Outcome of Titanium Elastic Nailing in Fracture Shaft of Femur in Children Aged 6-16 Years - A Short Term Study

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ABSTRACT

BACKGROUND: Fracture shaft of femur is one of the most common major pediatric injuries. Management of femoral diaphyseal fractures is controversial in the age group of 6-16 years. We aim to study the short term outcome and complications of such fractures treated operatively with titanium elastic nail system (TENS).

MATERIALS AND METHODS: Thirty six children aged 6 to 16 years with femoral diaphyseal fractures, who were treated with retrograde TENS from July 2011 to December 2014 were included in the study. Closed fractures were classified according to Winquist-Hansen as grade I(n-25), grade II(n-7) and grade III(n-4) and open fractures were classified according to Gustilo-Anderson as grade I(n-2) and grade II(n-1). The final results were evaluated with the help of Flynn's criteria.

RESULTS: The duration of follow-up ranged between 8 months and 18 months. All fractures united with grade 3 callus at durations ranging between 6 and 12 weeks (average 8.5 weeks). According to Flynn's criteria, the results were excellent in 30 (83%) patients and satisfactory in 6 (17%) patients. No patient had a poor result. Per-operative complications were nail bending in 2 and cortical perforation in 2 cases. Limb lengthening was seen in 5 cases (1-1.5 cm). Skin irritation at the entry portal site due to prominent nail was noted in 5 cases.

CONCLUSION: TENS is a safe and effective treatment option for diaphyseal femoral fractures in children between 6-16years.

KEY WORDS: Femoral diaphyseal fracture, pediatric age, titanium elastic nailing.

INTRODUCTION

Fracture shaft of femur is one of the most common major and incapacitating pediatric injuries treated by orthopaedic surgeons. It represents 1 to 2% of all fractures in the pediatric population.[1-3] The commonest causes are falls, and road accidents.[4]

The treatment has traditionally been age-related, influenced by the location and the type of the fracture and associated injuries.[5,6] The treatment for these fractures ranges from immediate closed reduction and hip spica, traction and a plaster cast later on, to surgical stabilization with intramedullary devices, plates and screws, and external fixators.[7-9] There is little disagreement regarding the treatment of younger children (less than 5 years of age) and adults (>16years). For children aged between 5 and 16 years, there is a wide variety of surgical and nonsurgical treatment options available with no clear consensus as to the preferred method of treatment.[10] Compared with younger children, patients in this intermediate age group have a higher risk of shortening, mal-union, and risk of prolonged immobilization.[11] Certain complications like pin tract infections, refracture after implant removal, growth arrest, and avascular necrosis of capital femoral epiphysis associated with surgical methods like external fixation, plates, and intramedullary nails have led to a search for the ideal fixation device for pediatric population.[12,13]

Titanium Elastic Nailing System (TENS) has become a good choice of stabilization in pediatric femoral shaft fractures. The established advantages of this technique include early union, early mobilization, early weight bearing, easy implant removal, small incision, scar acceptance, high patient satisfaction rate and no risk to growth plate or blood supply of femoral head[7,14-16.] Flexible titanium elastic nails can be used in unstable pediatric femoral diaphysis fracture with good long-term results[17].

AIMS AND OBJECTIVES

Aims and objectives of our prospective study was to evaluate the short term outcome and complications of titanium elastic nails for the treatment of stable and unstable pediatric femoral fractures in the 6-16 years age group.

MATERIAL AND METHODS

In this prospective study, thirty six children between 6 to 16 years of age with femoral diaphysis fracture, who were treated with TENS at Nobel Medical College, Biratnagar, from July 2011 to December 2014 were included in our study. The fractures were classified according to Winquist-Hansen and open fractures were classified according to Gustilo-Anderson classification.[18,19] Grossly comminuted (Winquist-Hansen Grade-IV), Gustilo- Anderson Grade-III open fractures, pathological fractures, fractures associated with metabolic bone disease, fractures in non ambulatory children, and in children with neuromuscular disease were excluded from this study. Written informed consent was taken from parents or other family members before inclusion in the study.

We recorded demographics, mode of injury, side, site and type of fracture, associated injuries, time to assisted and unassisted weight bearing, and complications. All procedures were performed on a radiolucent operating table. The standard operating technique is described.

OPERATIVE TECHNIQUE

Under regional/general anesthesia the patient was positioned supine on the fracture table with adduction of the affected limb 10 to15 degrees. Closed reduction of the fractured femur was done. The alignment was confirmed with fluoroscopy in both the A-P and lateral views. Longitudinal skin incision of 2 cm was made 2.5 to 3 cm proximal to distal femoral physis over lateral and medial aspect of thigh and the entry point into bone was made by a bone awl at a 45 degree angle relative to the shaft axis. A pair of titanium elastic nails of equal diameter (nail diameter= 40% of femoral medullary canal diameter) were inserted after proper contouring through the entry points and advanced proximally to fracture site. After closed reduction they were further advanced into the proximal fragment to diverge laterally towards the greater trochanter and medially towards the femoral neck .

Stability of fracture was checked under image intensifier control. Finally the protruding parts of the nails were bent for initial few cases, and cut keeping a small part outside the distal femoral entry point ,but for later cases it was cut without bending . Wounds were closed in layers. In stable fracture, lower limb is kept elevated over a pillow without any external splint. If the fracture was rotationally unstable then a hip spica or high groin cast was applied for 2 to 3 weeks. Sitting up in bed and static quadriceps exercises were started on the first post operative day. Knee mobilization and non-weight bearing and crutch walking was started on 2nd or 3rd post operative day and after plaster removal for those immobilized in plaster.

Patients were followed up at weekly intervals for 4 weeks, 2 weekly for 12 weeks and then once every 6 months. At each visit, limb alignment and rotation, range of motion of hip and knee, condition of wound and skin were recorded. Tenderness at the fracture site and lower extremity length were determined by clinical examination. Progression of union at the fracture site was assessed radiologically using Anthony et al scale for grading callus formation**[Table 1]**[20]. Full weight bearing was allowed once union was confirmed.

At final follow-up, patients were assessed for coronal or sagittal mal-alignment, limb length discrepancy and any implant associated complications. The final results were evaluated using Flynn criteria.[7]

RESULTS

There were 20 boys and 16 girls in this series with an average age of 9.08 (range 6 to16) years at the time of injury. The predominant mode of injury was fall from height (n=18, 50%) followed by road traffic accident (n=10, 28%). Right limb involvement was seen in 26 (72%) whereas left limb was involved in 10 (28%) cases. Fracture site were: 4 in the proximal third, 28 in midshaft, and 4 in the distal third of shaft of femur.

Fractures were classified according to Winquist and Hansen classification: Grade-I (n= 25), Grade-II (n= 7), Grade-III (n= 4). According to the Gustilo and Anderson classification, there were 2 cases of grade-I and 1 case of grade-II open fracture **[Table 2]**.

One patient had associated ipsilateral both bone fracture of forearm and two had associated type I distal physeal injury of radius of left forearm. All cases were operated within 8 (mean 3.6) days of injury. The duration of follow-up ranged between 8 months and 18 months with an average of 16.06 months. The hospital stay ranged between 5 and 14 days (mean 7.5 days). All 33 closed fractures were managed by closed reduction. Open fractures were managed by debridement and primary fixation. In 30 cases (83.3%), no post-operative immobilization was used. 2 (5.55%) cases of Winquist and Hansen grade II with long spiral pattern of fracture were immobilized in a high groin cast, and 4(11%) cases of Winquist and Hansen grade III were immobilized with hip spica for 2 to 3 weeks.

Bridging callus was first noted on follow-up radiographs at an average of 3.5 weeks and partial weight bearing was allowed. All fractures united with grade 3 callus between 6 and 12 weeks (mean 8.5 weeks). Out of 36 cases, 10 cases with an average age of 7 years achieved union in 6 weeks, 22 cases with an average age of 9.27 years healed at 9 weeks and 4 cases with an average age of 13.5years healed at 12 weeks. The time to full weight bearing ranged from 6 to12 weeks. Thirty-two patients achieved full range of motion of knee while 4 cases had terminal restriction of knee flexion (10 – 20 degrees), which improved after nail removal.

Functional outcome of patients was evaluated by Flynn scoring system. The results were excellent in 30 (83%) patients and satisfactory in 6 (17%) patients. No patient had poor results **[Table 3]**. All 25 patients of Winquist-Hansen Grade-I and 5 patients of Grade-II showed excellent results. All four patients of Winquist-Hansen III, two patients of Winquist-Hansen II, and one patient of Gustilo- Anderson Grade-II showed satisfactory results.

There was no case of postoperative neuro-vascular deficit in the operated limb or mortality. Per-operative complications were seen in 4 cases: 2 had nail bending and 2 had cortical perforations of the opposite cortex just proximal to the entry portal. Limb length discrepancy was seen in 5 cases: all showing lengthening. Out of five cases two showed lengthening of 1.5 cm and three showed less than 1 cm lengthening. One case had nail bending 4weeks after surgery following a fall and was treated with repeat TENS nailing. Two cases had varus angulation of 5 degrees. Out-toeing of 5 degree was seen in one case. There were no cases of valgus, procurvatum, and recurvatum malalignment. There was no implant failure, refracture, superficial or deep infection in this series. Skin irritation at the entry portal site due to prominent nail was noted in those 5 cases in which nail ends were bent, resulting in limitation of terminal movement of knee joint in four cases which improved after nail removal. The pre injury level of activity was restored in all cases after an average of 7 months (range 5 to 8 months). The nails were removed after an average of 23 weeks (range 20 to 32 weeks).

Fig. 1-(a) Eight year boy presented with fracture shaft of femur,

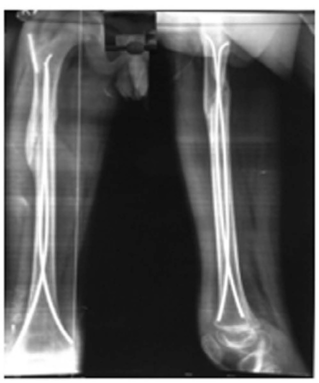

Fig. 1-(b) fracture healed with grade 3 callus

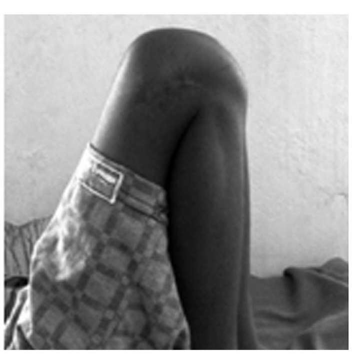

Fig. 1-(c) knee ROM at final follow-up.

Fig. 2 (a) Sixteen year boy presented with fracture shaft of femur

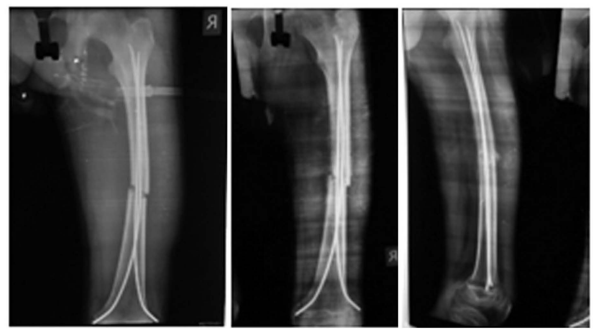

Fig. 2 (b) immediate post-op x-ray,(c,d) x- ray after 8 weeks of operation.

DISCUSSION

Femoral diaphysis fractures occur frequently in children, but controversy still exists regarding the ideal treatment. In the past, conservative treatment was the preferred method for the treatment of diaphyseal fractures in children and young adolescents. However, to avoid the effects of prolonged immobilization, to reduce the loss of school days and for better nursing care, the operative approach has been gaining popularity. Recent studies have also increased awareness of the psychological and economic effects of spica casting on children and their families[21]

A variety of therapeutic alternatives such as external fixators, compression plating, rigid intramedullary nailing and flexible intramedullary nailing are being used for femoral shaft fractures in children.[22] External fixator provides good stability and early mobilization but it associated with the risk of pin tract infection and takes a longer time for weight bearing.[23,24] Plate osteosynthesis is associated with extensive soft tissue dissection, greater blood loss, relatively longer duration of immobilization, risks of infection and hardware failure.[27] Solid intramedullary nail is ideal for skeletally mature children but when attempted in skeletally immature patients it is associated with avascular necrosis of the femoral head, thinning of femoral neck and growth arrest of greater trochanter with secondary coxa valga deformity.[15,25,26]

Internal fixation by elastic intramedullary nail has been gaining popularity and it is gradually replacing the conservative treatment and other forms of internal fixation methods between the age groups of 5-16 years. Titanium elastic nailing system (TENS) is a form of flexible intramedullary nail which acts as an "internal splint" that shares loads, maintains length and alignment while permitting enough fracture site motion for callus formation. Results from several studies have shown that it allows rapid mobilization, potentially no risk for osteonecrosis, low risk for physeal injury and reduced risk of refracture.

Ligier et al 28 reported outcomes of 118 children (123 fractures) with femoral diaphyseal fractures of age between 5 to 16years treated with TENS. They found only 1 case of deep wound infection and 13 cases of skin ulceration or local inflammatory reaction due to nail protrusion. They did not report any case with disability and gait abnormalities over a 1 year follow up period.

Flynn and colleagues[8] reported outcomes for 48 children (mean age 10.2 years; range 6-16 years) with 49 fractures treated with TENS. They found no angulation, mal-alignment or LLD more than 1 cm but reported 8 cases of nail-tip irritation near the insertion site (2 led to wound breakdown and early hardware removal), 1 refracture caused by premature (6.5-week) nail removal, and 1 case of nail bending after a fall (corrected by closed reduction, which led to delayed union and was treated with external fixation).

Narayanan et al[16] analyzed their first 5-year experience in 78 children with 79 femoral fractures treated by TENS. Complications included pain/ irritation at the insertion site (41), radiographic malunion (8), refracture (2), transient neurologic deficit (2) and superficial wound infection (2). Ten patients required re-operation prior to union. Malunion and/or loss of reduction requiring reoperation was strongly associated with the use of nails of mismatched diameters (odds ratio = 19.4) and comminution of more than 25% (odds ratio =5.5). Pain at the insertion site was significantly associated with bent or prominent nail ends. Most complications are minor, and many are preventable. They also observed that comminuted fractures that compromised more than 25% of the femoral diaphysis presented higher rates of pseudarthrosis or delayed union, thus suggesting that the stability should be increased using external fixation.

Several studies have shown that overgrowth may occur after a femoral diaphysis fracture during childhood, and that this may create a discrepancy in the lower limbs that persists until adolescence and young adulthood.[4,29] Reynolds suggested that overgrowth occurred because of the increased vascularization needed for consolidation, and not through a compensatory mechanism.[30] It has been suggested that cerebral dominance may have a role in this: one study did not present significant shortening and most of the patients were affected on the right side.[4] It is unnecessary for the lower limbs to be of precisely equal size, given that at the time of skeletal maturity 40-70% of the normal population presents discrepancies. This is greater than 2 cm in 0.1% of the population.[4]

Luhmann et al[31] concluded that fixation of femoral fractures in overweight patients and use of flexible intramedullary nails of smaller diameter were associated with greater sagittal angles, and that the coronal angle was correlated with the size of the nail and technical failure.

Rathjen et al[17] reported that the complications in cases of unstable fractures of the femoral diaphysis in children treated using flexible femoral nails in their study were similar to the complications in cases of stable fractures.

Our results are comparable with other studies in terms of union rate, no implant failure or refracture after nail removal. The most common complication is pain and irritation at the entry site which is minor and can be decreased by advancing the nail ends at the level of supracondylar flare of femur. In our study, pain and entry site irritation was noticed in those 5 cases in which nail ends were bent. Other complications were limb lengthening of 1 to 1.5 cm in 5 cases and malalignment of 5 to 10 degree in 3 cases which were left as it is because it will correct by remodelling. Most patients in our study had excellent result according to Flynn scoring system and no patient had a poor result.

CONCLUSION

The titanium elastic nail is an effective and viable treatment option for femoral shaft fractures in the 6-16 years age group. Although our sample size is small, we conclude that TENS can be used for both stable and unstable such fractures excluding Winquist-Hansen grade IV pediatric femoral diaphysis fracture. The minor complications encountered in our series could have been easily avoided by not bending the external ends of the nail.

CONFLICT OF INTEREST: Nil

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TABLES

Table 1. Anthony et al scale for grading of callus formation

Grade 0	No identifiable fracture healing
Grade 1	Primary bone healing with no or little 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 femur

Table 2. Summary of fracture characteristics(n=36)

Fracture location N=36	Pattern N=36	Winquist-Hansen grade N=36	Gustilo-Anderson grade N=3
Proximal(4)	Transverse(14)	I(25)	I (2)
Midshaft (28)	Oblique (10)	II(7)	II(1)
Distal (4)	Spiral (9) Comminuted (3)	III(4	III(0)

Table 3. Flynn's classification method and outcome scoring			
	Excellent	Satisfactory	Poor
Leg length in-equality	<1cm	<2cm	>2cm
Malalignment	5 degree	10 degree	>10 degree
Pain	None	None	Present
Complications	None	Minor and resolved	Major and/or lasting mor-bidity
Patient result			
N= 36(%)	30(83%)	6(17%)	0

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