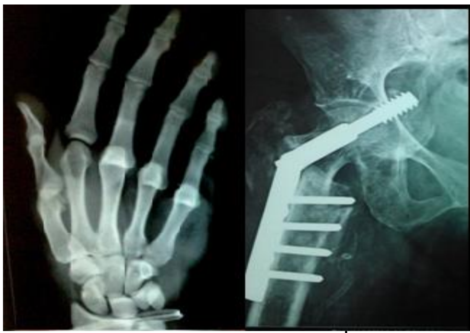

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Surgical management of fracture shaft of femur in children aged between 5 to 16 years using elastic stable intramedullary nailing

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Abstract
Femoral shaft fractures including subtrochanteric and supracondylar fractures, represent approximately 1.6% of all bony injuries in children. Most fractures in children are the result of high velocity accidents. Most of the injuries in children were due to fall from swings on a play ground. More recently a variety of therapeutic alternatives such as external fixation, compression plating and flexible or locked intramedullary nailing have become available, to help decrease impairment, increase convenience and decrease the cost of treatment. In this study 20 patients aged between 5 to16 years, with fracture shaft of femur were treated with flexible intramedullary nail. Upon evaluation by the FLYNN criteria, we had 45% (n=9) excellent results, 40% (n=8) of successful results and 15% (n=3) of poor results.

Keywords: Paediatric femoral shaft fractures, Elastic stable intramedullary nail

Introduction

Femoral shaft fractures account for 1.6% of all paediatric injuries [1]. In children 5 years or younger, early closed reduction and application of a spica cast is an ideal treatment for most diaphyseal fracture. In skeletally mature adolescents, use of antegrade solid intramedullary rod has become standard treatment. But, the best treatment for children between five to sixteen years of age is still debatable. Compared with younger children, patients in this intermediate age group have a high risk of shortening and malunion when conservative measures are used. Children managed with traction and spica cast as a treatment modality have to undergo various adverse physical, social, psychological and financial consequences in view of their prolonged immobilization. Various other modalities like external fixation, plates and screws, use of solid antegrade intramedullary nail are available. However, the risk of certain complications, particularly pintract infection and refractures after external fixation or osteonecrosis with solid nails do not make them a favourable choice. In the past seven years fixation with flexible intramedullary nails have become a popular technique, for stabilizing femoral fracture in the school aged children. ESIN fixation system is a simple, effective and minimally invasive technique. It gives stable fixation with rapid healing and prompt return of the child to the normal activities. This study was intended to assess the results following treatment of fracture shaft of femur by flexible intra-medullary nail or elastic stable intramedullary technique.

AIM

This prospective study aims to analyze the efficacy of Elastic Stable Intramedullary Nailing (Tens) in the treatment of fracture shaft of femur in children aged between 5 to 16 years with special emphasis on their technical difficulties and complications.

Materials and Methods

In this study 20 patients aged 5-16 years, with fracture shaft of femur were treated with flexible intramedullary nail with Titanium Elastic Nails (Tens) at Sree Balaji Medical College and Hospital, Chennai from January 2016 to December 2018. All the patients had given a written consent for publication of their clinical and radiological data and appropriate clearance was obtained from the institution's research and ethical committee.

The recruitment time was for 24 months till December 2017 and the study period was of 36 months, so that the minimum follow-up period shall be at least 12 months (range: 12 to 35 months)

Inclusion Criteria

- Children and adolescent patients of both the sex aged between 5 to 16 years with diaphyseal femur fracture.

Exclusion Criteria

- Patients not conforming to the aforesaid age criterion.
- Patients unfit for surgery.
  Comminuted and segmental fractures.
- Fracture involving the distal 1/3rd of femoral shaft.
- Pathological fractures of femur as a result of a metabolic disorder or conditions like osteogenesis imperfecta.

As soon as the patient was brought to casualty, patients airway, breathing and circulation was assessed. Then a complete skeletal survey was carried out to rule out other concomitant injuries. Plain X-ray of femur, both AP and lateral view were taken including both the hips and the knee joints. Limb was rested in a Thomas splint.

Surgical technique

Nail selection

Titanium elastic nails are available in five diameters 1.5, 2, 2.5, 3, 3.5 and 4 mm and are upto 440mm in length. The nails are colour coded for easy identification. (Figure 1). Nail diameter is equal to 0.4 X internal minimum diameter of bone. Alternatively, the size of the nail can be determined using the formula given by Kasser and Beaty [2]. It states that the size of the nail is determined by dividing the femoral diaphyseal internal diameter measured on both antero-posterior and lateral radiographs by 2 and subtracting 0.5 mm. The following sizes are typically used for children of average stature.

6-8 years: 3.0mm nails.
9-11 years: 3.5 mm nails.
12-16 years: 4.0 mm nails.

Two nails selected should be of the same diameter inorder that the opposing bending forces are equal, thereby avoiding malalignment. (Figure 2).

The elastic nails work on the biomechanical principle of symmetrical bracing action with a three point fixation at the two metaphysical ends and a central diaphysial cortex. (Figure 3).For achieving the best results, as suggested by Deitz H.G. *et al*. [3]. Four properties must be addressed *viz*; rotational stability, translational stability, axial stability and flexural stability.

Procedure

Step I: Positioning and draping

The patient may be placed supine on a fracture table with a traction boot (Figure 4). If fracture reduction can be accomplished with manual reduction, we can use a standard radiolucent table. Position the image intensifier on the lateral side of the affected femur for AP and lateral view of the thigh from hip to knee. The set up must allow the surgeon to access both medial and lateral aspects of the distal femur. Reduce the fracture and confirm alignment with 'C' arm in both AP and lateral views. Prepare and drape the leg from hip to knee.

Step II: Contouring the nail

Contour both nails into a bow shape with nail tip pointing towards the concave side of the bowed nail. The apex of the bend should be at fracture site and at a distance, 3 times the diameter of bone, usually it requires about a 30 degrees bend (Figure 5).

Step III: Nail Entry Point

The selection of entry point for the nails in medial and lateral sides are at the top of the flare of the femoral condyles, so that after insertion, they will tend to bind against the flare of the condyle. If the nail insertion is too low it will tend to back out. An incision in made on the lateral side of leg 2.5 cm to 3 cm above the physis. The fascia lata is incised and vastus lateralis is retracted. Select the next largest drill bit relative to the diameter of the nail. Use drill sleeves to protect the soft tissues. Start the drill bit perpendicular to the bone surface, penetrate the cortex. Use a curved bone awl, enlarge the hole at a 45° angulation. Similarly make a medial entry point in the similar manner (Figure 6). Then opening the medial side, be careful not to let the drill bit slip posteriorly in the region of the femoral artery.

Step IV: Nail insertion and fracture reduction

Both the nails are inserted through entry points one after the other and are driven upto the fracture site. Using 'C' arm align the nail tip so that the convex side will glance off from far cortex (Figure 7). It is very important that sufficient reduction of the fragment in achieved so that about half of the medullary canal overlap. Use the 'F' tool for reduction which is a radiolucent device (Figure 8). Viewing with image intensifier, note which nail will be the easiest to drive across the fracture site. This nail is advanced 2cm into proximal fragment and then rotated. Motion of the proximal fragment demonstrates that the nail is in the proximal fragment. At this point it is advanced further. By rotating this nail further reduction of fracture can be accomplished and then second nail is inserted. Don't advance the first rod so far until the second rod crossed the fracture site. If the first rod in advanced too far, it will shift the fragments and make the passing of the second rod difficult.

Step V: Nail advancement and cutting

The traction is released and both the nails are advanced to their fullest length. Any deformity can be corrected by altering the position of nail. Varus or valgus angulation can be corrected by the rotation of the nail whose concavity faces the same direction of deformation through 180°. The two curves which were originally diametrically opposite are now facing the same direction. Opposing the deforming force and correcting axial deformation with saggital angulations, the two nails are directed so that their convexity opposes deformation (Figure 9). If there is any significant malrotation, the child must be repositioned and nailing redone. The cut off point for the nail should be 1 to 2 cm out side the cortex, bending of the nail tip sometimes irritates the soft tissues (Figure 10).

Step VI: The closure

The wound in closed in layer and a water proof dressing applied. Bend the knee to 90 degrees, Check the freedom the knee movements (Figure 11)

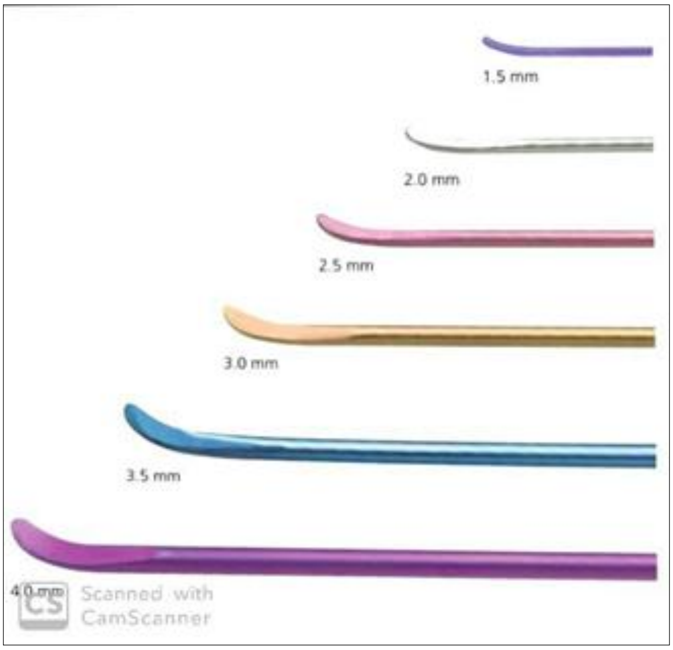


Fig 1: Colour Coded Tens Nail.

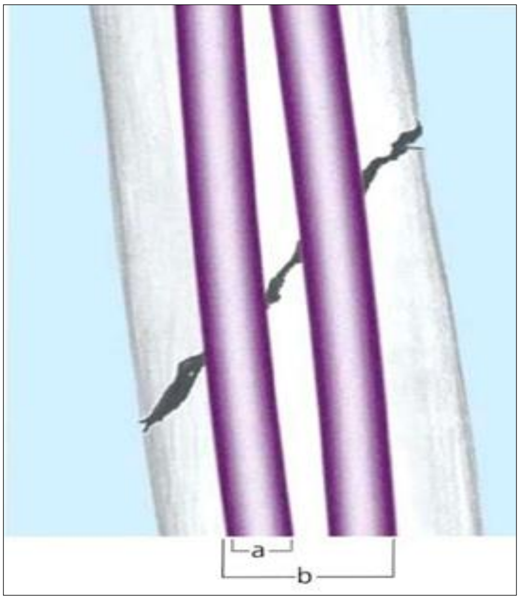
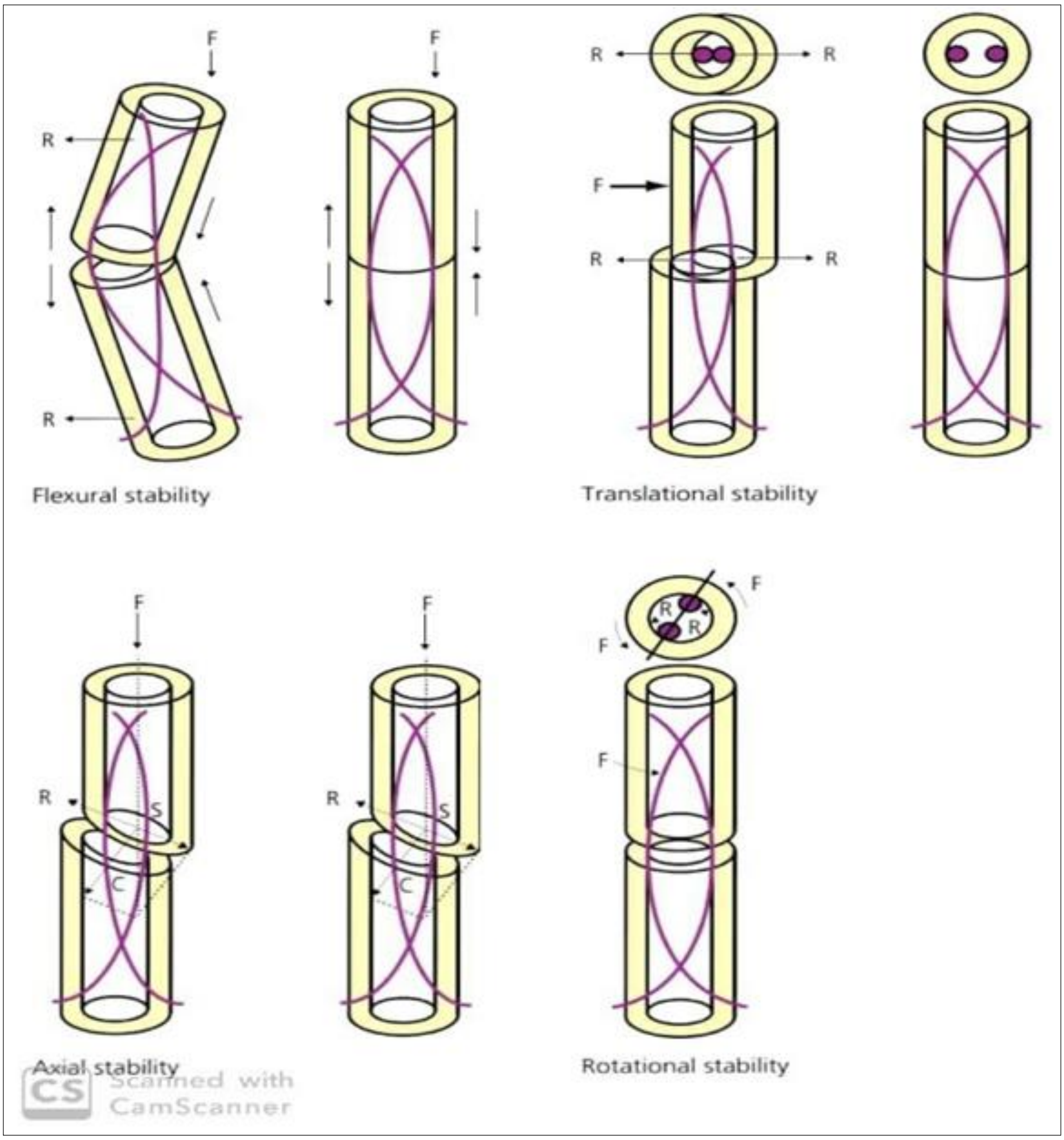


Fig 2: The nail should be Chosen such that the diameter of the nail (a) should not exceed 40% of the width of the medullary canal at the narrowest point (b).



R= Restoring force on the nail
S = Shear force
C = Compressive force.

Fig 3: F= Force acting on the bone

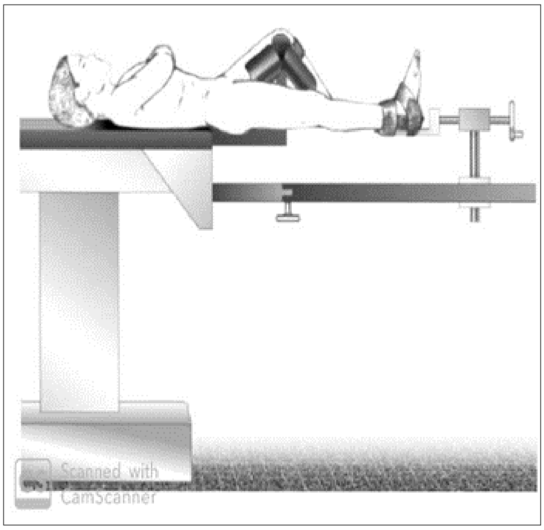


Fig 4: Patient Positining.

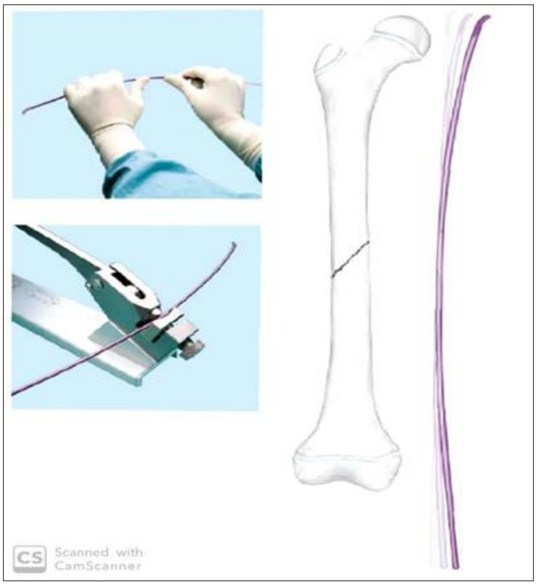


Fig 5: Contouring the Nail.

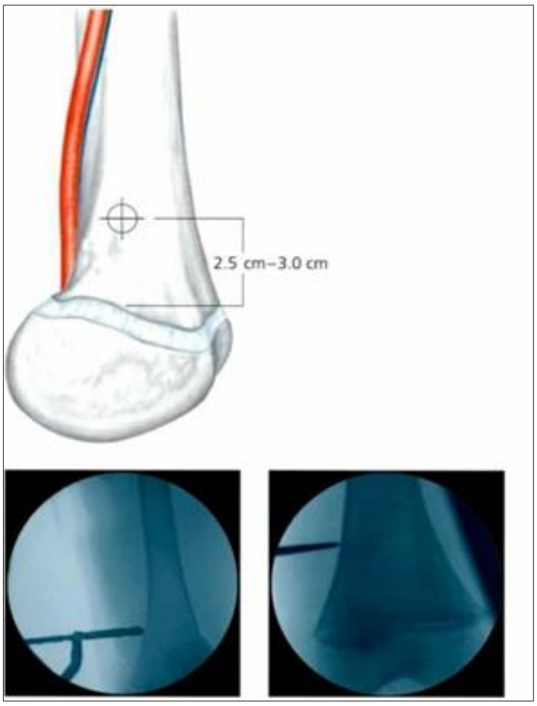


Fig 6: Nail Entry Point.

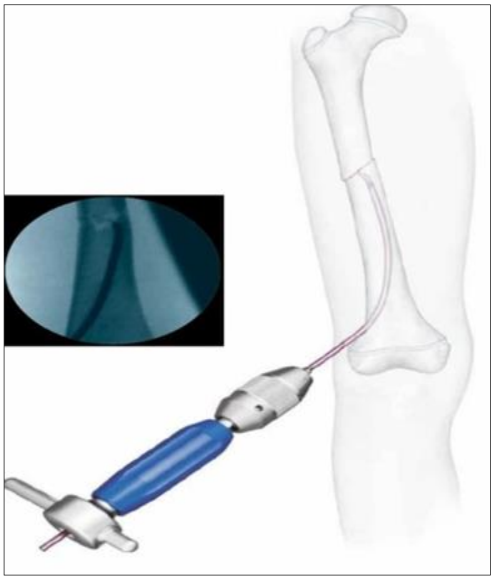


Fig 7: Negotiating the Nail

Fig 8: the ‘f’ tool. Through the fracture site.

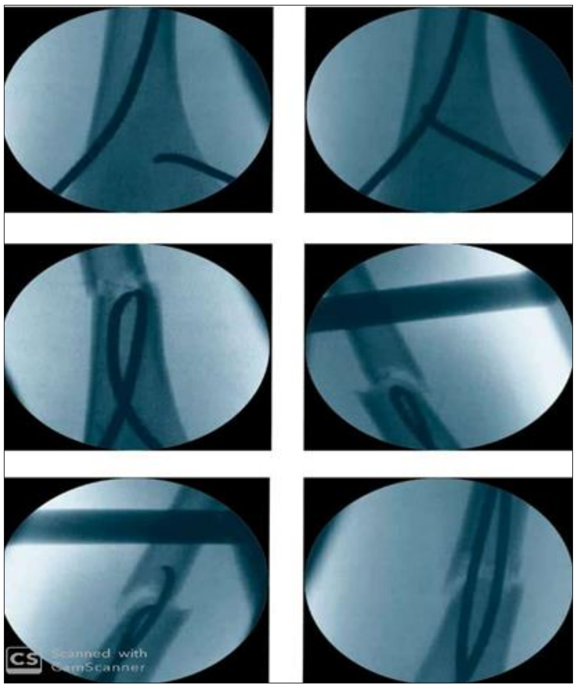


Fig 9: C-Arm Images.

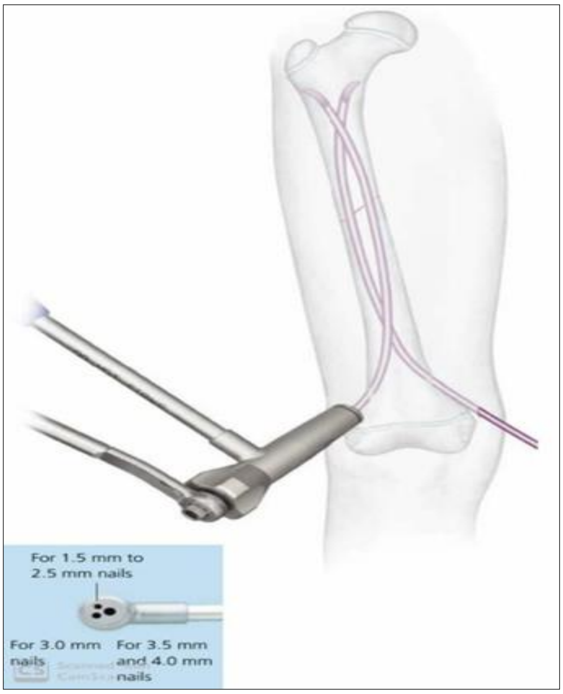


Fig 10: Nail Cutting

TOOL.

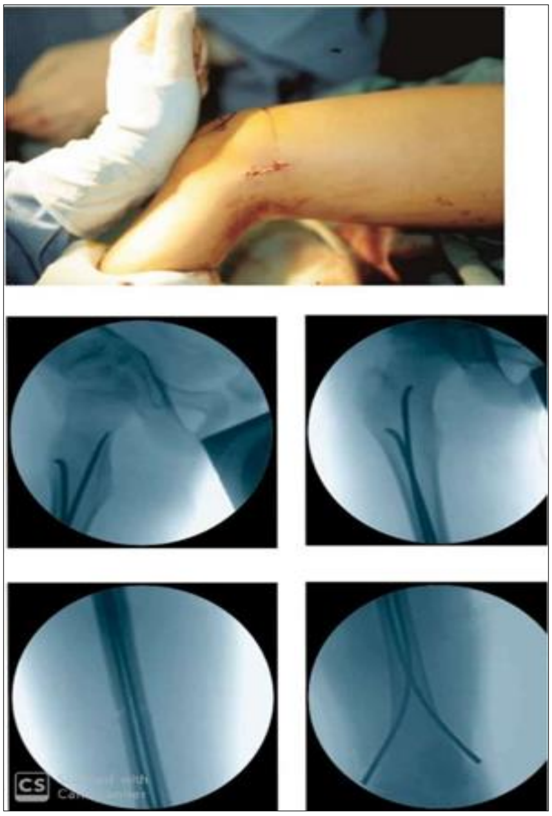


Fig 11: Closure and Final C-Arm Images.

Post-Op Protocol

With usual transverse fracture, no external immobilization is necessary. The patient is started on range of motion of knee and hip. Weight bearing will depend on the fracture pattern and stability. Progression of weight bearing should be at the discretion of surgeon. When early callus formation is observed weight bearing can be increased, external support can be discontinued when radiographic healing is complete.

Nail Removal: Usually nails for fracture shaft of femur are removed at 6 to 9 months.

After Surgery

Each child was followed upto a minimum of 12 months after the surgery(range: 12 to 35 months). Post-operatively the patient was immobilized in a resting Thomas splint (Figure 12). Patients were started on quadriceps exercise as soon as the pain subsided. After 3 weeks, the range of motion exercise were started, partial weight bearing was allowed after visible callus was seen. With radiological evidence of union, full weight bearing was started after 6-8 wks. Follow-up were carried out at 6, 12, 24 weeks and then at 1 year post-op.

Follow-up antero-posterior and lateral radiographs were reviewed for each post-operative visit. These radiographs were analysed for coronal and saggital plane malalignment and for shortening if any across the fracture site. Patients range of motion of knee, hip and limb length discrepancy, degree of pain or swelling documented. Rotational deformity of the femur were measured using foot progression angle (Figure 13). All operative and post-operative complications and secondary unplanned procedures were noted.

Fig 12: Thomas Splint.

Fig 13: Foot Progression Angle.

All patients were followed until fracture union occurred. The follow-up period ranged from 12 months to 35 months. Results were analysed both clinically and radiologically.

The results were evaluated according to the Tens Scoring System used by Flynn *et al.* [4]. As shown in Table I. The radiological evaluation was done as per Anthony's Radiological Criteria as shown in table 2.

Table 1: The FLYNN Scoring Criteria for Tens (4).

	Excellent	Successful	Poor
Limb length discrepancy	< 1.0 cm	1 to 2 cm	>2 cm
Sequence disorder	5 degrees	10 degrees	>10 degrees
Pain	Absent	Absent	Present
Complication	Absent	Mild	Major complication or increased morbidity

Table 2: Anthony's Radiological Criteria

Grade 0	No identifiable fracture healing.
Grade 1	Primary bone healing with little or no periosteal new bone formation.
Grade 2	Periosteal new bone formation on two sides of the femur.
Grade 3	Periosteal new bone formation on three or four sides of the femur.

Results

Table 3: Age and Sex distribution

Age in years	Male 'n' % age		Female 'n' % age		Total 'n' % age	
5 to 8	4	25%	1	25%	5	25%
9 to 12	7	43.8%	1	25%	8	40%
13 to 16	5	31.2%	2	50%	7	35%
Total	16	100%	4	100%	20	100%

Table 4: Mode of Injury.

Nature of trauma	No of cases 'n'	Percentage (%age)
RTA	11	55
Fall while playing	7	35
Fall from height	2	10

Table 5: Ratio of the sidedness, level of fracture, type of fracture and pattern of fracture.

Parameter	Description	Ratio
Sidedness	Right:Left	11:9
Level of fracture	Proximal third: Middle third	8:12
Type of fracture	Closed fracture: Open fracture	18:2
Pattern of fracture	Transverse: Oblique: Spiral	14:4:2

Table 6: Associated Injuries.

Head Injury	2
Abdominal Injury	1
Ipsilateral Tibia	1
Pelvic fracture	1

Table 7: Time Interval between Trauma and Surgery.

Duration in days	No of cases 'n'	Percentage (%age)
<24 hours	7	35
2-4 days	10	50
5-7 days	1	5

Table 8: Type of Reduction.

Reduction method	No of cases 'n'	Percentage (%age)
Closed	18	90
Open	2	10

Table 9: Stay in Hospital.

Hospital Stay	No of cases 'n'	Percentage (%age)
6-9	8	40
9 -12	10	50
>12	2	10

Table 10: Anthony's Radiological Criteria

Grade 0 (Week 1 to 2)	No identifiable fracture healing.
Grade 1 (Week 3 to 4)	Primary bone healing with little or no periosteal new bone formation.
Grade 2 (Week 5 to 8)	Periosteal new bone formation on two sides of the femur.
Grade 3 (n=20; average callus formation at 9.4 weeks)	Periosteal new bone formation on three or four sides of the femur.

Table 11: Time for union.

Time for union	No of cases 'n'	Percentage (%age)
8 weeks	12	60
10 weeks	4	20
12 weeks	4	20

Table 12a: Minor Complications

Complication	No of cases 'n'	Percentage (%age)
Superficial Infection	2	10
Nail end irritation due to protrusion	3	15
Total	5	25%

Table 12b: Major Complications

Complications	No of cases 'n'	Percentage (%age)
Varus angular malalignment >10 degrees	2	10%
LLD above 2cm	1	5%
Non-union	0	0%
Total	3	15%

In our series we had maximum number of cases in 9 to 12 age group 40% (n=8). This was followed by 35% (n= 7) in the 13 to 16 age group. The remaining 25% (n=5) belonged to the age group 5 to 8 years. The most common mode of injury was RTA 55% (n=11) followed by fall while playing 35% (n=7) and remaining 10% (n=2) were sustained due to fall from height. Table no: [5]. summarises the distribution of various parameters such as sidedness of injury, level of fracture, level of fracture, type of fracture and pattern of fracture. 55% (n=11) were right side fractures, 60% (n=12) constituted middle third fractures. 90% (n=18) comprised of closed fractures. 70% (n=14) constituted transverse pattern of fracture. 25% (n=5) patients had associated injuries which included head injury, abdominal injury and associated fractures of the lower limb. 35% (n=7) cases were surgically operated within 24 hours. 50% (n=10) were operated within 4 days. 5% (n=1) was operated within 7 days, this delay was because of complicating head injury. 10% (n=2) of our cases required open reduction because of soft tissue interposition. The average stay in the hospital in our series was 9.6 days. The average time for bone union in our series was 9.4 weeks. We had 25% cases (n=5) with minor complications like superficial infection and nail end protrusion. We had 15% cases (n=3) with major complication like varus angular mal-alignment of over 10 degrees and LLD above 2 cm. We analysed our final results with Tens Evaluation Score Given by Flynn *et al*. [4]. We had Excellent results in 45% (n=9) cases; Successful results in 40% (n=8) cases and Poor results in 15% (n=3) cases.

Case Illustrations
Case 1

Fig 14: Pre-Op X-Ray.

Fig 15: Post-Op X-Ray.

Case 2

Fig 16: Pre-Op X-Ray.

Fig 17: Post-Op X-Ray.

Discussion

Table 13: How our study compares with other studies

Parameters	Our study	Mohammed *et al.* (5)	Santosha *et al.* (6)	Jyotirtmayee *et al.* (7)	Ramprakash *et al.* (8)	Roop *et al.* (9)	Rajesh *et al.* (10)
Number of patients in the study	20	10	30	25	73	35	48
Flynn Criteria							
Excellent	9	10	20	19	59	25	40
Satisfactory	8	0	9	4	10	8	8
Poor	3	0	1	2	4	2	0
Hospital Stay	9.6 days	7 Days	15.23 Days	7 Days	5.1 Days	12.30 Days	7.3 Days
Mean time taken for surgery	66 Min	45 Min	59 Min	60.75 Min	67 Min	63 Min	65 Min
Union	9.4 Weeks	9 Weeks	11.8 Weeks	7.9 Weeks	10.2 Weeks	9.6 Weeks	9 Weeks
Side							
Right	11		18			20	
Left	9		12			15	
Level:							
Proximal	8	6	18	16	51	7	7
Middle	12	2	7	6	17	28	36
Distal	0	2	5	3	5	0	5
Pattern							
Spiral	2	2	2	4	0	0	6
Oblique	4	2	3	7	21	0	12

Transverse	14	5	16	11	49	15	24
Comminuted	0	0	2	3	3	0	0
LLD	1/20	0/10	2/30	6/25	13/73	3/35	5/48
Malalignment	2/20	0/10	1/30	4/25	11/73	3/35	4/48
Nail end irritation due to protrusion	3/20	0/10	0/30	2/25	2/73	5/35	12/48
PWB	6 Weeks	4 Weeks				4.56 Weeks	4.5 Weeks
FWB	8 Weeks	11.2 Weeks			10.5 Weeks	8.3 Weeks	9 Weeks
Return to school	8.5 Weeks					7.8 Weeks	9 Weeks

In has been commonly accepted that surgical intervention is indicated in paediatric femoral shaft fracture in the age group of 5-16 years. These are generally open fracture, poly-trauma with concominant head injuries and neuro-vascular wounding. Due to the advantages such as earlier return to function, less joint stiffness, lesser wound complication, Mal-union, Non-union, reduction in duration of hospitalization and cost makes intramedullary nailing one of the best methods of choice in children of the school going age.

In children, intervention using elastic nails are technically easier than the use of rigid nails. Using ender nails is little bit difficult becauses it is very hard and the canal diameter is a restricting factor in ender nail.

The studies have shown that the intremedullary fixation with TENS can be performed successfully in age group of 5-16 years. The mean age in our series was 7.5years.

Some authors reported that they were using elastic nails in compound fracture upto to Grade 3. We have used it for 2 cases of compound G II injuries in our series.

Most of the femoral fractures we treated were transverse. However Ligier *et al*. [11]. Have demonstrated that it can be successfully used in oblique and spiral fractures as well.

Flynn *et al*. and Ligier *et al*. [11]. Reported mean hospitalization was about 5-10 days by this method. In our series the mean hospitalization was 9.6 days.

The most common complication in treating femoral shaft fractures in children is limb length discrepancy. Significant discrepancy is LLD above 2cm. We had 1 case of LLD at 2. 5cm, which reduced to 1.6 cm at 30 months follow-up and he had no ambulatory issues or any limp.

Another complication in a paediatric femoral shaft fracture in angulatory malunion.

Herndon *et al*. [12]. Reported 7 of his 24 patients treated with spica casting developed malunion but none of the 21 patients who were treated by elastic nail developed malunion. Gaplin *et al*. [13]. Had reported that 2 patients out of 35 developed malunion by this technique and they had excellent improvement in angulation deformity in the final follow-up. We had 2 cases of malunion especially of varus mal-union of 12 degreesand 14 degrees respectively. This did not give any functional difficulty for the patients. The above two complications were the reason for our 15% (n=3) cases being classified as poor, in adherence to FLYNN criteria. We analysed rotational deformities by clinically measuring the foot progression angle and looking for in-toeing or out-toeing when the child stands. In our series there were no rotatory mal-union. Other complications in our series was the protrusion of nail in 3 cases causing skin irritation and knee stiffness. Luhmann *et al*. [14]. Indicated that the technical problem can be minimized if the part of the nail which is left outside the femur in smaller than 2.5 cm. Many studies recommended allowing walking using crutches after the pain subsided. But Flynn *et al*. suggested that it is ideal to allow partial weight bearing, when there is development of callus and full weight bearing only after there is clinical and radiographic evidence of union. In our series we began NBW crutch walking from POD 2, toe touch walking by week 4, PWB by week 6 and FWB at 8 weeks.

Conclusion

Early return to school is possible in this technique when compared with conservative methods. Based on our experience and results, we conclude that Elastic Stable Intramedullary Nailing technique is an ideal method for treatment of children in the school going age with femoral shaft fractures. It gives elastic mobility promoting rapid union at fractures site and stability which is ideal for early mobilization. It gives lower complication rate, good outcome when compared with conservative line of management. Over years of controversy, worldwide there is resurgence of opinion favouring operative fixation [15]. Lascombes *et al*. [16]. Had stated that in children above 6 years of age, TENS is indicated in femoral diaphysial fracture until epiphyseal closure except in severe Gustillo Anderson open type III fractures. A word of caution though is to realise that in grossly comminuted, long oblique and spiral fractures TENS cannot guarantee adequate post-operative immobilisation is mandated [15]. In these circumstances other surgical options must be contemplated. Case selection and age criteria are to be adhered to for getting reliably good result with TENS. Further nail diameter mismatch or opting for smaller diameter nails are associated with a high incidence of varus valgus angulation, as highlighted by the series of Narayan *et al*. [17].

References

1. Beaty JH, Kasser JR. Rockwood and Wilkins' Fractures in children. 7th ed. Philadelphia: Lippincott, 2010, 656-67.
2. Kasser Jr, Beaty JH. Femoral shaft fractures. In Rockwood and Wilkins Fractures in Children. 5th Ed. New York: Lippincott Willis and Wilkins, 2001, 941-80.
3. Deitz HG *et al*. Intramedullare Osteosynthese im Wachstumsalter. Urban and Schwarzenberg; Muchen, 1997.
4. Flynn JM, Skaggs DL, Sponseller PD, Ganley TJ, Kay RM, Kellie Leitch KK. The operative management of paediatric fractures of the lower extremity. J Bone Joint Surg Am. 2002; 84:2288-300.
5. Gammal EL-ADL, Mohammed F, Mostafa, Mohammed A, Khalil, Ahmed Enan. Titanium elastic nail for paediatric femoral and tibial fractures. Acta Orthop. Belg. 2009; 75:512-520.
6. Santosha, Gulrez S. Titanium elastic nailing for paediartic femoral shaft fractures: a prospective descriptive study. Int J Res Orthop. 2017; 3:501-7.
7. Bhanipati Jyotirtmayee, Mohapatra RGA. Observational study on titanium elastic nailing in femoral shaft fractures in children. Int. J Res Orthop. 2019; 5:32-7.
8. Ramprakash Lohiya *et al*. Flexible intramedullary nailing in paediatric femoral fractures. A report of 73 cases. Journal of Orthopaedic Surgery and Research. 2011; 6:64.
9. Singh Roop, Sharma SC, Magu NK, Singla A. Titanium elastic nailing in paediatric femoral diaphyseal fractures.

Indian J Orthop. 2006; 40:29-34.
10. Rajesh Govindasamy, Ramkumar Gnanasundaram, Saravanan Kasirajan, Syed Ibrahim, Jimmy Joseph Melepuram. Elastic stable intramedullary nailing of femoral shaft fracture- Experience in 48 children. Arch Bone Jt. Surg. 2018; 6(1):39-46.
11. Ligier JN, Metaizeau JP, Prevot J, Lascombes P. Elastic stable intramedullary nailing of femoral shaft fractures in children. J Bone Joint Surg Br. 1988; 70:74-7.
12. Herndon WA, Mahnken RF, Yngve DA, Sullivan JA. Managent of femoral shaft fractures in the adolescent. J paediatric Orthop. 1989; 9(1):29-32.
13. Galpin RD, Willis RB, Sabano N. Intramedullary nailing of paediatric femoral fractures. J Pediatric Ortho, 1994.
14. Luhmann SJ1, Schootman M, Schoenecker PL, Dobbs MB, Gordon JE. Complications of titanium elastic nails for paediatric femoral shaft fractures. J pediatr Orthop, 2003.
15. Saikia K, Bhuyan S, Bhattacharya T, Saikia S. Titanium elastic nailing in femoral diaphyseal fractures of children in 6-16 years of age. Indian J Orthop. 2007; 41(4):381-5.
16. Lascombes P, Haumont T, Journeau P. Use and abuse of flexible intramedullary nailing in children and adolescents. J Pediatr Orthop. 2006; 26:827-34.
17. Narayanan UG, Hyman JE, Wainwright AM, Rang M, Alman BA. Complications of elastic stable intramedullary nail fixation of paediatric femoral fractures and how to avoid them. J Pediatr orthop. 2004; 24(4):363-9.