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Flexible intramedullary nailing for femoral diaphyseal fractures in children

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ABSTRACT

Background & Objectives: Although various treatment options are available for the treatment of femoral diaphyesal fractures in children, the titanium flexible nailing has gained popularity because it is safe, easy procedure with rapid recovery and high success rate. The aim of this study was to evaluate the outcome of titanium elastic nails in treating paediatric femoral diaphyesal fractures at Patan Hospital. **Materials & Methods:** There were 35 cases which were all fixed with titanium flexible intramedullary nail under image intensifier at the Patan hospital from January 2013 and December 2015. Patients were evaluated in follow-ups to observe the alignment of fracture, infection, delayed union, nonunion, limb length discrepancy, implant failure, range of movement of hip and knee joints, and time to unite the fracture. The final results were evaluated using criteria of titanium elastic nail (TEN) outcome score described by Flynn et al. **Results:** The mean age of the patients was 8.51 years. Among 35 patients (22 boys and 13 girls), there were 19 mid-shaft fractures, nine proximal third fractures and seven distal third fractures. Fracture patterns were transverse (22), oblique (10), spiral (2), and comminuted (2). The mean time for fracture union was 8.17 weeks radiologically whereas 9.83 weeks clinically. According to TEN outcome score, excellent and good results were in 28 cases (80%) and seven cases (20%) respectively. **Conclusion:** Flexible titanium nailing is a safe and satisfactory treatment for diaphyseal femoral fractures in children, because it provides rapid recovery, short rehabilitation and immobilization as well as very high union rate with few complications.

Key words: Femoral diaphyesal fracture; flexible intramedullary nail

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INTRODUCTION

An ideal treatment for femoral diaphyseal fractures in children is the one that controls the length and alignment, comfortable for the patient and convenient for the family. Treatment ranges from nonsurgical methods (e.g., closed reduction with spica casting or traction followed by casting) to surgical stabilization (using intramedullary devices, external fixation, or internal fixation with plate and screws).[1-6] Casting with or without traction is still the preferred treatment for isolated femur fractures in children of preschool age.[7] Over the past few decades, pediatric orthopedists has increasingly recognized the advantages of operative fixation and rapid mobilization.[1] However, the risks of certain complications like pin-tract infection and re-fracture after external fixation, or avascular necrosis after solid antegrade IM nailing, have prevented these methods from becoming adopted as the best treatment.

The Titanium elastic nailing system (TENS) has gained popularity as the choice of fixation in paediatric femoral shaft fracture as they allow early mobilization and good functional outcome.[1,2,7-9] The flexible intramedullary nail functions as an internal splint that at least theoretically holds length and alignment while permitting enough fracture-site motion for callus formation. In this study, we evaluated the outcomes of titanium elastic nails in treating paediatric femoral diaphyseal fractures at Patan Hospital.

MATERIALS AND METHODS

This study included 35 children (22 boys and 13 girls) admitted at the Patan hospital from January 2013 and December 2015. Accent from the children was also taken along with the consent from the parents. The study was authorized by the institutional review committee. All the patients between five and twelve years with closed diaphyseal femoral fractures were enrolled into the study. Their mean age was 8.51 years. The mechanisms of injury were road traffic accidents, falls from a height and sports injuries. Exclusion criteria were open fracture, closed fracture with additional injuries, underlying neuromuscular disease, metabolic bone disorder, or pathological fracture. All the fractures were fixed with titanium elastic nails (TENs).

Operative technique:

The procedure was performed under general anesthesia with the patients in a supine position, without the use of a fracture table. Prophylaxis antibiotics were given to all the patients according to their bodyweight. All nails were inserted in a retrograde fashion. Two nails of the same diameter were used. The diameter of the nail was approximately 40% of the narrowest diameter of the diaphysis. The limb was prepared and draped to give access to the entire femur and knee joint and to permit manual manipulation of the thigh. The image intensifier was placed to get antero-posterior and lateral view of the femoral shaft. A one to two cm longitudinal incision was made over the medial and lateral surfaces of the distal femur, starting two to 3 cm proximal to the distal femoral epiphyseal plate. The soft tissue was split down to the bone with a hemostat. The medial and lateral entry points were created with the help of awl, which was directed towards the diaphysis to facilitate the nail insertion. Appropriate sized two nails (2 to 4mm diameter), one lateral and one medial, were inserted via the entry points with the help of T-handle. The nails were carefully pushed up the medullary canal while the fracture was reduced by closed manipulation. If closed reduction had failed, a mini-open reduction was performed, through approximately 2 to 3 cm long lateral incision, centered on the fracture line, after blunt dissection with a finger. Image intensifier was used again to confirm the nail insertion to the proximal fragment. Distally, the nails were cut so that one cm remained outside of the cortex for easy removal later. Wound washed with normal saline and closed in a regular fashion. All patients were immobilized in an above knee posterior slab. Post-operative check X-rays were done on the next day of the surgery. Non-weight bearing crutch walking was started on the first or second post-operative days as permitted by the post-operative pain. Patients were discharged on the fourth post-operative days.

Sutures were removed on the 14th post-operative day. Slab was also removed on the same day with exception among the spiral and comminuted fractures. Those fractures were immobilized for few more weeks depending on the appearance of satisfactory callus on the follow up radiographs because of fear of malalignment. Then all the patients were sent to the physiotherapy department for quadriceps strengthening exercise and range of movement of knee and hip joints. All the patients were followed up at 6th, 12th and 24th weeks. At follow ups, the patients were examined clinically as well as radiologically. Weight bearing with a pair of crutches increased when early callus formation was seen on follow up radiographs. Crutches discontinued when radiographic and clinical healing was complete. The criteria for radiographic union was appearance of bridging callus on three of four cortices on two radiological views and clinical union was painless at fracture site on movement and full weight bearing without support. Malalignment was measured by goniometer on plain radiographs. Limb length discrepancy was assessed by measuring both limbs from anterior superior iliac spine to medial malleolus in supine position. Any difference of length in the fractured limb as compared to the normal one was taken as limb length discrepancy. Major postoperative complications were defined as nonunion, delayed union, anterior/posterior angulations of more than 20°, varus/valgus angulations of more than 10° (malalignment criteria based on previous studies[1,4,9]), infection, refracture, nail irritation requiring hardware removal, and nail breakage. Minor postoperative complications were defined as nail irritation that resolved without intervention, asymptomatic nail migration, and any perioperative problem that resolved without surgical intervention or early hardware removal. The final results were evaluated using criteria of titanium elastic nail (TEN) outcome score described by Flynn et al.[1] The patients were followed up with a mean period of 10.46 months (range: nine to 12 months), followed by removal of the implants.

RESULTS

All 35 children were available till final follow up. Twenty two (62.9%) patients were boys and 13 (37.1%) were girls. Twenty one children (60%) had fracture due to fall from the height, eight (22.9%) had road traffic accidents and six (17.1%) had sports injuries as the mechanisms of the injury. Twenty five (71.4%) femoral fractures occurred on the right side whereas ten (28.6%) on the left side. Nineteen fractures (54.3%) occurred on the middle third, nine (25.7%) on the proximal third and seven (20%) on the distal third of the femur. Twenty two fractures (60%) are of transverse, ten (28.6%) were oblique, two (5.7%) were spiral and two (5.7%) were comminuted types. Twenty seven (77.1%) fractures were operated with closed reduction whereas eight (22.9%) fractures required mini-open at the fracture site.

The mean time delay in surgery from the day of injury was 2.34 days (range: 1 to 6 days). The mean duration of hospital stay after surgery was 2.46 days (range: two to four days). All fractures united radiologically with a mean duration of 8.17 weeks (range: six to 10 weeks) and clinically with a mean duration of 9.83 weeks (range: eight to 12 weeks).

We had six malunion cases among all 35 patients. Out of these, varus malalignment of eight and 10 degrees occurred in two patients (5.7%), valgus malalignment of five degrees occurred in one patient (2.9%) and anterior angulation of five, five and 10 degrees occurred in three patients (8.6%). Limb lengthening occurred in three patients (8.6%) with less than one cm. At follow-up, all patients had unrestricted movement of the hip and knee joints. However, five children had minor complications of implant prominence leading to the bursa formation around the tip of the nails, which did not become infected and resolved after early removal (within four to five months of surgery) of the implants. No children had infection, delayed union, non-union and implant failure. All the results were clinically evaluated using TEN outcome score described by Flynn et al.[1] (table 1.)

DISCUSSION

The ideal device to treat diaphyseal femur fractures in children would be a simple, load-sharing internal splint allowing mobilization and maintenance of alignment for a few weeks until bridging callus forms without risking to the physes or blood supply to the femoral head. TENs is one of the devices which offer these features.[1] The micromotion conferred by the elasticity of the fixation promotes faster external bridging callus formation. The elasticity of titanium is also reported to reduce the amount of nail deformation during insertion, and to promote callus formation by limiting stress shielding.[1,2,9]

For more than three decades, French surgeons[9-11] have used titanium elastic nails to achieve stable intramedullary fixation. Ligier et al.[9] reported excellent results, with no major angular or rotational malunions, after treatment of 123 fractures with titanium elastic nails. An initial multicenter study by Flynn et al.[1] showed excellent or satisfactory results in fifty-seven of fifty-eight cases treated with such nails.

In the present study, we evaluated the outcomes of titanium flexible nailing for pediatric femoral shaft fractures at Patan hospital. In our series, all fractures united radiologically within six to 10 weeks with a mean period of 8.17 weeks. All the patients could able to bear full weight without pain and support at a mean duration of 9.83 weeks with a range of eight to 12 weeks.

Table 1. TEN outcome scoring by Flynn et al.[1]

Parameter	Excellent result	Satisfactory result	Poor result
Limb length inequality	< 1 cm	< 2 cm	> 2 cm
Malalignment	Upto 5 degree	5 to 10 degrees	> 10 degrees
Pain	None	None	Present
Complication	None	Minor and resolved	Major complications and/or lasting morbidity
Our study (n=35)	28 (80%)	7 (20%)	0

Flynn et al.[1] evaluated 58 patients with femoral fracture shafts fixed with titanium elastic nails found that all fractures healed within an average of 8.5 weeks (range, two to 12 weeks) and the patients walked without assistive devices. Callus was first noted on follow-up radiographs at an average of four weeks. Fracture healing in children is fast and age-dependent. In children below five years, fracture usually heals between four and six weeks. In children between five and ten years, fracture unites in eight to 10 weeks whereas in adolescence, the healing process is longer and takes 10 to 15 weeks.[12]

It is true that the intramedullary flexible nail could not effectively control the rotation and tranlation of the fragments, particularly in cases of spiral and comminuted fractures. We had two (5.7%) spiral fractures as well as two (5.7%) comminuted fractures. In these cases, we prolonged the duration of posterior slab until fracture becomes stable. Though it may not always hold the fractured bone according to three point fixation; fracture heals without undue complications. However, we had six cases of malunion. Three patients (8.6%) aged nine, 11 and 12 years had anterior angulations of five, five and 10 degrees respectively; two patients (5.7%) aged seven and eight years had varus malalignment of eight and 10 degrees respectively whereas only one patient (2.9%) of aged nine years had valgus malalignment of five degrees. All these malalignments were within acceptable ranges for their age groups. The acceptable range of angulations according to the age group was varus/ valgus angulations up to 10 degrees and anterior/ posterior angulations up to 15 degrees for six to 10 years. Similarly, varus/valgus angulations up to five degrees and anterior/posterior angulations up to 10 degrees were acceptable for 11 years to the maturity.[13] Wallace and Hoffman[14] had shown that the femoral shaft fractures angulated 10 to 18 degrees in children less than 13 years corrected spontaneously in 85% of cases. We had only three cases (8.6%) of limb lengthening in our series, all of them had less than 1 cm of lengthening. Flynn et al.[1] also reported six cases of leg length inequality of 1 to 2 cm among their 58 fractures. Another study among 112 patients by P Singh, R Kumar[15] reported eight cases of limb length inequality. Among those eight cases, six had less than 1 cm and two had 1 to 2 cm of limb length inequality. Mazda et al.[16] also showed 1 to 1.5 cm lengthening among three of their 34 patients. The fractured femur may be initially short from overriding of the fragments at union; growth acceleration occurs to make up the difference, but often this acceleration continues and the injured leg ends up being longer. The potential for growth stimulation from femoral fractures has long been recognized, but the exact cause of this phenomenon is still unknown.[13] All patients had normal range of movements at hip and knee joints at final follow up. No one had developed infection, delayed union, non-union or implant breakage. In our case series, five children had minor complications of implant prominence leading to the bursa formation around the tip of the nails, which did not become infected and resolved after early removal (within four to five months of surgery) of the implants. A similar complication was mentioned by the different authors in their case series.[1,4,9,13,15,16]

According to TEN outcome score described by Flynn et al.[1], we had 28 cases (80%) and seven cases (20%) with excellent and satisfactory results respectively. An initial multicenter study showed excellent or satisfactory results in fifty-seven of fifty-eight cases treated with such nails.[1] Another study[8] among 138 patients showed excellent result in 115 patients, satisfactory result in 14 patients whereas only nine patients had poor results. They compared between the Ender nail with TEN. Of the 72 Ender nail group results, 57 were excellent, nine satisfactory, and six poor; of the 66 TEN group results, 58 were excellent, five satisfactory, and three poor. Similarly another study reported excellent results in 33 of 43 patients (77%) and to satisfactory results in the other 10 patients (23%), regardless of whether the fractures were treated by closed or open reductions.[17]

This study had some limitations. First, because this was a single-center study, the results should be generalized with caution. Other surgeons may find different results or complication rates. Second, we had few sample size, so further studies with large sample size and comparison with other modalities of the treatment is required for further supporting our findings.

CONCLUSION

Flexible intramedullary titanium nailing is a safe and satisfactory modality of treatment and is relatively easy to perform in diaphyseal femoral fractures in children. It can provide a rapid recovery, short rehabilitation and immobilization as well as very high union rate with few complications.

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