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SURGICAL MANAGEMENT OF PAEDIATRIC LONG BONE FRACTURES OF LOWER LIMB BY TITANIUM ELASTIC NAILS

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Keywords:

Femur; Fractures; Intramedullary Nailing; Lower extremity; Pediatric; Tibia; Titanium.

Abstract

Aim: To demonstrate the effectiveness of intramedullary fixation of displaced long bones shaft fractures in skeletally immature children using the elastic stable intramedullary nails.

Materials And Methods: The study was conducted from October 2012 to April 2015in Mahatma Gandhi Memorial Hospital, Warangal. We included Twenty eight pediatric patients(20 male and 8 female), who underwent surgical fixation of 30 long bone fractures by TENS were included in this prospective study. The average age of the study group was 9.8years and mean follow-up was 24 months. There were 12 femoral, 18 tibial fractures included in 28 patients and subjective satisfaction was assessed.

Results: Road traffic accident was the main mode of injuries. The most common long bone fracture was femur40% and 60% tibia fracture. Pattern of fracture 33.3% transverse,13.3%communited,20% oblique,26.7% spiral, 6.7% segmental. Level of fracture 80% middle third. Time interval between trauma and surgery was average 3.65 days. Average duration is 50.20 min. Average duration of immobilization is 7.2 wks. Duration of stay in hospital was 10.25 days. Time of union is 10.35 weeks. Time of wt bearing in present study is 11.8 wks. Follow up done for period of 24weeks. According to Flynn's criteria, 89% of patients were excellent and 11% satisfied; no patients reported their outcome as not satisfied.

Conclusion: On the basis of results Titanium Elastic Nailing is the best method of choice for the management of long bone fractures in children, because its elastic mobility promoting rapid union at fractures site. It allows early mobilization with lower complication rate.

Introduction

Surgical treatment of long bones fractures in children must first consider the fact that excellent results can be achieved with non-operative care, with reported union rates of more then 90%, and 100% full functional recovery1.Occasionally, reduction cannot be maintained due to excessive shortening, angulation, or malrotation at the fracturesite, making operative intervention necessary2.In the last two decades there was an increase dinterest in the operative treatment of paediat ricfractures ,although debate persiste do veritsindications.3

The biomechanical principal of the TEN is based on the symmetrical bracing action of two elastic nails inserted into the metaphysis, each of which bears against the inner bone at three points 4,5. This produces the following four properties that are essential for achieving optimal results: flexural, axial, translational and rotational stability 4.

Children managed with traction and spica cast as a treatment modality has to undergo various adverse physical, social, psychological and financial consequences, of prolonged immobilization. Various other modalities include external fixation, plates and screws, use of solid antegrade intramedullary nail are available. However, the risk of certain complications, particularly pin tract infection and refractures after external fixation or osteonecrosis with solid nails. 6

In the past two decades, operative management of certain fractures provided markedly better results than closed management. In the past decade years, fixation with flexible intramedullary nails have become popular technique, for stabilizing femoral fracture in school aged children.6, 7 ESIN fixation system is a simple, effective and minimally invasive technique. It gives stable fixation with rapid healing and prompt return of child to normal activity. This study was intended to assess the results following treatment of long bone fracture in lower limbs by flexible intra medullary nail or elastic stable intramedullary technique.8

Elastic stable intramedullary nailing of long bone fractures in the skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications. Many studies have supported the use of this technique in the femur, citing advantages that include closed insertion, preservation of the fracture hematoma, and a physeal-sparing entry point.7, 9

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 complications.10

The purpose of this study was to evaluate our results following fixation of unstable long bone fractures with TENS. We have evaluated all patients for fracture reduction, return to activity, complications and clinical outcome given in accordance to Flynn criteria.

Materials And Methods:

Patients aged 5 to16 years that underwent TENS fixation of long bone fractures from October 2012 to April 2015 at our institution were the subjects of the study. The study was approved by our institutional review, Inclusion criteria were: age above 5 years and below 16 years with traumatic closed or open femoral and/or tibial fractures atmid-shaft and junctional upper-middle third or lower-middle third.

Patients with extreme proximal or distalfemoral and/or tibial fractures closer to the epiphysealplate and patients with grade III C open femoral and/or tibial fractures were excluded from the study. Patients with incomplete clinical and/or radiological data, patients with pathological fracture, and patients with follow-up less than one year were also excluded from the study.

28 cases (20 males and 8 females) with 30 fractures of average age of 9.8 years were included in the study were followed up for mean of 24 weeks.28 cases admitted were thoroughly investigated. A detailed history regarding mode of trauma was taken. X rays of affected limb An teroposterior and Lateral views were taken. Mode of Injuries were due to motor vehicle accident, fall from height and sports related injuries. In 23 patients the fracture was reduced by closed means, whilst in the other 5 open reduction was required due to difficulty in reduction and soft tissue interposition. Indication for surgery was inability to attain stable reduction with closed treatment. None of the patients developed complications during their course of treatment. After consent planning for surgeries were done. Among long bone fractures 40% femur ,60% tibia. Fractures classified according to AO classification, like 33.3% transverse,13.3%communited,20% oblique,26.7% spiral, 6.7% segmental.

Surgical procedure was performed in supine position. selection of nail done by Flynn etals formula or intra operatively assessed. Nail diameter: 40% of the width of the narrowest point of the medullary canal on AP and LATERAL view Nail length: Is assessed under fluoroscopy intraoperatively, In Femur distal to proximally, extension of the nail the distal femoral physis to proximally 2 cm distal to the capital femoral physis an 1 cm distal to the greater trochanteric physis11. In Tibia nail inserted from proximal to distally, nail extension 2cm from the proximalphysis to 5mm proximal to the distal physis. Bone was exposed with a longitudinal incision. Soft tissue was spread using artery forceps. The periosteum was incised longitudinally with cortex exposed. With the help of sharp awl, entry was made through the cortex to obtain access to the medullary cavity. Care was taken to ensure that growth plate was not breached in any of the cases while making the entry point. In the lower limbs two nails were inserted for tibia and femur, these nails were bent prior to insertion and were inserted manually using T-insertion handle. Once fracture site was reached two nails then fracture was manipulated under C-Arm guidance to obtain reduction and nails were passed further into metaphysis and adequate three point fixation was ensured with tip of nails facing opposite directions by this symmetrical bracing action of two elastic nails inserted into the metaphysis, each of which bears against the inner bone at three points was followed. Position of the nail was confirmed in Anteroposterior and Lateral views. Post-operatively, a patient are immobilized with long leg slab with a pelvic band for femur fracture or above knee POP slab for tibia fracture for 6 weeks and such immobilization was continued for another 2-3 weeks based on 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.
Follow Up: Assessment done at 6, 12 and 24 weeks.
At each follow up patients are assessed clinically, radiologically and the complications are noted.At the end of 24 weeks of follow up the patients were evaluated clinically by using Flynn's criteria.

Results

"P" VALUE ANALYSIS

There was no significant association (p value >0 .3)observed between
Variables(Age,Gender,Modeofinjury,Boneaffected,PatternofFractureandTime Interval between trauma and surgery) and Incidence of complication
No major complications encountered in any of the 28 patients. However one case with superficial infection and bursa at nail insertion was noted. Outcomewas graded as excellent in comparison to Flynn's criteria9

Table I. — TENS outcome score (Flynn et al.[9])

Variables at 24 wks	Poor results	Satisfactory results	Excellent results
Limb-length inequality	> 2.0 cm	< 2.0 cm	< 1.0 cm
Malalignment	> 10 degrees	10 degrees	5 degrees
Pain	present	none	none
Complication	Major and lasting morbidity	Minor and resolved	none

Age incidence: In the present study 6(21.4%) of the patients were 5-8 years, 14 (50%)were 9 to 12 years and 8(28.5%) were 13 to 16 years age group with the average age being 9.8 years.

Sex incidence: There were 8(20%) girls and 20(70%) boys in the present study. The sex incidence is comparable to other studies in the literature.

Mode of Injury: In the present study RTA was the most common mode of injury accounting for 16 (57%) cases, sports injury accounted for 8 (28.5%) cases and fall from height accounted for 4 (14.2%) of the cases.

Bone affected: out of 28 patients 30 fractures occurred in that 12(40%) femur fracture and 18 (60%) tibia fracturehappened.

Side affected: right side fractures are very high 63.3% when compared to left side (36.6%)

Pattern of Facture: In our study, 33.3% transverse, 13.3%communited, 20% oblique, 26.7% spiral and 6.7% segmental.

Level of Fracture: Fractures involving the middle 1/3rd accounted for cases24(80), proximal 1/3rd – 2(6.7%) and there are 4 (13.3%) distal 1/3rd fractures in our study.

Time interval between trauma and surgery: In the present series, 3 (10%) patients underwent surgery within 2 days after trauma, 9(30%) in 3 – 4 days, 15(50%) in 5 – 7 days and 3(10%) patients after 7 days.

Duration of surgery in minutes: In the present study, duration of surgery was < 30 mins in 6(20%) case, 30-60 mins in 16 (53.3%) cases, 61-90 mins in another 6 (20%) cases and 91-120 mins in 2 (6.7%) of the cases.

Post-operative immobilization/mobilization: In our study,12 (40%) cases were immobilized (long leg slab with a pelvic band for femur fracture postoperatively for 4 weeks and such immobilization was for 3 weeks in rest of the18 (60%) cases of tibia fracture.

The period of immobilization was followed by active hip and knee/knee and ankle mobilization with non-weight crutch walking. The advantage of the present study was early mobilization of the patients.

Duration of stay in the hospital: The duration of stay in the hospital ≤ 7 days for 3 (10%)patients, 8-10 days for 9 (30%), 11-15 days for 15 (50%) and 3 (10%) patients stayed for more than 15 days with associated injuries. The average duration of hospital stay in the present study is 10.2 days.

Time for union: In our study union was achieved in <3 months in 23 (76.6%) of the patients and 3 – 4.5 months in 5 (16.6%) and 4.5- 6 months in 2(6.6%). Average time to union was 10.35weeks.

Time of full weight bearing: In the present study, unsupported full weight bearing walking was started in <12 weeks for 23 (76.6%) of the patients, between 12 and 18 weeks in 5 (16.6%) and at 20 weeks in 2 (6.6%) patient. The average time of full weight bearing was 11.8 weeks.

Discussion

Surgical management of long bones of lower extremity in paediatric age group has been controversial. Multiple treatment options have been tried over past two to three decades. Complications were found to be associated with every treatment option: Immobilization with spica cast alone or along with traction was found to be associated with complications like limb-length discrepancy, angulation, psychological and economic complications.[11-13] Also it involved prolonged bed rest and loss of days from school for adolescents and school-aged children and it added to the babysitting problem in homes with both the parents working.

External fixator resulted in pin tract infection, loss of reduction, refracture after removal of external fixator, malunion and loss of days from school.[14] Plating as a treatment modality is not practiced commonly for paediatric fractures in children as it involves bigger surgical incision leading to higher likelihood of infection, stripping of periosteum and loss of fracture haematoma.

Wound infection and impingement was found to be associated with minimally invasive plate osteosynthesis (MIPO) used in management of paediatric tibial fractures.[15-16] In case of femoral fractures, MIPO has been associated with malalignment and delayed union. Intramedullary K-wire fixation has also been used for pediatric femoral fracture. But stability and fracture angulation is a disadvantage to be taken care of.[17]
An ideal implant for the treatment of paediatric lower extremity long bone fractures should be load sharing, allowing early mobilisation, without disrupting the blood supply of epiphyseal growth plates, maintains limb length and alignment till the fracture healing marked by bridging callus occurs.[18]

TENS has been designed for the treatment of diaphyseal fractures in children and is being used presently for the treatment of paediatric femoral fractures,[19-23] and, increasingly, for surgical management of paediatric tibial fractures.[24-25] It is based upon the principle of **three point fixation that works by balancing forces between two opposing flexible implants**.[26]

This method achieve biomechanical stability from the divergent ‘‘C’’ configuration which creates six points of fixation and allows the construct to act as an internal splint. This is in contrast to Enders nails that achieve stability from nail stacking and canal fill.26,27
Titanium nails provide stable and elastic fixation, leading to controlled motion at the fracture site leading to healing by callus formation. [9,18,26,27]

In present study hospital stay is more compare to other studies,Our average operative time, , bone healing time, and nail removal time were quite similar to other data in literature.[3,12-17]Rotational malalignment was not noted in this study due to utmost care being taken during intraoperative limb positioning.

Ligier et al[19],Flynn et al.[9]and Gamal et al.[18] have reported a similar finding, supportingthe concept that TENS can give rotational stability provided adequate care is taken during nail insertion and following operation.
None of the patients in our study developed compartment syndrome during their course of treatment which was different from findings of Sanker at al.[28] who reported four patients developing compartment syndrome during course of treatment and three patients with impending compartment syndrome for whom fasciotomies were performed at the time of index surgery.

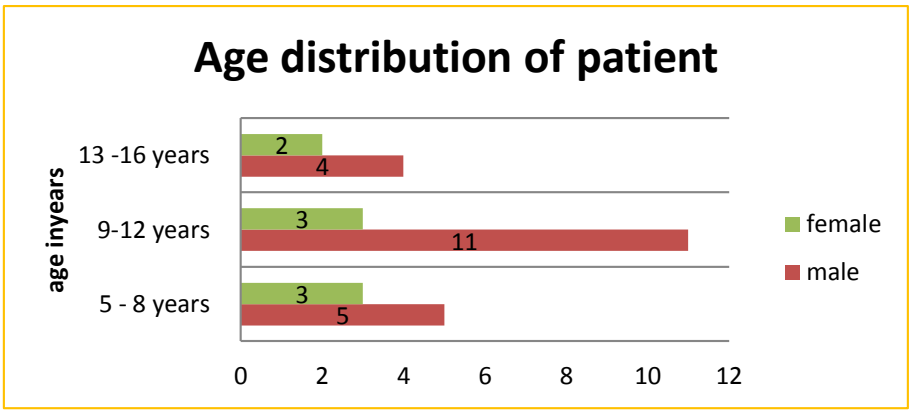
None of the patients in our series required any secondary surgical intervention or readmission following discharge, except for nail removal.
Limb shortening was observed in 2 cases (6.7%) with an average of 1 cm (Range 0.7-1.3cm) for which authors believe that a longer follow-up duration is required to determine its persistence or correction.
No major complications were encountered but few minor complications were like superficial infection,limb shortening,bursa at tip of nail.

Outcome was graded by Flynn’s criteria as excellent,satisfactory and poor.In our present study we achieved 90% excellent outcome 10% satisfactory,no poor outcome.

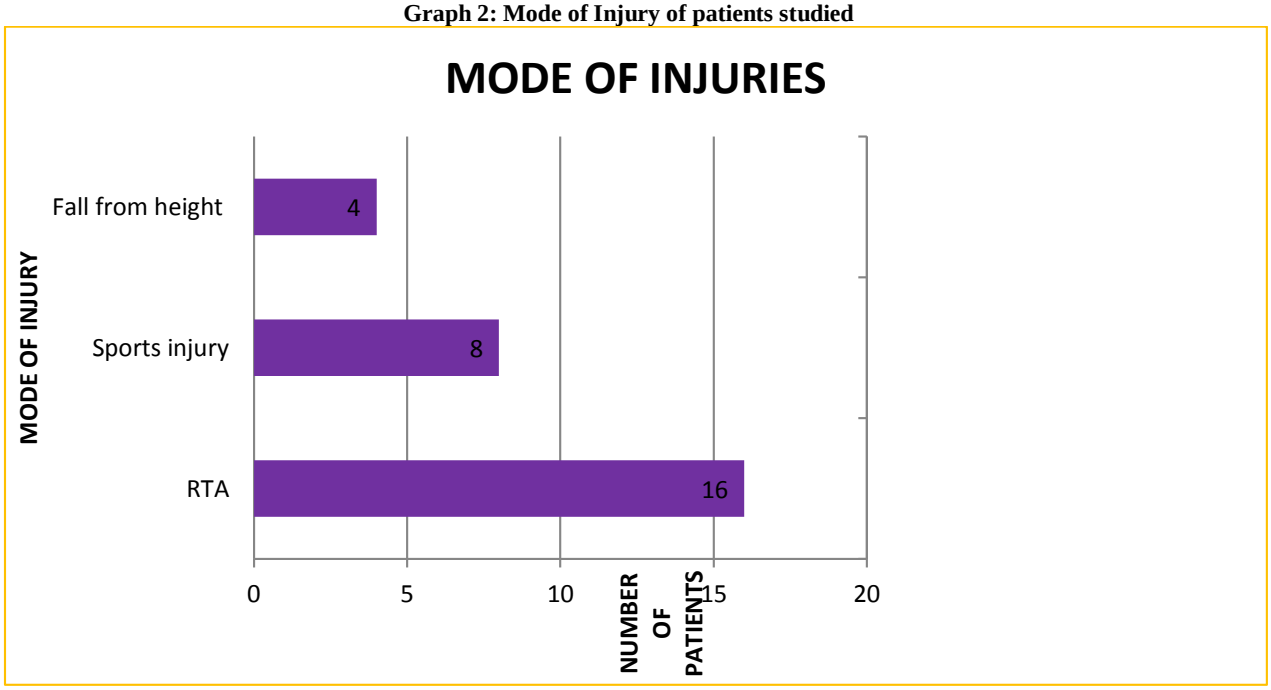
Conclusion

Based on our experience and results, we conclude that TITANIUM ELASTIC NAILING SYSTEM (TENS) is an ideal method for treatment of paediatric long bone fractures.The ESIN for shaft fractures is a minimally invasive, simple andwell reproducible technique with a steep learningcurve. Because of the excellent objective and subjective results, the operative stabilization of long bones fractures with ESIN should be recommended to the pediatrics patients. This technique has many merits over a more traditional plating technique including a minimally invasive technique, a less time consuming procedure and easier metal work removal.
It 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 blood less, lesser radiation exposure, minimally invasive, and physeal-protective surgical method.

GRAPH1:AGEDISTRIBUTION OFPATIENTS



Graph 2: Mode of Injury of patients studied



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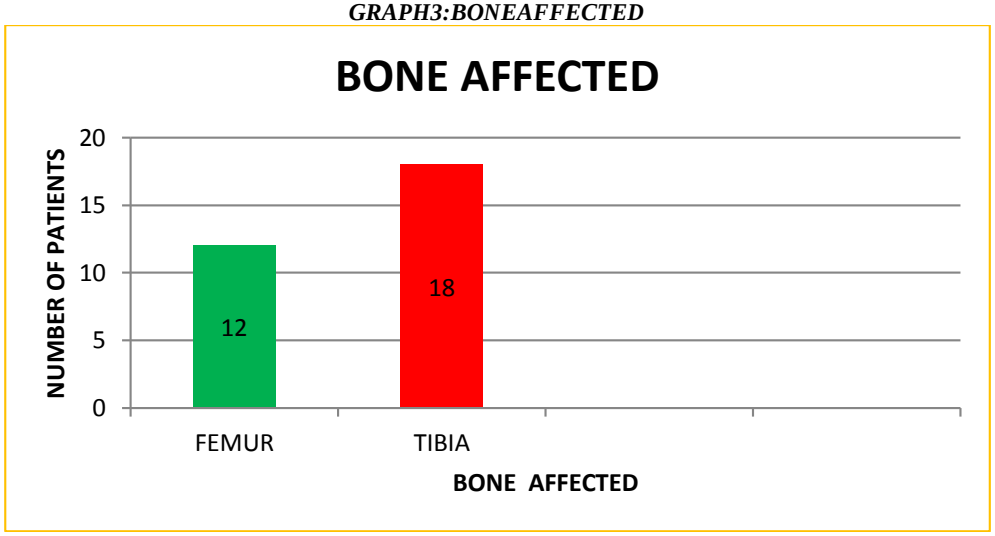
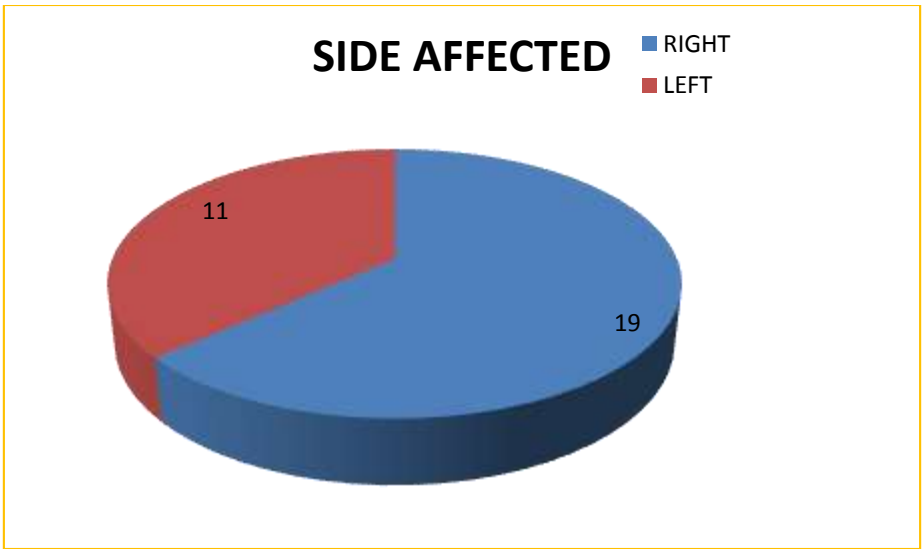
GRAPH3:BONEAFFECTED



GRAPH4:SIDEAFFECTED



Indian Journal of Medical Research and Pharmaceutical Sciences
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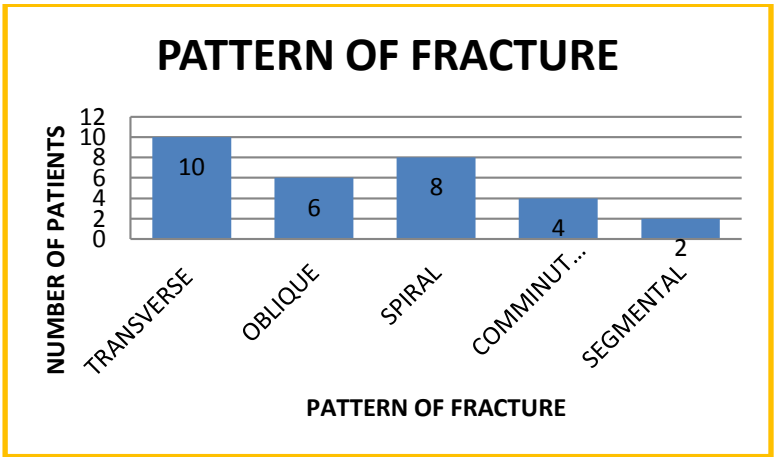
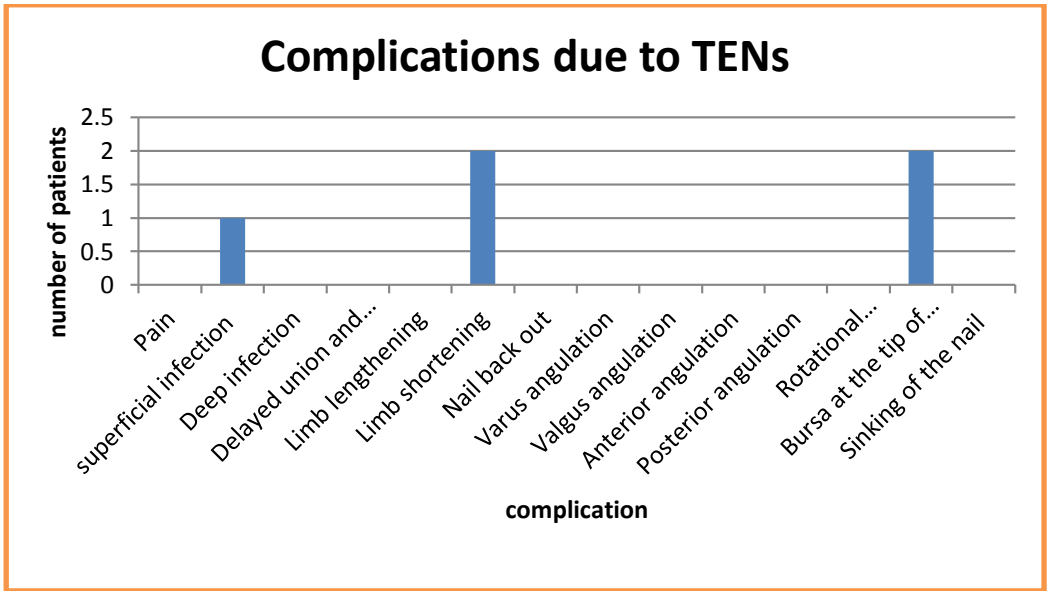
GRAPH 5:PATTERN OF FRACTURE



GRAPH 6: COMPLICATIONS



Indian Journal of Medical Research and Pharmaceutical Sciences
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Figure 1:A radiograph picture ofIpsilateral femur and tibia fracture

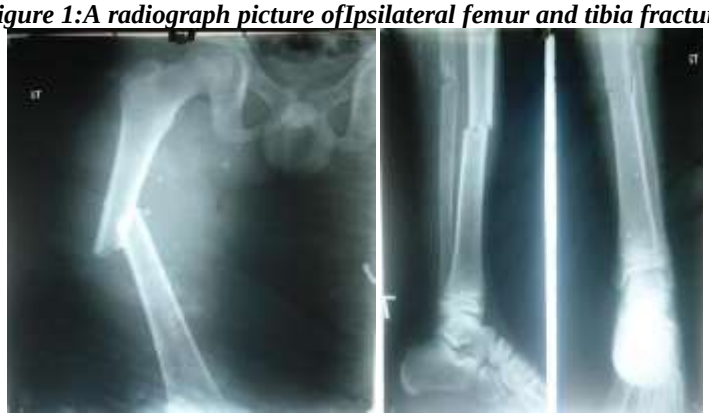

Figure 2:A radiograph picture of 3weeks post operative follow up Ipsilateral femur and tibia fracture

Figure 3:A radiograph picture of6 months post operative follow up Ipsilateral femur and tibia fracture

Indian Journal of Medical Research and Pharmaceutical Sciences
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Figure 4:A radiograph picture of immediate post operative Elastic Nail removal of Femur

Figure 4:A radiograph picture of immediate post operative Titanium Elastic Nail removal ofTibia

Figure 4:Clinical photograph shows that full range of Hip and Knee movements in 6 months follow up case of unstable ipsilateral tibia and femur fracture left side,

Figure 5:Clinical photograph shows that full range of Ankle movements in 6 months follow up case of unstable ipsilateral tibia and femur fracture left side, PLANTAR FLEXION and DORSIFLEXION same as normal limb

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