Pediatric Femoral Shaft Fracture Management By Titanium Elastic Nailing; A Prospective Study Of 112 Patients
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Citation

Abstract
Objective – To assess the usefulness of TENS in treatment of pediatric femoral shaft fractures, which is one of most common pediatric major injuries encountered to orthopedic surgeon. Material and method – The study was conducted on 112 patients admitted at Govt. Medical College, Haldwani in the Department of Orthopedics from January 2007 to January 2012. We included patients of age group of 5 -15 years with fracture shafts of femurs excluding grade 3 compound fractures and pathological fractures. Patients were followed more than a year. Greater emphasis was given on complication analysis, major complications like limb length discrepancy, infection, angulations, and loss of knee movement were noted. Functional outcomes were analyzed according to Flynn criteria. In our prospective study by using Flynn criteria, 86 had excellent results, 24 had satisfactory results, and 2 had poor results. Discussion and conclusion - Treatment of long bone fracture in pediatric age group by titanium elastic nail is broadly under acceptance. Technical ease, good functional outcome, preservation of epiphysis, low complications are very favorable point for TENS use for femoral shaft fracture. Encouraging reports and low complication from our study also supports exclusive use of TENS in pediatric femoral shaft fracture in age group 5-15 years.

INTRODUCTION
Femoral shaft fractures are among the most common major pediatric injuries treated by orthopaedic surgeons(1). Most femoral fractures in children are closed injuries and traditionally have been treated by closed methods. The management of pediatric femoral fractures as noted by Galplin (2) evolved gradually in past decade toward operative approaches because of desire for more rapid recovery and reintegration of patients, with recognition that prolonged immobilization have negative effects on children. For children between ages 5-15 years, there are a wide range of conservative and surgical options available. It ranges from spica casting, traction followed by casting as prime modalities in conservative options. External fixation, plate fixation and nails are main modalities of surgical intervention.

An ideal fixation(3) device for pediatric femur fracture would be load sharing internal splint maintaining reduction for few weeks until a callus forms. Special precaution should be taken for preventing physics damage and blood supply damage to femoral head. Titanium elasticity limits amount whether how much nail will be deformed during insertion. Elasticity promotes callus formation by limiting stress shielding. Titanium also has excellent bio compatibility. Many observations show that flexible intramedullary nail fixation meet these requirements because it allows rapid mobilization, no risk for osteonecrosis, low risk for physical injury and reduced risk for refracture. Ligier and colleagues(4) were first to report beneficial use of TENS in treatment of femur fractures in children. In a 5yr study of 123 children which included 1 yr. follow up results were excellent with no non-unions, leg length discrepancies, malunion, gait anomalies or refractures. Flynn and colleagues(3) furthered the use of Elastic nails by doing multicentric study involving 58 children, outcome were excellent. The need for operative intervention of femoral shaft fracture arose because of changing social, psychological trends and no acceptances of prolonged immobilization and hospital stay. Traction and hip spica application(5) is slowly giving way to operative stabilization of femoral shaft fractures by intramedullary devices.

MATERIAL AND METHODS
After taking consent from ethical committee 112 pediatric patients having femoral fractures aged between 5-15 years, were treated using titanium elastic nails from January 2007 to January 2012; cases of Grade I and II compounding and
all closed fractures were included in study. Associated injuries were seen in 20 cases like head injury, chest and abdominal injury, as well as ipsilateral fractures of leg bones and foot. Cases with metabolic disorders, neuromuscular problems, and infective etiology leading to fracture were excluded from our study.

The cases were admitted from emergency and outpatient departments in our hospital. They were treated initially by below knee skin traction while waiting for surgery. The ages of children ranged from 5-15 years with an average age of 9 years. Male children were 69% (77 cases). The right limb was involved in 62% (70 cases). According to fracture patterns: transverse fracture pattern was the most common with 60% (67 cases), commination was seen in 10 cases; mid 1/3 was the most common site of fractures seen in 68% (76 cases). TENS of standard length 440mm was used and a diameter of nails (range 2.0mm-4.0mm) was used. To determine the size of titanium nails to be used, the femoral diaphyseal internal diameter (narrowest) was measured; the proper nail diameter is no more than forty percent of the width of the canal (narrowest) and a selection of two nails of the same diameter was done so opposing bending forces were equal\(^{(6)}\).

Technique:- The patients were placed on an orthopaedic table and a reduction of the fracture by traction guided by fluoroscopy was done. We used blunt-ended nails of titanium. The nails were 440 mm long with diameters of 2.5mm, 3mm, 3.5mm, or 4 mm depending on the child’s diaphyseal medullary canal diameter. The nails preoperatively were prepared and angled at 45 degrees about 2 cm from one end to facilitate penetration of the medullary canal. With the help of a T- handle and by rotatory movements of the wrist, introduction of the nails through a drill hole, made by 4mm drill bit 2cm above the physis was done. Two nails, one lateral and one medial to stabilize the fracture were used. They were carefully pushed up the medullary canal to the already reduced fracture site. After touching the opposite internal cortex, the nails bend themselves in the direction of the long bone’s axis. The nails were crossed distal to the fracture site (minimum up to 4 to 6 cm distal). Rotation of the T- handle or manipulation of the limb to direct the pins into the opposite fragment was done. It was ensured that both nails were in the canal across the fracture site. Care was taken not to twist the nails more than 90° otherwise cork screw phenomenon may have been created. When they passed the fracture level, the traction was released, and the nails were pushed farther and fixed with their tips in the spongy tissue of the metaphysis. The distal portion of the nails was left slightly protruding for ease of removal after bending. The fracture was finally stabilized by two nails, each with three points of fixation.

Post operative period:- The limb was rested on a pillow and a cylindrical slab was applied. Patients were discharged after stitch removal on the tenth post operative day. The initial follow up was done every forth day for 2 months then monthly for 6 months. At the beginning of the 4\(^{th}\) week partial weight bearing was allowed, full weight bearing was allowed once a callus was visualized on X-Ray. Patients were followed up at three monthly intervals after 6 months. X-Rays were done on every visit after clinical evaluation. The nails were removed when complete healing of the fracture had occurred (usually after 1 year). The final results were evaluated using criteria of Flynn.(3) The patients were followed up for more than a year.

Table-1- Features of Patients who were selected for study along with their numbers.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male; 69% (77)</td>
</tr>
<tr>
<td></td>
<td>Female; 31% (35)</td>
</tr>
<tr>
<td>Age group</td>
<td>5-10 years: 58% (65)</td>
</tr>
<tr>
<td></td>
<td>10-15 years: 42% (47)</td>
</tr>
<tr>
<td>Fracture type</td>
<td>Spiral: 15% (17)</td>
</tr>
<tr>
<td></td>
<td>Short oblique: 25% (28)</td>
</tr>
<tr>
<td></td>
<td>Transverse: 60% (67)</td>
</tr>
<tr>
<td>Fracture with comminution</td>
<td>10 cases</td>
</tr>
<tr>
<td>Side involved</td>
<td>Right side: 62% (70)</td>
</tr>
<tr>
<td></td>
<td>Left side: 38% (42)</td>
</tr>
<tr>
<td>Site of fracture</td>
<td>Proximal third shaft: 21% (24)</td>
</tr>
<tr>
<td></td>
<td>Middle third shaft: 68% (76)</td>
</tr>
<tr>
<td></td>
<td>Distal third shaft: 11% (12)</td>
</tr>
<tr>
<td>Mode of injury</td>
<td>RTA: 43% (48)</td>
</tr>
<tr>
<td></td>
<td>While playing: 57% (64)</td>
</tr>
<tr>
<td>Average Surgery time</td>
<td>535 minutes</td>
</tr>
<tr>
<td>Average School return</td>
<td>13 weeks</td>
</tr>
</tbody>
</table>

RESULTS

The average time gap between injury and surgery was 5 days during which skin traction was applied. The duration of surgery was about 45 min to 75 min and was conducted
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Under C-Arm in general or spinal anesthesia. In all patients close reduction under C-Arm was achieved. Average medullary canal size was 6mm and two nails were used of same diameter. Cork screwing in one case was observed. Blood loss was minimal. Median hospital stay time was 10 days and patients were discharged after removal of the stitches; A cylindrical slab was applied for 3 weeks and patients were not allowed to walk. Partial weight bearing was started at 4 weeks. The patients were asked to come for regular follow ups. During follow up visits the patients were evaluated clinically as well as radiologically by X-Rays (callus was looked for). Full weight bearing started at 6-12 weeks depending on callus (average time was 8 ½ weeks). Fracture healing time was 6-14 weeks (average was 8 weeks). The commonest complication encountered in our series was skin irritation. Skin irritation at the insertion site was seen in 17 cases. This disappeared when nail was removed. In two cases trimming of the nail proved helpful. Misalignment was seen in 6 cases; 2 cases had varus tilt of 15°; ant tilt of 10° was seen in 4 cases. Shortening (Limb Length Discrepancy) was seen in 4 cases; these cases were of comminution and the weight of the patients was found to be more than 50 kilograms. No case of lengthening was seen. Range of movements at the knee returned well after physiotherapy. 0-140° was seen in 80% cases. In 20% cases the terminal 20-30° of flexion were hampered. The knee flexion improved when nails were removed and rigorous physiotherapy was prescribed for patients. There were no cases of delayed or non union in our study. There was only one case with soft tissue infection which was healed with intravenous antibiotics when prescribed for a week. The nails were removed after a year. There were no refractures after nail removal. No cases of physal growth arrest were seen. Per operative technical difficulties in closed reduction were encountered in 4 cases and cork screwing was seen in one case. No case of migration of the nail was observed. The results were evaluated according to Flynn criteria and it was found that 86 cases were excellent. 24 cases had satisfactory result while 2 cases showed poor outcome.

Table-2: Complications in Management of Femoral shaft fracture with Titanium Elastic nail. It includes all possible complication which were encountered during surgery and follow up of patient management

**DISCUSSION**

The treatment of closed femoral shaft fractures in children has traditionally been traction and casting but children in the 5-15 year age group experienced a change in trend. Prolonged immobilization, short hospitalization of the child, concerns of the parents, risk of joint stiffness and delayed functional recovery have all prompted orthopaedicians to advocate for intramedullary nailing in form of ender’s nail or titanium nails. The ideal implant should be simple, load sharing, and allow mobilization as well as maintain length until a callus forms. Mazda et al (7) treated 34 femoral shaft fractures with TENS and observed that the elastic properties of titanium provide good stability and is safe. In our series the fractures united within 3 ½ months with no case of non union and delayed union. Transverse fractures of mid one third united slightly earlier than the average union time. This may be comparable to another study of Roop Singh et al (8) in which average time of union was 4 months. In the present study partial weight bearing started at 4 weeks and full weight bearing at 8 weeks. Flynn et al and Mazda et al (3,7) observed walking without assistive devices at average of 8.5
weeks and 9.5 weeks respectively. In patients using TENS, hospitalization decreased, and in the present series it was 10 days. In another study of Nascimento FP(9) et al patients spent an average 9.4 days in the hospital. Return to school was about 3 months in our series. Migration of nails was not observed in the present series which may be attributed to balancing forces of two flexible titanium nails. On contrary Karaoglu et al(10) observed two cases of proximal migration in a series of 31 femoral fractures stabilized with enders nail. There was only one case of infection that involved only soft tissue and was amicably treated with antibiotics; however no case had infection up to the bone. Similar results were reported by Roop Singh(8) et al in their study. Per operative difficulty was observed in four cases in form of failure of closed reduction which was treated by removal of soft tissues interposition by open means. The cork screw phenomenon must be detected using C-Arm and should be avoided at all costs. No cork screwing was observed. The nails were removed after one year. No case of refracture was seen in follow up of two years.

Figure 4
Fig-1 – Pre operative X-ray of Right sided Femoral shaft fracture of 10 year old child sustained while playing.
Figure 5
Fig-2-Immediate post operative X-ray Showing fracture femur with Titanium Elastic nail put in retrograde fashion.

Figure 6
Fig-3- post operative x-ray after 9 month follow up. Figure showing united femoral fracture without any deformity.
Figure 7
Fig-4 Follow up X-ray of child after implant removal. Figure showing completely united femoral shaft fracture.

Figure 8
Fig-5 and 6-Figure showing 10 year old child with almost return of all function activity, implant was removed after 1 year.
Figure 9

Limb length discrepancy is another problem; According to Staheli(11) shortening is more likely in patients older than 10 years and overgrowth is more likely in patients younger than 10 years. In our series 4 case of LLD was observed and all were shortening because of commination with >50 kg weight and early weight bearing. No case of overgrowth because of weight was observed. Angulations(12,13,14) at the fracture site during fracture healing is a known complication seen in 6 cases of femoral fractures in our study. In the retrospective analysis it was found that there was commination at the fracture site or mismatch between nail diameter used. The weight of the patients also contributed to this situation so it was concluded that fracture fixation with sticking to biomechanical rules and slightly delay in full-weight bearing could avoid this situation. Skin irritation(15) due to nail ends was the commonest problem seen in one-seventh of the cases. It was due to nails being left too long and sometimes excessively bent for facilitating easy removal. Nails that were left long also irritated the iliotibial tract causing knee flexion problems. This problem was improved once the nails were removed or trimmed and physiotherapy initiated.

Our results pointed out that children older than 12 years and heavier than 50 kg were more likely to have a complications. Similar observations have been reported by Flynn(12,13) in a recent study.

CONCLUSION

The perceived advantage of this technique includes early union due to repeated micromotion at the fracture site. Early mobilization, early weight bearing, scar acceptance, and easy implant removal as well as economic benefits and high patient satisfaction(16) rates are the result. In conclusion, titanium elastic nail fixation is a simple, easy, rapid, reliable and effective method for management of pediatric femoral fractures between the ages of 5 to 15 years.

References

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