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Original article

Treatment of pediatric femoral shaft fractures by stainless steel and titanium elastic nail system: A randomized comparative trial

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ABSTRACT

Purpose: Literature suggests that the lower modulus of elasticity of titanium makes it ideal for use in children compared with stainless steel. Better fracture stability was observed in association with titanium nails on torsional and axial compression testing. However, stainless steel nails are stiffer than titanium counterparts, which may provide a rigid construct when fixing paediatric femoral shaft fractures. Complications have been observed more frequently by various researchers when titanium nails are used for fracture fixation in patients with increasing age or weight. The concept of this study was to compare the functional outcome after internal fixation with titanium elastic nail system and stainless steel elastic nail system in paediatric femoral shaft fractures.

Methods: The study was conducted on 34 patients admitted in the department of orthopaedics, LLRM Medical College & SVBP Hospital, Meerut, India from January 2013 to August 2014. We included patients aged 5–12 years with fracture of the femoral shaft, excluding compound fractures, pathological fractures and other lower limb fractures. Patients were treated by titanium ($n = 17$) or stainless steel ($n = 17$) elastic nail system and followed up for one year. The clinical parameters like range of motion at hip and knee joints, time to full weight bearing on the operated limb and radiological parameters like time to union were compared between two groups. A special note was made of intra- and post-operative complications. Functional outcomes were analysed according to Flynn criteria.

Results: Based on the Flynn criteria, 59% of patients had excellent results, 41% had satisfactory results, and no one showed poor results. There was no clinically significant difference between the two groups with respect to time to union and full weight bearing. But the incidence of puncture of the opposite cortex while inserting the nail and trying to advance it through the diaphysis during operation is greatly different. Only one such case was observed in titanium group but five in stainless steel group.

Conclusion: Majority of paediatric femoral shaft fractures are now treated operatively by elastic stable intramedullary nails. Operative intervention results in a shorter hospital stay and has economic and social benefits over conservative treatment. The cost of stainless steel nail is one third the cost of titanium nail. However, the clinico-radiological results are not significantly different between titanium and stainless steel nails at one year follow-up as observed by our study.

Introduction

Studies have shown equal or superior stability of titanium nails over stainless steel nails.[1,2] Titanium V alloy has lower modulus of elasticity, higher yield strength, almost equal tensile strength, and better biocompatibility and MRI compatibility as compared to 316L stainless steel. Literature suggests that the lower modulus of elasticity of titanium compared with stainless steel makes it more ideal for use in children.[3,4] Better fracture stability was observed in association with titanium nails on torsional and axial compression testing by Mahar et al.[1] Titanium intramedullary nails are associated with a lower rate of infection as shown by various animal studies.

Stainless steel nails are stiffer than their titanium counterparts which may provide a rigid construct when fixing paediatric femoral

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shaft fractures.[5] The use of stainless steel nails for adolescent and obese children was suggested. Titanium nails have more chances of deformity due to their increased flexibility.[5] More frequent complications have been observed by various researchers when titanium nails are used for fracture fixation in patients with increasing age or weight.[6]

This study aims to compare the functional outcome after internal fixation with titanium elastic nail system and stainless steel elastic nail system of paediatric femoral shaft fractures.

Materials and methods

A total of 40 patients between the age of 5–12 years and with closed fractures of the femoral shaft presenting to emergency and orthopaedics were included in this study. Out of them 34 patients successfully completed one-year follow-up and were included in the analysis. Seventeen patients were managed with titanium nails (Group 1) and the same number of patients was managed with stainless steel nails (Group 2) according to randomisation table. Patients with compound fractures, pathological fractures, other lower limb fractures, or presence of any comorbid illness were excluded.

Preoperatively patients were placed in Thomas Knee splint with below knee skin traction. They were randomly assigned into Group 1 or 2 based on a randomization table. Elastic nails of standard length i.e. 440 mm and 2.0–4.0 mm in diameters were used. The diameter of the individual nail was selected based on Flynn et al's formula[7] (Diameter of nail = Width of the narrowest point of the medullary canal on AP and lateral views × 0.4 mm). The length of the nail was determined intraoperatively by fluoroscopy. Two nails of the same diameter were used.

The patients were placed on an orthopaedic fracture table and a reduction of the fracture by traction guided by fluoroscopy was done. Pre-angled nails which were angled at 45° about 2 cm from one end were used. An entry point was made with the help of bone awl approximately 2 cm above the physis on lateral side. A nail loaded onto a T handle was then inserted through the entry point into the medullary canal by rotator movements of the wrist and advanced upto fracture site. Another nail was introduced using the same technique from the medial side and advanced upto fracture site. The nails were then crossed across the already reduced fracture site one by one. It was ensured that both nails were in the canal across the fracture site by fluoroscopy. Traction was released when the nails crossed the fracture site and then they were advanced further. Medial nail was advanced till it was within 2 cm of proximal femoral capital physis whereas lateral nail was inserted till it was about 1 cm from greater trochantric physis. Nails were left protruding about 0.5–1.0 cm at the distal end for easy removal later on.[8]

In the postoperative period limbs were simply rested on the pillow or placed in a T-K splint based on postoperative reduction and preoperative fracture pattern. Sutures were removed on the 12th postoperative day. Patients were taught isometric straight leg raises, quadriceps and hamstrings strengthening exercises with active, active-assisted and passive knee range of motion. Non-weight bearing with axillary crutches was started immediately after operation when tolerated. Weight bearing status depends on fracture configuration after reduction but in general partial weight bearing was started at around 4 weeks and progressed to full weight bearing when bridging callus appeared and fracture line was not visible on X-rays. Patients were followed up at regular intervals of one month, three months and six months postoperatively. At each follow-up patients were assessed clinically, radiologically and the complications were noted. The nails were removed when complete healing of the fracture occurred (usually between 10 and 12 months). The final results were evaluated using the criteria of Flynn et al. A typical case is presented in Fig. 1.

Results

The average age of patients in this study was 8.6 years in Group 1 and 8.2 years in Group 2, including more males. The left side was involved in 70.59% and 82.35% of cases respectively (Table 1). As for the fracture location, the middle third femoral shaft was mostly involved, accounting for 58.82% in both groups. Transverse fracture was the most common fracture type in Group 1 (52.94%) while spiral pattern the most common in Group 2 (52.94%). Most fractures were Winquist type 1 comminution (Table 2). The mean time interval between trauma and surgery in Group 1 was 4.24 days and Group 2 was 5.35 days. Majority of the patients were immobilized in the postoperative period for about 4 weeks (64.71% and 70.59%).

Table 1
Demographic data of patients (*n*, %). In each group, the total number of patients is 17.

Group	Age (yr)	Gender		Involved side	
		Male	Female	Right	Left
Titanium	8.6	10 (58.82)	7 (41.18)	5 (29.41)	12 (70.59)
Stainless steel	8.2	11 (64.70)	6 (35.30)	3 (17.65)	14 (82.35)

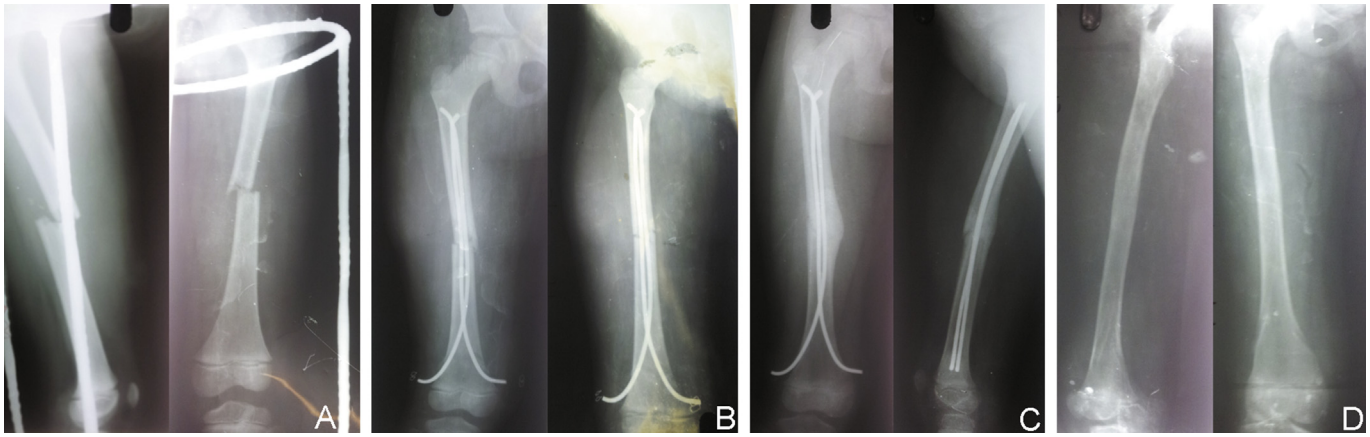

Fig. 1. A 7-year-old female child with transverse fracture of the middle third femoral shaft, Winquist type 1. **A**: Preoperative; **B**: Immediate postoperative; **C**: Three months after operation; **D**: After the removal of hardware.