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## Outcome of Titanium Elastic Nailing in the Surgical Management of Femoral-Shaft Fracture in Children

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### ABSTRACT

**Introduction:** Femoral shaft fracture is one of the most common orthopedic injuries of the children. These fractures treated non-operatively by traction followed by hip spica require prolonged hospitalization causing undue physical and psychological stress for patient and patient family. Loss of reduction is also commonly seen with hip spica that leads to unacceptable complications like angular deformities and limb length discrepancies. Titanium Elastic Nailing (TEN) is becoming widely accepted treatment for femoral shaft fractures in children due to its simplicity and physeal protective stable load sharing construct that allows early mobilization. The purpose of this study was to see the outcome of operative treatment of femoral shaft fracture in children by TEN.

**Methods:** A retrospective observational study was carried out in the Department of Orthopedics in National Academy of Medical Sciences, National Trauma Center from February 2017 to January 2019. Study was undertaken in 22 children between the age group of 5-14 years with femoral shaft fractures. Fixation with TEN was done for all fractures within nine days of injury. Patients were assessed radiologically as well as clinically until fractures healed. The results were evaluated using Flynn scoring criteria.

**Results:** Radiological union was seen in all cases between 6–12 weeks after surgery. The mean operating time was 58 (48-115) minute and mean hospital stay after surgery was 9 (6-15) days. Results were excellent in 14 patients (63.63%), satisfactory in 6 patients (27.37%) & poor in 2 patients (9%). Six patients had skin irritation at nail insertion site which resolved after removal of nails. Functional range of motion in both hip and knee joints of affected limb was preserved in all cases after the removal of nails.

**Conclusion:** TEN is an effective and safe treatment of femoral shaft fractures in children of 5-14 years of age group.

**Keywords:** Femoral shaft fractures, Pediatric fracture, Titanium Elastic Nailing

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## INTRODUCTION

Femoral shaft fracture is one of the most common orthopedic injuries of the children.<sup>1</sup> It accounts for 1.6% of all paediatric bony injuries.<sup>2</sup> Increased economic burden to the family and psychological impact to the children are highly associated with this type of injury.<sup>3</sup> Fractures are mostly caused by fall injury during play or physical abuses. Transverse fractures are caused by low velocity trauma whereas comminuted or segmental fractures are caused by high velocity trauma.<sup>4</sup> The management options for paediatric femoral shaft fractures include both non-operative and operative techniques.<sup>3</sup> Previously most of the fractures were effectively managed non-operatively and only unstable and displaced fractures were treated by various fixation techniques. Fractures treated non-operatively by traction followed by hip spica require prolonged hospitalization causing undue physical and psychological stress for patient and patient family. Loss of reduction that leads to unacceptable complications like angular deformities and limb length discrepancies are also commonly seen with hip spica. Likewise, Plaster related complications, and difficulties in toileting and keeping personal hygiene are also not uncommon with hip spica procedure.<sup>5</sup> In order to avoid the undesirable issues associated with hip spica, increasing trend towards operative management of femoral shaft fractures in paediatric patients has seen for past few decades. Operative management options include a plate and screws fixation, application of external fixators, intramedullary interlocking nailing, enders nailing, and titanium elastic nailing. But the controversy regarding the ideal implant still exists.<sup>6</sup> Though plating of femoral shaft fracture offers rigid fixation, it requires a larger exposure with the potential for increased blood loss and scarring. Moreover, being a load bearing device there is risk of re-fracture and growth disturbances with plating.<sup>7</sup> Enders nails or Rush nails have also been used but, these have poor rotational stability and require multiple nails to achieve fracture stability.<sup>8</sup> With the evolvement of newer techniques, treatment of femoral shaft fractures in children continued to improve.<sup>7</sup> The ideal device to treat pediatric femoral shaft fracture would be a simple, load sharing internal splint that allows early mobilization and maintain the fracture alignment until bridging callus forms. TEN offers these beneficial features as it works on the principal based on the symmetrical bracing action of

two elastic nails inserted into the metaphysis. Each nail fixes against the inner bone at three points and develop a stable load sharing construct.<sup>4, 6</sup> TEN is a simple, physeal protective load sharing internal splint that allows micro motion at the fracture site and early fracture union.<sup>9</sup> This study was carried out to find out the outcome of operative treatment of fracture shaft of femur in children by TEN. The results were evaluated by Flynn et al scoring criteria.<sup>10</sup>

## METHODS

This is a retrospective cross-sectional study done from July 2017 to August 2019 at National Academy of Medical Sciences (NAMS), National Trauma Center. Approval was taken from the institute. Twenty-two patients with closed shaft femur fractures in the age group of 05-14 yrs (an average age of 8.1 yr) were taken for the study. Diagnosis of displaced femoral shaft fracture with open femoral physis was made with pre-operative radiographs. Fractures were classified according to system of Winquist.<sup>11</sup> Patients with extreme proximal or distal femoral fractures closer to the epiphyses, open fractures, pathological fractures and fractures associated with metabolic bone diseases or neuromuscular disorders were excluded in the study. Fixation with TEN was done for all femoral shaft fractures within 9 days of injury. The diameter of the individual nail was selected as per Flynn *et al.*'s formula<sup>12</sup> (Diameter of nail = width of the narrowest point of the medullary canal on AP and Lateral view  $\times$  0.4 mm) as well as the intra-operative assessment. The diameter of the nail was chosen so that each nail occupies at least one third to 40% of the medullary cavity whenever possible.

## Surgical technique

All operations were performed by orthopedic surgeons. The patient was positioned on fracture table. Closed reduction was achieved with image intensifier. Under aseptic precaution 2cm longitudinal skin incision was made over the medial and lateral surface of the distal femur, starting 2 cm proximal to the distal femoral epiphysis. The periosteum was incised along the line of skin incision longitudinally and the cortex was exposed. With the help of sharp awl, near cortex was perforated and the awl angled to enter the medullary cavity in the middle of the width of the cortex. Proper sized nails were used. Two nails with the same diameter were selected

to balance the opposing bending forces and avoid mal-alignment. Both nails were contoured into bow shaped with nail tip pointing to the concave side of nail, apex of bow should be at the level of fracture. Under image intensifier control, the nails were driven with rotatory movement with the help of T-handle one after another. The tip of the nail that entered the lateral femoral cortex should come to rest just distal to the trochanteric epiphysis. The opposite nail should be at the same level towards the calcar region. The nails were put in a double 'C' construct to ensure a three point fixation for better stability. Once fracture reduction was acceptable and nails are properly placed, end of the nails were cut. The nail was cut in such a way that 1cm of nail remained outside the cortex. The extra osseous portion of nail was bent away from the bone and buried to use it for removal later on. Wound closed in layers and dressing was applied. Antibiotic was given to all patients for 5 days. Most patients were discharged on 10th postoperative day.

Post operatively patients were kept in supine position with limb elevated on a pillow. Non weight bearing mobilization was started from second post-operative day or as per tolerance of the patient. Partial weight bearing was started 2 weeks after surgery in cases of midshaft transverse fractures and delayed to 4 weeks in cases of oblique and comminuted fractures. Full weight bearing was allowed once fracture is united clinically and radiologically.<sup>13</sup> Patients were evaluated at two weeks, six weeks, three months, six months and one year after surgery radiologically as well as clinically until fractures healed and for any complication. The results were evaluated using Flynn scoring criteria.<sup>9</sup> Routine removal of these implants was recommended 6-9 months after surgery when the fracture line was no longer visible radiologically.

## RESULTS

The study included twenty-two patients comprising 16 boys and 6 girls. The predominant mode of injury was road traffic accident (RTA) (63.7%) followed by fall injury (27.3%). Mid-shaft transverse fractures were found to be the commonest type of fracture in the study (Table 1 and 2). Radiological union was seen in all cases between 6–12 weeks after surgery. Time for achieving unassisted full weight bearing was between 8-12 weeks after surgery. The mean operating time was 58 (48-115) minute and mean hospital stay after

surgery was 9 (6-15) days. Results were excellent in 14 patients (63.63%), satisfactory in 6 patients (27.37%) and poor in 2 patients (9%) according to Flynn's scoring criteria.

**Patients had been studied and their details are mentioned in the table**

**Table 1 Demographics**

No. of patients	22
Male:female	16:6
Mean age(year)	8.1
<b>Mode of injury</b>	
RTA	14
Fall injury	8

**Table 2 Fracture characteristics**

Location	
Proximal	5
Midshaft	15
Distal	2
<b>Pattern</b>	
Transverse	14
Oblique	7
Comminuted	1
<b>Winqvist grading</b>	
Grade I	14
Grade II	4
Grade III	3
Grade IV	1

**Table 3 Flynn et al scoring criteria.**

	Excellent	Good	Poor
Limb length discrepancy	<1cm	<2cm	>2cm
Angulations in degrees	<5	5-10	>10
Pain	Absent	Absent	Present
complications	Absent	Mild	Major/extended period for resolvable morbidity

There were three cases of varus angulation (6°, 8°, 9°), and one case had anterior angulation (8°). Out of these four malunion cases, three cases were distal third with one comminuted fracture and one case was proximal third femur fractures. In three cases, there

was limb lengthening of about 1.5 cm, but it was clinically not significant. All three cases were distal third femur fractures. Other complications included infection at nail insertion site in four cases. Out of those four cases, two cases got cured with a prolonged course of antibiotics however, two cases got cured only after removal of nails. Likewise, two cases presented with proximal migration of nail insertion site due to failure to remove nails in time although no long term complication occurred in these cases. There was no case of physeal injury. Six patients had skin irritation at nail insertion site which resolved after removal of nails. Nail was removed between 6-12 months after surgery with mean time of 9 months. Functional range of motion in both hip and knee joints of affected limb was preserved in all cases after the removal of nails. Surgical scar was cosmetically acceptable.

## DISCUSSION

Multiple treatment options are available for femoral shaft fractures but controversy remains over which method is superior in a given situation. Conservative treatment by skin traction followed by hip spica was the preferred method in children and adolescents in the past. Due to prolonged immobilization, loss of school days of children and difficulty in nursing care, need of operative treatment gained popularity for past two decades. Various operative techniques have been described for the treatment of pediatric femoral shaft fracture with variable clinical benefits. Fracture treating with plate and screws is a viable operative option, but associated with big exposure, relatively longer duration of immobilization, infection, risks of delayed union and bigger dissection for plate removal.<sup>14</sup> Another operative technique external fixator provides good stability and early mobilization but associated with risk of pin tract infection, delayed union, non-union, and refracture after fixator removal.<sup>15</sup> Other operative technique like intramedullary interlocking nail, which provides a strong stable fixation is also an option available for the treatment. But studies have shown that nailing was associated with development of avascular necrosis of the femoral head and coxa valga in patients with open femoral physes. However, some studies claimed a good result with interlocking nail if nail inserted into intramedullary canal avoiding piriform fossa as entry site<sup>16</sup>. Likewise, other intramedullary fixations like, K wires fixation, Enders nail and Rush nails have also been used to treat this

kind of fractures. But studies reported that these techniques are lacking with the adequate stability in terms of angular and rotational stability.<sup>17,18</sup>

An ideal treatment for pediatric femoral fractures is the one that maintains the length and alignment, that shares the load, does not violate the open physis and is comfortable for the patient and patient parents. Moreover, the treatment should cause the least economical as well as psychological impact.<sup>19,20,21</sup> Titanium Elastic Nail (TEN) seems superior over other surgical methods particularly in this age group because it permits micro motion at the fracture site that promotes faster external bridging callus formation. Moreover, TEN is a load bearing internal device that allows early mobilization.<sup>18,22</sup> Since it is a closed procedure, periosteum is not disturbed and there is no disturbance to fracture haematoma. This also enhances fracture healing and lessens the risk of infection. Kumar R et al<sup>9</sup> found TEN superior over hip spica, the non-operative procedure carried out in the treatment of diaphyseal femoral fractures in children. Similarly, Shemshaki HR et al<sup>23</sup> found that TEN has advantages over hip spica in their comparative study.

In this study there were three cases of varus angulation (6°, 8°, 9°), and one case of anterior angulation (8°). Out of these four malunion cases, three cases were distal third with one comminuted fracture and one case was proximal third femur fracture. This shows fracture geometry and location is an important causal factor in the development of angular deformity. So, selection of type of surgical implant on the basis of fracture type should be considered properly to avoid unwanted deformity. Angular deformities observed in this study were considered to be benign as malunion of as much as 25 degrees in any plane will remodel enough to give normal alignment of the joint surfaces<sup>24</sup>. In three cases, there was limb lengthening of about 1.5 cm where fracture location was again at the distal third of femur. This was probably the increased vascularity at the growth plate during the process of fracture healing. The study conducted in 58 children with femoral fracture concluded that overgrowth after fracture of the femur in children is a universal phenomenon.<sup>25</sup> The study also added that a mean increase in length of 0.85 cm could be expected in the affected femur although those below 2 years old had less potential for such overgrowth. According to

another study, the overgrowth continued after fracture healing for a limited time period, then ceased with no change in discrepancy throughout the remainder of skeletal growth. They also noticed that average femoral lengthening of 9.2 mm which varies from 4 mm to 2.7 cm, commonly in children between 2 to 10 years old in their study.<sup>26</sup>

In this study all the fractures were united between 6–12 weeks after surgery. Time for achieving unassisted full weight bearing was between 8-12 weeks after surgery. Similar result was found in other studies with little variations in the time for unassisted full weight bearing after surgery.<sup>6, 27</sup> Results were excellent in 14 patients (63.63%), good in 6 patients (27.37%) and poor in 2 patients (9%). Similar study conducted in 30 patients, found excellent in 21 patients (70%), good in 6 (20%) and poor in 3 patients (10%). Similarly, study conducted in 11 patients found excellent in 6 patients (55%), satisfactory in 4 patients (36%) and poor in 1 patient (9%) 2. Six patients had pain at nail entry site possibly due to skin irritation over prominence of cut end of TEN. Pain was experienced more in immediate post-operative days. Infection at nail insertion site was seen in 4 cases. Infection controlled in 2 cases with regular wound dressing whereas 2 cases required nail removal to control infection. In this study, mean hospital stay after surgery was 9 (6-15) days. In other similar studies, hospital stay was between 4 to 6 days.<sup>2, 27</sup> Reason for long mean hospital stay in this study could be the policy adopted by us not to discharge patients until wound appears healthy enough to heal. However, Range of motion of ipsilateral knees and hips returned to normal after physiotherapy following nail removal.

## CONCLUSION

TEN is a simple, minimally invasive surgical technique that does not interfere with growth, and is associated with a rapid return to daily activity. Therefore, it is an effective and safe treatment of fractures shaft of femur in children of 5-14 years of age group.

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