Original Article

Management of Diaphyseal Lower Limb Fractures in Paediatric Age Group with Elastic stable Intramedullary Nailing

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ABSTRACT

Aim : The purpose of this study is to analyze the efficacy of elastic stable intramedullary nailing(ESIN) in the treatment of fracture shaft of femur and tibia in children aged between 4 to 15 years with special emphasis on complications.

Materials and Methods: This was a prospective ,observational study conducted in chalmedaanandrao institute of medical sciences, karimnagar. All children and adolescent patients between 4 and 15 years of age with diaphyseal fractures of femur and tibia meeting the inclusion and the exclusion criteria during the study period were the subjects for the study. Totally, 20 cases were studied without any sampling procedure. Patients were followed up at 4 weeks, 8 weeks 12 weeks, 6 months and 1 year after surgery and assessed clinically and radiologically. The final outcome is assessed as per Flynn's criteria as excellent/ satisfactory/ poor.

Results: Twenty patients were enrolled into the study out of which 15 (75%) were boys and 5 (25%) were girls. Average age of patient was 9.8 years and average time taken to heal the fractures (both clinical and radiological) was 10.35 weeks. 4 (20%) had developed pain at site of nail insertion during follow up evaluation, all of which resolved by the end of 16 weeks follow up Superficial infection was seen in1 (5%)case, No patient in our study had major limb length discrepancy (i.e. > ± 2cm). Nail back out was not seen in any of the cases.

Conclusions: Titanium elastic nail fixation is a simple, easy, rapid, reliable and effective method for management of pediatric femur and tibial fractures in patients with operative indications. There may be the chances of complication following the TENS but these are avoidable as well as manageable with careful precautions

Key words: Titanium elastic nail, paediatric femoral and tibial fractures

INTRODUCTION

Elastic stable intramedullary nailing (ESIN) 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. [1,2,3]

In the past seven years fixation with flexible intramedullary nails have become popular technique, for stabilizing femoral fracture in school aged children gradually applied to other long bone fractures in children [4,5] as it represents a compromise between conservative and surgical therapeutic approaches with satisfactory results and minimal complications. [6,7,8]

Fractures femur constitute about 1.6% of pediatric fractures when managed with traction and spica cast as a treatment modality has to undergo various adverse physical, social, psychological and financial conse quences, 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 refracture persists. [9,10]

For the vast majority of tibial shaft fractures in the children, closed reduction and casting is an effective form of treatment and remains the gold standard of care. Occasionally, reduction cannot be maintained due to excessive shortening, angulation, or malrotation at the fracture site, making operative intervention necessary. [11]

MATERIALS AND METHODS

The study was a prospective, observational study conducted in Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar. There were 20 children who underwent Elastic stable intramedullary nailing for treatment of pediatric femur and tibial fractures. Patients' demographic data, mode of injury, union rate, and complication rates were evaluated.

Inclusion Criteria

1. 4-15 years of age
2. Diaphyseal femur and tibia fractures
3. Simple fractures (closed fractures)

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 patient is placed in supine 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 was made over the medial and lateral surface of the distal femur, starting 2 cm proximal to the distal femoral epiphyseal plate; a 3.2 mm drill bit was used at a point 2.5 cm 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 with rotatory movementor 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 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

The starting point for nail insertion is 1.5–2.0 cm distal to the physis, sufficiently posterior in the sagittalplane 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 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 ofthe 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 tibialphysis.

Post-operatively, patients are immobilized with above knee POP slab for 6 weeks for lower limb. 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.

Followup

Assessment done at 3, 6, 12 and 24 weeks. At each follow up patients are assessed clinically, radiologically and the complications are noted.

Table 1: Clinical assessment of femur and tibia shaft fracture

Joints Movements	Hip		Knee		Ankle	
	Flexion	Extension	Flexion	Extension	Dorsi-Flexion	Plantar-Flexion
Full Range	0 -160	0-10	0 -140	-	0 -35	0 -45
Mild Restriction	0 -140	0-10	0 -120	-	0 -30	0 -35
Moderate Restriction	0 -100	0-10	0 -100	-	0 -20	0 -25
Severe Restriction	<100	-	<100	-	< 20	< 25

Table 2: TENS outcome score (Flynn et.al)

Results Variables at 24 weeks	Excellent	Satisfactory	Poor
Limb-length inequality	< 1.0 cm	< 2.0 cm	> 2.0 cm
Mal allignment	5 degrees	10 degrees	>10 degrees
Unresolved pain	absent	Absent	Present
Other complications	None	None	None

Table 3: Additional variables

Variables outcomes	Excellent	Satisfactory	Poor
Range of movements	Full range	Mild restriction	Moderate
Time for union	8-12 weeks	13-18 weeks	>18 weeks
Unsupported weight bearing	8-12 weeks	13-18 weeks	>18 weeks

RESULTS

Twenty patients with diaphyseal fractures of the femur(11), tibia(9) were treated with titanium elastic nailing. Children and adolescents aged between 4 to 15 years were included in the study.

40% of patients were between 4-7 years, 40 % of patients from 8 – 11 years and 20% 12 to 15 years age group with the average age being 9.8 years.

75% of the patients were boys and 25% girls. RTA was the most common mode of injury accounting for 13 (65%) cases followed by accidental fall -6(30%).

Transverse fractures accounted for 10(50%) cases, comminuted fractures 2(10%), oblique fractures-5(25%) and spiral fractures –3(15%). Fractures involving the middle1/3rd accounted for 12 (60%) cases distal and proximal 1/3d accounting for 20% each.

All the patients were prepared and operated as early as possible once the general condition was stable and the patient was fit for surgery. The average duration between trauma and surgery was 3. 65 days with 11(55%) patients undergoing surgery within 3 days and 8 (40%) cases in 4-6 days.

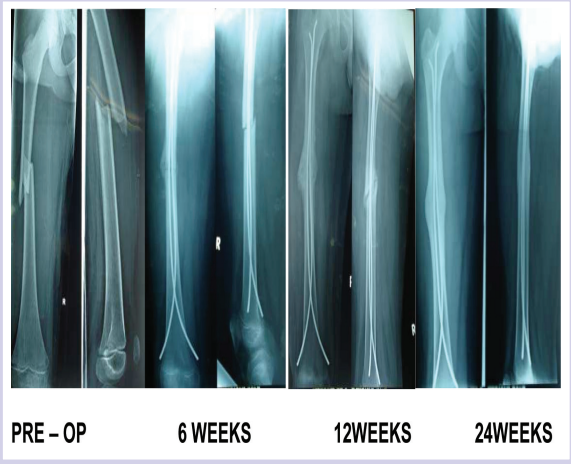
Duration of surgery for majority of fractures (17 cases 85%) was Less than 90 minutes. The average duration of surgery is 70.75 minutes. Average duration of immobilization was 7.2 weeks Average duration of stay in hospital was 10.25 days Union was achieved in<3 months in 16(80%)of the patients with average time to union being 10.35 weeks.

Full weight bearing walking was started in <3 months for 14(70%) of the patients. 90% patients had full range of hip, ankle in the present study and 2(10%) patients had mild restriction in knee flexion at 24 weeks.

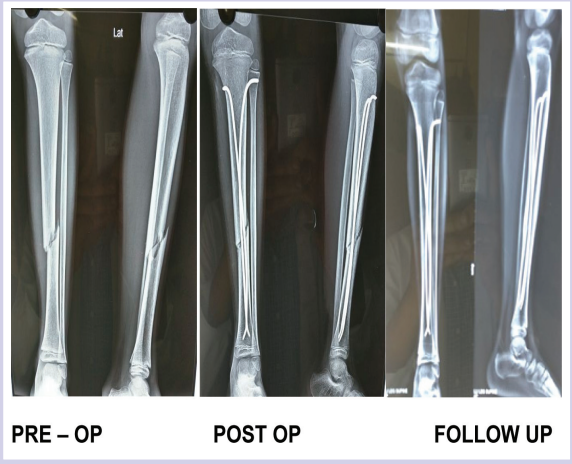
4 (20%) had developed pain at site of nail insertion during follow up evaluation, all of which resolved by the end of 16 weeks follow up superficial infection was seen in 1 (5%)case, No patient in our study had major limb length discrepancy (i.e. > ± 2cm). Nail back out was not seen in any of the cases.

Table 4: Demographic profile

Parameters	n (%)
Gender	
Male	15 (75%)
Female	5 (25%)
Side	
Right	11 (55%)
Left	9 (45%)
Mechanism of injury	
Accidental fall	6 (30%)
Motor Vehicle injury	13(65%)
Fall from height	1 (5%)
Pattern of fracture	
Transverse fractures	10 (50%)
Oblique fractures	5(25%)
Spiral fractures	3 (15%)
Comminuted fractures	2(10%)



Radiological Photographs of Case 1



Radiological Photographs of Case 2

DISCUSSION

Over the past 20 years, paediatricorthopaedists have tried a variety of methods to treat paediatric lower limb fractures to avoid prolonged immobilisation and complications. Each method has had its own complications:spica cast immobilisation alone or following traction had resulted in limb-length discrepancy, angulations, rotational deformity, psychological and economic complications.[12,13]

External fixation had resulted in pin-tract infection, loss of knee range of motion, delayed union, non-union, and refracture after fixator removal.[12] Solid antegrade intramedullary nailing had resulted in avascular necrosis of the femoral head, trochanteric epiphysiodesis, and coxavalga.[13,14]

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.[16,17]

Ender nails are stainless steel implants that proved to be inadequate for adult femoral and tibial fractures but may be effective for paediatric fractures although they may be not elastic enough as their modulus of elasticity is higher than titanium nails. 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.[4,5,15,16]

The principle of Ender nail fixation is canal filling with the nails, while TENs work by balancing the forces between the two opposing flexible implants. To achieve this balance, the nail diameter should be 40% of the narrowest canal diameter or more; the nails should assume a double-C construct. They should have similar smooth curve and same level entry points.[18]

This study was designed to allow for a critical analysis of our experience with TENs for paediatric lower limb fractures after reviewing the theoretical background and other published data regarding this technique to master it first and to avoid all posssible technical errors.

The retrograde femoral nailing technique was adopted in this study as it is easier, provides mechanical stability, and avoids the risk of fracture at the proximal entry points near the trochanteric region. Use of the antegrade technique was not required in our cases, which may be related to the fact that extreme distal femoral fractures close to the epiphyseal plate were excluded from this study.

These fractures are indeed considered as non ideal indications, while extreme proximal femoral fractures are considered as non ideal indications for retrograde nailing due to the risk of complications such as loss of reduction, malunion, and rotational deformity.[20]

Tibial nailing can be performed retrograde or antegrade, although the antegrade technique is easier and mechanically more stable with less soft tissue irritation, but in general there has been no difference in outcome. Three fractures of the distal 1/3 of the fibula associated with tibial fractures were fixed with one antegrade TENs through a small incision in the middle or upper third before fixing the tibial fractures, without any complications.

Our average operative time, radiation exposure, hospital

stay, bone healing time, and nail removal time were similar to other data in literature.[19] The development of the TENs fixation method has put an end to criticism of the surgical treatment of paediatric 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

The low incidence of complications reported in this study especially for malunion and limb-length discrepancy may be related to exclusion of extreme proximal and distal femoral fractures, meticulous adhesion to all technical requirements of the technique, and the use of postoperative immobilisation in cases with concern about stability.

In the present study, 4 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. Flynn JM etal reported 38(16.2%) cases of pain at site of nail insertion out of 234 fractures treated with titanium elastic nails.[2]

Superficial infection was seen in 1(5%) case in our study which was controlled by antibiotics Flynn JM etal. reported 4(1.7%) cases of superficial infection at the site of nail insertion out of 234 fractures treated with titaniumelasticnails. Pin tractinfection is a major disadvantage of external fixation application.

18(90%) patients had full range of motion in the present study and 2 (10%)Patients had mild restriction in knee flexion at 24 weeks, but normal range of knee flexion was achieved at 8 months.

CONCLUSION

Titanium elastic nail fixation is a simple, easy, rapid, reliable and effective method for management of paediatric femoral and tibial fractures between the age of 4 to 15 years, with shorter operative time, lesser blood less, lesser radiation exposure, shorter hospital stay, and reasonable time to bone healing.

CONFLICT OF INTEREST :

The authors declared no conflict of interest.

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