth plate to open the cortex at a right angle. The drill is then inclined 10° to the distal femoral cortex. A nail is introduced with a T-handle by rotation movements of the wrist.[10,11,12]

Under image intensifier control, the nail was driven with rotatory movement or with a hammer to the fracture site, which is aligned to anatomical or near anatomical position with proper attention to limb rotation and length. By rotation, movements of the T-handle with or without limb manipulation, the nail is directed to the proximal fragment, which is pushed into better alignment by the nail. At the same time, the second nail is advanced to enter the proximal fragment and in the meantime any traction is released to avoid any distraction and both nails are pushed further till their tips become fixed into the cancellous bone of the proximal femoral metaphysis without reaching the epiphyseal plate. The tips of the nail that enter the lateral femoral cortex should come to rest just distal to the trochanteric epiphysis. The opposite nail should be at the same level towards the calcar region; too short nails should be avoided.[13,14]

The two-nail construct should be in a symmetrical alignment face to face with the maximum curvature of the nails at the level of the fracture.

Distally, the nails are cut leaving only 0.5-1 cm outside the cortex. The extra osseous portion of the nails is kept as it is or slightly bent away from the bone to facilitate removal later on. In all cases, care is taken to use nails with similar diameters to use the largest possible diameter and to use the double C construct to ensure 3-point fixation.

Procedure for TENS Nailing of Diaphyseal Fracture of Tibia Antegrade Fixation- General/spinal anaesthesia is administered and patient is placed in supine position on a radiolucent table. The operative extremity is then prepared and draped free. Under fluoroscopy, the fracture site and proximal tibialphysis are marked. The starting point for nail insertion is 1.5-2.0 cm distal to the physis sufficiently posterior in the sagittal plane to avoid injury to the tibial tubercle apophysis. A longitudinal 2 cm incision is made on both the lateral and medial side of the tibial metaphysis just proximal to the desired bony entry point. Using a hemostat, the soft tissues are bluntly dissected down to bone. Based on preoperative measurements, an appropriately-sized implant is selected so that the nail diameter is 40% of the diameter of the narrowest portion of the medullary canal. A drill roughly 0.5 cm larger than the selected nail is then used to open the cortex at the nail entry site; angling the drill distally down the shaft facilitates nail entry. Both nails are then inserted through the entry holes and advanced to the level of the fracture site.[15,16]

Under fluoroscopic guidance, the fracture is reduced in both the coronal and sagittal planes and the first nail is advanced past the fracture site. If proper intramedullary position of the nail distal to the fracture site is confirmed on anteroposterior and lateral views, then the second nail is tapped across the fracture site. Both nails are advanced until the tips lie just proximal to the distal tibialphysis. Fluoroscopy is again used to confirm proper fracture reduction as well as nail position.[17,18,19,20]

To minimise soft tissue irritation, the nails are backed out a few centimetres and cut along proximal tibial metaphysis. A tamp is used to readvance the implants until <1 cm of nail lies outside of bone. Care is taken not to bend the nails away from the bone to facilitate cutting as it is found that this increases nail prominence and subsequent skin irritation. The two incisions for nail entry are closed in a layered fashion and the wounds are well padded with gauze.

Postoperative Care

- 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 5 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.

Postoperatively, patients were immobilised with long leg cast with a pelvic band for femur fracture or above knee POP cast for tibia fracture for 6 weeks and such immobilisation was continued for another 2-3 weeks based on radiological assessment. The period of immobilisation was followed by active hip and knee/knee and ankle mobilisation with non-weight-bearing crutch walking.

Full weight-bearing was started by 8-12 weeks depending on the fracture configuration and callus response.

Follow Up- Assessment done at 6, 12 and 24 weeks. At each follow up, patients were assessed clinically, radiologically and the complications were noted.

OBSERVATIONS

Study Design- Surgical outcome of paediatric diaphyseal fractures of lower limb are seen in 40 patients treated by elastic nailing.

Age in Years	Number of Patients	Percentage
5-8	25	62.5
9-12	7	17.5
13-16	8	20
Total	**40**	**100**

Table 1. Age Distribution of Patients Studied

Gender	Number of Patients	Percentage
Male	25	62.5
Female	15	37.5
Total	**40**	**100**

Table 2. Gender Distribution of Patients Studied

Mode of Injury	Number of Patients	Percentage
RTA	26	65
Self-fall	10	25
Fall from height	4	10
Total	**40**	**100**

Table 3. Mode of Injury of Patients Studied

Bone Affected	Number of Patients	Percentage
Femur	25	62.5
Tibia	15	37.5
Total	**40**	**100**

Table 4. Bone Affected

Side Affected	Number of Patients	Percentage
Right	26	65
Left	14	35
Total	**40**	**100**

Table 5. Side Affected

Pattern of Fracture	Number of Patients	Percentage
Transverse	22	55
Oblique	8	20
Spiral	7	17.5
Segmental	0	0
Comminuted	3	7.5
Total	**40**	**100**

Table 6. Pattern of Fracture

Level of Fracture	Number of Patients	Percentage
Proximal 1/3rd	12	30
Middle 1/3rd	20	50
Distal 1/3rd	8	20
Total	**40**	**100**

Table 7. Level of Fracture

Postoperative Immobilisation	Number of Patients	Percentage
6 weeks	30	75
9 weeks	10	25
Total	**40**	**100**

Table 8. Postoperative Immobilisation

Duration of Stay	Number of Patients	Percentage
≤7	6	15
8-10	9	22.5
11-15	20	50
>15	5	12.5
Total	**40**	**100**

Table 9. Duration of Stay in Hospital Stay in Days

Time of Union	Number of Patients	Percentage
<1-12 weeks	32	80
>12-18weeks	7	16
>18-24 weeks	1	4
Total	**40**	**100**

Table 10. Time for Union

Range of Movements in Degrees	No. of Patients	Percentage
Full range	37	92.5
Mild restriction	3	7.5
Moderate restriction	0	0
Severe restriction	0	0
Total	**40**	**100**

Table 11. Range of Movements at 24 Weeks (Degrees)

Time of Full Weight-Bearing	Number of Patients	Percentage
≤12 weeks	32	80
>12 weeks	7	16
>18-24 weeks	1	4
Total	**40**	**100**

Table 12. Time of Full Weight-Bearing

Complications	Minor	Major	Nil	Total
No. of patients	16	0	24	**100**
Percentage	40	0	60	**100**

Table 13A. Complications

Complications		No. of Patients	%
Pain		6	15
Infection	Superficial	2	5
	Deep	-	-
Inflammatory reaction		1	2.5
Delayed union and non-union		-	-
Limb lengthening	<2 cm	1	2.5
	>2cm	-	-
Limb shortening	<2 cm	1	2.5
	>2cm	-	-
Nail back-out		-	-
Malalignment		-	-
a. Varus angulation		1	2.5
b. Valgus angulation		1	2.5
c. Anterior angulation		-	-
d. Posterior angulation		-	-
e. Rotational malalignment		-	-
Bursa at the tip of the nail		2	5
Sinking of the nail into the medullary cavity		1	2.5

Table 13B. Complications

Outcome	Number of Patients (n=40)	Percentage
Excellent	30	75
Satisfactory	10	25
Poor	0	0
Total	**40**	**100**

Table 14. Outcome

Outcome Variables	Excellent %	Satisfactory %	Poor %
Range of movements	92	8	0
Time of union	85	15	0
Unsupported weight-bearing	90	10	0

Table 15. Outcome for Additional Variables in the Present Study

Clinical Variables	Total Number of Patients (n =40)	Complications (Minor)		P Value
		Absent(n =24)	**Present(n=16)**	
Age in Years				0.518
5-8	25(62.5%)	13(54%)	12(75%)	
9-12	7(17.5%)	5(20%)	2(12%)	
13-16	8(20%)	6(25%)	2(13%)	
Gender				0.567
Male	25(62.5%)	18(75%)	7(44%)	
Female	15(37.5%)	6(25%)	9(56%)	
Mode of Injury				0.380
RTA	26(65%)	16(66%)	10(62%)	
Fall	10(25%)	5(21%)	5(31%)	
Fall from height	4(10%)	3(13%)	1(7%)	
Bone Affected				0.678
Femur	25(62.5%)	18(75%)	7(44%)	
Tibia	15(37.5%)	6(25%)	9(56%)	
Pattern of Fracture				0.708
Transverse	22(55%)	15(63%)	7(44%)	
Oblique	8(20%)	6(25%)	2(12%)	
Spiral	7(17%)	2(8%)	5(31%)	
Communitated	3(7.5%)	1(4%)	2(30%)	

Table 16. Association of Incidence of Complications with Clinical Variables Studied

Figure 2. Position of Patient

Figure 3. Draping

Figure 4. Incision

Figure 5. Entry Point Made with Bone AWL

Figure 6. TENS Nail is Being Introduced Using Inserter

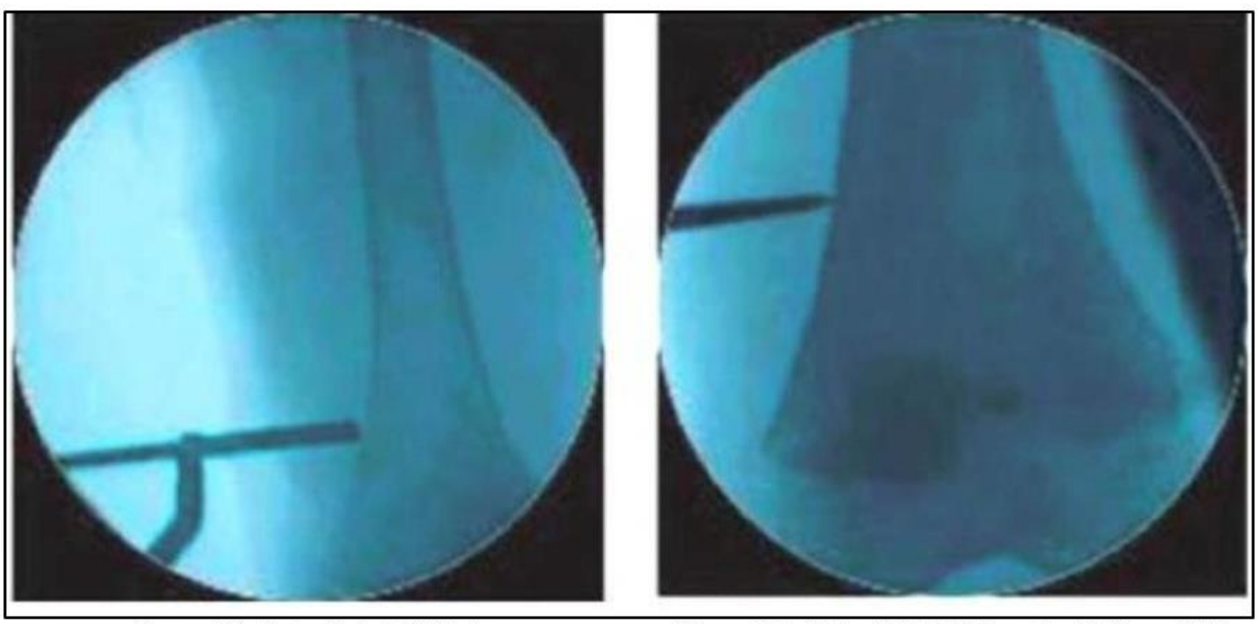


Figure 7A. Entry Point Drilled *Figure 7B. Entry Point Widened with Bone AWL*

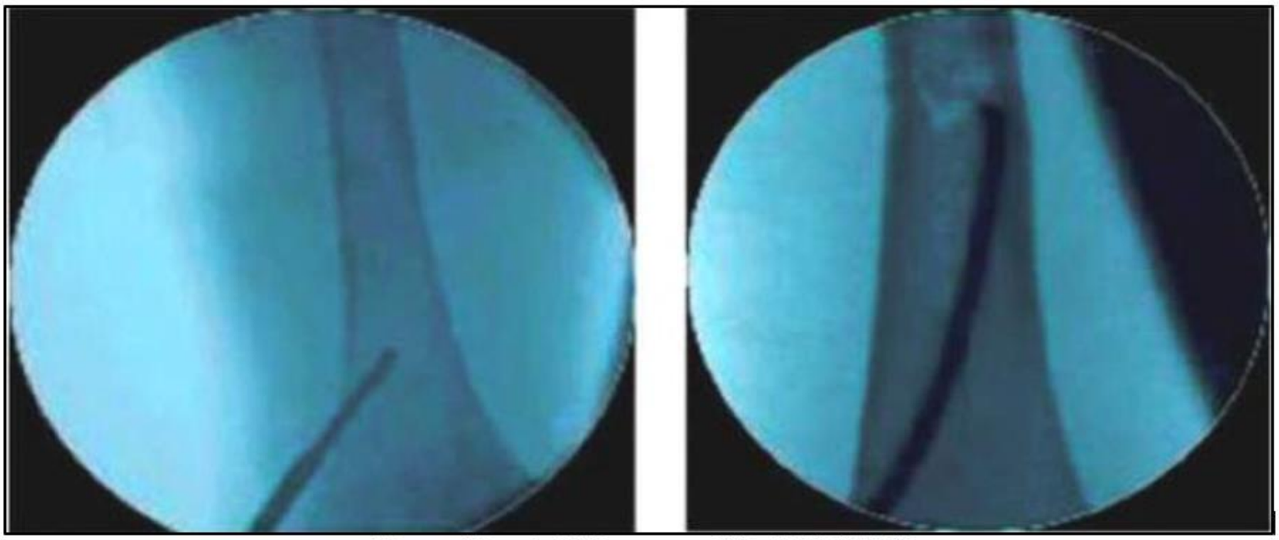


Figure 8A and 8B. Passage of the Nail (ESIN)
A. Nail Introduced on Medial Side *B. Medial Nail Passed Until Fracture Site*

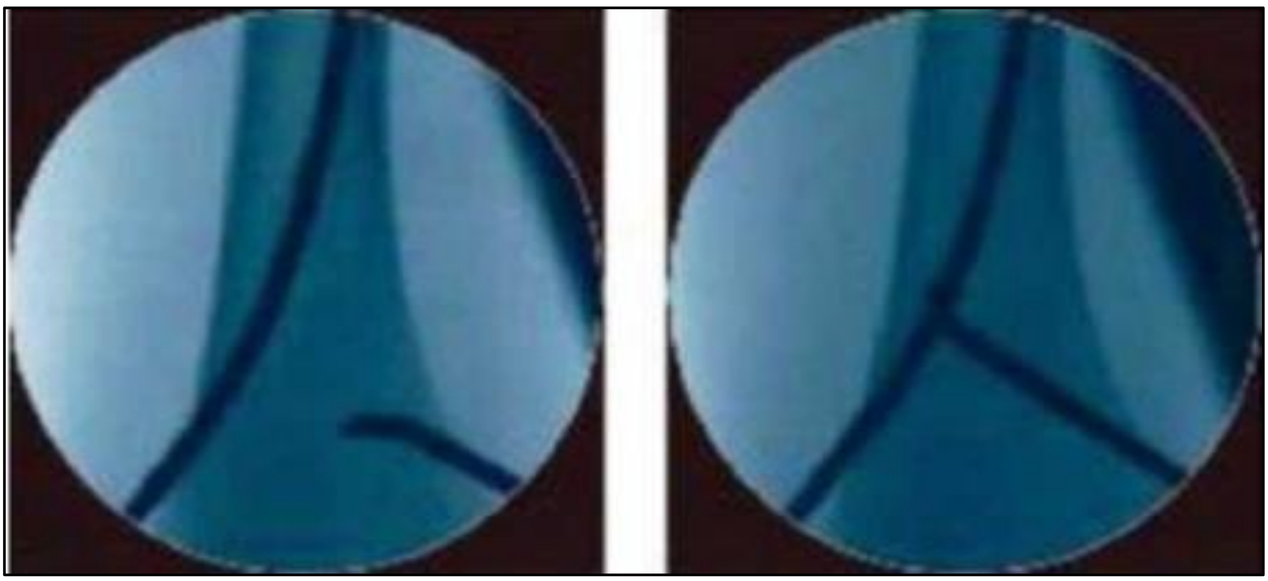


Figure 9. Another Nail Passed From Lateral Side

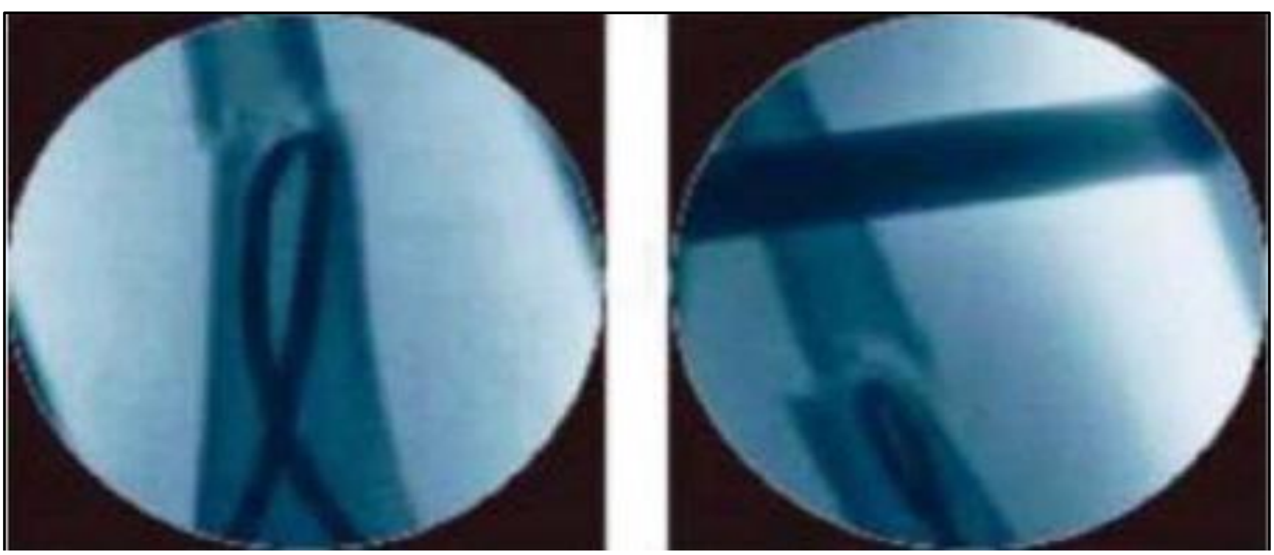


Figure 10. Both Nails Passed upto Fracture Site

Figure 11A. Medial Nail Passed Beyond Fracture Site

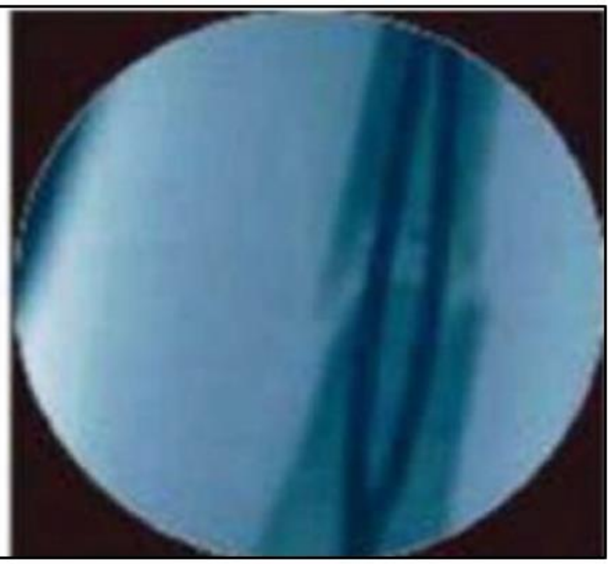


Figure 11B. Lateral Nail Passed Beyond Fracture Site

Figure 12A. Medial Nail Passed Till Greater Trochanter

Figure 12B. Lateral Nail Passed till Femoral Neck

Figure 13. Closure of Surgical Wound Tibia

Figure 14. Positioning of the Patient with Draping

Figure 15. Incision

Figure 16. Entry Point Made With Bone Awl

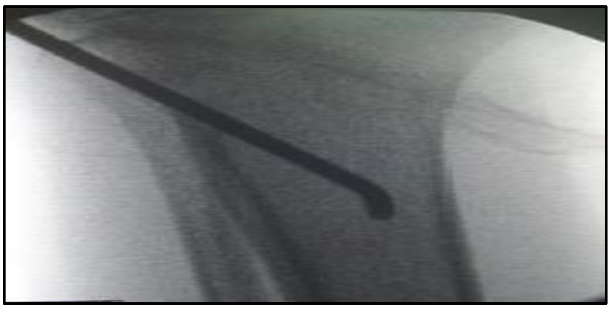


Figure 17. TENS Nail is Introduced Using Inserter

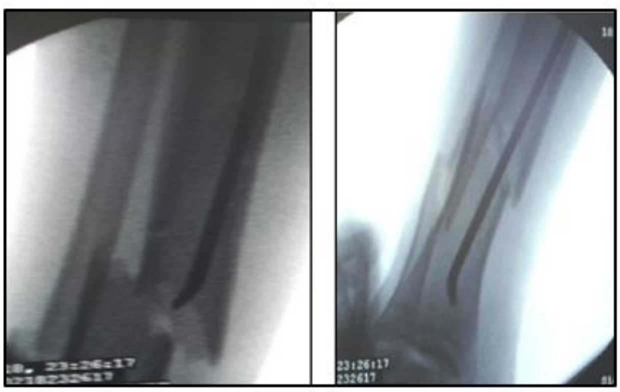
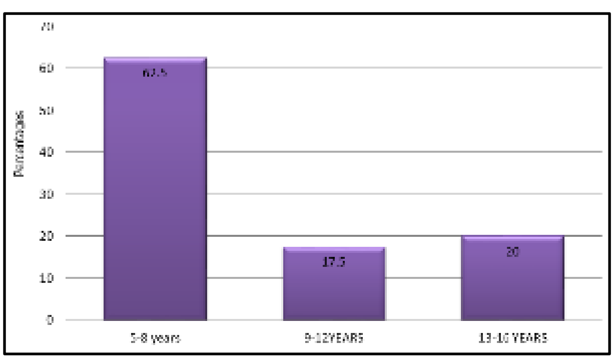
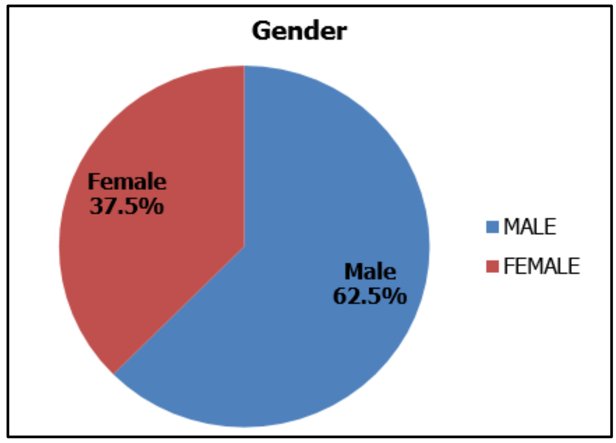


Fig. 18A *Fig. 18B*

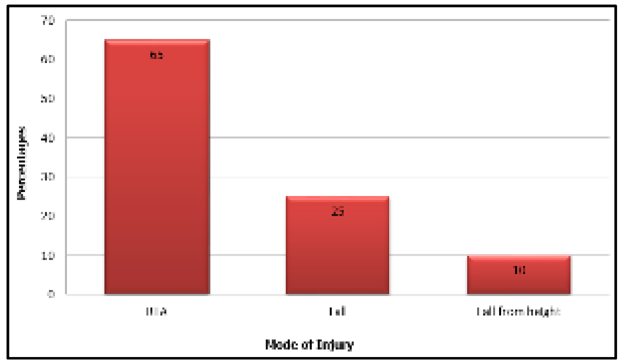
Figure 18A. Nail Progressed in the Medullary Canal through the Fracture Site Insertion of the Second Nail. Figure 18B. The Second Nail Being Progressed in the Medullary Canal Across the Fracture Site after Wound Closure



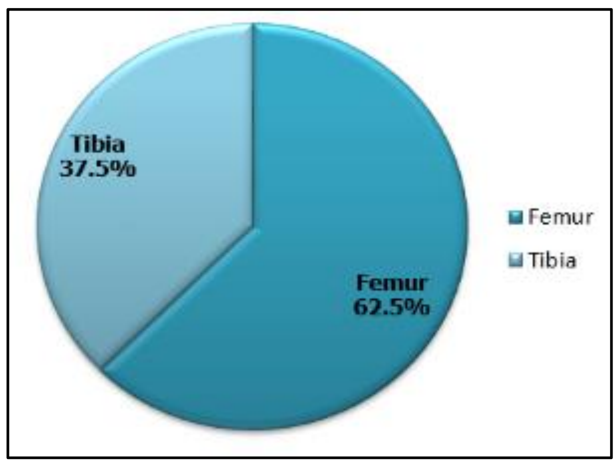
Graph 1. Age Distribution of Patients Studied



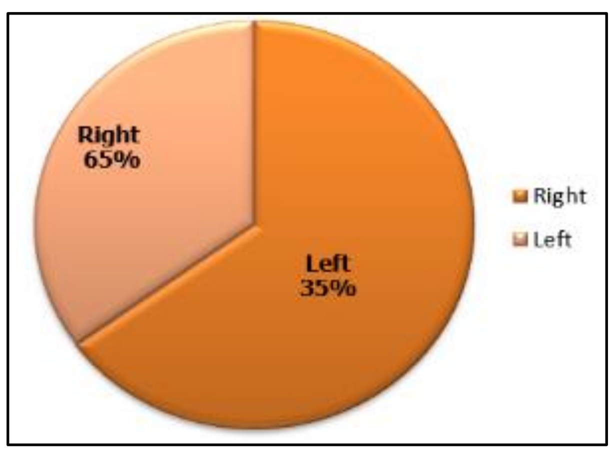
Graph 2. Gender Distribution of Patients Studies



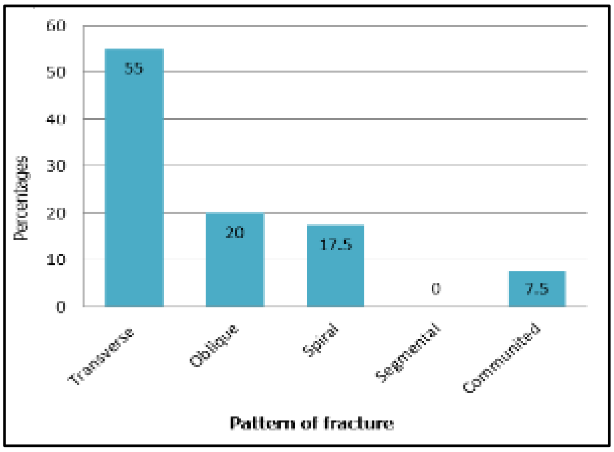
Graph 3. Mode of Injury



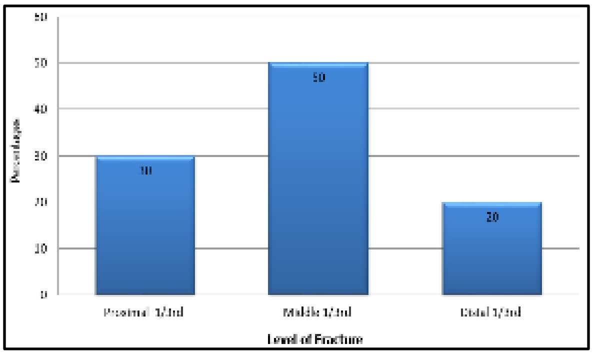
Graph 4. Bone Affected



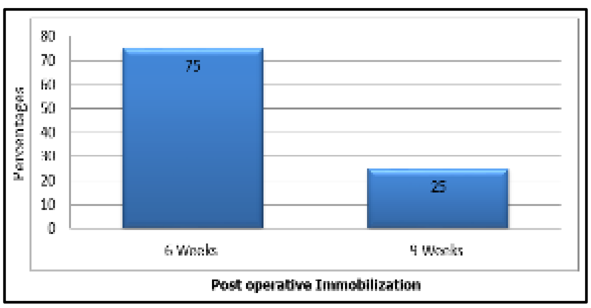
Graph 5. Side Affected



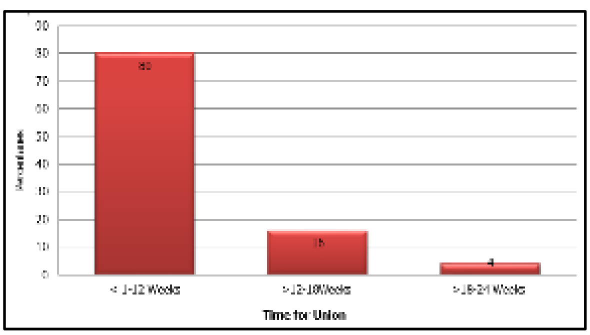
Graph 6. Pattern of Fracture



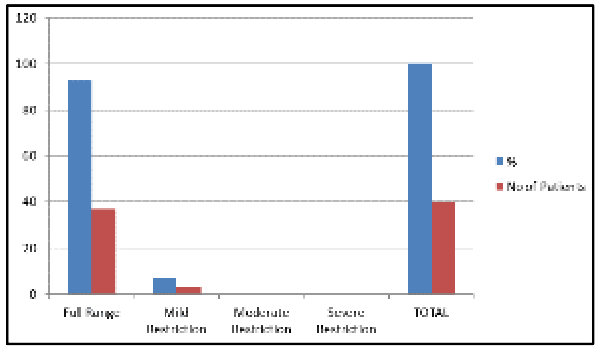
Graph 7. Level of Fracture



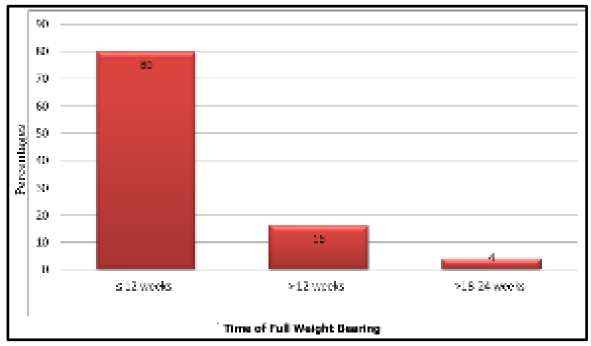
Graph 8. Postoperative Immobilisation



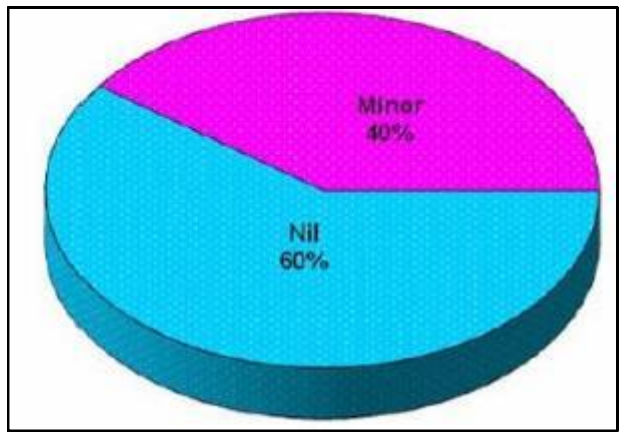
Graph 9. Time for Union



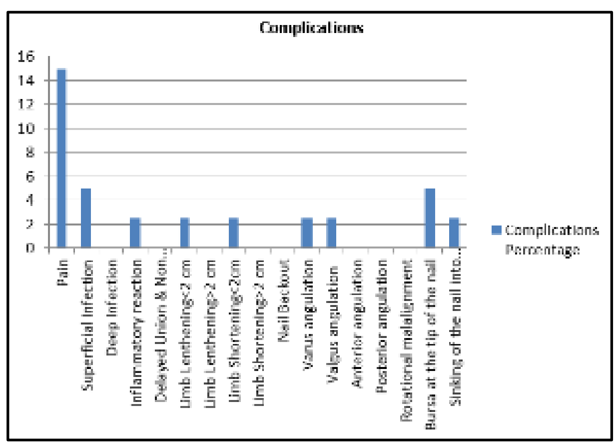
Graph 10. Range of Movements at 24 weeks (Degrees)



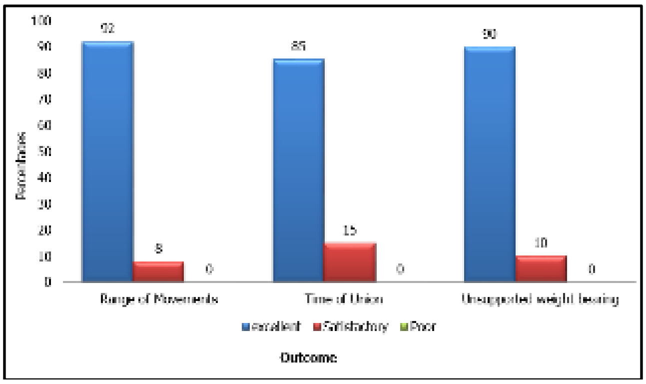
Graph 11. Time of Full Weight-Bearing



Graph 12A. Complications



Graph 12B. Complications



Graph 13. Outcome

Radiological and Clinical Photos

Case 1

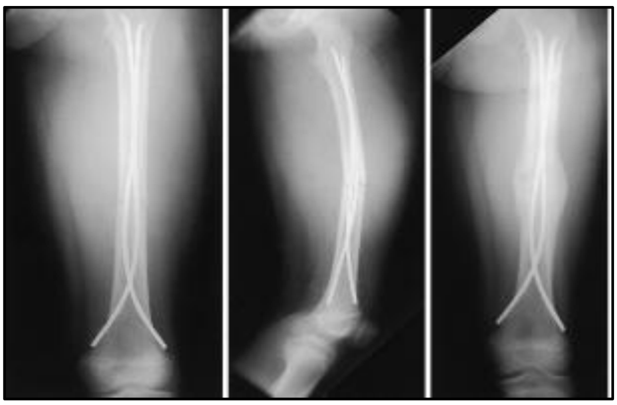
Case 2

Case 3

Case 4

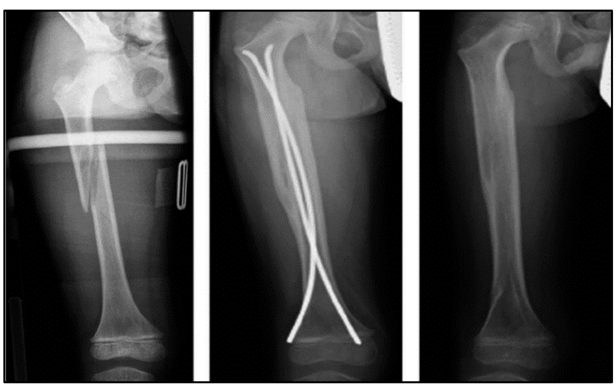
Scar Photo

Case 5



Postoperative After 1 Month After 6 Months

Case 6



Preoperative after 6 Months after Nail Removal

DISCUSSION

The goal of treatment for paediatric long bone shaft fractures is to provide stable fixation and early mobilisation. In the present study, 25 (62.5%) of the patients were 5-8 years, 7 (17.5%)were 9 to 12 years and 8 (20%) were 13 to 16 years age group with the average age being 9.8 years. There were 25 (62.5%) boys and 15 (37.5%) girls in the present study. The sex incidence is comparable to other studies in the literature.

The period of immobilisation was followed by active hip and knee/knee and ankle mobilisation with non-weight crutch walking. The average duration of immobilisation was 7.5 weeks.

The advantage of the present study was early mobilisation of the patients.

The average duration of hospital stay in the present study is 11.0 days.

The mean hospital stay was 12 days in Kalenderer O et al study.

Average hospitalisation time was 11.4 days in the study conducted by Mann DC, et al.

In our study, average time to union was 12.5 weeks. Oh C.W et al reported average time for union as 10.5 weeks.

In our study, closed reduction of the fracture leading to preservation of fracture haematoma, improved biomechanical stability and minimal soft tissue dissection led to rapid union of the fracture compared to compression plate fixation.

In the present study, unsupported full weight-bearing walking was started in <12 weeks for 32 (80%) of the patients between 12 and 18 weeks in 7(16%) and at 20 weeks in 1 (4%) patient. The average time of full weight-bearing was 11.5 weeks.

All patients had full range of hip and ankle motion in the present study and 3 (7.5%),1(2.5%) had lengthening (femur - 1.2cm). No patient in our study had major limb length discrepancy.

In the present study, the final outcome was excellent in 30(75%) cases, satisfactory in 10 (25%) cases and there were no poor outcome cases.

CONCLUSION

Based on our experience and results, we conclude that elastic stable intramedullary nailing technique is an ideal method for treatment of podiatric diaphyseal fractures. The technique offers several advantages including better reduction, dynamic axial stabilisation, shorter hospitalisation with early mobilisation and low complication rate. It gives lower complication rate and good outcome when compared with other methods of treatment.

It is a simple, easy, rapid, reliable and effective method for management of paediatric femoral and tibial fractures between the age of 5 to 16 years with shorter operative time, lesser blood loss, lesser radiation exposure, shorter hospital stay and reasonable time to bone healing.

It gives stable fixation with rapid healing and prompt return of child to normal activity without any limb length discrepancy.

Because of early weight-bearing, rapid healing and minimal disturbance of bone growth, ESIN may be considered to be a physiological method of treatment.

Our study results provide new evidence that expands the inclusion criteria for this treatment and shows that ESINs can be successfully used regardless of fracture location and fracture pattern.

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