

## OUTCOME OF TITANIUM ELASTIC NAIL FIXATION IN SKELETALLY IMMATURE DIAPHYSEAL FEMORAL FRACTURES

Mallam Kiran Kumar<sup>1</sup>, Batchu Soyal Rao<sup>2</sup>

<sup>1</sup>Assistant Professor, Department of Orthopaedics, ACSR Government Medical College, Nellore, Andhra Pradesh.

<sup>2</sup>Assistant Professor, Department of Orthopaedics, ACSR Government Medical College, Nellore, Andhra Pradesh.

### ABSTRACT

#### BACKGROUND

Skeletally immature femoral shaft fractures are relatively uncommon but serious injuries can disrupt the lives of children and their parents and can result in significant long-term disability. Management of femoral diaphyseal fractures in the age group of 6-14 years is controversial and there has been a resurgence worldwide for operative fixation. We wanted to evaluate the efficacy of titanium flexible intramedullary nails for the treatment of femoral shaft fracture in children.

#### METHODS

This prospective study was conducted in the Department of Orthopaedics in A.C.S.R. Govt. Medical College from December 2016 to Jan 2019. Thirty-three paediatric patients in age group 6-14 years with closed diaphyseal femoral fractures were stabilized with two titanium nails. All patients were operated under spinal or general anaesthesia and were followed up clinically and radiologically for two years. The final results were evaluated using the criteria of Flynn et al. Technical problems and complications associated with the procedure were also analysed.

#### RESULTS

Overall results were excellent in 78.7% (26/33), successful in 15.1% (5/33) and poor in 6.0% (2/33). All the fractures healed with an average time to union of 9.3 weeks (6-12 weeks). Average hospital stay was 8.5 days (7-18 days) and return to school was early with an average of 10 weeks. The soft tissue discomfort and infection near the knee produced by the nails' ends was the most common problems encountered. Insignificant limb length discrepancy was seen in 3 children, but this remains a potential problem which needs close follow-up until skeletal maturity. There was no delayed union or refractures.

#### CONCLUSIONS

Titanium elastic intramedullary nailing is an excellent technique in the surgical treatment of diaphyseal fracture in 6-14 years children. It is safe, less invasive, has fewer complications and avoids prolonged hospitalization with good results and is economical.

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#### BACKGROUND

Treatment of long bone fractures in children continues to improve as newer techniques evolve. Conservative treatment remains the mainstay, given the excellent remodelling ability of the immature bone in children.<sup>1</sup> However, unstable fractures of long bones require operative treatment to maintain alignment and preserve function.<sup>2</sup> There is little disagreement regarding the treatment of younger children (usually less than 6 years of age) and these can be treated with immediate Spica casting.<sup>3</sup> These young children tolerate the cast well, are easily managed at home and mild to moderate fracture displacement and angulation correct well by growth and remodelling. The cost of care is low and outcome is generally good. Older children (usually

older than 14 years of age) show good response with standard locked intramedullary femoral nailing techniques. For children that occupy the middle age group between 6-14 years, there are a wide variety of surgical and nonsurgical treatment options available as early Spica casting, traction followed by casting, external fixation, plate fixation, reamed intramedullary rods and flexible intramedullary nails with no clear consensus as to the preferred treatment.<sup>4</sup> Several options are available for operative treatment but with the development of titanium flexible nail the treatment of long bone fractures, particularly femur has undergone a dramatic change. A number of other intra-medullary devices like the Rush nail or Ender's nails are available for treatment of paediatric fracture, but these have poor rotational stability and require multiple nails to achieve fracture stability.

#### METHODS

This prospective study was carried out at Orthopaedics department of A.C.S.R. Medical College from December 2016 and January 2019. After obtaining approval from our institutional board and informed consent, thirty three paediatric patients (25 boys, 8 girls) in the age range of 6-14 years (average 9.5 years) (Figure 1) with recent (<3 days) closed femoral shaft fractures were stabilized with

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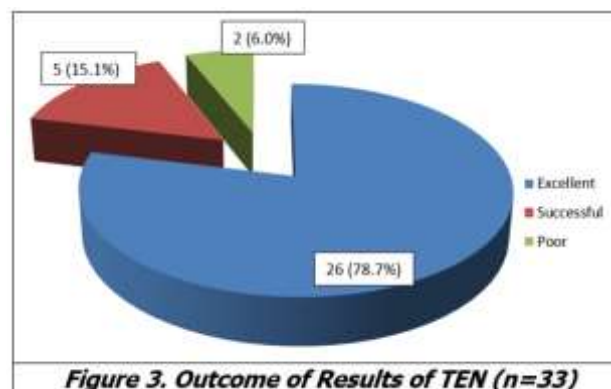
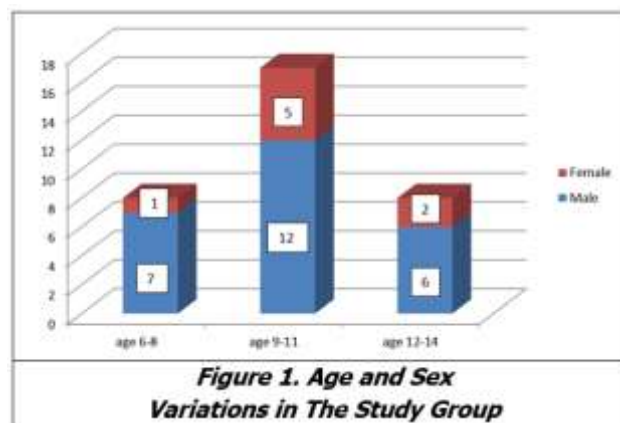
*Dr. Batchu Soyal Rao,*  
*Assistant Professor,*  
*Department of Orthopaedics,*  
*ACSR Government Medical College,*  
*Nellore – 524004, Andhra Pradesh.*  
*E-mail: drsoyalrao@gmail.com*  
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Titanium Elastic Nail (TEN). Most of the fractures were due to road traffic accidents (n=25, 75.7%). Right-sided involvement was seen in 19 cases (57.5%) and associated injuries were seen in nine cases (27.2%). Ten fractures were in the proximal third, 18 in the middle third and five were in the distal third. Fifteen fractures were transverse, eight minimally comminuted, five were short oblique and five were long oblique. Majority of the patients (n=27) underwent surgery within seven days of their injury. The surgery was performed under general anaesthesia with the patient on the fracture table in supine position. Two Titanium Elastic Nails of identical diameter were used (23 of MATRIX and ten of INOR). Six cases required insertion of nails with different diameter because of the intraoperative difficulty in driving the second nail into the proximal fragment. TENs available in standard length of 440 mm were used. The diameter of the nail (range 2.0 mm - 4.0 mm) to be used was determined on the basis of the size of medullary canal of the femur of the particular patient. The diameter of the individual nail was selected as per Flynn et al's formula<sup>5</sup> (Diameter of nail = Width of the narrowest point of the medullary canal on Anteroposterior and Lateral view x 0.4 mm) and intraoperative assessment. The diameter of the nail was chosen so that each nail occupies at least one-third to 40% of the medullary cavity. Fractures were reduced using fluoroscopic guidance. Fractures were inserted in retrograde fashion with medial and lateral incision 2.5-3.5 cm above the physis. The nails were present sufficiently so that apex of the bowed nails rested at the same level on the fracture site to ensure a good equal recoil force. Open reduction was required in four cases due to soft tissue interposition and failure to negotiate one nail to the proximal fragment. The nails were driven proximally so that both were divergent and the tips got anchored minimum 1 cm distal to the physis. Postoperatively patients were nursed in supine position with the operated leg elevated on a pillow. Long knee brace was used in three cases of distal third fractures, where fixation was not adequate. Patients were mobilized without weight bearing on the fifth to seventh day postoperatively. Partial weight bearing was started at three weeks and full weight bearing by six to eight weeks depending on the fracture configuration, callus response and associated injuries. All patients were followed for a period of one year and observed radiologically as well as clinically until fractures healed and for any complication. According to the criteria the results are graded as excellent when the fractures unite within 10 weeks without any complication, good when union occur within 16 weeks with treatable complications or 22 weeks like superficial infection and knee stiffness and poor when union occur before or after 16 weeks with one or more permanent complications like osteomyelitis, implant failure, non-union, limb shortening and permanent knee stiffness. Delayed union was recorded when the fracture united between two to four months while non-union was noted when union had not occurred after four to six months of treatment. The final results were evaluated using the criteria of Flynn et al<sup>6</sup> (Table 1).

Limb Length Discrepancy	Excellent <1.0 cm	Successful <2.0 cm	Poor >2.0 cm
Sequence disorder	5 degrees	10 degrees	>10 degrees
Pain	Absent	Absent	Present
Complication	Absent	Mild	Major complication and/or extended Period for resolvable morbidity

**Table 1. Flynn et al's Scoring Criteria for TEN<sup>8</sup>**



## RESULTS

The median duration of surgery was 72 min (45-110 min). The mean hospital stay was 8.5 days (7-18 days). A patient with head injury had to stay for a longer period (18 days). The hospital stay was dictated by associated injuries and the adequacy of fixation. All 33 patients were available for evaluation after a mean of 18 months (10-24 months) of follow up. Radiological union was achieved in all cases in a mean time of 9.3 weeks (6-12 weeks) (Figure 2). Full weight bearing was possible in a mean time of 9.8 weeks (6-12 weeks). The results were excellent in 26 patients (78.7%), successful in five (15.1%) and poor in two patients (6.0%) as per the scoring criteria for TEN by Flynn et al<sup>6</sup> (Figure - 3). Four patients had virus angulation (15° and 6° each) whereas one had valgus angulation (12°). Entry site irritation occurred in eleven patients. Five patients had skin breakdown at entry site which led to superficial infection and the infection resolved with seven days oral course of antibiotics. Limb lengthening of less than 1.5 cm was found in five cases both clinically as well as radiologically, which was clinically insignificant. Results were better for children less than 10 years of age. Leaving nail end long (>2 cm) and untrimmed was significantly associated with entry site irritation. Functional range of movement of knee was achieved in an average of 9.3 weeks (6-32 weeks).

## DISCUSSION

Although femoral shaft fractures constitute fewer than 2% of all paediatric fractures, the choice of treatment has remained a constant challenge to the orthopaedics fraternity. Till the end of 19<sup>th</sup> century 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 for the last two decades. Plate osteosynthesis is still widely used. It is associated with a large exposure, relatively longer duration of immobilization and the risks of delayed union, infection and a large dissection for plate removal.<sup>7,8</sup> The external fixator provides good stability and early mobilization, but is associated with the risk of pin tract infections and it takes a longer time for weight bearing.<sup>9,10</sup> Intramedullary K-wire fixation has also been used for paediatric femoral fracture but stability and fracture angulation are the disadvantages to be taken care of. Interlocking nail is ideal for skeletally matured children. Reports of avascular necrosis of femoral head, coxa valga have been reported with interlocking nail when attempted in skeletally immature patients.<sup>11,12</sup> However there have been proponents for using interlocking nail in the 11-16 years of age group, avoiding the pyriformis fossa as entry site, with good results.<sup>13</sup>

Titanium elastic nail (TEN) seems advantageous over other surgical methods particularly in this age group because it is simple, is a load-sharing internal splint that doesn't violate open physis, allows early mobilization and maintains alignment. Micromotion 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 less risk of infection. Flynn et al. Found TEN advantageous over hip spica in treatment of femoral shaft fractures in children.<sup>14</sup> Buechsenschuetz et al, documented titanium nail superior in terms of union, scar acceptance and overall patient satisfaction compared to traction and casting.<sup>15</sup> Ligier et al. Treated 123 femoral shaft fractures with elastic stable intramedullary nail and all fractures are united with thirteen children developed entry site irritation.<sup>16</sup> Narayanan et al. found good outcome in 79 femoral fractures stabilized with TEN.<sup>17</sup> Similarly, Saikia K C et al. observed successful outcome in 20 femoral fractures stabilized with TEN.<sup>18</sup> There is no comparative study regarding the efficacy of Ender Nail, Rush Nail or Titanium Elastic Nail. All the nails give good results. Ender Nail and Rush Nail have poor rotational stability and require multiple nails to achieve good fixation. Moreover, Ender Nail is not elastic and flexible enough for paediatric fractures as stated by Ligier. Heinrich et al. Observed good results in 78 femoral fractures treated with Ender Nail.<sup>19</sup>

Fracture geometry and the location is an important determinant for selection of surgical techniques. Transverse, short oblique and minimally comminuted fractures are suitable for TEN as stated by Flynn et al. Narayanan et al.<sup>17</sup> They further stated that transverse, short oblique, short spiral fractures with minimum comminution in the 5-12 years age group were the best indications for TEN. Lascombes et al.<sup>20</sup> Stated that TEN could be indicated in all femoral diaphyseal fractures of children above six years of age till epiphysis closed except severe Type III open fractures. Titanium elastic nail does not provide adequate stability in comminuted, long oblique or spiral fractures. Even if it is contemplated, postoperative immobilization becomes essential. Appropriate alternatives other than titanium elastic nail should be considered in such circumstances.

The most common complication of Titanium elastic nail is entry site irritation and pain.<sup>6,7</sup> Other complications include limb length discrepancy, angulation of fracture, refractures and infection. Entry site irritation in our series was seen in four cases. We found that entry site irritation was significantly associated with long and prominent nail end (>2 cm). Similarly, smaller and mismatch nail diameter that was incidentally used in three cases was associated with increased incidence of varus/valgus angulation, which conforms to the finding by Narayanan et al.<sup>17</sup> In their series. All these findings were statistically significant.

## CONCLUSIONS

Titanium elastic nailing (TEN) is an effective and viable treatment option in selected cases of femoral diaphyseal fractures in the 6-14 years age group.

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