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Percutaneous TENS in Pediatric Diaphyseal Femoral Fractures- Respects Biology and Ends Happily

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Abstract

Femoral shaft fractures are amongst the most common major pediatric injuries treated by orthopaedic surgeons. They represent 1-2% of all fractures in the paediatric population. Paediatric males are affected more commonly than females. [1]

There are various methods available for operative stabilization of paediatric femoral shaft fractures, which include external fixation, compression plating and rigid and flexible intramedullary nailing. [2]

There is no uniform consensus on the treatment modality for femoral shaft fracture in school-aged children between 6 years to16 years.

Titanium elastic nailing system (TENS) is a recent and widely used technique which allows stable reduction, maintenance of reduction and early mobilization. [3]

American Academy of Orthopaedic Surgeons (AAOS) recommends with strong evidence based support in favour of the use of flexible intramedullary nailing for treating children age five to eleven years diagnosed with diaphyseal femur fractures. [4, 5]

This device exploits a child's denser bone, rapid healing and ability to remodel during period of bone growth. Here, we establish this axiom by a detailed case presentation, who was successfully treated with flexible intramedullary nailing for diaphyseal fracture of the femur.

KEYWORDS: Femur shaft fracture, Pediatric, Titanium elastic nails, Fracture

Case presentation

A male 11 years old child attended the emergency room of our level 1 trauma hospital with fracture of the right side of shaft of femur following a road side accident (RSA). He was primarily immobilized with Thomas splint in the fractured extremity. Pre-operative radiographs were taken, which included full length femur AP view and Lateral views. It showed mid shaft transverse displaced fracture of the femur (Figure 1). After the anesthesia fitness patient was posted for surgery. The diameter of the nail was assessed preoperatively on radiographs. The size of flexible nail should be approximately 40% of the diameter of the femoral canal at its most narrow point (Isthmus). A systemic antibiotic i.e. a third generation cephalosporin was administered parenterally just before anaesthetic induction. The surgery was performed with the patient under general anaesthesia. The patient was positioned in supine position on the fracture table with the injured extremity held in a traction boot. C -arm is used to position in order to facilitate anteroposterior (AP) and lateral views intraoperatively during the surgery. The standard

introduction technique of titanium elastic nailing in femur used was Retrograde (ascending). Perineal post should be well padded to avoid any injury to the nearby structures. Image intensifier assistance was used to locate the position of skin incision and for creating entry hole within the distal femoral metaphysis. The entry point was around 2.5-3 cm above the physis by using longitudinal incisions on either side. The entry points were ensured to be at similar levels both medially and laterally. Skin, superficial and deep fascia was dissected along the line of incision and blunt dissection was carried out till the periosteum was reached. Medullary canal was subsequently opened using an awl or drill bit. The next largest drill bit size relative to the diameter of nail was selected, so that the opening is slightly larger than the size of the selected nail. The drill bit was started perpendicular to the bone surface, then slowly angulated to 45◦ in relation to axis of shaft and 10◦ anteriorly. Then the drill bit was advanced at this angle until it reached the medullary canal. The two titanium nails of an equivalent diameter were selected ensuring that proper nail diameter shouldn't be over forty percent (40%) of the width of the canal. Hence both the nails of equal size would be filling 80% of the isthmic region of the medullary canal. Pre-contoured nail was driven under image intensifier control by toggling or with back and forth reciprocating movement or with a help of a hammer up to the fracture site. The reduction was facilitated by giving traction and manipulation at the fracture site. A nail was introduced into the medullary canal of the proximal fragment. The second pre-contoured nail was advanced to enter the canal of the proximal fragment. Subsequently, traction was released to avoid distraction at the fracture site. Then, both nails were pushed further till their tips became fixed into the cancellous bone of the proximal femoral metaphysis. The double C construct of these nails with maximum curvature at the fracture level ensures 3- point fixation. The tip of the nail that entered the lateral femoral cortex was introduced to just distal to the trochanteric epiphysis while the medial one was inserted up to the same level towards the calcar region (Figure 2). Distally the nails were cut leaving about 1.5 to 2cm outside the bone and allowed to lie flushed with the bone surface to allow easy extraction in future (Figure 2). Wound was closed in layers and sterile dressing was done. An above Knee (high groin) slab was applied. Average operative time for this procedure was 1hour. Post-operative AP and Lateral radiographs of the full-length femur were taken on the next day. Patients were advised ambulation with strict non-weight bearing on the injured extremity from next day. At 2 weeks, the slab was replaced by a knee Immobilizer brace on an out patient basis and was encouraged to do knee bending exercises. Patients were assessed clinically and radiologically at each follow-up. Weight-bearing as tolerated, was allowed as callus was noted in the radiograph at around 6 weeks and full weight bearing was allowed once fracture united at around 4 months (Figure 3). Observations were made regarding fracture union, range of motion at the knee joint, limb length discrepancy, rotatory and angular deformity. The final result was evaluated using scoring criteria by Flynn et al. [6, 7] and was found to be excellent in our case. The duration of follow up was up to 24 months.

Discussion

Despite the increase in surgical treatment choices, fixation techniques and improved imaging methods, the basic rules described for the treatment for pediatric fractures remain valid today. These basic rules as described by Dameron and Thompson mentions that the simplest treatment is best; the initial treatment should be permanent where ever possible; perfect anatomic reduction is not essential for perfect function; restoration of alignment is more important than fragment position and overtreatment is usually worse than undertreatment. [8]

There is no universal classification system available for pediatric shaft femur fractures. Fractures are usually classified descriptively either on the basis of i) configuration - transverse/spiral/oblique ii) comminution – comminuted or non-comminuted and iii) presence/absence of soft tissue coverage around fracture- open/closed. The most common type of fracture is a simple, transverse, non-comminuted, diaphyseal fracture accounting for more than 50% of the cases. [9]

With better understanding of biology of fracture healing and with advances in fixation methods and operative techniques, there has been a general trend toward operative stabilization of shaft fractures in children. [10]

Titanium rods are superior to steel rods as they have unique biological properties which includes being less reactive and inert to the host tissues alongside favorable mechanical properties like flexibility, strength and durability of implants.[11] Titanium elastic nails are hypoallergenic, magnetic resonance imaging compatible, and have higher elastic modulus and superior osteointegration properties [12].

Moreover, it has also been observed that stainless steel nails hamper remodelling and consequently increased the chances of re-fracture. [13]

TENS was first introduced in 1982 by the Nancy team in France under the name of Embrochage Centro Medullaire Elastique Stabile (ECMES). [14]

Titanium elastic nail is advantageous over other surgical methods particularly in 5-14 years age group because it is a simple, load sharing internal splint type device that doesn‘t violate open physis, allows early mobilization and maintains alignment. It works on the basic principle of three-point fixation. This principle is referred to as ‘trifocal buttressing’. [15, 16]

It provides flexible, axial, translational and rotational stability, thus promoting early mobilization and early weight bearing. Micro-motion conferred by the elasticity of the fixation promotes faster external bridging callus formation. The periosteum is not disturbed and being a closed procedure there is no disturbance of fracture hematoma which further serves to provide the concept of biological healing without adding any risk of infection. Also, the resultant scar is small and high patient satisfaction.

All currently available elastic nails have beaked or hooked ends to allow satisfactory sliding down while inserting along inner surface of the diaphysis without impacting on opposite cortex.

According to Moroz et al [17], the ideal patient for flexible intramedullary nailing is the child between the ages of 5 and 11 years old with a length-stable femur fracture, in the mid 80% of the diaphysis, who has a bodyweight less than 50 kg. Diameter of individual nail is selected as per Flynn et al’s formula (Diameter of nail= Width of the narrowest point of medullary canal on Antero posterior and Lateral view x 0.4mm). All titanium nails were bent at insertion site and cut near to bone leaving 1.5-2cm of nail protruding for later easy removal. In this treatment described by the ‘Nancy team’, nail is selected by measuring 40% of the narrowest diameter of the medullary canal. Elastic intramedullary nail (EIN) treatment works by balancing the forces between the two opposing flexible implants. TEN is an elastic stable intramedullary nail that works on the principle of three-point fixation by resisting distraction and compression forces. [18, 19]

It is recommended to use 2 nails of same thickness to avoid valgus and varus or axial deformity which may be due to different restoring forces. Difficulties with fracture reduction as well as advancing the 2nd nail may tempt the surgeon to rotate the nail more than 180 degrees. This may lead to one nail being wound around the other leading to the corkscrew phenomenon. In such cases construct becomes rotationally and axially unstable and should be avoided.

Postoperative immobilization and time to initial protected weight-bearing varies along with the choice of immobilization depends primarily on the treating surgeon.
Callus formation on radiographs can be graded. It is Grade 0 -No identifiable fracture healing; Grade 1- Primary bone healing with little or no new bone formation; Grade 2- Periosteal new bone formation on two sides of femur; Grade 3- Periosteal new bone formation on three or four sides of femur [-3]: Anthony et al., scale for grading of callus formation [20].

Conclusion

The flexibile internal nailing (FIN) functions as an internal splint mantaining length and alignment and can be successfully used regardless of age, weight, fracture location, and fracture pattern. TENS (Titanium Elastic Nailing System) has distinct advantages in terms of short operative time, short duration of hospital stay, fracture stability, early mobilization, early union, and early return to function, reasonable bone healing time, good range of movements of knee, good functional outcome and low incidence of complications. It is done with mini incisions. It does not interrupt the social life of the child and family due to the short hospital stay, improves the range of motion by allowing early movement, and allows rapid recovery as it does not disturb the fracture biology. It is safe due to its acceptable complication rate. There is a significant learning curve, so treatment should not be used only occasionally.

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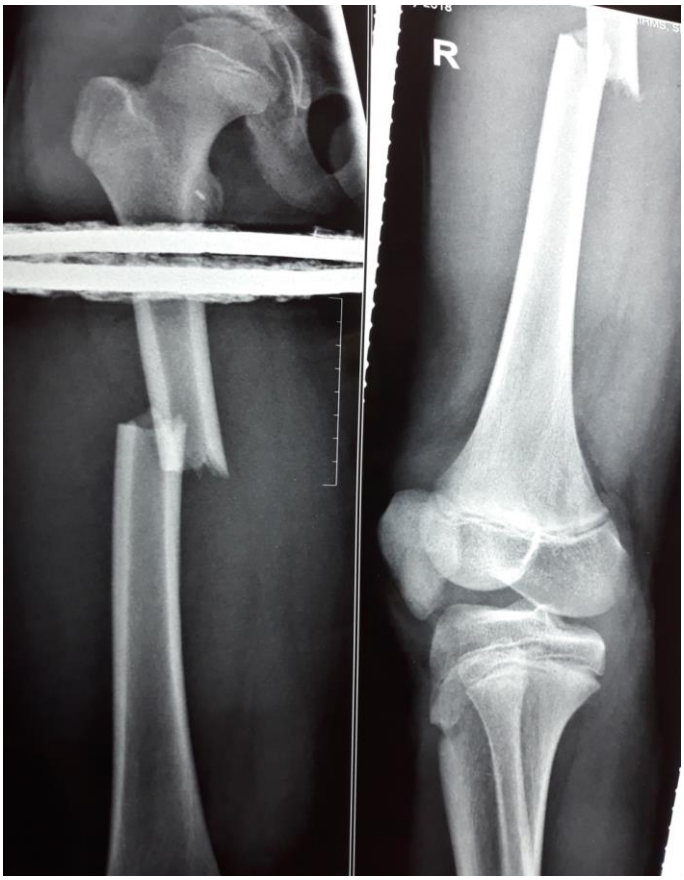

Figure 1- It shows mid shaft transverse displaced fracture of the shaft of femur with Thomas splint

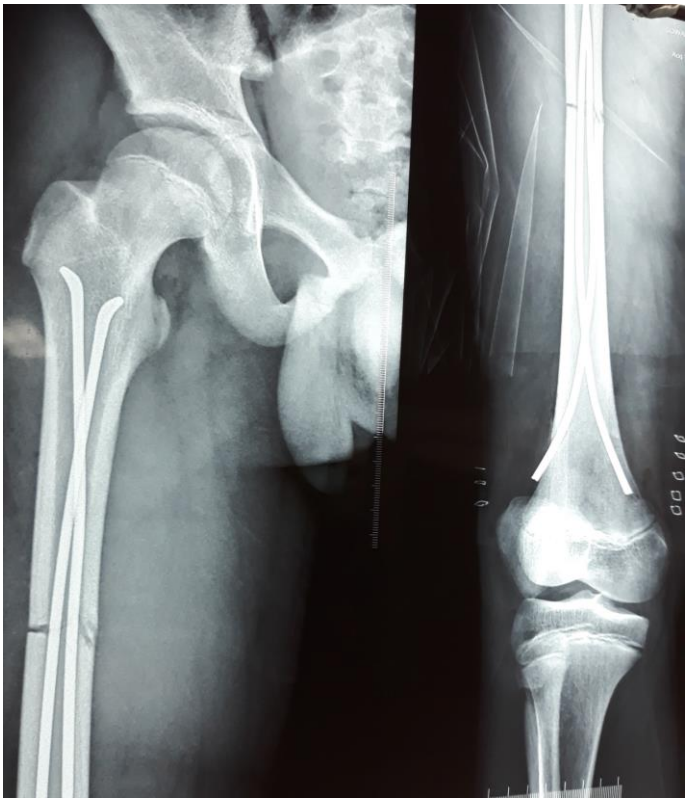

Figure 2- It shows good fracture reduction and proximal and distal extent of the TENS after the surgery

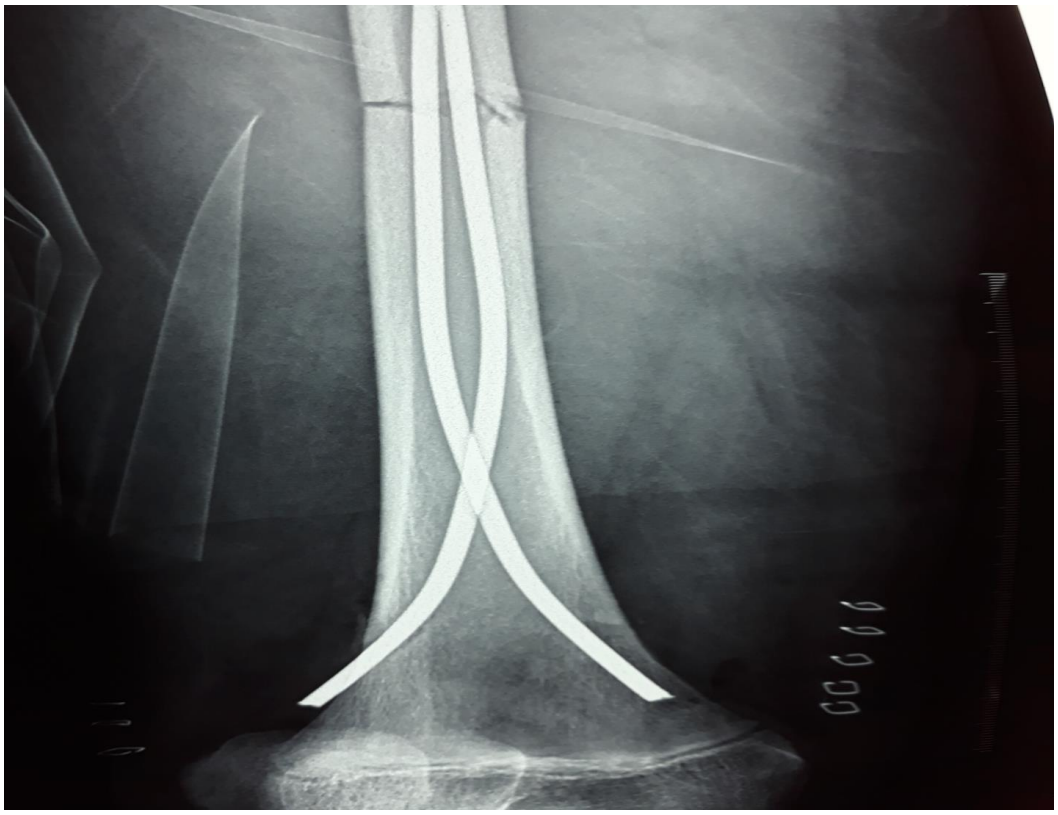

Figure 2- It shows good fracture reduction after surgery

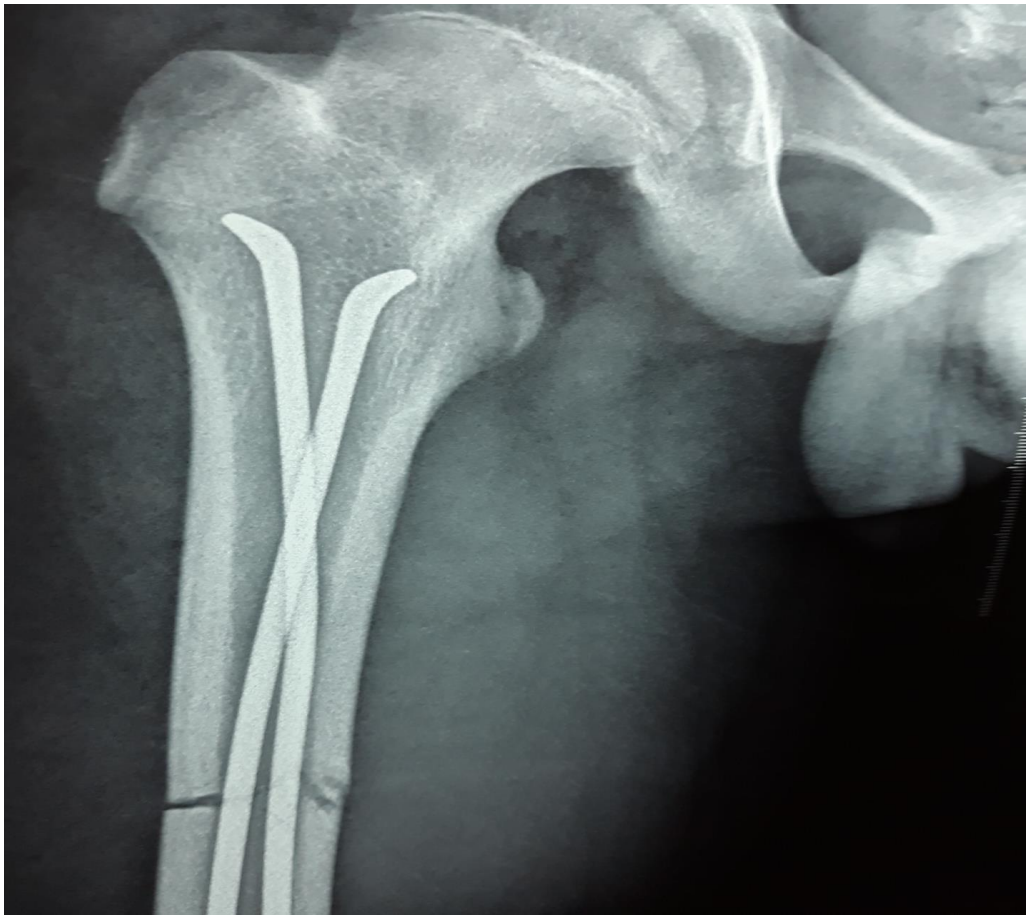

Figure 2- It shows good fracture reduction with proximal extent of TENS

Figure 3- It is showing complete fracture union with callus formation at 4 months follow up

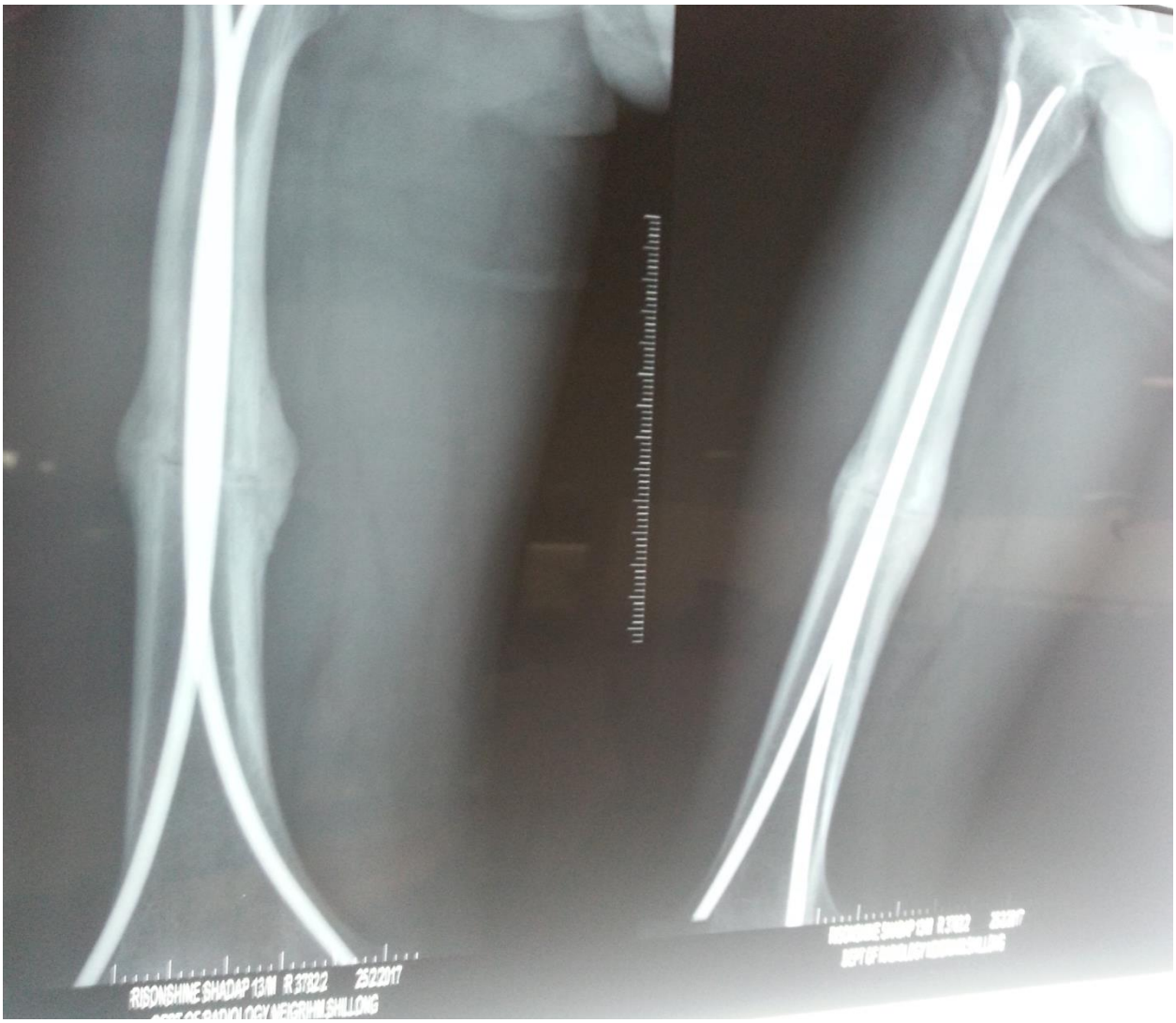

Figure 3- It is showing complete fracture union with callus formation at 4 months follow up