

Outcome of pediatric subtrochanteric femur fractures treated with titanium elastic nail

Ravindra Patil^{1,*}, Mohammed Abdul Azeem²

¹Associate Professor, Dr. VRK Women Medical College, Hyderabad, ²Assistant Professor, Dept. of Orthopedics, Shadan Institute of Medical Sciences, Hyderabad

***Corresponding Author:**

Email: drmazeem7@gmail.com

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 titanium elastic nail fixation of subtrochanteric femur fracture in children and young adolescents.

Methods: A total of 50 children aged between 5 to 12 years with subtrochanteric femur fracture treated with titanium elastic nail 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 7.9 yrs with 42 boys and 8 girls. 36(72%) fractures were length stable and 14(28%) were length unstable. 5(10%) had open fracture. Full weight bearing ambulation was achieved at an average of 6.6 weeks and radiological union at 10.7 weeks. Outcome results were excellent in 26(52%), satisfactory in 20 (40%) and poor in 4 (8%) patients. The major complications were seen in 4 (8%) patients and minor complications in 24 (48%) patients. Complication rate was higher for length unstable fractures than length stable fractures.

Conclusion: Our results indicate that subtrochanteric femur fractures treated with titanium elastic nail show excellent to satisfactory results in majority of patients, however minor complication rate in these fractures is pretty high, more so with length unstable subtrochanteric femur fractures.

Level of Evidence: Therapeutic level IV

Keywords: Subtrochanteric femur fractures, Pediatric, Treatment, Titanium elastic nails

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.^(1,2,3,4,5) Subset of femoral shaft fractures in subtrochanteric and supracondylar regions are at a higher rate of complications when treated with titanium elastic nails.^(1,2,6,7,8) 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 successful 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 titanium elastic nails 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⁽¹⁸⁾ (Pic 1). 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.



Fig. 1: Radiograph demonstrating the method used to define subtrochanteric fracture. If (a/b) multiplied by 100 is less than 10 the fracture was classified as subtrochanteric. A -distance between lesser trochanter to fracture site. B- total femur length defined as the distance between top of femoral head and medial epicondyle

Exclusion criteria were 1. Femur fractures that were not in the subtrochanteric region 2. Those treated with any method of fixation other than titanium elastic nails 3. Pathologic fractures 4. 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. The technique of elastic intramedullary nail have been described previously by many authors.^(13,15)

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 level⁷. 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.⁽⁶⁾

Table 1: Flynn titanium elastic nail outcome scoring system

	Excellent	Satisfactory	Poor
Malalignment degree	<5	6-10	>10
Leg length discrepancy cm	<1.0	1.0-2.0	>2.0
Pain	None	None	Present
Complication	None	Minor and resolved	Major complications/ lasting morbidity

Titanium Elastic Nails Outcome Scoring system⁽¹⁾ (Table 1) 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 50 patients (42 boys and 8 girls) met the inclusion criteria for the present study. The average age of the patients in this study was 7.9 years and the average weight was 30 kg (range, 17 to 50 kg). There were five (10%) open fractures. 36(72%) were length stable and 14 (28%) were length unstable fractures. Average length of hospitalization was 3.2 days. Post-operative immobilization was used in 28 patients

in the form of above knee slab. All 14 patients with length unstable pattern were immobilised postoperatively. Patients were advanced to full weight bearing at an average of 6.6 weeks. Average time to radiographic union was 10.7 weeks. The implants were removed in all of patients at an average of 10.4 months after the initial surgery. The average length of follow-up was 2 years.

Two patients had knee stiffness and underwent manipulation under anesthesia.

Table 2: Demographic data

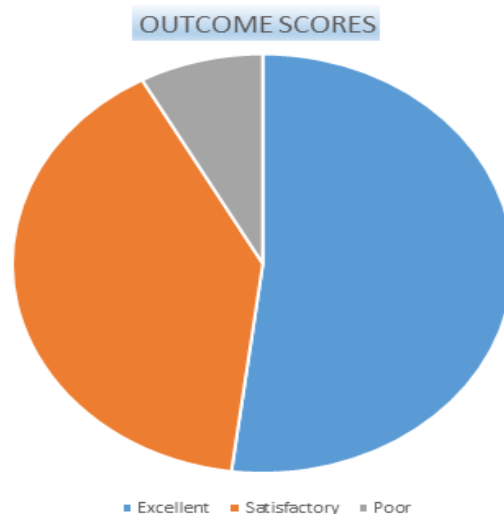
	Titanium elastic nail
Age yrs	7.9 (mean)
Sex	
Male	42
Female	8
Weight Kg	29 (mean)
Fracture Pattern	
Length stable	36
Length unstable	14

Results were evaluated using Flynn titanium elastic nails coring system. Excellent results were demonstrated in 52%, satisfactory results in 40% and 8% of patients showed poor results. Major complications were seen in 4 (8%) patients and minor complications in 24 (48%) patients (table III). Six patients had more than one complication. Fracture malalignment was seen in 8 patients at the time of radiographic union. Leg length inequality was seen in 8 patients. Pain from prominent implants was seen in 6 patients. Knee stiffness in 2 patients, Infection at insertion point in 2 patients, Saphenous nerve paresthesia in 2 patients, skin maceration from cast in 2 patients were other complications. Malalignment ranged from 6-15 degrees with varus being the most common deformity. All 8 patients with Malalignment belonged to length unstable group. leg length inequality ranged from 1 cm longer(2 patients) to 1 cm shorter(6 patients). Six patients with shortening had length unstable fracture pattern. Patients with a longer limb had length stable pattern of fracture.

Table 3: Complications

Fracture Malalignment	8
Leg length inequality	8
Affected limb long	2
Affected limb short	6
Pain from prominent implants	6
Knee stiffness	2
Infection	2
Nerve Injury	2
Skin maceration	2

4 patients(8%) treated with titanium elastic nail required surgery for major complications. Two patients underwent revision surgery to trim prominent nails.



Pic 2: Length unstable fracture with loss of reduction and Malalignment and shortening



Pic 3: Length stable fracture fixed with titanium elastic nails



Pic 4: Length stable subtrochanteric femur fracture treated with titanium elastic nail showing good union



Discussion

Most of the literature on femoral shaft fractures treated with titanium elastic nails is on mid-shaft fractures. To our knowledge this is the largest published series to date of pediatric subtrochanteric femur fractures treated with titanium elastic nail in school-age children and young adolescents.

There is no consensus in the literature on the definition of a pediatric subtrochanteric femur fracture.^(17,18,21) Pombo and Shilt recently defined a pediatric sub-trochanteric 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.⁽¹⁸⁾ 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.

There are few previous reports in the literature on the treatment of pediatric subtrochanteric femur 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 non-operatively 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 non-operative treatment.⁽²²⁾ 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

non-operative management of sub-trochanteric femur fractures in this age group.

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 1.6cm, respectively. The leg-length inequality was thought to be secondary to physiological overgrowth. There were no other complications and no poor results. The authors recommended advancing the lateral nail into or just distal to the greater trochanter apophysis, and advancing the medial nail into the femoral neck just short of the proximal femoral physis. This slight modification in the technique may decrease the forces at the fracture site, and help control rotation and angulation.⁽¹⁸⁾ Only 12 patients (24%) in our study had nails placed using this technique. Perhaps our complication rate would have been lower if this technique had been used for all of the patients treated with titanium elastic nails. Despite this technique modification, 2 patient still developed fracture shortening and increased angulation that resulted in revision surgery for trimming of nails.

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^(1,3) and length-unstable fracture patterns.^(1,3,6,8) Frequently described complications include fracture shortening and angulation that lead to painful, prominent, or exposed nails, malunion, and leg-length discrepancy.^(1,3,6-8) Ho et al⁽³⁾ reported a 22% complication rate with proximal third femur fractures managed with titanium elastic nails. Our study showed higher rate of complication 56% when compared to Ho et al. In Flynn et al⁽¹⁾ 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⁽⁶⁾ and Sink et al⁽⁷⁾ reported a higher complication rate and risk of unplanned surgery with length-unstable femur fractures treated with titanium elastic nails. Proximal third femur fractures or length unstable fractures treated with titanium elastic nails may benefit from additional postoperative immobilization^(1,4,6) although Sink et al⁽⁷⁾ did not find that routine use of a single-leg spica cast decreased the complication rate. In our study post-operative immobilization did not affect complication rate except for 2 patients who had skin maceration from cast. All 4 patients with major complications were immobilised with cast for 3-6 weeks and still developed complications.

Pic 5: Length unstable fracture treated with TENS**Pic 6: Lateral view length unstable fracture treated with TENS**

Numerous studies have demonstrated good results with alternative methods of fixation for proximal third femur fractures and length-unstable femoral shaft fractures in children.^(6-8,10-15) Rathjen et al⁽¹⁰⁾ 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.⁽⁹⁾ In our study no fracture was treated with stainless steel elastic nails. 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.⁽¹²⁾ 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.⁽¹⁴⁾ Sink et al⁽¹⁵⁾ 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. Similarly, we found that the complication rate was nearly 4 times higher for length-unstable subtrochanteric femur fractures treated with titanium elastic nails when compared to length stable patterns.

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 subtrochanteric fractures treated with other methods were not compared with titanium elastic nail. A third limitation is different technique for fixation by different surgeons as data was collected from 3 centers.

In conclusion, our results indicate that titanium elastic nail fixation of pediatric subtrochanteric femur fractures is associated with excellent outcome scores and a lower overall complication rate with length stable fracture patterns. Length unstable fracture have higher complication rate when treated with titanium elastic nails. Length unstable fracture fixation with submuscular or open plating need to be compared with titanium elastic nails in a randomized study to get a conclusive treatment for these difficult fractures.

References

1. Flynn JM, Hresko T, Reynolds RA, et al. Titanium elastic nails for pediatric femur fractures: a multicenter study of early results with analysis of complications. *J Pediatr Orthop.* 2001;21:4-8.
2. Flynn JM, Luedtke L, Ganley TJ, et al. Titanium elastic nails for pediatric femur fractures: lessons from the learning curve. *Am J Orthop.* 2002;31:71-74.
3. Ho CA, Skaggs DL, Tang CW, et al. Use of flexible intramedullary nails in pediatric femur fractures. *J Pediatr Orthop.* 2006;26:497-504.
4. Luhmann SJ, Schootman M, Schoenecker PL, et al. Complications of titanium elastic nails for pediatric femoral shaft fractures. *J Pediatr Orthop.* 2003;23:443-447.
5. Moroz LA, Launay F, Kocher MS, et al. Titanium elastic nailing of fractures of the femur in children. Predictors of complications and poor outcome. *J Bone Joint Surg Br.* 2006;88:1361-1366.
6. Narayanan UG, Hyman JE, Wainwright AM, et al. Complications of elastic stable intramedullary nail fixation of pediatric femoral fractures, and how to avoid them. *J Pediatr Orthop.* 2004;24:363-369.
7. Sink EL, Gralla J, Repine M. Complications of pediatric femur fractures treated with titanium elastic nails: a comparison of fracture types. *J Pediatr Orthop.* 2005;25:577-580.
8. Sink EL, Faro F, Polousky J, et al. Decreased complications of pediatric femur fractures with a change in management. *J Pediatr Orthop.* 2010;30:633-637.
9. Ellis HB, Ho CA, Podeszwa DA, et al. A comparison of locked versus non-locked enders rods for length unstable pediatric femoral shaft fractures. *J Pediatr Orthop.* 2011;31:825-833.
10. Rathjen KE, Riccio AI, De La Garza D. Stainless steel flexible intramedullary fixation of unstable femoral shaft fractures in children. *J Pediatr Orthop.* 2007;27:432-441.

11. Wall EJ, Jain V, Vora V, et al. Complications of titanium and stainless steel elastic nail fixation of pediatric femoral fractures. *J Bone Joint Surg Am.* 2008;90:1305–1313.
12. Caird MS, Mueller KA, Puryear A, et al. Compression plating of pediatric femoral shaft fractures. *J Pediatr Orthop.* 2003;23:448–452.
13. Hedequist DJ, Sink E. Technical aspects of bridge plating for pediatric femur fractures. *J Orthop Trauma.* 2005;19:276–279.
14. Kanlic EM, Anglen JO, Smith DG, et al. Advantages of submuscular bridge plating for complex pediatric femur fractures. *Clin Orthop Relat Res.* 2004;426:244–251.
15. Sink EL, Hedequist D, Morgan SJ, et al. Results and technique of unstable pediatric femoral fractures treated with submuscular bridge plating. *J Pediatr Orthop.* 2006;26:177–181.
16. Daum R, Jungbluth KH, Metzger E, et al. Results of treatment of subtrochanteric and supracondylous femoral fractures in children. *Chirurg.* 1969;40:217–220.
17. Jeng C, Sponseller PD, Yates A, et al. Subtrochanteric femoral fractures in children. Alignment after 90 degrees-90 degrees traction and cast application. *Clin Orthop Relat Res.* 1997;341:170–174.
18. Pombo MW, Shilt JS. The definition and treatment of pediatric subtrochanteric femur fractures with titanium elastic nails. *J Pediatr Orthop.* 2006;26:364–370.
19. Ligier JN, Metaizeau JP, Prevot J, et al. Elastic stable intra- medullary nailing of femoral shaft fractures in children. *J Bone Joint Surg Br.* 1988;70:74–77.
20. Metaizeau JP. Stable elastic intramedullary nailing for fractures of the femur in children. *J Bone Joint Surg Br.* 2004;86:954–957.
21. Ireland DC, Fisher RL. Subtrochanteric fractures of the femur in children. *Clin Orthop Relat Res.* 1975;110:157–166.
22. Jarvis J, Davidson D, Letts M. Management of subtrochanteric fractures in skeletally immature adolescents. *J Trauma.* 2006;60: 613–619.