European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 09, Issue 02, 2022

Stainless steel versus titanium elastic nail system in treatment of pediatric femoral shaft fractures: A comparative analysis

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Abstract

Femoral shaft fractures are one of the common fractures in paediatric age group. They represent approximately 1.6% of all bony injuries in children. The preference of treatment of femoral shaft fracture in each child depends upon age of the child, the location and type of the fractures. Elastic stable intramedullary nailing is the minimally invasive technique, the short operation time, and the preservation of the growth plate.
The purpose of the present study is to analyse the result of titanium and stainless-steel elastic nail in paediatric femoral fractures in 5-12 years of age group. No statistically significant difference was found in stability of fractures treated with both the methods. Both methods have their own advantages. Stainless steel nails are much cheaper as compared to titanium elastic nails which is important aspect in Indian scenario.

Keywords: Elastic nailing system, stainless steel, titanium, pediatric femoral shaft fractures

Introduction

Femoral shaft fractures are one of the common fractures in paediatric age group. They represent approximately 1.6% of all bony injuries in children. These fractures have bimodal age distribution with peak at 2 and 17 years. The preference of treatment of femoral shaft fracture in each child depends upon age of the child, the location and type of the fractures [1].
Traction and casting were observed as excellent treatment for all femoral shaft fractures in children from last generations. Duration of hospitalization was highest in case of femoral fractures. Advantages of Spica cast include low cost, better safety profile, acceptable leg length equality, healing time and motion [2]. The methods included external fixation, compression plating and intramedullary nailing with either rigid or flexible nails [3].
Elastic stable intramedullary nailing is the minimally invasive technique, the short operation time, and the preservation of the growth plate. Titanium and stainless steel are commonly

used to manufacture elastic nails. These metals provide adequate stabilization to the fractured bone [4]. Some complications have been reported in previous studies such as bursitis caused by the nail tip, delayed union, and non-union, commonly occur in patients with body weights of >55 kg or patients aged >13 years [5].

We know that the biomechanical properties of titanium are often outstanding as compared to those of stainless steel for intramedullary fracture fixation. *In vitro* mechanical studies have demonstrated equal or superior fixation of paediatric femoral fractures with use of titanium elastic nails as compared with stainless steel elastic nails [6].

Intramedullary nail fixation does not damage growth cartilage as it is a percutaneous technique. It keeps intact the fracture hematoma, maintains stability in three planes and provides opportunity to an early weight bearing giving an early rehabilitation at low cost with a minimal rate of complications [6]. it facilitates early weight bearing and walking. It aims to develop early bridging callus which contributes to rapid restoration of bone continuity [2]. In addition, it requires much less operative time and fluoroscopy time [7].

So, the purpose of the present study is to analyse the result of titanium and stainless-steel elastic nail in paediatric femoral fractures in 5-12 years of age group.

Materials and Methods

A total of 30 patients between the age of 5-12 years and with closed fractures of the femoral shaft were included in this study. Fifteen patients were managed with titanium nails (Group 1) and the same number of patients was managed with stainless steel nails (Group 2). Patients with compound fractures, pathological fractures, other lower limb fractures, or presence of any comorbid illness were excluded. Patients were divided in two groups, one group to be treated with stainless steel nailing and other with titanium elastic nailing. All patients were operated in supine position. 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.

The inclusion criteria were as follows

- Patients 5-12 years of age.
- Patients with diaphyseal femur fracture.
- Patients with closed fractures.
- Patients whose weight is less than 50 kilograms.

The exclusion criteria

- Patients with active infections.
- Patients with open fractures, pathologic fractures, fracture line that extend either to the
- Proximal or distal femur.
- Patients with head trauma.
- Non-ambulatory patients.
- Patients with presence of any comorbid illness.
- Patients whose weight is more than 50 kilograms.

Stainless steel nails of required length were used. Medial and lateral incisions were taken after proper preparation. Using awl, 2-2.5 centimetres proximal to physics, entry point was made. Nails were selected in a way that each nail should occupy at least 40% of canal by thickness. Nail lengths were predetermined on C-arm for stainless steel nailing. Two nails of similar thickness were bent approximately 25° at 1.5 centimetres from blunt ends. Both nails were passed up to fracture site. Closed reduction was done and whenever required open reduction was done and either of nail was passed in proximal fragment followed by second nail. Nails hammered to their final position. Thorough wound wash was given. Wounds closed in layers. Sterile dressing applied. Sutures were removed on outpatient basis between 10-14th day. Patients were allowed partial weight bearing to full weight bearing at between 8-12 weeks as per pain tolerance of patients X-rays were taken at every follow up. Clinically wound related complications and limb length discrepancy was monitored. Results were classified as per criteria described by Flynn *et al.* 2001 [2] all cases were at least followed for minimum duration of six months. Cases were further followed till the nail removal was done at varying periods.

Results

In this study, 30 patients are included 15 in each group. All the subjects are between the ages of 5-12. Minimum age for the groups was 5 years. Maximum age for stainless steel nailing group was eleven years and for titanium elastic nailing group was twelve years. The difference between the mean ages of patients was found statistically insignificant ($p > 0.05$) between two selected groups of stainless steel and titanium elastic nailing. It indicates that there was no age bias while selecting patients for treatment as regards to age. Both the groups include more males as compared to females. The left side was involved in 80% and 86.66% of cases respectively.

Table 1: Demographic data of patients (n %). In each group, the total number of patients is 15.

Group	Gender		Involved side	
	Male	Female	Right	Left
Titanium Group I	10(66.66%)	5(33.33%)	3(20%)	12(80%)
Stainless steel Group II	9(60%)	6(40%)	2(13.33%)	13(86.66%)

Table 2: Fracture location in patients

Group	Fracture location		
	Upper third	Middle third	Distal third
Titanium Group I	3(20%)	10(66.66%)	2(13.33%)
Stainless steel Group II	4(26.66%)	10(66.66%)	1(6.66%)

Middle third femoral shaft was mostly involved fracture location in both the groups that is 66.66%. In group I it was followed by upper third (20%) and then distal third (13.33%).In group II also same pattern was followed.

Table 3: Fracture type in patients

Group	Fracture Type		
	Transverse	Short Oblique	Spiral
Titanium Group 1	8(53.33%)	2(13.33%)	5(33.33%)
Stainless steel Group 2	4(26.66%)	2(13.33%)	9(60%)

In group I, Transverse type of fracture was most common which is in 8 patients where as in group II the spiral type of fracture was common in 9 patients.

Table 4: Time of full weight bearing and union

Time to full weight bearing and union	Titanium	Stainless steel
≤ 12 weeks	13	12
>12 weeks	2	3

There was no significant clinico-radiological difference in terms of time to full weight bearing and fracture site union between two groups.

Table 5: Different complications after the ESIN

Complication	Titanium (Group I)	Stainless-steel (Group II)
Pain at the site of insertion	8(53.33%)	6(40%)
Minor angulation	0	0
Limb lengthening discrepancy	1(6.66%)	1(6.66%)
Inflammatory bursa	2(13.33%)	3(20.66%)
Puncture of the opposite cortex	1(6.66%)	3(20.66%)

Minor complications were observed in 12 patients in Group I and 11 patients in Group II with no major complications. Eight patients in Group I and six patients in Group II reported pains at the site of nail insertion .Both groups have only one patient reported Limb lengthening discrepancy.

In group I, 2 patients and in group II, 3 patients experienced inflammatory bursa at the site of nail insertion. These problems resulted from surgical technique errors due to prominent hardware at the nail insertion site and did not produce long-term sequelae. Both pain and inflammatory bursa resolved within few weeks by giving oral antibiotics and analgesics. Range of motion at hip and knee was normal in all the patients. The most significant complication between two groups was puncture of the opposite cortex intraoperatively, which occurred while inserting the nail and trying to advance it through the diaphysis. It was observed in only one patient in Group 1 (6.66%) and in three patients in Group 2 (20.66%).

Discussion

Elastic stable intramedullary nailing is considered for the treatment of paediatric femoral shaft fractures due to its principles of elastic stability and balanced forces. (Attained by using the nails of the same diameter). There are certain advantages of ESIN such as early union, early mobilization, early weight bearing, acceptance of scar, minimally invasive surgery, privilege of prior selection of proper implant length (any excess nail length is cut off), easy implant removal and high patient satisfaction rate. Most important factor is that no power instrument is required for implant insertion [8, 9]. The cited advantages of titanium include a lower modulus of elasticity in comparison with stainless steel, biocompatibility, Osseo integration, and magnetic resonance imaging compatibility, whereas titanium has strength less than that of stainless steel [10, 11].

Therefore, most of the paediatric femoral shaft fractures are now treated surgically. Small incision is required for these procedures. They usually require less time and minimal blood loss occur without damaging epiphyseal area. This facilitates shorter hospital stay and has economic benefits. Some studies do compare titanium plates with stainless steel plates which show that the titanium plates led to the emergence of a small amount of periosteal callus without revealing any fracture instability. This also allows the radiological assessment of fracture union. Titanium plates also produced less bone loss and less soft-tissue reaction than stainless steel plates. In our study the number of patients with normal range of motion at hip and knee in Group I was 14 (93.33%), while in Group II the number was 15(100%). The average duration of progressing to full weight bearing in our study was 11.4 weeks.

The number of patients in Group I with union occurring across fracture site within 12 weeks was 12, While in Group II it was 13. The average duration was 11.8 weeks. El-Adl *et al.* [12] in their study recorded a mean of 12 weeks for union across fracture site.

In this study, minor complications were observed in 12 patients in titanium group and 11 patients in stainless steel group with no major complications. Wall *et al.* in their study reported that the malunion rate was significantly higher in the titanium group (23.2%; 13/56) than in the stainless-steel group (6.3%; 3/48) which was in contrary with our study. The risk of malunion was nearly four times lesser in the stainless-steel group than in the titanium group.

Almost similar results between two implants were noticed in the study by Rios *et al.* which is consistent with our study [13]. According to study performed by Lohiya *et al.* 2011, there was no difference in results with type of nail used in his series (p = 0.12). Furthermore, he concluded that stainless steel nails produce results similar to titanium nails at considerably lesser price [14]. In another study performed by Kumar *et al.* 2011 in sixty-two fractures treated with flexible intramedullary nailing, he found similar results of fractures stabilized with titanium elastic nails and stainless-steel nails [15].

In the present study, the total outcome according to Flynn's criteria was excellent in 58.82% of patients and satisfactory in 41.18% with no poor results.[2]The average time range from implantation to extraction was 11-12 months, and we could easily remove the hardware without any difficulty. Major limitation was that the exact biochemical properties and composition of the titanium and stainless-steel implant used in the study, which differs from manufacturer to manufacturer, was also not taken into consideration. This was also reported by Tank *et al.* [16]. The cost of Titanium elastic nail is almost three times the cost of stainless-steel system. However, there is no significant difference in clinico-radiological results of the two groups at one year follow-up.

Conclusion

We found that for femoral shaft fractures in paediatric age group between five to fifteen years, flexible intramedullary nailing is the effective method with excellent results and less complications. No statistically significant difference was found in stability of fractures treated with any of the method. Both methods have their own advantages. Stainless steel nails are much cheaper as compared to titanium elastic nails which is important aspect in Indian scenario.

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