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Original Article

The Outcome of Pediatric Femur Fractures Fixation with Titanium Elastic Nail System

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ABSTRACT

Introduction: Pediatric femur fractures are commonly present because of high-velocity injuries in children. It is the most common reason for pediatric hospital admission due to trauma. There is a spectrum of choices for fixation for these fractures, but the best method has always been debated. In this study, we share our experience of fixation of pediatric diaphyseal femur fractures at our center using Titanium Elastic Nail System.

Method: A hospital-based prospective study was conducted between January 2019 to June 2022. Patients aged between 5 to 12 years with shaft of femur fracture and body weight of less than 49 kg were included in the study. Children with pathological fractures, ipsilateral limb injuries, metabolic bone disease, and neuromuscular disorders were excluded. All patients were followed up till nine months with radiographic and clinical assessment.

Result: A total of 47 children were included in this study. The mean age was 8.08±2.17 years, and the mean weight was 26.55±6.46 kg. Postoperatively the mean union time was 11.36 weeks, whereas the mean time for full weight bearing was 9.70 weeks. Two (4.25 %) patients had transient superficial wound infection. Four (8.51%) patients had skin irritation due to nail tips, and five (10.63%) patients had more than 1cm of limb length discrepancy. Limb malalignment >10 degrees was noted in two (4.25%). At the end of nine months, 70.21% reported excellent, 25.53% satisfactory, and 4.25% poor outcomes as per Flynn's criteria.

Conclusion: Titanium Elastic Nailing System is a minimally invasive pediatric femur fracture fixation method with relatively few associated complications and predictable favorable outcomes.

Keywords: Diaphyseal, Pediatric femur fracture, Titanium Elastic Nailing System

INTRODUCTION

Femoral diaphyseal fractures are common injuries among the pediatric population, representing 1.6-2% of all bony injuries in children.[1,2] Most femoral shaft fractures result from simple falls to high-velocity injuries. Treatment options vary depending on age, degree of comminution, and open or closed fracture type. [3]

Early closed reductions and spica cast application are the mainstays of treatment in children below five whereas, antegrade nailing has become the standard treatment in children near skeletal maturity.[4,5] Variety of treatment methods exists for femoral fracture management from the age above five till near skeletal maturity. However, the optimum one is still controversial.[5,6]

Non-surgical management of femoral shaft fractures in these age groups is frequently accompanied by loss of reduction, mal-union, and psychological intolerance.[7] Although the fracture can be managed with plate osteosynthesis, it is associated with larger exposure, increased blood loss, scarring, and infections.[8]

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TENS is now increasingly used at various centers as it is argued to be simple, effective, and minimally invasive. It preserves physis, confers stable fixation, and provides rotation stability. [9] Moreover, preservation of hematoma and micro-motion enhance early healing and return to normal activity.[7, 10, 11]

Although similar studies are available in the literature, most of them belong to Western population where the difference in outcome might be affected by body habitus, more standardized implants and instruments, and the level of involvement of children in outdoor activities. So, we aim to study the outcome of TENS in our population where differences may lie in the parameters mentioned above.

METHODS

In this hospital-based prospective study, 47 patients with diaphyseal femur fractures were treated with titanium elastic nails at a tertiary hospital from January 2019 to June 2022. Children with femoral shaft fractures between 5 to 12 years whose body weight was less than 49 kg were included in the study; in contrast, children with pathological fractures, ipsilateral limb injury, metabolic bone disease, and neuromuscular disorder were excluded.

After all pre-op preparation and clearance, written consent was taken. The patient was supine on the radiolucent table,

and general anesthesia was given. The operative extremity was painted and draped. The entry site was marked under fluoroscopy guidance at 2-3 cm proximal to distal femoral physis. Two titanium elastic nails of the same size that is 40 % of the isthmus of the femur (Flynn et al. formula), as determined preoperatively and confirmed intraoperatively, were introduced in a retrograde manner after reducing the fracture.[12] The nails were inserted in a double C construct with their tips fixed to the cancellous bone of the proximal femur without breaching the epiphyseal plate. Attempt was made to get the maximum nail curvature at the fracture site. Nails were cut, leaving 1.5- 2 cm of the nail outside the cortex for removal of nails after the union of the fracture. The distal end of the nails was not bent and was made to lie flush with the metaphyseal flare of the distal femur.

Postoperatively, isometric quadriceps exercise was started from day one. Range of motion and mobilization by non-weight bearing with a walker or crutches was commenced as soon as the patient became pain-free. A slab or knee immobilizer, if present, was removed after four weeks. Partial weight bearing was started at four weeks. Complete weight bearing was allowed after the bony union (union of 3 out of 4 cortices). All patients were followed at two weeks (suture removal), four weeks (slab removal), then every fortnightly to assess for radiological and clinical evaluation (progress of union, pain, and complications) till the fracture united. At nine months, follow-up patients were evaluated clinico-radiologically. Relevant demographic data, union time, complications encountered, and outcomes in terms of Flynn's et al. criteria were recorded.[12] Nails were advised to be removed after nine months post-surgery to avoid re-fracture. However, earlier removal was considered for children presenting with hardware irritation.

Microsoft Excel and SPSS version 20.0 (SPSS Inc., Chicago, IL, USA) were used for data collection and analysis. Results on continuous measurements were presented as mean with standard deviation, whereas categorical data were expressed as numbers (%).

RESULTS

In our study, 78.2% of cases were boys. The male-to-female ratio was 3.7:1. Among them, 42.55 % of patients were in the age group 5-7 years, 40.42 % were in the age group 8-10 years, and 17.02 % were above ten years of age. The mean age of patients was 8.08 ±2.17 years, and the mean weight was 26.55±6.46 kg.

In our study, RTA was the most common mechanism of injury, consisting of 82.97 % of cases, whereas fall from height was noted in 17.02 % of cases. Among them, 63.82 % of patients had fractures of the right femur, whereas 36.17 % had left femur fractures. Transverse, oblique, spiral and comminuted fractures were observed in 38.29%, 34.04%, 19.14 %, and 8.5% of patients, respectively. The study revealed that 57.45 % of patients had middle 3rd femur fracture, 23.40 % had proximal 3rd, whereas 19.15% had distal 3rd femur fracture.

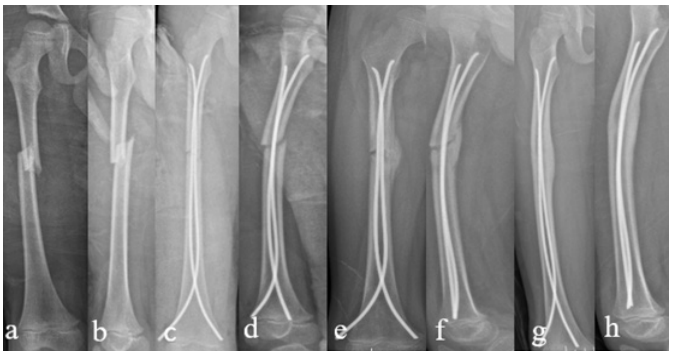
Of 47 cases, 42 (89.36%) underwent closed reduction and Titanium Elastic Nailing System (TENS) fixation. However, 5 (10.63 %) required open reduction due to the failure of closed reduction.

Postoperatively, the mean union time was 11.36±1.62 weeks, whereas the mean time for full weight bearing was 9.70 ±1.56 weeks.

Two (4.25 %) cases of superficial wound infection were treated with dressings and oral antibiotics. Four (8.51%) patients had skin irritation due to nail tips and were reluctant in knee mobilization leading to stiffness. Early removal of nails and physiotherapy resolved the issue.

In our study, five (10.63%) patients had clinical limb length discrepancy of more than one cm. Two cases with fracture comminution suffered a shortening of more than one cm, whereas three patients suffered limb lengthening of more than one cm. Limb malalignment of more than five degrees was noted in 12(25.53%) cases, among which two (4.25%) patients had more than 10 degrees of malalignment. One had varus, and the other had valgus malalignment. Both had comminuted fractures of the femoral shaft.

In our study, 70.21% of patients had excellent, 25.53% had satisfactory, and 4.25% had poor outcomes, as per Flynn's et al. criteria. Poor results were only found among the patients sustaining comminuted femoral fractures. Two out of four, i.e., 50% of comminuted femoral fracture patients, had poor outcomes



Figures a and b show pre-op x-ray; Figures c and d show immediate post-op x-ray; Figures e and f show x-ray at eight weeks; and Figures g and h show x-ray at 12 weeks.

DISCUSSION

Orthopedic surgeons have tried various methods to treat pediatric femur diaphyseal fractures to avoid prolonged immobilization, loss of fracture reduction, malalignment, limb length discrepancy, psychological complications, loss of school days, and better nursing care.[13,14] Multiple treatment modalities are available, and controversy persists over which method is superior to another in each situation. However, the ideal device to treat pediatric fractures should be a simple, load-sharing internal splint that allows early mobilization while maintaining length and alignment until bridging callus forms and does not endanger the physis or blood supply to the femoral head leading to osteonecrosis. [12]

Though it is reported that pediatric femoral shaft fractures are common in males with approximately a 2.5:1 male-to-female ratio.[15] However, in the present study, boys outnumbered girls

by 78.72. % (37 cases) vs. 21.27% (10 cases) with boy to girl ratio of 3.7:1. This could be explained by the fact that in our part of the world, boys are more involved in outdoor activities than girls and hence are more likely to have road traffic accidents.

In this study, the mean±SD age of patients was 8.08±2.16 years, and the range was 5-12 years as per inclusion criteria. The mean age of the present study was slightly lower than that of Ligier et al. (mean±SD: 10± 0.16 years, range 5 to 16 years) and Flynn et al. (mean: 9.5 years).[12, 16]

In the present study, the mean weight of the patient was 26.55±6.46 kg and ranged from 16 to 40 kg, which is less than in Khazzam et al.[17,] who reported a mean weight of 36.78 kilograms as patients up to 17 years of age were included in his study.

In the present study, road traffic accident was the mode of injury in most children (82.97%, 39 cases), while the remaining 17.02% (eight cases) had fall injury. Thapa et al. also reported that road traffic accident was the primary cause of femoral shaft fractures in his study.[18] Road shares the common place for working, playing, cycling, and driving in low-income countries, and hence the incidence of road traffic injuries is relatively high.[19]

In this study, most patients presented with a transverse and oblique fracture pattern, i.e., 38.29 % and 34.04 %, respectively, while spiral and comminuted patterns were noted in 19.14% and 8.5 % of the children, respectively. In the study by Ligier et al., 38.21% were transverse, 17.88% were oblique, 15.4% were spiral, and 25.2% were the comminuted type of femoral shaft fractures, similar to our findings.[16]

Most patients (57.45%) had a middle-third femur shaft fracture. 23.40% of the patients had an upper-third femur fracture, and 19.15% had a lower-third femur fracture. Lohiya et al. reported 69.86% middle third, 23.28% proximal third, and 6.84% distal third femoral shaft fracture.[20] In this study, 10.63% of the cases underwent TENS fixation via open reduction and 89.36 % via close reduction. An Indian study by Bhuyan et al. reported a 10% open reduction and a 90% closed reduction, similar to ours.[21]

Our study's mean±SD fracture union time was 11.36±1.62 weeks (range 8-16 weeks). This result was similar to Oh et al.[,] who reported a mean union time of 10.5 weeks.[22] Another study by Suggu et al. showed 12 weeks of median union time.[23] In our cases, the mean±SD time of full weight bearing was 9.70±1.55 weeks. Flynn et al. and Uçar et al. observed walking with complete weight-bearing at an average of 8.5 and 9.5 weeks, respectively, in patients operated with TENS.[14, 24]

In our study, five (10.63%) patients had more than one cm of limb length discrepancy at the final follow-up. Two (4.25 %) cases with fracture comminution suffered a shortening of more than one cm, whereas three (6.38 %) suffered limb lengthening of more than one cm. We do not use an end cap that might prevent collapse and shortening in case of comminuted fracture. A similar complication was seen in the study by Ligier et al. (11.2%, seven out of 62 cases).[16] However, longer follow-up will be needed to determine the incidence of permanent, clinically significant leg-length discrepancy.

In our study, more than five degrees of limb malalignment was noted in 12(25.53%) cases, among which two (4.25%) patients had more than 10 degrees. One had varus, and the other had valgus malalignment. Both had comminuted femoral shaft fractures, which could have been avoided with adequate plaster stabilization or traction, a brief period of bed rest, or a femoral brace.

TENS does not disturb the fracture hematoma as a closed procedure, so the chance of infection is significantly less. Only two cases of superficial wound infection were noted, as this procedure is minimally invasive. Similarly, Saseendar et al. reported no incidence of infection, superficial or deep.[25]

Skin irritation due to nail ends was encountered in this series in four (8.51%) cases. Ligier et al. observed 13 (10.56%) skin ulceration or local inflammatory reaction due to nail protrusion among 123 patients.[16] Outward bending of the nail to facilitate retrieval has been recommended for many years. However, this can cause anything from irritation to skin necrosis and infection and should be avoided.[26] In our study, all nails were cut, leaving 1.5- 2 cm of the nail outside the cortex. The distal end of the nails was not bent and made to lie flush with the metaphyseal flare of the distal femur as recommended by Narayanan et al.[27] Knee stiffness was seen in four (8.51%) of our cases. It was due to nail irritation, so the patients were reluctant to move the knee. It subsided after the removal of the nail.

In our study, 70.21% of patients had excellent, 25.53% had satisfactory, and 4.25% had poor outcomes, as per Flynn's et al. criteria. Flynn et al. reported excellent results in 65% of the children, while satisfactory and unsatisfactory results were in 25% and 10%.[12] Another study in Nepal by Mishra et al. reported excellent results in 80 % and good results in the remaining 20% with no poor results.[28] Fracture geometry and location are essential determinants for surgical outcomes. In our study, TENS gave excellent results in transverse and short oblique fractures. In contrast, it had many poor results (two out of four cases) while treating comminuted fractures. Transverse, short oblique, and minimally comminuted fractures are suitable for TENS, as stated by Narayanan et al. and Flynn et al..[27,29]

Titanium elastic nail seems advantageous over other surgical methods, particularly in this age group, because it is a simple load-sharing internal splint that does not violate open physis, allows early mobilization, and maintains alignment. 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 the fracture hematoma, thereby having less risk of infection.[28, 30]

CONCLUSION

Titanium elastic nailing is minimally invasive, provides optimum fracture stability, and promotes early fracture healing with good functional outcomes. There are a few insignificant associated complications. We thus recommend this practical and viable option to treat femoral shaft fracture in the pediatric population.

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