



ISSN: 2395-1958  
IJOS 2018; 4(4): 850-857  
© 2018 IJOS  
www.orthopaper.com  
Received: 26-08-2018  
Accepted: 30-09-2018

**Dr. Sagar K**  
Asst Professor NRIIMS Vizag  
Department of orthopaedics,  
JJM Medical College, Davangere,  
Karnataka, India

**Dr. Vamsi Krishna Reddy D**  
Resident Department of  
orthopaedics, JJM Medical  
College, Davangere, Karnataka,  
India

**Dr. Ramesh R**  
Professor Department of  
orthopaedics, JJM Medical  
College, Davangere, Karnataka,  
India

## A clinical study of surgical management of diaphyseal fractures of shaft of femur in children and adolescents using flexible nails

**Dr. Sagar K, Dr. Vamsi Krishna Reddy D and Dr. Ramesh R**

DOI: <https://doi.org/10.22271/ortho.2018.v4.i4k.110>

### Abstract

**Aim and Objective:** In this study 20 patients, aged 5 to 16 years, with fracture shaft of the femur were treated with retrograde flexible intramedullary nailing at Bapuji Hospital and Chigateri General Hospital, attached to J.J.M. Medical College in the period from September 2013 to September 2015.

**Materials and Methods:** The study includes patients with femoral shaft fractures admitted and examined according to protocol. Associated injuries were noted. Clinical and radiological investigations were carried out and medical fitness for surgery to undergo flexible nailing fixation for the sustained fracture was taken.

Patients were followed up at 1,2,3,6 months intervals till fracture union and once at 1 year after surgery. A minimum of 20 cases were studied without any sampling procedure.

**Keywords:** laminectomy, cervical myelopathy, multilevel cervical cord compression, fusion, deformity

### Introduction

#### Inclusion criteria

- Children & adolescent patients between 5 to 16 years of age
- Stable femoral shaft fractures
- Type I Compound fractures

#### Exclusion criteria

- Patients aged less than 5 years and more than 16 years of age
- Patients medically unfit for surgery
- Comminuted and segmental fractures
- Type II & Type III Compound fractures
- Very distal (or) very proximal fractures that precludes nail insertion

Flexible intramedullary nailing of pediatric femoral fractures either with stainless steel or titanium (Nancy) rods can be performed either ante grade or retrograde. The benefit of elastic internal fixation is that a healthy environment for fracture healing with some motion leads to increased callus formation. Properly used,

Flexible intramedullary rods provide sufficient stability in the fracture so that a cast is not needed, but they lack the rigidity of an external fixation device, which inhibits fracture healing. This lack of rigidity and inability to lock the flexible rods may predispose to deformity either with angular or axial deviation in unstable fractures. The lack of rigidity also may create an environment in which muscle spasm and postoperative pain become more of a problem than with traditional rigid intramedullary fixation devices.

### Elastic nailing of femoral fractures carries with it a few controversies

(a) Straight versus bent rods, (b) titanium versus steel, (c) immobilization versus no immobilization postoperatively, and (d) ante grade versus retrograde insertion.

### Correspondence

**Dr. Vamsi Krishna Reddy D**  
Resident Department of  
orthopaedics, JJM Medical  
College, Davangere, Karnataka,  
India

Mechanical testing of femoral fracture fixation systems showed that the greatest rigidity is provided by an external fixation device and the least by flexible intramedullary rodding. Stainless-steel rods are stronger than titanium in bending tests. Stainless-steel rods have greater intrinsic strength and therefore are not as dependent on the opposing bend technique.

### Indications

- Useful in treating femoral shaft fractures in children between the ages of 5 to 16 years. In these patients rigid nail can damage the growth plate
- The indications in pediatric age group include femoral shaft fracture with head injury, polytrauma, spasticity, multiple long bone fractures. In < 10 years, loss of adequate alignment after conservative treatment and age group more than 10 years.
- Useful in treating femur shaft fractures in adolescents.
- Pertrochanteric fracture in an elderly patient whose general condition is not fit for internal fixing such as sliding screw.
- Uncomminuted shaft fractures of the femur
- In polytraumatized patient, flexible nails are useful for easy and quick fixation of the fracture.
- Useful in polio patients with fractures of the long bones.
- Fractures of the shaft of the humerus and tibia.
- The advantage is there is no shortening and malunion.

The general principle is to introduce the nails at the portal of entry, which is at the end of the bone, farthest away from the fracture.

### Advantages

- The avoidance of reaming and the use of small diameter flexible nails lessens the risk of injury to growth plates in the femur.
- There is no need of measuring the size of the nail as all nails come in same size and have to be cut accordingly.
- Avoidance of the distal growth plate is critical in any surgical intervention on an immature femur because of the amount of longitudinal growth arising from this area.<sup>43</sup>
- Biodynamic ally, it is advantageous because the fracture site takes an active part in the weight bearing process because of the telescoping effect and is brought under physiological compression because of muscle tension and weight bearing.
- The flexible pins, installed in the medullary canal, result in a shorter moment of force that helps to distribute stress more evenly along the length of long bones.
- In the case of femoral fractures, the pins distribute the stresses evenly along the entire length of the femoral cortices during weight bearing.
- Due to the relative ease and speed of intramedullary fixation with the flexible nail, operative time is usually decreased.
- The curvature and flexibility of the flexible nail give it a spring action as it passes through the medullary space, so that it may be deflected into good cancellor's bone.
- These nails permit a greater degree of bending at the fracture site than the conventional intramedullary rods and thus do not provide rigid internal fixation of the fracture. This may be the advantage they offer with early callus formation and healing compared with more rigid

form of fixation.<sup>9</sup>

- They provide axial stability and this form of fixation works best when there is good cortical contact at the fracture site.
- Traction forces are transformed to compression forces on the fracture by two bent pins that cross each other and touch the bone at three points.
- These nails provide three points fixation. First is in the isthmus, 2nd and 3rd in the distal metaphyseal cortex at the entry points of the medial and lateral nails.<sup>5</sup>

### Biomechanics of flexible nailing

The rigidity of the flexible intramedullary nail is adequate to the rigidity of the bone. Incoming forces, which lead to material breakage in rigid implants, are transformed and bend the implant. The elasticity of the implant and its ability of reversible deformation reset the intramedullary gliding nail into its original position due to resisting forces.

If the intramedullary gliding nail is present, arises a new 'zero point', that means that the reset forces reset the gliding nail in its 'new' point of origin.

Osteosynthesis with plates and screws concentrate all biomechanical forces in a one point compression zone, so that bending forces on one side induces big tension forces on the opposite one

In case of a rigid intramedullary nail which clamps inside the medullary canal, changing induced forces may lead to varus angulation of the bone due to implant deforming or may result in nail breakage.

The basic principles are two intramedullary gliding nails in opposite position which form a Y-shaped buttress. The induced forces on the implant are reduced at about 30 %.

The intramedullary gliding nail may absorb incoming forces, which lead to implant breakage in rigid implants, due to ability to reverse deforming.

Axial deforming forces (F) distract a gliding nail. It's reset-forces (R) correct the axial failure.

Frontal pushing forces distract both gliding nails. The appropriate reset-forces push them back into its original position.

In oblique fractures the axial induced force (F) is split into shearing (S) and a compression-component (C). The intramedullary gliding avoids and strengthens.

Rotational winding of the gliding nails one around each other built up tension to correct malpositioning.

A sagittal pushing force reduces the contact area within the intramedullary canal and provokes, due to induced tension, the reset of the fragments. If there are eccentric sagittal forces it leads to ante or recurvate which will be corrected by the elasticity of the implants.

The aim of this biological, minimally invasive treatment is to achieve a level of reduction and stabilization that is appropriate to the age of the child.

The biomechanical principle of the flexible nailing is based on the symmetrical bracing action of the two elastic nails inserted into the metaphysis, each of which bears against the inner bone at three points. This produces the following four properties: Flexural stability, axial stability, Translational stability, Rotational stability. All four are essential for achieving optimal results.

### Complications

- To avoid complications, the surgical procedure should never be started before adequate reduction.
- For the stability of the osteosynthesis, the anchorage of

the nails in the proximal fragment is of utmost importance

## Results

All the patients were followed until fracture union occurred. The follow up period ranged from 6 months to 2 years. Results were analyzed both clinically and radiologically.

**Table 1:** Age Distribution

Age in years	No. of cases	Percentage
5 - 8	12	60
9 - 12	7	35
13 - 16	1	5

Majority of the patients i.e. 12 (60%) were in the age group of 5-8 years, followed by 7 (35%) patients in 9-12 years. The youngest patient was 5 years and oldest patient was 14 years. The mean age in our study was 8.5 years.

**Table 2:** Sex Distribution

Sex	No. of cases	Percentage
Male	16	80
Female	4	20

Majority of the patients were males i.e. 16 (80%)

**Table 3:** Mode of Injury

Nature of trauma	No. of cases	Percentage
RTA	16	80
Fall from height	3	15
Fall while playing	1	5

The major cause of fracture in our study was RTA in 16 (80%) patients and fall from height in 3 (15%) patients.

**Table 4:** Side affected

Side affected	No. of cases	Percentage
Left	10	50
Right	10	50

Right femur was involved in 10 (50%) patients and left femur in 10 (50%) patients.

**Table 5:** Pattern of Fracture

Pattern of fracture	No. of cases	Percentage
Oblique	11	55
Transverse	6	30
Spiral	3	15

In the present series, 11 (55%) were oblique fractures, 6 (30%) were transverse and 3(15%) were spiral fractures.

**Table 6:** Level of the Fracture

Level of fracture	No. of cases	Percentage
Proximal	6	30
Middle	11	55
Distal	3	15

Middle1/3rd of the shaft was involved in 11(55%) cases and proximal1/3<sup>rd</sup> in 6 (30%) cases.

**Table 7:** Type of Fracture

Type of fracture	No. of cases	Percentage
Closed	19	95
Open	1	5

19 (95%) were closed fractures and 1 (5%) was open fractures. Open fracture belonged to Gustilo & Anderson Type I.

**Table 8:** Time interval between trauma and surgery

Reduction	No. of cases	Percentage
>24 hours	0	0
2-4 days	14	70
5-7 days	6	30
> 7 days	0	0

14 (70%) patients were operated between 2 to 4 days and 6 (30%) patients were operated between 5-7 days. The commonest time interval between trauma, and surgery was 2-4 days.

**Table 9:** Type of Reduction

Reduction	No. of cases	Percentage
Closed	17	75
Open	3	15

In 2 patients, fracture pattern was spiral. Closed reduction was attempted, but was not possible. Open reduction was done and fracture was fixed with flexible nails.

In one patient, the fracture was in the proximal 1/3rd. Closed reduction was attempted but was not possible.

**Table 10:** Type of nail

Type of nail	No. of cases	Percentage
Titanium nails	13	65
Stainless steel nails	7	35

In 65% of cases titanium nails were used and in remaining 35 % of cases stainless steel nails were used. Selection of nails was done based on patient affordability.

**Table 11:** Size of nail

Size of nail	No. of cases	Percentage
2 mm	6	30
2.5 mm	3	15
3 mm	8	40
3.5 mm	2	10

In most of the cases (40%) 3 mm diameter nails were used. 2 mm nails were used in 30 % of the cases and in other 15 % cases 2.5 mm were used. Only in one case 4 mm nails were used.

**Table 12:** Stay in Hospital

Hospital stay in days	No. of cases	Percentage
6 - 9	9	45
10 -12	5	25
>12	6	30

9 pts (45%) stayed in hospital for about 6-9 days.

**Table 13:** Time for union

Time for union	No. of cases	Percentage
8 weeks	8	40
10 weeks	6	30
12 weeks	6	30

Fracture union was defined as the period between operation and full weight bearing without external support and a radiographically healed fracture.

In our series, time to union ranged from 8 to 12 weeks

average being 10.2 weeks.

**Table 14:** Complications

Complications	No.of cases	Percentage
Limb lengthening		
> 5mm	-	-
< 5mm	-	-
Limb shortening		
> 5mm	-	-
< 5mm	-	-
Infection	2	10
Delayed union and non-union	-	-
Nail impingement at entry point	2	10
Mal alignment		
a. Varus angulation	-	-
b. Valgus angulation	-	-
c. Anterior angulation	-	-
d. Posterior angulation	-	-
e. Rotational malalignment	-	-
Knee Stiffness	2	10

**Postoperative Immobilization**

Postoperative immobilization was done if fracture is unstable. All patients were allowed to walk with the help of walker, not bearing weight on the operated limb from the 1st post-operative day.

**Follow Up**

Patients were followed up at intervals of 3 months, 6 months, 1 year and 2 years post-operatively. The functional outcome was assessed using Flynn’s scoring criteria.<sup>65</sup>

**Flynn’s scoring criteria**

	Excellent	Successful	Poor
Limb length Discrepancy	<1.0 cm	<2.0 cm	>2.0 cm
Mal-alignment	5°	10°	>10°
Pain	Absent	Absent	Present
Complication	Absent	Mild	Major complication and/or extended period for resolvable morbidity

According to Flynn’s criteria, result was excellent in 18 (90%) cases and Successful in 2 (10%) cases.

**Clinical Case 1**



**Fig 1: A. Pre-Op B. Immediate Post-Op**



**C. 3 Months Postop D. 1 Year Postop**



**E. After Implant Removal**

**Clinical Case 2.**



**Fig 2: A. Pre-Op B. Immediate Post-Op**



**C. 3 Months Postop D. 6 Months Postop**



**E. After Implant Removal**

**Discussion**

The treatment of femoral shaft fractures in children, particularly those who are between 5 to 14 years of age is

controversial. Operative treatment is becoming more-well accepted. Each of the surgical methods described have specific advantages and potential complications that must be appreciated by the treating surgeon. The present study was conducted to assess the results of flexible nail fixation of femoral shaft fracture in children and adolescent patients. Because of the increasing costs of health care, surgical fixation of children's fractures with resultant early mobilization and discharge from the hospital has become increasingly popular. Recognizing the relative safety and efficacy of femoral fracture fixation with flexible intramedullary nails, several large medical [23] children and adolescents, proving the value of this method.

**Age Distribution:** In the present study 12 (60%) of the patients were 5-8 years old and 7 (35%) were 9 to 12 years age group with the average age being 8.5 years. Fabiano Prata Nascimento *et al.* [23] treated femoral shaft fractures in age range 5 to 14 yrs with average age being 9.6 yrs. Alenjandro uribe Rios *et al.* [22] conducted a prospective study regarding effects of stainless steel flexible nails in children aged between 5 and 12 yrs, in a study group of 48 patients. The average age was 8.6 years.

**Sex Distribution:** There were 4 (20%) girls and 16 (80%) boys in the present study. The sex incidence is comparable to other studies in the literature. Fabiano Prata Nascimento *et al.* [23] reported that there were 16(53.3%) male patients and 14 female patients. There were 40 boys and 8 female in the study conducted by Alenjandro uribe Rios *et al.* [22] This male preponderance can be explained as boys are more active and are more prone for accidents and falls. Mode of Injury: In the present study RTA was the most common mode of injury accounting for 16 (80%) cases and fall from height accounted for 3 (15%) cases. Bar-on E, *et al.* [7] conducted study on 20 femoral shaft fractures. Motor vehicle accident was the cause of injury in 15 (75%) cases. In the study conducted by Alenjandro uribe Rios *et al.* [22] the commonest mechanism of injury was road traffic accidents in 37(77%) patients and 8 (16.7%) patients had fall from height. In the study conducted by Fabiano Prata Nascimento *et al.* [23] RTA was the most common mechanism. RTA was seen in 19(63.3%).

**Pattern of Fracture:** In our study, oblique fractures accounted for 11 (55%) cases, transverse fractures accounted for 6 (30%) cases and spiral fractures accounted for 3 (15%) cases. Heinrich SD, *et al.* [1] noted 35 (44.87%) transverse fractures and 14 (17.94%) oblique fractures in their study and Cramer KE. *et al.* [3] noted 35(61.4%) transverse fractures and 16 (28.07%) spiral fractures. In the study conducted by Fabiano Prata Nascimento *et al.* [23] they noted transverse in 18 patients, oblique in 8 patients, spiral in 2 patients and comminuted in 2 patients. Level of Fracture: Fractures involving the middle 1/3rd of the femoral shaft accounted for 11 (55%) cases and those involving the proximal 1/3rd accounted for 6 (30%) cases in our study. Ozturkman Y *et al.* [9] noted 18 (69.23%) fractures in the middle 1/3rd and 3(11.53%) fractures in the proximal 1/3rd of the shaft, whereas Heinrich SD *et al.*,5 noted 54 (69.23%) fractures in the middle 1/3rd and 10 (12.82%) fractures in the proximal 1/3rd of the shaft. Cramer KE. *et al.* [3] noted 40 (70.17%) fractures in the middle 1/3rd and 13 (22.8%) fractures in the proximal 1/3rd of the shaft.

**Type of fracture:** Most of the femoral shaft fractures in

children are closed injuries. In our study 19 (95%) cases were closed fractures and 1 (5%) case was an open fracture of Gustilo & Anderson Type I. Fabiano Prata Nascimento *et al.* 64 reported 28 (93.3%) closed and 2 (6.7%) open fractures. In the study conducted by Alenjandro uribe Rios *et al.* [22] 42 (82.3%) patients had closed fractures, 6 patients had type 1 compound fracture and 2 patients had type 2 compound fracture. Time interval between trauma and surgery: In the present series, commonest duration between trauma and surgery was 2 to 4 days. 14 (70%) underwent surgery within 2 to 4 days after trauma.

**Average duration between trauma and surgery** was 4.5 days in the study done by Kalenderer O, *et al.* [13] In our study 3 (15%) patients were operated within 24 hours. 23 (40.35%) patients were operated within 24 hours in Cramer KE, *et al.* [3] study. In the study conducted by Alenjandro uribe Rios *et al.* [22], the average time elapsed from initial injury to surgery was four days Type of Reduction: In our study, closed reduction was done in 17 (85%) cases and open reduction was done in 3 (15%) cases. In 2 patients, fracture pattern was spiral. Closed reduction was attempted, but was not possible. Open reduction was done and fracture was fixed with flexible nails. In one patient, the fracture was in the proximal 1/3rd. Closed reduction was attempted but was not possible. In 5 (6.41%) fractures, open reduction was done to facilitate passing the nail across the fracture site in Heinrich SD, *et al.* [4] study. Closed nailing was done in all cases in a study conducted by Fabiano Prata Nascimento *et al.* [23] In the study conducted by Alenjandro uribe Rios *et al.* [22] the fracture focus had to be opened to perform the reduction in 11 (21.5%) fractures.

**Type of nails used:** In our present study stainless steel flexible nails were used in 7 cases and in 13 cases titanium nails were used. The type of nail used depended on the affordability of the patient. In our country, titanium implants are costly; therefore stainless steel nails present an effective, more economical alternative in the treatment of femoral shaft fractures. The results reached in both the short and the long term are the same as those reached with titanium nails, as reported in the literature. Mechanical testing of femoral fracture fixation systems showed that the greatest rigidity is provided by an external fixation device and the least by flexible intramedullary rodding. Stainless-steel rods are stronger than titanium in bending tests. Stainless-steel rods have greater intrinsic strength and therefore are not as dependent on the opposing bend technique [22].

**Nail size used:** In most of the cases (40%) 3 mm diameter nails were used. 2 mm nails were used in 30% of the cases and in other 15 % cases 2.5 mm were used. Only in one case 4 mm nails were used. Post-operative mobilization/immobilization: In our study, no post-operative immobilization was done either in the form of pop cast or supplementary immobilization. Infante AF, *et al.* [8] treated 190 children with immediate hip spica casting, the average duration of immobilization in their study was 7 weeks. John Ferguson *et al.* [14] treated 101 children with immediate hip spica casting. They immobilized children on an average duration of 6 to 8 weeks with spica casting. The average length of immobilization in plaster was 67.4 days in Oss R.H. *et al.* [6] study. In the study conducted by Alenjandro uribe Rios *et al.* [63] no other immobilization treatments like plaster or orthosis were used. In the study conducted by Fabiano Prata Nascimento *et al.* [23] no casts for

supplementary immobilization were used. The advantage of the present study was early mobilization of the patients. Stay in the hospital: The average duration of hospital stay in the present study is 10.5 days. The mean hospital stay was 12 days in Kalenderer O, *et al.* [13] study. In a study conducted by Alenjandro uribe Rios *et al.* [22] the average length of hospital stay was 7.8 days. After surgery, the average length was 2.1 days for the group of patients with no associated injuries. Greisberg J *et al.* [10] compared the study of flexible intramedullary nailing with hip spica casting. They noted average hospital stay of 6 days in flexible intramedullary nail versus 29 days in hip spica casting group Average hospitalization time was 11.4 days in the study conducted by Mann DC, *et al.* [15] Gross RH, *et al.* [6] conducted a study on cast brace management of the femoral shaft fractures in children and young adults. The average length of hospitalization in their study was 18.7 days. Average hospitalization time in the study conducted by Fabiano Prata Nascimento *et al.* [23] was 9.43 days. Compared to the above studies conducted on conservative methods and cast bracing, the average duration of hospital stay was less in our study i.e. 11.4 days. Thereduced hospital stay in our series is because of proper selection of Patients, stable fixation and less incidence of complications. Time to union: In the present study, average time to union was 10.2 weeks. Oh C.W *et al.* [16]. reported average time for union as 10.5 weeks. Aksoy C, *et al.* [11] compared the results of compression plate fixation and flexible intramedullary nail insertion. Average time to union was 7.7 (4 to 10) months in the plating group and 4 (3 to 7) months for flexible intramedullary nailing. In the study conducted by Fabiano Prata Nascimento [23] *et al.* average healing time was 7.73 weeks. In our study, closed reduction of the fracture, leading to preservation of fracture hematoma and minimal soft tissue dissection led to rapid union of the fracture compared to compression plate fixation.

### Complications

**1. Range of motion:** All patients had full range of hip motion in the present study, 2 (10%) patients had terminal 45° restriction in knee flexion at 2 months, but normal range of knee flexion was achieved at six months. Loss of motion at the knee was seen in 14 (53.84%) patients in Herscovici *et al.* [19] study. Bar-On E, *et al.* [8] noted 20° loss of internal rotation at the hip in one patient treated with external fixation. Flynn J M *et al.* [16] atleast one case of knee stiffness in patients treated with spica casting which required manipulation under anaesthesia.

**2. Limb length discrepancy:** This is the most common sequele after femoral shaft fractures in children and adolescents. No patient in our study had significant limb length discrepancy (i.e.  $> \pm 2$ cm). Beaty *et al.* [51] reported, two patients had overgrowth of more than 2.5 cm necessitating epiphysiodesis, after conservative treatment. The mean limb length shortening was 0.35 cm in Kalenderer O, *et al.* [13] Ozturkman Y. *et al.* [9] observed mean leg lengthening of 7mm in 4 patients and mean shortening of 6mm in two children. Cramer KE, *et al.* [5] noted average limb lengthening of 7mm (range 119mm) in their study. Clinically significant limb discrepancy ( $> 2$ cm) did not occur in any patient in their study. Huber RI, *et al.* [52] noted children with femoral shaft fractures had a median difference in length compared with the other side of 0.5 cm. Gonzalez-Herranz P *et al.* [53] observed mean shortening of 32 mm (5 to 65mm) and average over growth of 11.4mm (5 to 20mm) in their

study conducted on spicacasting of the femur in children. John Ferguson *et al.* [12] noted more than 2cm shortening in 4 children after RLY spica treatment of pediatric femoral shaft fracture. In the study conducted by Alenjandro uribe Rios *et al.* [22] there were five cases of length discrepancy, two cases of 1-cm lengthening, and three cases of shortening (two of 1.5 cm, one of 1 cm). Fabiano Prata Nascimento *et al.* [23] showed the final shortening on the limb, after a follow-up period of at least 24 months, occurred in 6.7% of the cases (two patients), with 0.25 cm on average. Mazda K *et al.* [14] noted limb length discrepancy of more than 10mm in 3 (8%) of cases. Herndon WA, *et al.* [19] noticed limb length shortening ranging from 1 to 4.6cm in 7 patients. Comparing to limb length discrepancy in conservative methods, limb length discrepancy in our study was within the acceptable limits.

**3. Infection:** Superficial infection was seen in 2 cases in our study which was controlled by antibiotics. Pin tract infection is a major disadvantage of external fixation application. Baron E, *et al.* [9] reported 2 cases of deep pin tract infection in their patientstreated with external fixation. Blasier RD, *et al.* Davis TJ, *et al.* and Fein LH, *et al.* observed that the risk of pin tract infection ranges from 36% to 62% and the risk of refracture or fracture through a pin tract ranges from 0% to 36%. Alenjandro uribe Rios *et al.* [22] observed that there were two cases of superficial infection which were treated with oral antibiotics with no subsequent hospitalization, and without their final results being affected.

**4. Nail impingement at insertion site:** In the present series, nail impingement was seen in 2 (10 %) patients. In the study conducted by Fabiano Prata Nascimento *et al.* [23] acute complications were seen in two patients (6.7%). One had a migration of a nail and the other had a soft tissue irritation. The first patient needed a second intervention in order to have the tip of the nail cut. One felt pain during the first week postoperatively and needed another surgery to correct the loss of reduction of the fracture. In the study conducted by Alejandro *et al.* [22] seven (14%) cases of inflammation were observed at the insertion site because the nails were inserted within a cortical distance superior to the one suggested by the surgical technique; six of those cases occurred in the medial approach; and five required early reoperation (2 week) because of imminent skin injury.

**4. Mal-Alignment:** Some degree of angular deformity is frequent after femoral shaft fractures in children, but this usually remodels after growth. Varus/valgus malalignment: In our study there was no varus/valgus malalignment. Heinrich SD, *et al.* [10] reported 5° of varus angulation in one child in their study and 11 % of fractures had an average varus or valgus malalignment of 6°. John Ferguson MB, *et al.* [12] noticed 7° varus angulation in one patient in their study. Herndon WA, *et al.* [19] compared the results of femoral shaft fractures by spica casting and intramedullary nailing in adolescents. They noticed varus angulation ranging from 7 to 25° in 4 patients treated with spica casting and no varus angulation in surgical group. Herndon WA, *et al.* [64] noticed 12° valgus angulation in one patient treated with spica casting. Alenjandro uribe Rios *et al.* [22] observed two angular deformities in the valgus. Fabiano Prata Nascimento *et al.* [64] noticed valgus in 12(40%) and varus in 3(10%) patients. The varus and valgus malalignment that occurred in our study are within the acceptable limits. Antero posterior angulation: In the present study, there was no antero posterior angulation. Anteroposterior angulation ranged from 5.6° to 7.6° in

children treated with immediate spica casting in Infante AF, *et al.* [8] study. Ozturkman Y, *et al.* [9] noted an anterior angulation of 7° and a posterior angulation of 6° in 2 patients respectively. Herndon WA, *et al.* [19] noticed anterior angulation ranging from 8° to 35° in patients treated with traction and spica casting. 8% of the patients had an average anterior or posterior angulation of 8° in Heinrich SD, *et al.* [6] study. Bar-on E, *et al.* [27] noticed one case of posterior angulation treated by external fixation. Fabiano Prata Nascimento *et al.* [23] noticed 23(76.7%) anterior angulation and 5 (16.6%) posterior angulation.

**5. Rotational deformities:** A difference of more than 10° has been the criterion of significant deformity. In toeing or out toeing was not reported in our study, Heinrich SD, *et al.* [5] reported out toeing in 4 children with an average of 6° and two children with 7.5° of in toeing following flexible intramedullary nailing. No patient in our study had significant rotational deformity.

**6. Other complications:** In our study no proximal migration of nails was seen in any of the cases. Bar-on E, *et al.* [7] noticed proximal migration of the nail in one case. Kregor PJ, *et al.* [17] reported 13° anterior angulation in one case and overgrowth of the injured femur averaging 0.9cm in patients treated with compression plate fixation. Ward *et al.* [17] managed 24 children between the ages of 6 and 16 years old with 4.5mm DCP. Six patients had a limb length discrepancy of 1cm or more. One patient had bending of the plate and another had a stress fracture after the plate was removed. The advantages of the present study include minimal scarring, closed reduction, load sharing device, fracture heals by secondary callus formation which is more stronger and refracture is not a risk. Rigid intramedullary nailing is also described in the management of femoral shaft fractures. Raney EM, *et al.* [18] noticed premature closure of the greater trochanteric physis consequent to intramedullary nailing

## Conclusion

Based on our experience and results, we conclude that flexible intramedullary nailing is an excellent technique for the treatment of diaphyseal fractures of the femur in children and adolescents. → Road traffic accident is the most common mode of injury leading to femoral shaft fractures in children and adolescents. → Closed reduction is usually successful. → Flexible intramedullary nail introduction is easier. It provides stable fixation. → It is an excellent mode of treatment for simple transverse and oblique fractures of femoral shaft. → Closed intramedullary nailing is an efficient method and does not expose the patient to an undue risk of infection or non-union → Flexible intramedullary nailing leads to rapid union by means of preservation of the fracture haematoma and limited soft tissue exposure. → It appreciably reduces the length of the hospital stay and eliminates the need for prolonged rest in bed by providing early independent ambulation. Thus it reduces the morbidity and dependency of the patients. → There is no risk of significant limb length discrepancy → Varus/valgus, anteroposterior and rotational malalignments are within the acceptable limits with this procedure → In our country, titanium implants are costly ; therefore stainless steel present an effective, more economical alternative in the treatment of femoral shaft fractures. of the fracture haematoma and limited soft tissue exposure. → It appreciably reduces the length of the hospital stay and

eliminates the need for prolonged rest in bed by providing early independent ambulation. Thus it reduces the morbidity and dependency of the patients. → There is no risk of significant limb length discrepancy → Varus/valgus, anteroposterior and rotational malalignments are within the acceptable limits with this procedure → In our country, titanium implants are costly ; therefore stainless steel present an effective, more economical alternative in the treatment of femoral shaft fractures. There is no risk of premature greater trochanteric arrest, progressive coxa valga, avascular necrosis of the head of the femur and damage to the distal femoral physis when compared to rigid intramedullary nailing. → There is no risk of pin tract infection and refracture compared to external fixator application. → Functional results are excellent and complications are minimal. → This safe procedure can be recommended in children with multiple injuries, co-existent head injury and in children and adolescents aged 5 to 16 years.

## Summary

Twenty patients with diaphyseal fractures of the femur were treated with flexible-intramedullary nailing between September 2013 to September 2015, at Bapuji Hospital and Chigateri General Hospital, J.J.M. Medical College, Davangere. Children and adolescents aged between 5 to 16 years were included in the study with the average age being 8.5 years. Maximum number of patients were between 5-8 years of age and 80 % of the patients were boys. RTA and fall from height constituted for 95 % of the fractures in our study. 19 of the 20 fractures were closed and 1 was open (Type I Gustilo-Anderson). 11 (55%) were oblique, 6 (30%) were transverse and 3 (15%) were spiral fractures. 11 (55%) cases were located in the middle 1/3rd and 6 (30%) in the proximal 1/3rd of the femoral shaft. A thorough clinical and radiological examination was performed. All the patients were prepared and operated as early as possible once the general condition was stable and the patient was fit for surgery all the patients were operated on a fracture table. Closed reduction was done in 17 cases and fracture site was opened in 3 cases. We had difficulty in reducing 3 fractures. For those 3 cases, open reduction was done. None of the patients were immobilized postoperatively. Patients were allowed to do quadriceps and knee bending exercise in the 1st postoperative week. Average duration of stay in hospital was 10.5 days. All patients were allowed to walk with non-weight bearing depending on patient cooperation. The duration of follow up ranged from 6 months to 2 years. All the fractures were united between 8 to 12 weeks, with average time to union being 10.2 weeks All patients had full range of hip motion in the present study, 2 (10%) patients had terminal 45° restriction in knee flexion at 2 months, but normal range of knee flexion was achieved at six months. No patient in our study had significant limb length discrepancy (i.e. > ± 2cm). Superficial infection was seen in 2 cases (10%) in our study and was controlled by antibiotics. Nail impingement occurred in 2 cases. No patient had any malunion. Surgical management of diaphyseal fractures of femur in children and adolescents by flexible intramedullary nailing is simple, effective, provides early mobilization of the patients and rapid union. Functional results are excellent and complications are minimal. This procedure can be safely considered in the management of diaphyseal fractures of femur in children and adolescents aged 5 to 16 years.

## References

1. Operative stabilization of pediatric diaphyseal femur fractures with flexible intramedullary nails: A prospective analysis. *J Pediatr Orthop.* 1994; 14:501-507.
2. Carey TP, Galpin RD. Flexible intramedullary nail fixation of femoral fractures. *Clin Orthop and Rel Research.* 1996; 332:110-118.
3. Cramer KE, Tornetta P, Spero CR, Alter S, Miraliakbar H, Teefey J. Ender rod fixation of femoral shaft fracture in children". *Clin Orthop and Rel Research.* 2000; 376:119-123.
4. Keating J. *Cyclopedia of the disease of children*, Philadelphia JB. Lippincott. Speed K. 'Analysis of the results of treatment of fractures of femoral diaphysis in children under 12 years of age. *Surg Gynaec Obstet* 1921; 32:527-534
5. Rush LV. Dynamic intramedullary fracture fixation of the femur – Reflections on the use of the round rod after 30 years". *Clin Orthop and Rel Research.* 1968; 60:21-27.
6. Gross RH, Davidson R, Sullivan JA, Peeples RE, Hufft R. Castbrace management of the femoral shaft fracture in children and young adults. *J Pediatr Orthop* 1983; 3(5):572-582
7. Canale TS, Tolo VT. Fractures of the femur in children. *J Bone & Joint Surg.* 1995; 77-A (2):294-315
8. Infante AF, Jr Albert MC, Jennings WB, Lehner JJ. Immediate hip spica casting for femur fracture in pediatric patients - A review of 175 patients. *Clin Orthop and Rel Research.* 2000; 376:106-112.
9. Ozturkman Y, Dogrul C, Balioglu MB, Karli M. Intramedullary stabilization of pediatric diaphyseal femur fracture with elastic ender nails. *Acta Orthop Traumatol Jure.* 2002; 36(3):220-7.
10. Greisberg J, Bliss MJ, Ebersson CP, Solga P, d'Amato C. Social and economic benefits of flexible intramedullary nails in the treatment of pediatric femoral shaft fractures". *Orthopedics.* 2002; 25(10):1067-70.
11. Aksoy C, Caolar O, Yazyoy M, Surat A. Pediatric femoral fractures: A comparison of compression plate fixation and flexible intramedullary nail fixation. *J Bone & Joint Surg (Br).* 2003; 85-B(3):263.
12. Soames RW. *Skeletal system*: Williams PL, Bannister LH, Berry MM. A comparison of compression plate fixation and flexible intramedullary nail fixation. *J Bone & Joint Surg (Br).* 2003; 85-B(3):263.
13. Canale TS. Fractures and dislocations in children. In: Canale TS editor. *Campbell's Operative Orthopaedics*, 10th edition, St. Louis, Mosby. 2003; 2:1391-1568.
14. Kalenderer O, Agus H, Sanli C. Open reduction and intramedullary fixation through minimal incision with ender nails in femoral fractures of children aged 6 to 16 years". *Acta Orthop Traumatol Jure.* 2002; 36(4):303-9.
15. Ferguson J, Nicol RO. Early spica treatment of pediatric femoral shaft fractures. *J Pediatr. Orthop.* 2000; 20:189-92.
16. Mann DC, Weddington J, Davenport K. Closed ender nailing of femoral shaft fractures in adolescents. *J Pediatr Orthop.* 1986; 6(6):651-5.
17. Oh CW, Park BC, Kim PT, Kyung HS, Kim SJ, Inn JC. Retrograde flexible intramedullary nailing in children's femoral fractures. *Int Orthop.* 2002; 26(1):52-5.
18. Beaty JH, Austin SM, Warner WC, *et al.* "Interlocking intramedullary nailing of femoral shaft fractures in adolescents: preliminary results and complications. *J Pediatr Orthop.* 1994; 14:178-183.
19. Gonzalez-Herranz P, Burgos-Flores J, Rapariz JM, Lopez-Mondejar JA, Ocete JG, Amaya S. Intramedullary nailing of the femur in children-Effects on its proximal end. *J Bone and Joint Surg (Br).* 1995; 77-B:262-6.
20. Herndon WA, Mahnken RF, Yngve DA, Sullivan JA. Management of femoral shaft fractures in the adolescent". *J Pediatr Orthop.* 1989; 9(1):29-32
21. Ward WJ, Levy J, Kaye A. Compression plating for child and adolescent femur fractures. *J Pediatr Orthop.* 1992; 12:626-632.
22. Raney EM, Ogden JA, Grogen DP. Premature greater trochanteric epiphysiodesis secondary to intramedullary femoral rodding. *J pediatr Orthop.* 1993; 13:516-520.
23. Alenjandro Uribe Rios, Diego Fernando Sanm Arango. Carlos Oliver Valderrama Molina and Alvaro de Jesus Toro Posada. "Femoral shaft fracture treated with stainless steel flexible nails in children aged between 5 and 12 yrs at the HUSVP. *J Child Orthop.* 2009; 3:129-135.
24. Fabiano Prata Nascimento, Claudio Santili, Miguel Akkari Gilberto Waisberg, Susana dos Reis Braga, Patricia Maria Moraes de Barros Fucs. Short hospitalization period with elastic stable intramedullary nails in the treatment of femoral shaft fractures in school children. *J Child Orthop.* 2010; 4:53-60.
25. Flynn JM, Skaggs D, Sponseller PD, Ganley TJ, Kay RM, Leitch KK. The operative management of paediatric fractures of the lower extremity. *J Bone Joint Surg.* 2002; 84(12):2288-2300