

PEADIATRIC LONG BONES FRACTURE IN LOWER LIMBS TREATED BY TENS (TITANIUM ELASTIC NAILING SYSTEM) NAIL: A SURGICAL OUTCOME

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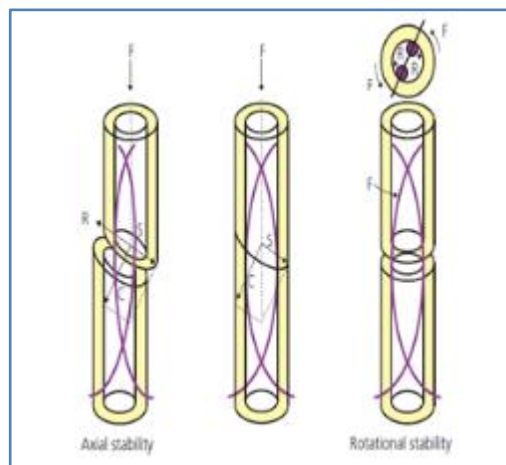
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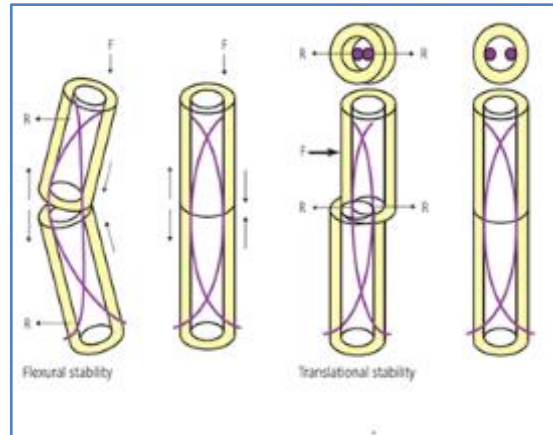
ABSTRACT: In the last two decades, there was an increased interest in the operative treatment of pediatric fractures, although debate persisted over its indications. There is a little disagreement concerning the treatment of long bone fractures in children less than 6 years (POP cast) and adolescents, older than 16 years (locked intramedullary nailing).¹ Controversy persists regarding the age between 6 to 16 years, with several available options: traction followed by hip Spica, external fixation, flexible, stable intramedullary nails, plate fixation, and locked intramedullary nailing. As no clear guidelines have been available until now despite efforts done initially by French surgeons, later on by European surgeons and recently by the Paediatric Orthopaedic Society of North America (POSNA)² Titanium elastic nail (TEN) fixation was originally meant as an ideal treatment method for femoral fractures, but 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 minimal complications³. Hence we have undertaken a prospective study of 30 cases in our institution about the outcome and efficacy of paediatric femoral and tibial diaphyseal fracture between age 6 to 16 years.

KEYWORDS: Peadiatic long bones, tens, tibial shaft fractures in peadiatric age group, femur shaft fractures in peadiatric age group.

INTRODUCTION: The ideal device to treat paediatric femoral and/or tibial fractures should be a simple, load sharing internal splint, allowing early mobilisation while maintaining length and alignment for several weeks until bridging callus forms, without endangering the blood supply to the epiphysis.^{2,4} TENs are more elastic, thus limiting the amount of permanent deformation during nail insertion; they promote healing by limiting stress shielding in addition to their biocompatibility without metal sensitivity reactions.



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(F – force acting, R- restoring force of the nail, S – shear force, C – compressive force.)

Inclusion Criteria:

1. 5-16 years of age.
2. Diaphyseal fractures.
3. Simple fractures (closed fractures).
4. Ipsilateral fractures.
5. Fracture with head injury.

Exclusion Criteria:

1. Metaphyseal fractures.
2. Compound fractures.
3. Pathological fractures.

PROCEDURE FOR TENS NAILING OF DIAPHYSEAL FRACTURE OF FEMUR RETROGRADE

FIXATION: General/ Spinal anesthesia is administered, and the patient is placed supine on a radiolucent table. The operative extremity is then prepped and draped free. Identify the physis by fluoroscopy, and mark its location on the skin. A 2 - 2.5 cm longitudinal skin incision was made over the medial and lateral surface of the distal femur, starting 2cms proximal to the distal femoral epiphyseal plate; a hemostat was used to split the soft tissue down to the bone, following which a 3.2 mm drill bit was used at a point 2.5cm proximal to the distal femoral growth plate to open the cortex at a right angle; the drill was then inclined 10° to the distal femoral cortex.

A nail was introduced with a T-handle by rotation movements of the wrist. Under image intensifier control, the nail was driven by a rotatory movement or with a hammer to the fracture site which was 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 was directed to the proximal fragment which was pushed into better alignment by the nail. At the same time the second nail was advanced to enter the proximal fragment and in the meantime, any traction was released to avoid any distraction, and both nails were pushed further till their tips became fixed into the cancellous bone of the proximal femoral metaphysis without reaching the epiphyseal plate.

The tips of the nail that entered 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. 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 were cut, leaving only 0.5 - 1 cm outside the cortex. The extra osseous portion of the nails was kept as it was or slightly bent away from the bone to facilitate removal later on. In all cases care was taken to use nails

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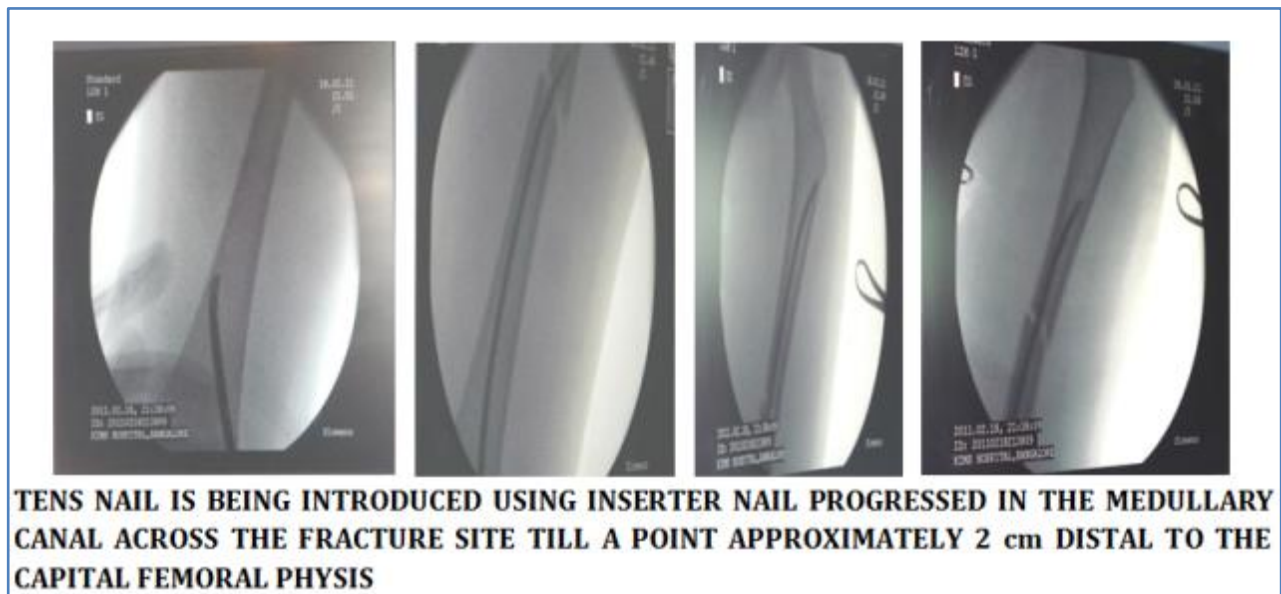
with similar diameters, to use the largest possible diameter, and to use the double C construct to ensure 3-point fixation.

PROCEDURE FOR TENS NAILING OF DIAPHYSEAL FRACTURE OF TIBIA ANTEGRADE FIXATION:

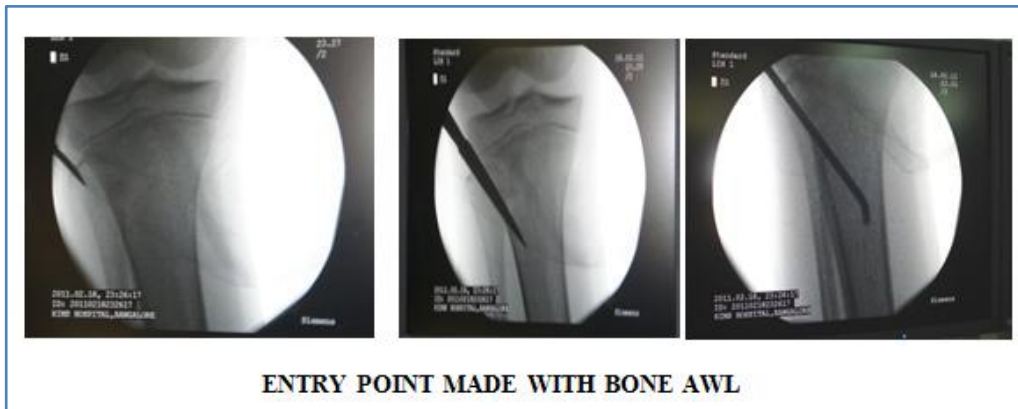
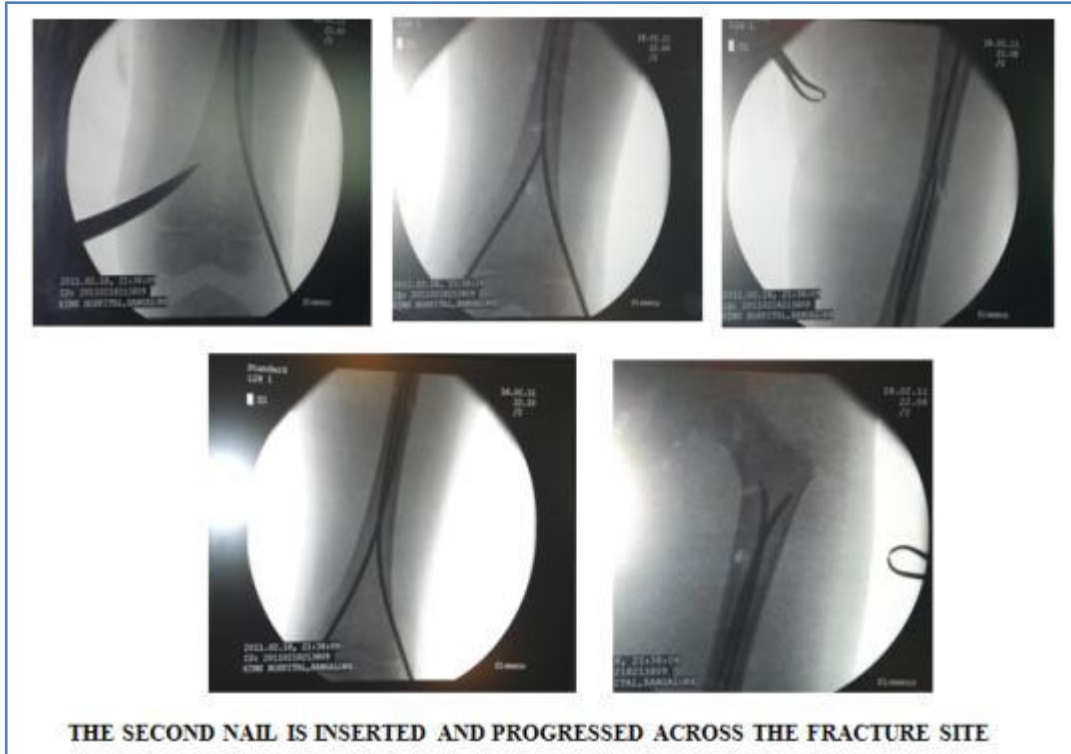
General/ Spinal anesthesia is administered, and the patient is placed supine on a radiolucent table. The operative extremity is then prepped and draped free. Under fluoroscopy, the fracture site and the proximal tibial physis are marked. The starting point for nail insertion is 1.5–2.0 cm distal to the 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 tibia metaphysis just proximal to the desired bony entry point. Using a hemostat, the soft tissues are bluntly dissected down to the 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. 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 tibial physis.

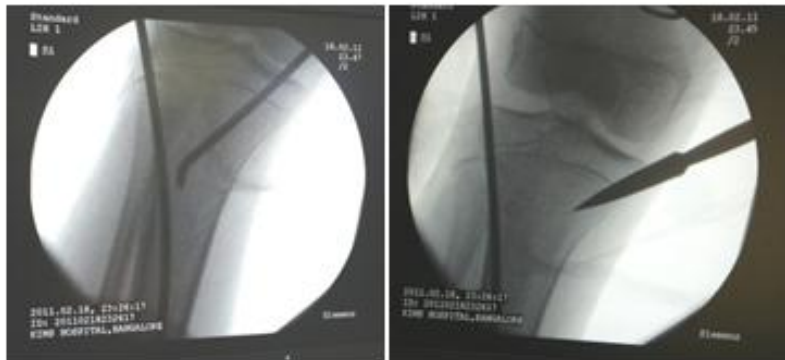
Fluoroscopy is again used to confirm proper fracture reduction as well as nail position. To minimize soft tissue irritation, the nails are backed out a few centimeters and cut along proximal tibial metaphysis. A tamp is used to re-advance the implants until <1 cm of nail lies outside of bone. Care is taken not to bend the nails away from the bone to facilitate cutting, as we have 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.



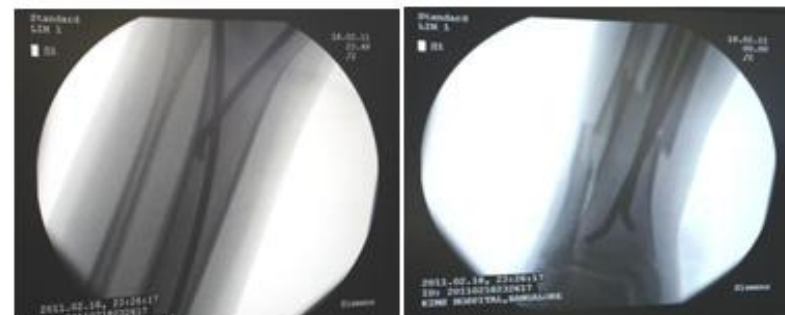
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NAIL PROGRESSED IN THE MEDULLARY CANAL THROUGH THE FRACTURE SITE



INSERTION OF THE SECOND NAIL



FOLLOW UP: A total of 30 cases was followed out of which 13 cases where a fracture shaft of femur and 17 cases where a fracture shaft of the tibia. An assessment was done at 6, 12 and 14 weeks. 21 cases where mobilized within 6 weeks.

MINOR COMPLICATIONS: 1. Pain at the site of nail insertion, 2. Minor angulation ($<10^\circ$ – saggital/coronal; $<10^\circ$ rotational mal-alignment) at final follow-up (24 weeks), 3. Minor leg length discrepancy ($<2\text{cm}$ – shortening/lengthening) at final follow-up (24 weeks), 4. Inflammatory reaction to nails, 5. Superficial infection at site of nail insertion, 6. Delayed union.

MAJOR COMPLICATIONS: 1. Angulation exceeding the guidelines ($>10^\circ$ – saggital/coronal; or $> 10^\circ$ rotational mal-allignment) at final follow-up, 2. Leg length discrepancy exceeding the guidelines ($>2\text{cm}$ – shortening/lengthening) at final follow-up, 3. Deep infection, 4. Loss of reduction requiring new reduction or surgery, 5. Surgery to revise the nail placement, 6. Compartment syndrome requiring surgery, 7. Neurological damage after nailing, 8. Delayed or nonunion leading to revision.

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OBSERVATIONS AND RESULTS: Maximum number of patients were in the age group 5-8 years-13 patients and 9-16 years- 17 patients out of which 21 males and 9 females. Mode of injury in the majority of the cases was a road traffic accident.

Side affected	Number of patients	%
Right	13	43.3
Left	17	56.7
Total	30	100.0
Side affected		

Pattern of fracture	Number of patients	%
Transverse	10	33.3
Oblique	7	23.3
Spiral	5	16.7
Segmental	0	0.0
Communitated	8	26.7
Total	30	100.0
Pattern of fracture		

All the patients where operated within 5 days of injury and all the cases where discharged within 5 days after surgery.

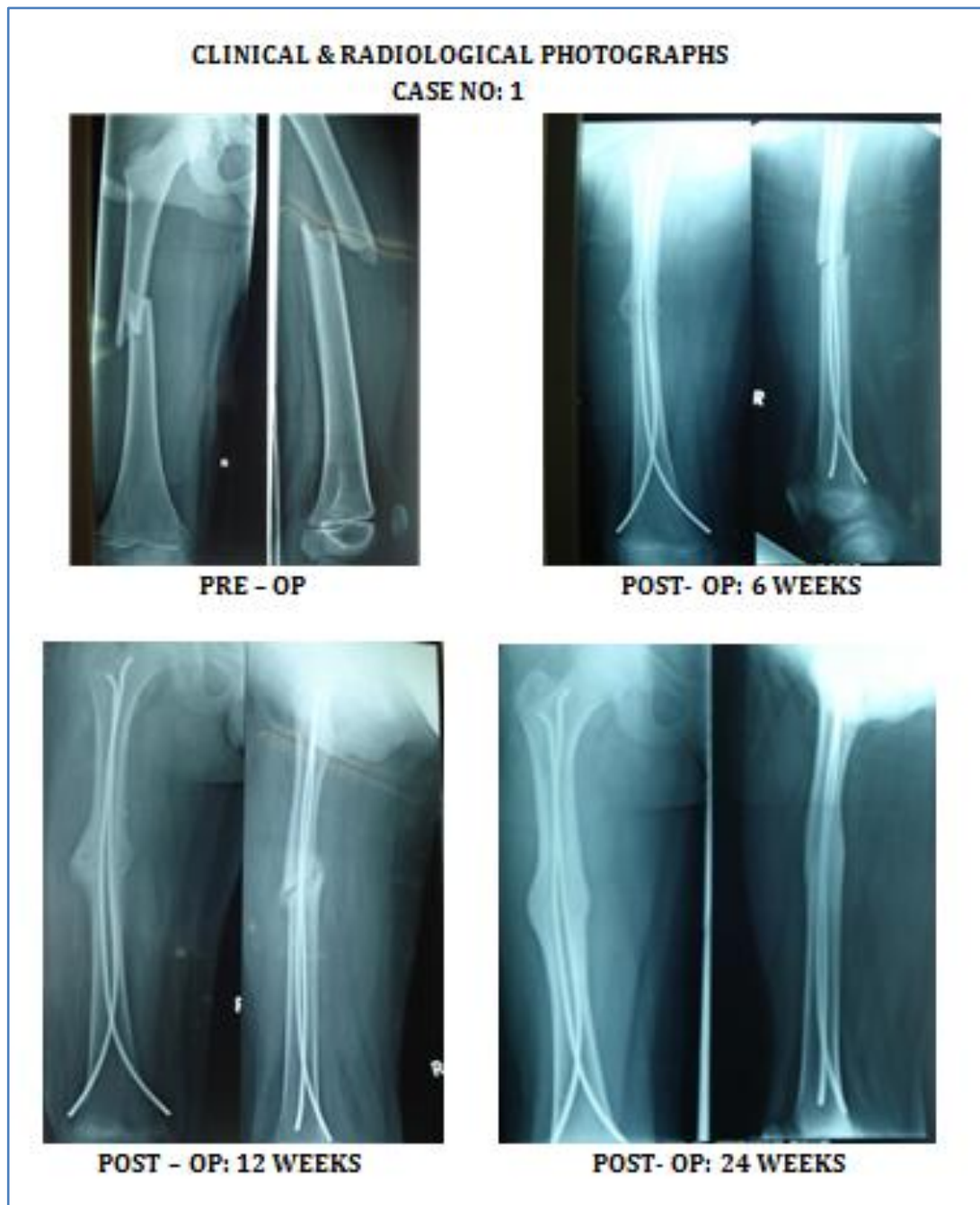
Time for union	Number of patients	%
</ = 12 weeks	24	80.0
>12 - 18 weeks	5	16.7
>18 - 24 weeks	1	3.3
Total	30	100.0
Time for union		

Range of movements(degrees)	Number of patients	%
Full range	28	93.33
Mild restriction	2	6.66
Moderate restriction	0	0
Severe restriction	0	0
Total	30	100
Range of movements at 24 weeks (degrees)		

Time of full weight bearing	Number of patients (n=30)	%
≤ 12 weeks	24	80.0
>12 - 18 weeks	5	16.7
>18 - 24 weeks	1	3.3
Time of full weight bearing		

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OUTCOME	EXCELLENT	SATISFACTORY	POOR
VARIABLES	(%)	(%)	(%)
Range of movements	93.3	6.7	-
Time for union	80	20	-
Unsupported weight bearing	80	16.7	3.3
Outcome			



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CASE NO.9



PRE - OP



POST OP: 6 WEEKS



POST OP: 12 WEEKS



POST OP: 24 WEEKS

CASE 23:



PRE - OP



POST OP : 6 WEEKS



POST OP : 12 WEEKS



POST OP : 24 WEEKS

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CASE NO. 18



PRE – OP



POST OP : 6 WEEKS



POST OP : 12 WEEKS



POST OP : 24 WEEKS

DISCUSSION: In the present study 13(43.3%) of the patients were 5-8 years, 7(23.3%) were 9 to 12 years and 10(33.3%) were 13 to 16 years age group with the average age being 9.8 years. There were 9(30%) girls and 21(70%) boys in the present study. In the present study RTA was the most common mode of injury, accounting for 16 (53.3%) cases, self-fall accounted for 11 (36.7%) cases and fall from height accounted for 3 (10%) of the cases.

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We studied 13 (43.3%) femoral and 17 (56.7%) tibial fractures. In our study, transverse fractures accounted for 10 (33.3%) cases, comminuted fractures- 8 (26.7%), oblique fractures - 7 (23.3%), spiral fractures - 5 (16.7%) and there were no segmental fractures. Fractures involving the middle 1/3rd accounted for 15 (50%) cases, proximal 1/3rd - 9 (30%) and distal 1/3rd - 6 (20%) of cases in our study. In our study, 21 (70%) cases were immobilized (long leg cast with a pelvic band for femur fracture/ above knee POP cast for tibia fracture) postoperatively for 6 weeks and such immobilization was for 9 weeks in the rest of the 9 (30%) of the cases. The period of immobilization was followed by active hip and knee/ knee and ankle mobilization with non-weight crutch walking. The average duration of immobilization was 6.9 weeks.

The advantage of the present study was early mobilization of the patients. In our study union was achieved in <3 months in 24 (80%) of the patients and 3 - 4.5 months in 6 (20%). Average time to union was 12.1 weeks. In our study, closed reduction of the fracture, leading to preservation of fracture hematoma, improved biomechanical stability and minimal soft tissue dissection led to the 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 24 (80%) of the patients, between 12 and 18 weeks in 5 (16.7%) and at 20 weeks in 1 (3.3%) patient. The average time of full weight bearing was 11.5 weeks.

COMPLICATIONS: In the present study, 7 (23.33%) patients had developed pain at site of nail insertion during initial follow up evaluation, which resolved completely in all of them by the end of 16 weeks. Superficial infection was seen in 1 (3.3%) case in our study, which was controlled by antibiotics. This is the most common sequel after femoral shaft fractures in children and adolescents. 2(6.66%) patients had shortening(femur - 1cm and 1 tibia - 0.7cm) and 1(3.33%) had lengthening (femur - 1.2cm) No patient in our study had major limb length discrepancy (i.e. > ± 2cm).

COMPLICATIONS	PRESENT STUDY (% incidence)	PREVIOUS STUDIES (% incidence)	
Pain at the site of nail insertion	23.33	16.2	J. M. Flynn et al.
Superficial infection	3.3	1.7	J.M.Flynn et al.
Range of motion	6.6	0.9	J.M.Flynn et al.
LIMB LENGTH DISCREPANCY (minor)			
Lengthening	3.3	5.0	Ozturkman Y. et al
Shortening	6.6	2.5	Ozturkman Y. et al
Nail back out	-	2.6	Carrey T.P. et al
MALALIGNMENT(minor)			
Varus/ Valgus	6.7	4.3	J.M.Flynn et al
Anteroposterior	-	8	Heinrich SD, et al
Rotational deformities	-	3.2	Heinrich SD, et al
Nail back out	-	2.6	Carrey T.P. et al

Assesment of Outcome: In the present study, the final outcome was excellent in 18 (60%) cases, satisfactory in 12 (40%) cases and there were no poor outcome cases.

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OUTCOME VARIABLES	EXCELLENT (%)	SATISFACTORY (%)	POOR (%)
Range of movements	93.3	6.7	-
Time for union	80	20	-
Unsupported weight bearing	80	16.7	3.3
OUTCOME FOR ADDITIONAL VARIABLES IN THE PRESENT STUDY			

CONCLUSION: Based on our experience and results, we conclude that ELASTIC STABLE INTRAMEDULLARY (TENS) technique is an ideal method for treatment of pediatric femoral and tibial diaphyseal fractures. It gives elastic mobility, promoting rapid union at fractures site and stability, which is ideal for early mobilization. It gives a lower complication rate, good outcome when compared with other methods of treatment.

Is a simple, easy, rapid, reliable and effective method for management of pediatric femoral and tibial fractures between the age of 5 to 16 years, with shorter operative time, lesser bloodless, lesser radiation exposure, shorter hospital stay, and reasonable time to bone healing? Because of early weight bearing, rapid healing and minimal disturbance of bone growth, ESIN (TENS) may be considered to be a physiological method of treatment.

Use of ESIN (TENS) for definitive stabilization of femoral and tibial shaft fractures in children is a reliable, minimally invasive and physseal-protective treatment method. 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.

SUMMARY: Thirty patients with diaphyseal fractures of the femur⁽¹³⁾ and tibia⁽¹⁷⁾ were treated with titanium elastic nailing between September 2009 to September 2011 at KIMS Hospital, Bangalore. Children and adolescents aged between 5 to 16 years were included in the study. The development of the TENS fixation method has put an end to criticism of the surgical treatment of pediatric long bone fractures, as it avoids any growth disturbance by preserving the epiphyseal growth plate, it avoids bone damage or weakening through the elasticity of the construct, which provides a load sharing, biocompatible internal splint, and finally it entails a minimal risk of bone infection

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