PEDIATRIC SUBTROCHANTERIC FEMUR FRACTURES TREATED WITH OPEN OR SUB MUSCULAR PLATING

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Abstract:

Background: Titanium elastic nailing system has been accepted as a standard modality of treatment for pediatric femur fracture in 5-12 year age group with excellent results. Subset of patients with fracture in subtrochanteric and supracondylar region have shown higher rate of complications than shaft fractures when treated with titanium elastic nailing system. The purpose of the present study was to retrospectively evaluate the outcomes and complications of Open/submuscular plating of subtrochanteric femur fracture in children and young adolescents.

Methods: A total of 30 children aged between 5 to 12 years with subtrochanteric femur fracture treated with open or submuscular plating between 2010-2016 were identified. A fracture that was located within 10% of the total femur length below the lesser trochanter was classified as subtrochanteric fracture. We retrospectively evaluated the outcomes and complications using Flynn TEN scoring criteria. Outcomes were classified as excellent, satisfactory or poor. A major complication was defined as one which requires surgical intervention. Minor complications were defined as one which resolved without surgical intervention.

Results: The mean age of the study group was 8.4 yrs with 21 boys and 9 girls. 18(60%) fractures were length stable and 12(40%) were length unstable. No patient had open fracture. Full weight bearing ambulation was achieved at an average of 9 weeks and radiological union at 10.7 weeks. Outcome results were excellent in 24(80%), satisfactory in 5 (17%) and poor in 1(3%) patients. The major complications were seen in 1 patient and minor complications in 5(17%) patients.

Conclusion: Our results indicate that subtrochanteric femur fractures treated with open/submuscular plating show excellent results in majority of patients. Length unstable subtrochanteric femur fractures are best treated with plating methods than titanium elastic nail. Length stable fractures show similar results with plating or titanium elastic nailing system.

Key words: Subtrochanteric femur fractures, pediatric, treatment, plating, submuscular
Introduction

Femoral shaft fractures in school age children and young adolescents are most commonly treated by titanium elastic nails. Most of the literature supports use of titanium elastic nails in middle 3/5 of femoral diaphysis with excellent outcomes.\(^1\)\(^-\)\(^5\) Subset of femoral shaft fractures in subtrochanteric and supracondylar regions are at a higher rate of complications when treated with titanium elastic nails.\(^1\)\(^,\)\(^2\)\(^,\)\(^6\)\(^-\)\(^8\) Reported complications include loss of reduction with shortening and angulation. Leg length discrepancy, prominent hardware and malunion are eventual outcomes of loss of reduction. Minimally invasive submuscular plating. Open plating and Ender’s nail have been reported by many authors as successfull treatment options.\(^8\)\(^,\)\(^13\)\(^,\)\(^15\)

Fractures in subtrochanteric femur region are rare and account for 4-10% of pediatric femur fractures.\(^16\)\(^,\)\(^17\) These fractures usually result from trauma and high energy injuries resulting in length unstable patterns. Due to the forces of hip abductors, iliopsoas and short external rotators the proximal fragment is displaced into abduction, flexion and external rotation. Due to the unopposed forces maintaining reduction is difficult in these fractures. Under 5 years closed reduction and Spica casting is the treatment of choice. In adolescents intramedullary nail with trochanteric entry is the preferred treatment. The optimal treatment for subtrochanteric femur fracture is yet to be established. Various methods including stainless steel flexible nails, titanium elastic nails, Minimally invasive plating and open plating have been described as preferred treatment for these fractures. The purpose the present study was to study the outcomes and complications of open/submuscular plating in pediatric subtrochanteric femur fractures. Outcomes were based on Flynn criteria and classified as Excellent, satisfactory and poor. Complications were divided into Major and Minor. Complications requiring surgical intervention were defined as Major and other which were managed non surgically as Minor.

Methods

This was a Multicenter, retrospective comparative study. Approval was obtained from each center’s Ethics board before data collection and analysis. We performed a medical records search to identify children aged 5 to 12 years, with traumatic subtrochanteric femur fractures that were treated with titanium elastic nails between 2010 and 2016. All medical records and radiographs were reviewed to confirm that the fracture site was in the subtrochanteric region.

We defined a subtrochanteric femur fracture as a fracture that was located within 10% of the total femur length below the lesser trochanter. The first available postoperative full-length anteroposterior femur radiograph was used to determine the total length of the femur, which was defined as the distance between the top of the femoral head and the medial femoral condyle. Next, the distance between the inferior aspect of the lesser trochanter and the fracture site was measured. If this distance was less than 10% of the total length of the femur, the fracture was classified as subtrochanteric. Patients with fractures that met these criteria, underwent definitive surgery, and had complete clinical and radiographic follow-up until fracture union at any institution were included in this study. Exclusion criteria were 1.femur fractures that were not in the subtrochanteric region 2.Those treated with any method of fixation other than plating 3. Pathologic fractures4. fractures in patients with osteogenesis imperfecta, neuromuscular disorders, or any systemic disease that was associated with a predisposition to fractures or altered fracture healing, such as metabolic bone disease, were also excluded. Open plating was done through posterolateral approach after elevating vastus lateralis from intermuscular septum. The technique for submuscular plating was through small lateral incision at greater trochanter apophysis and plate tunneled distally through submuscular interval.

Fracture pattern was classified as length stable or length unstable. Length-stable fractures were transverse and short oblique. Length- unstable fractures were comminuted and long oblique, where the length of the obliquity was twice the diameter of the femoral shaft at that level. The data collected included age, weight, sex, fracture pattern, open fracture, postoperative immobilization, length of hospitalization, time to radiographic union, time to full weight bearing, time between radiographic union and advancement to full weight bearing, removal of implants, time to implant removal, and duration of follow-up. Radiographic union was defined as bridging callus across at least 3 of the 4 cortices seen on anteroposterior and lateral radiographs of the femur.
Table I: Flynn Titanium Elastic Nail Outcome Scoring System

<table>
<thead>
<tr>
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<th>Excellent</th>
<th>Satisfactory</th>
<th>Poor</th>
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<tbody>
<tr>
<td>Malalignment degree</td>
<td>&lt;5</td>
<td>6-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Leg length discrepancy cm</td>
<td>&lt;1.0</td>
<td>1.0-2.0</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>Pain</td>
<td>None</td>
<td>None</td>
<td>Minor and resolved</td>
</tr>
<tr>
<td>Complication</td>
<td>None</td>
<td>Minor and resolved</td>
<td>Major complications/ lasting morbidity</td>
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Titanium Elastic Nails Outcome Scoring system described by Flynn was used to classify the outcomes of fractures. We classified results as excellent, satisfactory, or poor based on residual leg-length inequality, fracture malalignment, pain, complications, and unplanned surgery for the treatment of complications. A patient’s overall outcome was determined by the category with the worst result. Fracture malalignment was determined based on the authors’ review of radiographs at latest follow-up. Malalignment was measured in the coronal and sagittal planes, and the greatest malalignment was recorded. Leg-length inequality was determined based on the clinical exam described in the medical record. The presence or absence of pain was recorded based on the most recent follow-up visit in the medical record. Presence of pain was defined as consistent complaints of pain, whereas absence of pain was defined as no or intermittent complaints of pain. Any complication that led to unplanned surgery was considered a major complication. Complications that resolved with nonoperative management or did not require any treatment were considered minor. Fracture malalignment > 6 degrees and leg-length inequality >1 cm were considered minor complications, if these did not lead to unplanned surgery, as these criteria denote a “satisfactory” result, rather than an “excellent” result, in the Titanium Elastic Nails Outcome Scoring system.

Results

A total of 30 patients (21 boys and 9 girls) met the inclusion criteria for the present study. The average age of the patients in this study was 8.4 years and the average weight was 30 kg (range, 17 to 50 kg). There were no open fractures. 18 (60%) were length stable and 12 (40%) were length unstable fractures. Open plating was done in 19 patients and submuscular plating in 11 patients. Average length of hospitalization was 4.2 days. Post operative immobilization was used in 6 patients in the form of above knee slab. All 6 patients with post operative immobilised were of length unstable pattern. Patients were advanced to full weight bearing at an average of 9 weeks. Average time to radiographic union was 10.7 weeks. The implants were removed in all of patients at an average of 12 months after the initial surgery. The average length of follow-up was 2 years.

Table II: Demographic Data

<table>
<thead>
<tr>
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<th>Titanium elastic nail</th>
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<tbody>
<tr>
<td>Age yrs</td>
<td>8.4 (mean)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>21</td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
</tr>
<tr>
<td>Weight Kg</td>
<td>30 (mean)</td>
</tr>
<tr>
<td>Fracture Pattern</td>
<td></td>
</tr>
<tr>
<td>Length stable</td>
<td>18</td>
</tr>
<tr>
<td>Length unstable</td>
<td>12</td>
</tr>
</tbody>
</table>

Results were evaluated using Flynn titanium elastic nails coring system. Excellent results were demonstrated in 80%, satisfactory results in 17% and 1% of patients showed poor results. Major complications were seen in 1 patient and minor complications in 5 patients. Fracture malalignment was seen in 2 patients at the time of radiographic union. Varus was the most common deformity with which varied from 6-8 degrees. Leg length inequality was seen in 4 patients. All 4 patients with had affected limb longer than normal limb. 3 patients had affected limb longer by 1, 1.1 and 1.2cm. One patient had affected limb longer by 2.9cm. This patient required epiphysiodesis at 18 months from index surgery. At most recent follow up 1cm limb length discrepancy was recorded.

Discussion

There are few previous reports in the literature on the treatment of pediatric subtrochanteric femur

![Image](pic1.jpg)
fractures with modern instrumentation. Jarvis and colleagues retrospectively reviewed 13 skeletally immature adolescents who had undergone treatment of a subtrochanteric femur fracture with a variety of different techniques. The 3 patients who were managed nonoperatively had unsatisfactory radiologic outcomes, including fracture malalignment up to 16 degrees and shortening of the affected limb by an average of 2.6 cm. Despite the very small sample size, the authors concluded that internal fixation was more effective than nonoperative treatment. With the wide range of fixation options that are currently available for treatment of femur fractures in school-age children and skeletally immature adolescents, and the low risk of associated complications, we recommend against nonoperative management of subtrochanteric femur fractures in this age group.

Most of the literature on femoral shaft fractures treated with titanium elastic nails is on midshaft fractures. There is no consensus in the literature on the definition of a pediatric subtrochanteric femur fracture. Pombo and Shilt recently defined a pediatric subtrochanteric femur fracture as a fracture that is located within 10% of the total femur length below the lesser trochanter. The authors based their formula on the adult definition of a subtrochanteric femur fracture, which is any fracture that occurs within 5 cm below the lesser trochanter, and the average length of the adult femur. We chose to use this definition as it takes into account the difference in femur lengths at various ages, as well as the difference in femur lengths among children of the same age.

Although titanium elastic nails are currently the most popular treatment option for femoral shaft fractures in children and young adolescents, several studies have demonstrated suboptimal results with fractures in the proximal third of the femur and length-unstable fracture patterns. Frequently described complications include fracture shortening and angulation that lead to painful, prominent, or exposed nails, malunion, and leg-length discrepancy. Pombo and Shilt examined 13 pediatric patients with subtrochanteric femur fractures treated with titanium elastic nails. Two patients had a residual leg-length inequality, where the affected limb was longer by 1.3 and 1.6 cm, respectively. The leg-length inequality was thought to be secondary to physiological overgrowth. There were no other complications and no poor results. In our study limb lengthening was the most common complication which can be attributed to physiological overgrowth rather than to the specific technique. Only one patient required surgical intervention for limb lengthening which was 2.9 cm. Ho et al. reported a 22% complication rate with proximal third femur fractures managed with titanium elastic nails. In Flynn et al. series, the only patient with a poor Titanium Elastic Nails Outcome Score was an 11-year-old child with a proximal, oblique comminuted fracture that healed with 15 mm of shortening and 20 degrees of varus angulation. Both Narayanan et al. and Sink et al. reported a higher complication rate and risk of unplanned surgery with length-unstable femur fractures treated with titanium elastic nails.

Numerous studies have demonstrated good results with alternative methods of fixation for proximal third femur fractures and length-unstable femoral shaft fractures in children. Rathjen et al. reported similar results when length-stable and length-unstable pediatric femoral shaft fractures were treated with stainless steel flexible intramedullary nails. Distal locking of the stainless steel nails may prevent fracture shortening and reduce complications in length-unstable fractures. Caird and colleagues demonstrated a 10% complication rate in 60 pediatric patients with femoral shaft fractures treated with compression plating. Twenty-five percent of the fractures were in the proximal third of the femur. Kanlic and colleagues found a 4% complication rate in 51 pediatric femoral shaft fractures treated with submuscular plating. Twenty-four percent of the fractures were in the subtrochanteric region and 55% of the fractures were unstable. Sink et al. reported excellent results in 27 children with length-unstable femur fractures treated with submuscular plating. Sink et al. also showed a significant decrease in overall and major complications.
when unstable fractures were treated with submuscular plating compared with titanium elastic nails. Our results are comparable to study by Sink et al.

One limitation of this study is that being a retrospective study the data collected is dependent on accurate documentation in medical records. A second limitation is that the titanium elastic nailing score system was used for scoring. A third limitation is different technique for fixation by different surgeons as data was collected from 3 centers. Surgeons unfamiliar with submuscular plating might have chosen open plating methods.

In conclusion, our results indicate that open/submuscular plating of pediatric subtrochanteric femur fractures is associated with excellent outcome scores and a lower overall complication rate. length unstable subtrochanteric femur fractures are best treated with plating method rather than titanium elastic nails. The technique of plating, open or submuscular plating did not affect the outcome or complications.

References


