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CLINICORADIOLOGICAL OUTCOME AFTER PERCUTANEOUS TITANIUM ELASTIC NAILING (TENS) IN PAEDIATRIC (6-12 YEARS) DIAPHYSEAL FEMUR FRACTURES

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ABSTRACT **INTRODUCTION :** Femoral shaft fractures comprises of 1.6% of all bony injuries in children but it is the most common fracture in children requiring hospitalization. The have slight male preponderance of 2.6:1. The mechanism of injury usually consists of high energy trauma either due to fall in young children or road traffic accidents in older children, with involvement of diaphysis of femur, where surgical intervention is mostly indicated. In infants less than 1 year age, physical abuse or metabolic disease should be considered as possible aetiology.

MATERIALS AND METHOD : We conducted a prospective study in a tertiary trauma care centre with the records and radiographs of 38 consecutive femoral shaft fractures stabilized with TENs over the evaluation period of 9 months from January 2021 to September 2021 . These fractures occurred in healthy school children (pathologic fractures were excluded). We recorded demographics, mechanism of injury, fracture type, associated injuries, intraoperative problems, postoperative immobilization, time to assisted and unassisted weight bearing, time to nail removal, and complications.

RESULT : In outcome analysis there was excellent result in 28 patients , the cases had to meet all criteria while 9 had a satisfactory result and there was one poor result. A 10 years old girl with a proximal, oblique comminuted fracture healed with 20 degrees of knee flexion contracture after six months post surgery due to poor physiotherapy and delayed follow up, she was managed with aggressive knee and hip physiotherapy , which yielded good range of motion in 2 months , with complete resolution , in this nail removal was delayed to upto 14 months

CONCLUSION : TEN of paediatric femoral shaft fractures achieves good bony union with minimal deformity and rapid mobilization with few complications. TEN may prove to be the ideal implant to stabilize many paediatric femur fractures, avoiding the prolonged immobilization and complications of traction and spica casting

KEYWORDS : Paediatric, Femoral Shaft Fractures, Femoral Diaphysis Fracture, Titanium Elastic Nail, Tens.

INTRODUCTION :

Femoral shaft fractures comprises of 1.6% of all bony injuries in children but the most common fracture in children requiring hospitalization. The have slight male preponderance of 2.6:1.[1]

The mechanism of injury usually consists of high energy trauma either due to fall in young children or road traffic accidents in older children, with involvement of diaphysis of femur, where surgical intervention is mostly indicated. In infants less than 1 year age, physical abuse or metabolic disease should be considered as possible aetiology.[2,3]

There can be different types of paediatric femoral shaft fractures as simple transverse, linear, oblique, spiral, greenstick or comminuted as seen in fig.1. It has been classified by AO in adults as seen in fig.2. But Muller AO has following classification for paediatric femoral shaft.[4] : Here type D denotes Diaphyseal, where as severity is classified with simple as 1 and wedge/complex/comminuted as 2.

32 - D/4.1 : simple complete transverse <30°
32 - D/4.2 : multifragmentary transverse <30°
32 - D/5.1: simple complete oblique or spiral >30°
32 - D/5.2: multifragmentary oblique or spiral >30°

The paediatric femur has high remodelling potential till 10 years of age and can tolerate up to 25 degrees of angulation in any plane, malrotation up to 25% and shortening up to 1 cm.[3,5]

They are managed based on age and size of child, type and location of injury, associated trauma and fracture pattern. There are a variety of treatment modalities in use, ranging from casting, traction then casting, K wire fixation, external fixators, intramedullary nailing and plate osteosynthesis. External fixators provide early mobilization and good stability but are associated with knee stiffness, pin tract infections and refractures. Intramedullary K wire fixation gives suboptimal stability and fracture angulation. Intramedullary interlocking nail when used in skeletally immature patient may lead to osteonecrosis of femoral head, trochanteric epiphysiodesis and coxa valga.[6]

MATERIALS AND METHOD:

We conducted a prospective study in a tertiary trauma care centre with the records and radiographs of 38 consecutive paediatric femoral shaft fractures stabilized with TENs over the evaluation period of 9 months from January 2021 to September 2021. These fractures occurred in healthy school children (pathological fractures were excluded). We recorded demographics, mechanism of injury, fracture type, associated injuries, pain score by VAS (fig.3), intraoperative problems, postoperative immobilization, time to assisted and unassisted weight bearing, time to nail removal, and complications. Postoperative examinations included a careful assessment of knee motion, limb-length inequality, limb rotation and alignment, and signs of irritation from the nail tip. Radiographs were evaluated for alignment, callus formation, and change in nail position. Bone pain and tenderness persisting more than 3 months postoperative without adequate radiological union is termed malunion. Coronal angulation of more than 10 degrees and sagittal angulation of more than 15 degrees, as parameters for malunion. Absence of radiological fracture union beyond 6 months of surgery is termed non-union.

Cases were followed up to their clinical end point of fracture union and return to full activity. Postoperative immobilization, time of immobilization, and time of protected weight bearing varied among the patients. we chose immobilization cast for 25, a hip–

knee–ankle–foot orthosis (HKAFO) fracture brace for 13 patients. The choice of postoperative immobilization depended primarily on the fracture pattern and degree of fixation.

Radiographs and clinical outcomes of one such 7 years female patient has been shown sequentially in figures 4, 5, 6 and 7.

Surgical technique:
Patients were taken on operating table in supine position under general anaesthesia. Scrubbing, painting and draping done. Fracture was reduced under fluoroscopy. A 1 cm longitudinal skin incision was made 2 cm proximal to the distal femoral epiphyseal plate, over the medial and lateral surface of the distal femur. Entry was taken with the help of bone awl. 2 appropriate sized prebent curved TENS nails with 40% of the narrowest diameter of the diaphysis each were used to achieve good three point contact. Nail was introduced with a T-handle by rotation movements of the wrist. Each nail was driven with gradual rotatory movements till fracture site, with occasional hammering if required. Then the second nail was introduced from the other entry point and then both nails are advanced through proximal fragment. Fracture reduction was checked under C arm and end of the nail was buried to keep less than 1 cm out of bone and wound closed.

Post operatively patients were kept in above knee plaster slab for 2 weeks to maintain adequate rotational stability. This plaster was removed after 2 weeks and knee mobilization started after removing the slab. Nil weight bearing walk with walker was started from 2nd post op day or as per tolerance of the patient. Patients were kept non weight bearing till 4 weeks and partial weight bearing was started from 4 wks. Complete weight bearing was gradually allowed after radiological union.

Nails removed at 6 to 9 months postoperative.
Demographics (Table 1)

Number of patients	38
Male	24
Female	14
Age (mean in years)	9.2±1.9
Weight in kg (mean)	33.8±10.2
Injury severity score	12.1±5.3

Parameters of surgical process assessment while TENS insertion (Table 2).

Operative Time in hours	1.6±1.1
Estimated Blood loss in ML	40.1±55.6
Fluoroscopy time in minutes	2.5±1.1
Length of hospital stay in days	3.7±3.3
Change in VAS	-1.6±3.1
Immobilization in days	14.5±3.2

Parameters of surgical process assessment while TENS removal (Table 3).

Operative Time in hours	0.9±1.1
Estimated Blood loss in ML	1.3±18.6
Fluoroscopy time in minutes	0.14±0.16
Length of hospital stay in days	1.7±0.5

RESULT:
The mean age at injury was 9.2 years (range, 6–12 years). 23 of the 38 patients sustained high energy injury leading to fractures . 5 children had multiple injuries no patient in the study had head or chest trauma. The most common pattern was simple midshaft fracture seen in 29 children; 5 were distal, 2 were proximal, and 2 were comminuted. Children who sustained an isolated femur fracture were mobilised early with assisted nil weight bearing walk by around 7- 8 days. By an average of 7.5 weeks (range, 3–11 weeks), patients walked without any assistive devices. Callus was first noted on follow-up radiographs at an average of 4 weeks. A summary of the problems encountered during the course of treatment is shown in pie chart in fig.8. There was some loss of reduction in the postoperative period in 2 cases (one proximal fractures and one distal fracture); postoperative immobilization was used in all the patients. Seven fractures healed with more than 5 degrees of angulation . Two children were noted to have 20 degrees of knee flexion contracture, due to excessive immobilization and inadequate physiotherapy due to delayed followup, which was managed with aggressive physiotherapy and later patients did not have any contracture. No patients reported loss of rotational alignment in the postoperative period. Irritation of the soft tissue near the knee by the nail tip occurred in eight patients, leading to a superficial infection in two cases which managed by oral antibiotics. There were no cases of osteomyelitis. In most cases, nails were routinely removed approximately 6 months after injury (when circumferential callus was solid, and the fracture line was no longer visible). No complications were associated with the nail-removal procedure. Despite the initial concerns about ingrowth into the titanium implant, all nails were extracted easily, with the latest removal being 14 months after implantation. In outcome analysis there was excellent result in 28 patients , the cases had to meet all criteria while 9 had a satisfactory result and There was one poor result. A 10 years old girl with a proximal third shaft comminuted fracture healed with 20 degrees of knee flexion contracture after six months post surgery due to poor physiotherapy, she was managed with aggressive knee and hip physiotherapy , which yielded good range of motion in 2 months , with complete resolution , in this nail removal was delayed to upto 14 months.

Outcome analysis of the surgical procedure (Table 4) :

Outcome analysis	Satisfactory	Poor outcome
Varus malunion	<10 degree	>10 degree
Leg length discrepancy	<2 CMS	>2 CMS
Knee flexion contracture	<10 degree	>10 degree
Procurvatum malunion	<10 degree	>10 degree

DISCUSSION:
In 1959, Dameron and Thompson stated 6 principles for management of femur shaft fractures: 1) Simplest treatment is the best treatment, 2) Initial treatment should be definitive whenever possible, 3) Anatomical reduction was not required for perfect function, 4) Alignment must be restored, especially rotational alignment, 5) The more growth that remained, the more remodeling was available, 6) Limb should be immobilized in a splint until definitive treatment is instituted.[7]

In children younger than 6 years age, most of the femoral diaphyseal fractures can be conserved with hip spica alone or traction followed by hip spica, due to potential of rapid healing and spontaneous remodelling with deformity correction. But this is also associated with prolonged treatment and immobilization leading to psychosocial and economic complications.[6,8]

Patients above 6 years, conservative management may lead to loss of reduction, malunion, noncompliance and plaster complications. As skeletal maturity progresses, remodelling potential decreases and angular deformity is no longer correctable.[9]

Paediatric femoral tens nailing was introduced up in 1982 by French surgeons. It acts as a load sharing internal splint sparing the open physis. There is accelerated external bridging callus formation due to micromotion at fracture site is attributed to decreased stress shielding due to elasticity of tens nail. Closed reduction with this technique also preserves the fracture hematoma and the periosteum and its blood supply. It decreases blood loss, operative time and radiation exposure as compared with other open techniques.[1]

Ten's nailing can be used in almost all femoral diaphyseal fractures except compound grade 3 fractures and postoperative immobilization is required after tens nailing in long oblique or spiral and grossly comminuted fractures. Increased risk of malunion and shortening has been observed in length unstable fractures.[10]

Titanium elastic nails are preferred over stainless steel due to the advantages of superior biocompatibility, osseointegration and compatibility with magnetic resonance imaging. Paediatric femoral titanium elastic nailing achieves adequate reduction with advantages of early mobilization, reduce loss of school days and complications related to prolonged immobilization.[11]

Entry site pain and irritation is the most common complication seen, followed by fracture angulation, limb length discrepancy and infection. Major complications include implant breakage and deep infections which is rare.[11]

Ten's nailing has been recommended for femoral shaft fractures as limited evidence by American Academy of Orthopaedic Surgeons clinical practice guidelines of 2010 in 5 to 11 years aged children. Mainly indicated in length stable fractures and children weighing < 49 kgs.[12]

In tens nailing of femur, 2 nails with size 40% of narrowest intramedullary canal diameter must be selected. Prebending both the nail of equal diameter is important for 3 point fixation. Both medial and lateral entry points must be at same level in metaphysis with 2 cms away for physis. Antegrade nailing is done in more distal fractures and retrograde nailing is done in more proximal fractures. Only a small part of tens nail (1 cm) must be left behind to avoid any difficulties while their removal later and also avoids tissue irritation. Removal of implant if performed is simple and done after 6 months postoperatively.[6,7]

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

FIGURES :

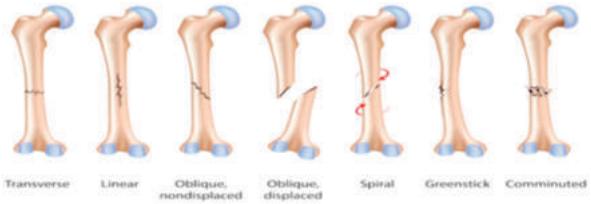

Figure 1 : showing different types of paediatric femoral shaft fractures.

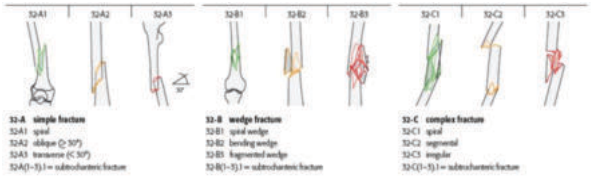

Figure 2 : showing AO classification for femoral shaft fractures.

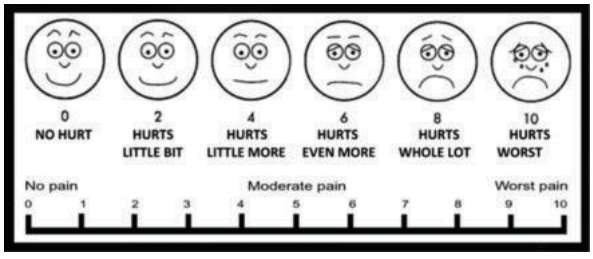

Figure 3 : showing VAS score for pain.

Figure 4 : Preoperative X rays showing a spiral right femur shaft fracture in a 7 years female.

Figure 5 : Immediate postoperative X rays after retograde TENS nailing.

Figure 6 : 4 weeks postoperative X rays showing good callus formation.

Figure 7 : X rays and clinical pictures at 6 months follow up showing satisfactory clinical outcome and fracture consolidation.

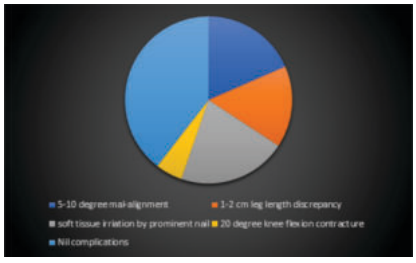

Figure 8: Pie diagram showing distribution of postoperative complications.

CONCLUSION:

TENS nail treatment is marred with potential loss of rotational alignment, though it did not occur in our series. Likewise, leg-length inequality was not a major problem. However, longer follow-up will

be needed to determine the incidence of permanent, clinically significant leg-length discrepancy. Fortunately, there were no cases of osteomyelitis after the soft tissue irritation. Though this group of mostly high-energy, the results were excellent or satisfactory in 37 of the 38 cases. Overall, TENS allowed rapid mobilization with few complications. TENS may prove to be the ideal implant to stabilize many paediatric femur fractures, avoiding the prolonged immobilization and complications of traction and spica casting

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