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ORIGINAL RESEARCH

Substantial rise in usage of elastic stable intramedullary nailing in treatment of unstable paediatric femoral shaft fractures by antegrade and retrograde methods: the real impact

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ABSTRACT

Background: Femoral shaft fractures in children require prompt and effective management to ensure proper healing and to minimize long-term disability.[1] The treatment of paediatric femoral shaft fractures has certainly been traditionally age-related, with decisions influenced by the type of injury, associated injuries, and the location and type of the fracture. Titanium Elastic Nailing (TEN) or Elastic intramedullary nailing (EIN) indeed emerges as a preferred stabilization method in certain types of fractures, particularly length-stable fractures such as transverse and short oblique fractures.[3,4,5] **Materials and Methods:** This is a prospective study conducted in a tertiary care teaching hospital from August 2021 to April 2024. For the study purpose, we analysed all admitted consecutive cases of femoral shaft fractures in children from 6 years of age to 16 years. The inclusion criterion were cases of length unstable femoral shaft fracture that were managed with titanium elastic nails and having at least six months of follow up. **Results**: The clinical results were evaluated using Flynn's criteria of scoring as, Excellent in 30 patients (93.33%), satisfactory in 4 patients (6.67%) and poor in none. Full weight bearing was possible in mean time of 10.1 weeks (range: 7-12 weeks). **Conclusion:** Closed reduction with EIN is very effective in management of paediatric shaft femur fractures with advantages of lower rate of infection, early union, early mobilization and good range of movements.

INTRODUCTION

Femur fractures are indeed among the most common and most disabling injuries in childhood.[6] These fractures typically result from high-energy trauma such as falls, sports injuries, or motor vehicle accidents. Conservative treatment of femoral shaft fractures in children younger than six years is highly effective due to their rapid healing and natural ability to correct angulation.[7] Spica casting, often preceded by traction, is the primary method employed, leveraging the child's inherent growth and remodelling potential to achieve optimal outcomes.[8,9] As children approach skeletal maturity, the capacity for bones to remodel and correct angular deformities diminishes significantly. Therefore, achieving accurate reduction of femoral shaft fractures becomes crucial in older children and adolescents.[10,11]

While nonoperative treatment can be effective for younger children, femoral shaft fractures in children older than six years often require surgical intervention to avoid the risks of loss of reduction, malunion, and complications associated with casting. Surgical options like flexible intramedullary nailing, rigid nailing, external fixation, and plates and screws provide better outcomes and facilitate a quicker return to normal activities.[12] Over the past two decades, there has been a growing tendency toward a more operative approach in treating femoral shaft fractures

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in children over six years of age. This shift is driven by the need for better outcomes, quicker recovery, and the ability to manage complications more effectively.

Titanium Elastic Nailing (TEN), or Elastic Intramedullary Nailing (EIN), has become the preferred method for treating paediatric femoral shaft fractures due to its minimally invasive nature, effective stabilization, and ability to support early mobilization.[13] This technique provides excellent outcomes, maintaining proper alignment and promoting rapid healing while avoiding damage to the growth plates. TEN has become the preferred choice for stabilizing paediatric femoral shaft fractures due to its numerous advantages.[14,15] These include promoting early union through micro motion, protecting the growth plates, enabling early mobilization and weight-bearing, providing minimal scarring, facilitating easy implant removal, and achieving high patient satisfaction rates. These benefits make TEN an effective and well-accepted method for treating long bone fractures in children, ensuring quick and reliable recovery with minimal complications.

MATERIALS AND METHODS

This was a prospective study conducted in Orthopaedic Department, Thoothukudi Medical College Hospital, Tamilnadu from August 2021 to April 2024. We included 34 paediatric patients of both sexes with isolated displaced femur shaft fractures in the age group of 6 years to 16 years. Cases those not willing for study, compound femur fractures , associated other bony injuries and those whose lost follow-up were excluded from this study X-rays were analyzed for the selection of cases. All standard protocols and norms were followed. Through clinical history was taken including age, sex, personal, past history. Routine Blood investigations were done. All patients were primarily immobilized with Thomas splint. Pre-operative x-rays were taken as follows - full length femur AP view and Lateral view.

By adhering to the methodical approach, including accurate preoperative measurements for femoral canal diameter in both the views in X-rays, application of Flynn's formula, and intraoperative adjustments, the elastic titanium nailing technique can be optimized for treating length-unstable femoral fractures. This ensures proper nail selection, adequate stabilization, and effective postoperative management, thereby supporting the hypothesis that this method is equally effective when principles and protocols are meticulously followed.

The diameter of nail was set as equal to the width of the narrowest point of the medullary canal on anteroposterior and lateral view x 0.4 mm (Formula: Diameter of Nail = Narrowest Canal Diameter x 0.4). All nails were inserted in a retrograde manner through a minimal incision avoiding the physis except in two cases were antegrade nailing was done.

Surgical Procedure

Under regional anaesthesia or general anaesthesia the patients are positioned on fracture table in supine position. Close reduction of the fractured femur is done by using longitudinal traction applied through a traction boot and gentle manipulative rotation. The aim of closed reduction is to obtain anatomical reduction, and the alignment is confirmed with fluoroscopy in both the anteroposterior (AP) and lateral views.

Retrograde nailing: Longitudinal skin incision of 2 cm is made at 2.5 cm proximal to distal femur physis level over lateral and medial aspect of thigh and the entry point is made by bone awl to a 45 degree angle relative to the shaft axis. Selected pair of titanium elastic nails of equal diameter (nail diameter that is 40% of femoral medullary canal diameter) are inserted after proper contouring (pre-bent 3 times the diameter of the medullary canal) through entry points and advanced proximally to fracture site(Figure 1). After close reduction they are further advanced into the proximal fragment to diverge laterally towards the greater trochanter and medially within the femoral neck for proper rotational stability. Throughout the procedure position of nails and stability of fracture are checked under image intensifier control. Finally the protruding parts of the nails were cut keeping a small part outside the distal femoral entry point and wounds were closed.

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Figure-1 shows A.Preop x-ray – Fracture shaft of femur at middle 1/3rd, B &C – United fracture shaft of femur with elastic nailing in situ by retrograde nailing

Antegrade nailing: By lateral approach, 3 cm skin incision made exactly 5 cm below the level of greater trochanter. To ensure 3 point fixation, first nail is entered from lateral femur at the level of lesser trochanter and the second nail is entered 1.5 cm anterior to the previous entry point (it requires two entry point).First prebent nail (from lateral entry point) is inserted ensuring that it has reached the fracture site. After closed reduction, the fracture site is negotiated and entered into the distal fragment under image intensifier. The second nail (from anterior entry point) is inserted gradually and at the level of middle third shaft its rotated to 180 degree so that it twist around the first nail and entered into the distal fragment ensuring three point fixation(Figure 2).

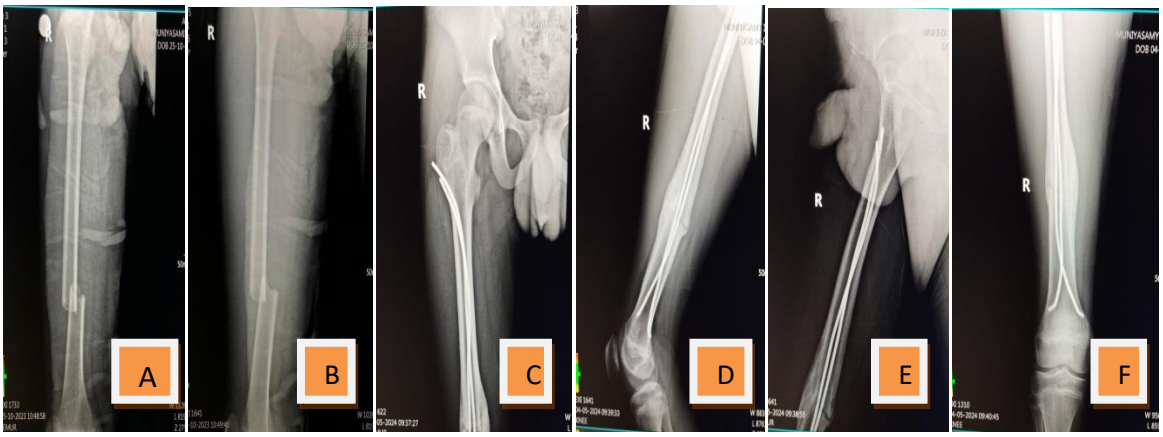

Figure 2 shows- A&B- Preop fracture shaft of femur distal 1/3 rd junction, C,D,E,F shows united fracture with elastic nailing by antegrade nailing

Postoperative protocol

All cases were immobilised in high above knee slab. They were discharged from hospital on 3-4 th postoperative day. Suture removal done on 12th day after surgery. Patients were periodically at 3rd week, 6th week, 10th week, 14th week and 20 week. After 3rd week the plaster of paris was removed and gradual knee mobilisation was started. Tolerated weight bearing allowed only when there is evidence of soft callus in x-rays usually by 8-10 weeks. All cases followed up periodically, both institutional and home rehabilitation was encouraged and ensured it's been done.

RESULTS

1. Demography data

Out of 34 cases, age distribution was from 6-16 years and the commonest age group was between 11-13 years. Mean age group is 12.5 years. Males were common in our study (26 cases) compared to females (8 cases). Right sided injury was more common (22 cases).

2. Mode of injury

In our study, road traffic accidents (pillion riders) were more common (Table 1).

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Table 1- Mode of injury

Mode of injury	Number of cases(n=34)
Road traffic accidents	23
Fall from stairs	6
Sports injury	5

3. Fracture pattern

In our series, oblique type of fracture was commonly noticed. We had almost equal number of transverse and spiral fractures in our study. Out of 34 cases, we had 26 cases with fracture at the level of middle 1/3rd and 8 cases at distal 1/3 rd for which retrograde nailing and antegrade nailing done respectively. In our series, we did closed reduction and elastic nailing in 25 cases and percutaneous reduction were needed in 9 cases.

Table 2 – shows the type of fracture pattern

Type of fracture configuration	Number of cases (n=34)
Oblique fracture	19
Transverse fracture	8
Spiral fracture	7

4. Size of elastic nail used

We commonly used 3- 3.5 mm sized elastic nails. Nail diameter which was calculated by Flynn et al formula, 44.11% (15/34) cases were treated with 3 mm nails. In 29.41% cases (10/34) 3.5 mm nails were used, 16.67% (05/34) cases were treated with 2.5 mm nails, 11.76% (04/34) of cases were treated with 2mm nails as seen.

5. Time for radiological union

Time to union ranged from 8 to 12 weeks. Time for union of 10 weeks duration was noted in 73.52% (24/34) cases. In 17.64% (06/34) cases it was 08 weeks and 11.76% (04/34) cases it was 12 weeks. Average union time was 10.1 weeks.

6. Functional outcome

According to Flynn score criteria, [16] excellent clinical outcomes were noted in 85.3% (29/34) cases and 14.7% cases (05/34) showed satisfactory outcome (Table 3).

Table 3- shows Flynn score of functional outcome

Parameters	Excellent result	Satisfactory result	Poor result
Limb length inequality	< 1cm	<2cm	>2cm
Malalignment	Upto 5 degree	5-10 degree	>10 degree
Pain	None	None	Present
Complication	Minor	Minor and resolved	Major complication with lasting morbidity
Our study(n=34)	**29/34 (85.3%)**	**5/34 (14.7%)**	**0**

7. Complications

Short term complications were noted in 17 cases which included: Knee stiffness in 03 cases (10%) and reduced after 3 weeks of physiotherapy. Thigh pain was noted in 04 cases (13.3%) and was treated with analgesics. Nail impingement was seen in 13.3% (04/34) cases and were treated with analgesics and early removal of nail. Malunion were noted in 01 case (3.3%) in a 12 year old male.

DISCUSSION

Paediatric trauma management, particularly of long bone fractures, is a critical aspect of paediatric healthcare that can have long-lasting impacts on a child's growth and development. Understanding the unique challenges presented by smaller bone size, open growth plates, and an immature vascular pattern is essential for orthopaedic surgeons.

Flexible intramedullary nailing has become a standard technique in orthopaedic surgery, especially in paediatric patients with long bone fractures. Its minimally invasive nature, preservation of growth plates, dynamic stabilization, and versatility make it a preferred choice over traditional methods in many cases.[17,18] Biological fixation allows micro movement at the fracture site which enhances callus formation and hence is best suited for paediatric age group.

Absolutely, while elastic flexible intramedullary nailing offers many advantages in the management of paediatric shaft of femur fractures, it's important to acknowledge and study the potential difficulties and complications associated with this technique. The complication rate is higher in obese and overweight children.

Flexible nailing must also include adequate three point fixation when the apex of the bend is at the fracture site. Contouring the apex of the bend to be at the fracture site requires meticulous work and depends on the level at which the fracture lies in the shaft. On

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occasions when the contouring is not satisfactory, an additional nail is used to add stability to the reduction. Using a minimum of two nails provides sufficient stability for paediatric femoral fractures, promoting biological fixation and facilitating fracture healing. This approach offers clinical and economic benefits while minimizing the risk of complications associated with excessive hardware.

The elastic, biocompatible nature of titanium elastic nail system (TENS) offers several advantages in the management of long bone fractures, including the limitation of permanent deformation, promotion of healing, and reduced risk of complications. Absolutely, the advantages of the titanium elastic nail system, especially in the 6-16 years age group, are multifaceted and stem from its ability to provide flexible stabilization while promoting early callus formation and bone continuity restoration. By promoting early callus formation, providing stable yet flexible fixation, and allowing for early mobilization while maintaining alignment, TENS contributes to favourable outcomes and improved functional recovery in this age group. Its simplicity, load-sharing properties, and physeal preservation make it a valuable option in orthopaedic surgery for paediatric femoral fractures.

In Saurabh Gupta et al, study 70% shaft fractures cases had no complications, only 20% had irritation at entry site, 5% had infection and proximal nail migration.[19] In DiveshJalan et al study, the most common complication encountered was soft tissue irritation at the nail entry site seen in 6 cases. There was no limb length discrepancy.[20] Where as in Vishal Kumar Mishra et al, study in 82.5% cases no limb length discrepancy.[21] But limb lengthening as noted in 04 cases (10%) and < 1cm shortening were in 3 cases (7.5%). In DiveshJalan et al, study lengthening was noticed in 4 (13.33%) cases, while no patient had shortening.

No patient had varus/valgus angulations, anterior and posterior angulations and rotational malalignment. Malunion was noted in 01 case (3.3%). Flynn et al, reported 10 (4.3%) cases of minor angulations out of 234 fractures treated with titanium elastic nails.[22] Singh et al. reported angulations in both anteroposterior and varus/valgus planes was seen in two cases and one case, in which two different diameter nails had to be used, had posterior bowing of 10° and 10° of varus tilt. We were able to compare our results with various studies.

CONCLUSION

The Titanium Elastic Intramedullary Nailing System offers numerous advantages in the management of paediatric femoral fractures, including shorter operative time, shorter hospital stay, fracture stability, early mobilization, early union, and low complication rates.[23]

Closed reduction with EIN is effective regardless of fracture location or pattern, and its indications are expanding as its benefits become more widely recognized. TENS is a safe and reliable treatment option with good long-term results, making it a preferred choice for paediatric orthopaedic surgeons treating long bone fractures in children.

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