Surgical Management Of Fractures Of The Femur Shaft In Children And Adolescents Using Flexible Nails - A Prospective Study

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Citation


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Abstract

In this prospective study 25 patients, aged 6 to 14 years, with fractures of the shaft of the femur were treated with retrograde flexible intramedullary nailing in the department of Orthopaedics at MMIMSR Hospital (Maharishi Markandeshwar Institute of Medical Sciences and Research) in the period from October 2012 to December 2013. Children and adolescents aged between 6 to 14 years were included in the study with the average age being 10.16 years. Maximum numbers of patients were between 9 to 11 years of age and 64% of the patients were boys.

RTA constituted for 60% of the fractures in our study and fall 40%. All fractures were closed 16 (64%) were transverse, 3 (12%) were oblique and 6 (24%) were spiral fractures.

23 (92%) cases were located in the middle 1/3rd and 2 (8%) 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 24 cases and fracture site was opened in one case. In one case the patient had an ipsilateral fracture of the femur shaft and the tibia.

On table open reduction was done and the patient was operated with flexible nailing at same time.

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 8.44 days. All patients were allowed to walk with non weight bearing depending on patient cooperation.

Patients were followed up to 6 months. All the fractures united between 10 to 12 weeks, with average time to union being 10.2 weeks.

All patients had full range of hip motion in the present study, 3 (12%) patients had 10 degree restriction of knee movements (flexion) which was corrected by rigorous physiotherapy, while 1 (4%) patients had terminal 45° restriction in knee flexion at 2 months, but normal range of knee flexion was achieved at six months.

In the present study, average limb lengthening was 0.6c m, average limb shortening was 0.5 cm.

No patient in our study had significant limb length discrepancy (i.e. > ± 2 cm).

Superficial infection was not seen in any case in our study. Nail impingement occurred in 3 (12%) cases. No patient had malunion.
According to FLYNN'S CRITERIA results evaluated as excellent in 22 cases (88%) and good in 3 (12%) cases.

Hence 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 6 to 14 years.

INTRODUCTION

Femoral shaft fractures account for 1.6% of all pediatric bony injuries. These fractures usually result from high energy force and the femoral shaft is subjected to major muscular deforming forces. Femoral shaft fractures usually result in haemodynamic instability when associated with intra-thoracic and intra-abdominal trauma (Wadell triad).

Fracture of the femur has bimodal incidence, the first peak is from 2 to 4 years of age and the second in mid-adolescence. It is almost agreed upon that the adult femoral shaft fractures are treated with intramedullary locking nail fixation.

However, there is little controversy over the treatment of infants and toddlers with femoral shaft fractures by using spica casting, but the treatment of pediatric and adolescent (age 6 to 14 years) femur fractures remains controversial.

Differences of opinion about treatment are greatest for patients who are too old for early spica casting and yet too young for adult type of management with a reamed nail.

Many options exist for treatment of fracture shaft femur although there is no one size fit all or cook book treatment algorithm.

Treatment options for femoral shaft fractures in children and adolescents.

A.) CONSERVATIVE METHODS:

a) Pavlik harness:

b) Immediate spica cast:

c) Traction and casting:

The two major drawbacks with this treatment are prolonged bed rest leading to separation of the child from routine activities and the expenditure incurred on the treatment during the stay in the hospital.

Time and clinical experience have shown that children with diaphyseal femur fracture do not always recover with conservative treatment. Angulation, malrotation and shortening are not always corrected effectively.

The management of paediatric femoral shaft fracture has evolved gradually in past decade towards more operative approach. This is because of a more rapid recovery and reintegration of the patient.

B) OPERATIVE METHODS:

a) External fixation:

b) Internal fixation

1) Compression Plating

2) Locked Intramedullary Nailing

3) Elastic Intramedullary Nailing

Antergrade locked intramedullary nailing techniques have shown a risk of proximal femoral deformities and avascular necrosis of the femoral head.

Complications arising out of fracture shaft femur in the paediatric age group and adolescents like limb length discrepancy, angular and rotational deformities, delayed union, non union, neurovascular injury, muscle weakness, are not effectively corrected by conservative methods.

The American Academy of Orthopaedic Surgeons (AAOS) developed guidelines and recommended intramedullary flexible nailing for paediatric femur diaphyseal fractures aged five to eleven years.

In this study we have extended our scope to evaluate the functional outcome of femoral shaft fractures in children and adolescents treated with intramedullary flexible nailing from age group 6 to 14 years. The study also included part of femoral shaft fractures adjoining the mid shaft in the proximal one third.
AIMS AND OBJECTIVES

OBJECTIVES:

To verify the advantages of operative method (elastic nail) in treating fractures of the femur shaft in children and adolescents in view of:

- Functional outcome
- Duration of union
- Complications (limb length discrepancy, angular deformity, infection)

REVIEW OF LITERATURE

HISTORICAL REVIEW:

On referring to the literature on fractures of the femur in children, one is at once struck by the wide variance as to the relative importance of the way to handle the cases. The English influenced by Pott, managed a patient on his side with the hip and knee flexed. Splinting was suggested as an alternative.

In the year 1890, at John Hopkins hospital, a full spica cast was introduced for the first time. Keating pointed out in 1890 that growth acceleration corrected shortening. Trials at open reduction using the lane plate or beef bone plates, intramedullary bone plugs of ivory or fresh bone, bone suturing with wire or external fixation apparatus failed to show acceptable results.

REVIEW OF COMPARATIVE STUDIES:

Rush LV (1968) studied about 211 cases of fractures of the femur shaft. He observed that a curved rod driven deeply into the lateral condyle enhances the fixation dynamically by 3 point pressure.

Gross RH et al (1983) conducted a study on 72 patients aged 5-19 years sustaining femoral shaft fractures which were treated with immediate cast bracing. They observed that adolescent males with a mid shaft fractures were the most difficult to manage and in this situation closed intramedullary nailing is recommended.


They concluded this procedure should be considered for the treatment of femoral shaft fractures in this age group.

Reeves RB et al (1990) performed comparative studies between groups of adolescents with a femur fracture treated operatively and treated by conventional traction and casting techniques. The operative group had better results with a shorter hospitalization time and reduced patient costs than did the non-operative groups.

Galpin RD et al (1994) conducted a retrospective study in 37 fractures of the femur in 35 skeletally immature patients of which 6 cases were treated by using Ender nails. Trochanteric arrest was not seen in any of the flexible nailing.

Karaoglu S et al (1994) concluded that in the adolescent age group ender nailing of femoral shaft fractures should be considered owing to the functional recovery with low morbidity and cost, providing early ambulation, early discharge from hospital and early return to school.

Canale TS et al (1995) observed that open reduction and plate fixation of femoral fractures in the age group of 5 to 10 years old children will result in femoral over growth and limb length discrepancy.

Carrey TP and Galpin RD (1996) have reported that flexible nailing seems better suited to paediatric femoral fractures because most have a stable pattern.

Skak SV et al (1996) conducted a long term follow up of 52 femoral shaft fractures treated by internal fixation in 50 children and adolescents. They noted that rigid intramedullary nailing should not be used in patients with open physes.

Bar-on E et al (1997) recommended the use of flexible intramedullary nailing for most paediatric fractures of the femoral shaft which justify surgery. They reserve external fixation for open or severely comminuted fractures.

Infante AF et al (2000) observed that the larger the child is the more difficult it will be to control the fracture with the hip spica cast and harder it will be to transport the patients in the hip spica cast. This has prompted orthopaedic surgeons to pursue surgical treatment for children with isolated femoral shaft fractures.

Lee SS et al (2001) observed that length and rotational control of midshaft femur fractures with two divergent ender nails may be sufficient for early mobilization.

Yamaji T et al (2002) indicated that the elasticity of the fixation obtained with ender nailing promotes more callus formation than rigid internal fixation.
formation.29

Ozturkman Y et al (2002) evaluated the results of using ender nails in femur shaft fracture in children. Union was achieved in all patients with a mean of 6.6 weeks. The femur length remained equal to that of the contralateral side in 76% of the cases. All but one patient had a symmetric walking pattern.15,30

Greisberg J et al (2002) compared patients treated with flexible IM nailing and spica casting. Patients treated with flexible IM nails achieved earlier independent ambulation, at an average of 19 days, compared to 106 days in the control group. They also attained earlier independent bathroom use (21 versus 79 days). Hospital stays were significantly shorter as well (6 versus 29 days). They observed that earlier return to school, independent ambulation, and independent bathroom use are advantages of this treatment modality.31

Aksoy C et al (2003) compared the results of compression plate fixation and flexible intramedullary nailing in 36 femoral shaft fractures in children. They observed that flexible intramedullary nailing maintains shorter operation time and shorter time to healing. The lack of need of post-operative immobilization and small incision for the insertion of the nail which is cosmetically more acceptable are the other advantages of this method.32

Khurram BARLAS & Humayun BEG (2006) recommended the use of flexible intramedullary nailing for most pediatric fractures of the femoral shaft between 5-15 years age which require surgery, as it is a safe procedure and produces reliable results.33

M. Khazzam et al (2009) demonstrated that use of flexible intramedullary nails in the treatment of femoral shaft fractures in children is successful regardless of patient age, fracture location, or fracture pattern.34

Alenjandro Uribe Rios et al (2008) conducted a prospective study regarding effects of stainless steel flexible nails in children aged between 5 and 12 years in a study group of 48 patients. They observed that this method was more effective. They also observed that the results provided a less expensive alternative. The average length of hospital stay was 7.3 days. Based on their study, this procedure has been highly recommended in fracture shaft of femur in this age group.35

Fabiano Prata Nascimento et al (2009) evaluated the safety and period of hospitalization of the treatment of femoral shaft fractures with titanium elastic nails (TEN) in the age range 5 to 14 years. The hypothesis was that TEN might be a low cost treatment, with good clinical results and short length of hospitalization.

In this study the patients spent an average of 9.4 days in hospital. The average period for the healing process was 7.7 weeks. Partial weight bearing was permitted 3.3 weeks after surgery. The incidence of overgrowth was 60%, with an average of 0.40 cm.36

Frech – Dorfler M, Hasler CC et al (2010) reported that immediate hip spica for unstable femoral shaft fracture in preschool children is still an effective option. They rationalized their study on the basis of great remodeling potential in preschool children.37

Shital N.P arikh, Viral V Jain, Jame Denning, et al (2012) conducted a prospective study to enumerate complications of flexible nailing which includes limb length discrepancy, nail impingement at entry point, superficial infection, proximal migration of nail, malalignment and joint stiffness with inadequate physiotherapy regime.38

MECHANISM OF INJURY

The etiology of femoral fracture in children varies with the age of the child. In children younger than walking age up to 80% of femoral fractures may be caused by abuse. 39, 40 In older children, femoral fractures are most likely to be caused by high velocity injuries, such as motor vehicle accidents which account for over 90% of femoral fracture in this age group. 41,42

A femoral fracture in a young child with no history suggestive of abuse or significant trauma should suggest the possibility of osteogenesis imperfecta.43

Generalized osteopenia may accompany neurologic diseases, such as cerebral palsy or myelomeningocele, leading to fracture with minor trauma in osteopenic bone.44 Stress fractures may occur in any location of the femoral shaft. Most occur in adolescents involved in sports activity such as foot ball and track.45

MATERIAL AND METHODS

In this prospective study 25 patients, aged 6 to 14 years, with fractures of the shaft of the femur were treated with retrograde flexible intramedullary nailing in the department of Orthopaedics at MMIMSR Hospital (Maharishi
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Markandeshwar Institute of Medical Sciences and Research in the period from October 2012 to December 2013.

Method of data collection:

The study included patients with femoral shaft fractures admitted and examined according to our 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, and 3 months intervals until fracture union was obtained and once at 6 months after surgery.

A sample size of 25 cases was selected randomly.

Inclusion criteria:

• Children and adolescent patients between 6 to 14 years of age
• Femoral shaft fractures (AO Type A1.2, A2.2, A3.2)
• Type I and II compound fractures

Exclusion criteria:

• Patients aged less than 6 years and more than 14 years of age
• Patients medically unfit for surgery
• Comminuted and segmental fractures (AO Type B and C)
• Type III Compound fractures
• Very distal (or) very proximal fractures that precludes nail insertion

As soon as the patients were brought to the hospital the patient’s airway, breathing and circulation were assessed. Then a complete survey including neurological assessment was carried out to rule out other significant injuries. On admission, patients were put through a thorough clinical examination and the general condition was assessed regarding hypovolemia, associated orthopaedic or other systemic injuries and resuscitative measures were taken accordingly which included intravenous fluids, splintage in Thomas splint or skin traction, continuous oxygen inhalation and closed monitoring for signs and symptoms of fat embolism.

Wounds when present were cleaned thoroughly; analgesics, antibiotics, tetanus toxoid, tetanus immunoglobulins and blood transfusion were given as needed.

A detailed history was taken, relating to the age, sex, occupation, mode of injury, past and associated medical illness.

Plain radiographs of AP and lateral views of the femur were taken including both hip and knee joints, to assess the extent of fracture comminution, the geometry and the dimensions of the fracture, i.e. fracture lines that propagate beyond the obvious fracture.

Radiographs of whole length of femur with knee and hip joints were mandatory in all patients to avoid missing of associated fractures of the trochanter and neck of femur.

Routine haematological investigations were done for all patients. Patients were operated as early as possible once the general condition of the patient was stable and fit for surgery.

Implant:

Flexible intramedullary nailing (stainless steel) was performed retrograde in all our patients. Flexible intramedullary nails are available in 2 mm, 2.5 mm, 3 mm, 3.5 mm, and 4 mm sizes.

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 nails 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 nail may predispose to deformity either with angular or axial deviation in unstable fractures.

Nail width:

The width of the canal is measured at the narrowest point (isthmus) in the diaphysis on both the AP and lateral view, and this number is divided by 2. This represents the maximum diameter of the nail that can be used and generally a nail at least 0.5 mm smaller than this radius should be used.
MEASUREMENT OF NAIL WIDTH:

**NAILS:**
Flexible nails are available in sizes of 2 mm, 2.5 mm, 3 mm, 3.5 mm, and 4 mm in both stainless steel and titanium.

**CURVED BONE AWL:**
Used to enlarge medullary space at the distal end of the femur.

**SKIN PROTECTOR:**
Protects bone and soft tissue at the surgical site.

**INTRODUCER/SETTING DEVICE:**
Inserts flexible nail into the prepared hole at the distal end of the femur.

**NAIL BENDER:**
Used for bending flexible nail.

**EXTRACTOR:**
Extracts flexible nail from femoral canal

**OPERATIVE PROCEDURE**

General anaesthesia was used in younger children and spinal anaesthesia was used in older children and adolescents. Under anaesthesia, the patient was put in supine position on the fracture table. The opposite limb was held on a knee rest with the hip flexed 90 degrees and abducted 30 degrees and the knee in 90° of flexion to allow visualization of the entire femur in both AP and lateral views with image intensifier. The image intensifier unit was positioned on the unaffected side of the patient.

Hip, thigh and knee regions were painted and draped. The image intensifier was used to localize the placement of skin incisions by viewing the distal femur in the AP and lateral planes. The level of the insertion of flexible nail should be 2.5 to 3 cm proximal to the distal femoral physis in the AP view and it should be in the middle of the cortex in the lateral view.

Incision of about 2 to 3 cm was put on both medial and lateral aspects of the thigh at the site of insertion of the nail. Soft tissue was split and the bone was exposed on both sides. A hole was made in the cortex by using 4.5 mm drill bit and then a bone awl was used to widen the cortical hole in the bone. The awl was then inclined 10° anteriorly and steeply angled in the frontal plane to facilitate passage of the nail through the dense paediatric metaphyseal bone.

Nail bending:
A gentle 30° bend was placed in the nail with the apex at what will be the level of the fracture. Next the nail tip was bent to facilitate placement and to allow the nail to bounce off the opposite cortex at the time of insertion.

Upon insertion, the nail glanced off the cortex as it advances towards the fracture site. Both medial and lateral rods were inserted to the level of the fracture.

At this point, the fracture was reduced using longitudinal traction and closed manipulation. After the first nail was driven approximately 2 to 3 cm across the fracture, the 2nd nail was driven across the fracture. The two nails then were driven into the proximal end of the femur with one driven toward the femoral neck and the other toward the greater trochanter. Fluoroscopy was used to confirm satisfactory reduction of the fracture and to ensure that the nails have not comminuted the fracture as they were driven into the proximal fragment. The nails were pulled back approximately 2 cm, the end of each rod was cut, and the rods were driven back securely into the femur. The end of the nail should lie adjacent to the bone of the metaphysis but should be at least 1 cm distal to the insertion hole to allow ease in later removal. Bending the nail ends should be avoided because it can cause a painful bursa over the nail end. Open reduction was done when closed reduction was not successful.

The incised wounds were then washed with betadine and normal saline and skin was sutured. Sterile pads were put and compression bandage was applied.

**COMPLICATIONS DURING OPERATIVE PROCEDURE**

In three patients nail tip was bent and cut too distally. One patient had an ipsilateral fracture of the femur shaft and tibia for which intra operative fracture reduction was
difficult.

IV antibiotics were given for total of three days and switched over to oral antibiotics for another five days. Quadriceps strengthening and active assisted range of motion exercises were began immediately. Knee bending exercises were started according to the patient's pain tolerance. Sutures were removed on the 10 postoperative day and patients were discharged when deemed fit for so.

The patients were mobilized with non weight bearing as soon as the pain and the general condition permitted.

Partial weight bearing was commenced after radiological assessment at 6 weeks postoperatively with walker.

Follow up:

Further follow ups were done at 1 month, 2 month, 3 months, and 6 months. Each patient was individually assessed clinically and radiographically.

Observations were made regarding the alignment of the fracture, the range of motion of knee and hip, limb length discrepancy, degree of pain or swelling and rotational deformity of the femur.

Rotational deformities were measured by using foot progression angle.

**METHOD TO MEASURE FOOT PROGRESSION ANGLE:**

The foot-progression angle (FPA) is estimated by observing the child's gait. It is defined as the angular difference between the axis of the foot and the line of progression.

**OPERATIVE PHOTOGRAPHS**

![Figure 1](image1.jpg)

**Figure 1**

Instrument Set

![Figure 2](image2.jpg)

**Figure 2**

Patient position on the operative table
Surgical Management Of Fractures Of The Femur Shaft In Children And Adolescents Using Flexible Nails - A Prospective Study

Figure 3
Draping

Figure 4
Opening the entry site

Figure 5
Entry site widened using bone awl

Figure 6
Introduction of the flexible nail

Figure 7
Both nails passed up to fracture site
Figures 8&9
Medial nail passed beyond fracture site & Lateral nail passed beyond fracture site

FUNCTIONAL ASSESSMENT:
The functional assessment was assessed based on FLYNN’S CRITERIA which included:

- Limb length discrepancy
- Angulation in degrees
- Pain
- Complications

GRADING OF RESULTS ACCORDING TO FLYNN’S CRITERIA:

EXCELLENT
A. Limb length discrepancy < 1cm.
B. Angulation < 5 degrees
C. Pain absent
D. No complication

GOOD
A. Limb length discrepancy 1 – 2 cm
B. Angulation 5-10 degrees
C. Pain absent
D. Minimal complication

POOR
A. Limb length discrepancy >2 cm
B. Angulation > 10 degrees
C. Pain present
D. Extended co morbid complications.

STATISTICAL ANALYSIS
The data for quantitative variables was presented as mean ± SD or median and interquartile range, as appropriate. For categorical variables number and percentages was calculated. Chi-square test or Fisher’s exact test was be applied to see the association between different variables.

Multivariate Regression analysis was applied to assess the independent contribution of different factors to outcome. A p value of < 0.05 was considered to indicate statistical significance. All calculations were two sided and performed using SPSS version 15 (Statistical Packages for the Social Sciences, Chicago, IL).

RESULTS
All the patents (25 cases) were followed until fracture union occurred. The follow up period ranged from 1 month to 6 months. Results were analyzed both clinically and radiologically.

Table 1
Age incidence

<table>
<thead>
<tr>
<th>AGE</th>
<th>GENDER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>6 to 8</td>
<td>4 (16%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>9 to 11</td>
<td>8 (32%)</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>12 to 14</td>
<td>4 (16%)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16 (64%)</td>
<td>9 (36%)</td>
</tr>
<tr>
<td>Mean ± S.D</td>
<td>9.5 ± 2.9</td>
<td>10.22 ± 2.3</td>
</tr>
</tbody>
</table>

12 (48%) patients were in the age group of 9-11 years, followed by 7 (28%) patients in 12 to 14 years. The youngest patent was 6 years and oldest patient was 14 years. The mean age in our study was 10.16 years.

Table 2
Sex incidence

<table>
<thead>
<tr>
<th>Sex</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
<td>36</td>
</tr>
</tbody>
</table>

Majority of the patents were males i.e. 16 (64%) and 9 (36%) females.

Table 3
Pattern of Fracture vs Nature of trauma

<table>
<thead>
<tr>
<th>Fracture Pattern</th>
<th>Nature of Trauma</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oblique</td>
<td>RTA</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>Spiral</td>
<td>While playing</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>Transverse</td>
<td></td>
<td>9 (36%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>15 (60%)</td>
</tr>
</tbody>
</table>

Chi-square value = 2.344, p = 0.3310

The major cause of fracture in our study was RTA 15 (60%) in patients and fall while playing in 10 (40%) patients.
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- A Prospective Study

Table 4
Pattern of Fracture vs Side affected

<table>
<thead>
<tr>
<th>FRACUTURE PATTERN</th>
<th>SIDE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>Oblique</td>
<td>2 (8%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Spiral</td>
<td>4 (16%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>transverse</td>
<td>3 (12%)</td>
<td>13 (52%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>9 (36%)</td>
<td>16 (64%)</td>
</tr>
</tbody>
</table>

Chi square value = 5.740, p= 0.57

Right femur was involved in 16 (64%) patents and left femur in 9 (36%) patients.

Table 5
Pattern of Fracture

<table>
<thead>
<tr>
<th>Pattern of fracture</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td>Oblique</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Spiral</td>
<td>6</td>
<td>24</td>
</tr>
</tbody>
</table>

In the present series, 16 (64%) were transverse fractures, 3 (12%) were oblique and 6 (24%) were spiral fractures.

Table 6
Pattern of Fracture vs Level of the Fracture

<table>
<thead>
<tr>
<th>FRACUTURE PATTERN</th>
<th>LEVEL OF FRACTURE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Middle</td>
<td>Proximal</td>
</tr>
<tr>
<td>Oblique</td>
<td>3 (12%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Spiral</td>
<td>4 (16%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Transverse</td>
<td>16 (64%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>23 (92%)</td>
<td>2 (8%)</td>
</tr>
</tbody>
</table>

Chi square value = 6.884, p= 0.32

Middle 1/3rd of the shaft was involved in 23 (92%) cases and proximal 1/3rd in 2 (8%) cases.

Table 7
Type of Fracture

<table>
<thead>
<tr>
<th>Type of fracture</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Open</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8
Pattern of Fracture vs Time interval between trauma and surgery

<table>
<thead>
<tr>
<th>FRACUTURE PATTERN</th>
<th>TRAUMA AND SURGERY</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 24 hrs</td>
<td>2-4 days</td>
</tr>
<tr>
<td>Oblique</td>
<td>2 (8%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Spiral</td>
<td>0 (0%)</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>transverse</td>
<td>0 (0%)</td>
<td>14 (56%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2 (8%)</td>
<td>21 (84%)</td>
</tr>
</tbody>
</table>

21 (84%) patients were operated between 2 to 4 days and 2 (8%) patients were operated within 24 hours. The commonest time interval between trauma, and surgery was 2-4 days.

Table 9
Pattern of Fracture vs Type of Reduction

<table>
<thead>
<tr>
<th>FRACUTURE PATTERN</th>
<th>TYPE OF REDUCTION</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open</td>
<td>Closed</td>
</tr>
<tr>
<td>Oblique</td>
<td>0 (0%)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>Spiral</td>
<td>0 (0%)</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>transverse</td>
<td>1 (4%)</td>
<td>15 (60%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1 (4%)</td>
<td>24 (96%)</td>
</tr>
</tbody>
</table>

Chi square = .586, p=.746

Figure 12

Closed reduction was done in all cases except one patient who presented to us with ipsilateral fracture shaft femur and tibia. Open Reduction was done and flexible nailing was performed at same time for both fractures.

Table 10
Type of nail

<table>
<thead>
<tr>
<th>Type of Nail</th>
<th>No. of Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>25</td>
<td>100</td>
</tr>
</tbody>
</table>

10 of 20
In the present study stainless steel nails were used in all cases.

### Table 11
Pattern of Fracture vs Size of Nail

<table>
<thead>
<tr>
<th>SIZE OF NAIL</th>
<th>FRACTURE PATTERN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oblique</td>
<td>Spiral</td>
</tr>
<tr>
<td>2 mm</td>
<td>0 (0%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>2.5 mm</td>
<td>2 (8%)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>3 mm</td>
<td>1 (4%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>3.5 mm</td>
<td>0 (0%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3 (12%)</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>Mean ± S.D</td>
<td>2.67 ± 0.28</td>
<td>2.67 ± 0.16</td>
</tr>
</tbody>
</table>

21 patients (84%) stayed in hospital for about 8-10 days. Average hospital stay being 8.44 days.

### Table 13
Pattern of Fracture vs Time for union

<table>
<thead>
<tr>
<th>TIME OF UNION</th>
<th>FRACTURE PATTERN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oblique</td>
<td>Spiral</td>
</tr>
<tr>
<td>8 weeks</td>
<td>1 (4%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>10 weeks</td>
<td>1 (4%)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>12 weeks</td>
<td>1 (4%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3 (12%)</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>Mean ± S.D</td>
<td>10 ± 2</td>
<td>9.67 ± 1.56</td>
</tr>
</tbody>
</table>

In most of the cases (44%) 3mm diameter nails were used. 2.5 mm nails were used in (32%) of the cases and in other (20%) cases 3.5mm were used. Only in 1 case (4%) 2mm nail were used.
Fracture union was defined as the period between operation and full weight bearing without external support and radiographically healed fracture. Spiral and oblique fractures united in shorter duration as compared to transverse fractures.

In our series, time to union ranged from 8 to 12 weeks with the average being 10.2 weeks.

Table 14
Complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limb lengthening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;5 mm</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>≤5 mm</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Limb Shortening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;5 mm</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>≤5 mm</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Infection</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nail impingement at entry point</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Mal alignment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Varus angulation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>b. Valgus angulation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>c. Anterior angulation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>d. Posterior angulation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>e. Rotational malalignment</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3 (12%) of patients had nail impingement at entry point.

Table 15
Pattern of Fracture vs Functional outcome

<table>
<thead>
<tr>
<th>FUNCTIONAL OUTCOME</th>
<th>FRACTURE PATTERN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oblique</td>
<td>Spiral</td>
</tr>
<tr>
<td>Excellent</td>
<td>3 (12%)</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>Good</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Poor</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3 (12%)</td>
<td>6 (24%)</td>
</tr>
</tbody>
</table>

Functional outcome were better in spiral and oblique fractures as compared to transverse fractures.

EVALUATION OF RESULTS:
CRITERIA FOR FRACTURE UNION:

A) CLINICALLY: Absence of pain and deformity at fracture site.
No abnormal mobility at fracture site.

B) RADIOLOGICALLY: Presence of bridging callus.
Obliteration of fracture line

CRITERIA FOR RESULTS: (FLYNN’S CRITERIA)

The data for quantitative variables is presented.
as interquartile range. For categorical variables number and percentages were calculated.

In our study, following results were noted:

Average limb lengthening was 0.6 cm whereas average limb shortening was 0.5 cm. Nail impingement was seen in 3 (12%) of cases. None of our patient had superficial skin infection, persistent pain and malunion or delayed union. According to FLYNN’S CRITERIA, results are evaluated as excellent in 22 cases (88%) and good in 3 (12%) cases.

CASE NO. 1
CASE NO. 3
CASE NO. 4
CASE NO 5
CASE NO. 7
CASE NO. 8
CASE NO. 10
CASE NO 14
CASE NO. 15
CASE NO. 23

DISCUSSION
The treatment of femoral shaft fractures in children, particularly those who are between 6 to 14 years of age is controversial. Operative treatment is becoming more well accepted.

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.

Indications:

Useful in treating femoral shaft fractures in children between the age of 6 to 14 years. In these patients a rigid nail can damage the growth plate. The indications in the pediatric age group include femoral shaft fractures with head injury, polytrauma, spasticity, multiple long bone fractures.

In < 10 years, loss of adequate alignment after conservative treatment and age group over 10 years.

Useful in treating femur shaft fractures in adolescents. Noncomminuted shaft fractures of the femur.

In polytraumatized patient, flexible nails are useful for easy and quick fixation of the fracture. 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

Age incidence:

In the present study 6 (24%) of the patients were 6-8 years old and 12 (48%) were 9 to 11 years age group with the average age being 10.16 years.

Fabiano Prata Nascimento et al36 treated femoral shaft fractures in age range 5 to 14 years with average age being 9.6 years.

Alenjandro uribe Rios et al35 conducted a prospective study regarding effects of stainless steel flexible nails in children aged between 5 and 12 years in a study group of 48 patients. The average age was 8.6 years.

Sex incidence:

There were 9 (36%) girls and 16 (64%) boys in the present study. The sex incidence is comparable to other studies in the literature. Fabiano Prata Nascimento et al 36 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.35

This male preponderance can be explained as boys are more active and are more prone for accidents and falls.

Mechanism of Injury:

In the present study RTA was the most common mode of injury accounting for 15 (60%) cases and fall while playing accounted for 10 (40%) cases.

Bar-on E, et al27, 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 al35, 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 al36 RTA was the most common mechanism. RTA was seen in 19(63.3%).

Pattern of Facture:

In our study, transverse fractures accounted for 16 (64%) cases, oblique fractures accounted for 3 (12%) cases and spiral fractures accounted for 6 (24%) cases.
Heinrich SD et al noted 35 (44.87%) transverse fractures and 14 (17.94%) oblique fractures in their study and Cramer KE, et al noted 35 (61.4%) transverse fractures and 16 (28.07%) spiral fractures. In the study conducted by Fabiano Prata Nascimento et al, they noted transverse in 18 patients, oblique in 8 patients, spiral in 2 patients, and comminuted fractures in 2 patients.

Level of Fracture:
Fractures involving the middle 1/3rd of the femoral shaft accounted for 23 (92%) cases and those involving the proximal 1/3rd accounted for 2 (8%) cases in our study. Ozturkman Y et al. 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 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 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 25 (100%) cases were closed fractures. Fabiano Prata Nascimento et al noted 28 (93.3%) closed and 2 (6.7%) open fractures. In the study conducted by Alenjandro uribe Rios et al, 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. 21 (84%) 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.

In our study, 2 (8%) patients were operated within 24 hours. 23 (40.35%) patients were operated within 24 hours in Cramer KE, et al study.

In the study conducted by Alenjandro uribe Rios et al, the average time elapsed from initial injury to surgery was four days.

Type of Reduction:
In our study, closed reduction was done in 24 (96%) cases and open reduction was done in 1 (4%) case. One patient presented to us with ipsilateral fracture shaft femur and tibia. Open reduction was done and flexible nailing was performed at same time for both fractures.

In 5 (6.41%) fractures, open reduction was done to facilitate passing the nail across the fracture site in Heinrich SD, et al study. Closed nailing was done in all cases in a study conducted by Fabiano Prata Nascimento et al. In the study conducted by Alenjandro uribe Rios et al, the 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 all cases.

In our country, titanium implants are costly; therefore stainless steel nails present an effective, more economical alternative in the treatment of femoral shaft fractures. 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 nailing. Stainless-steel nails are stronger than titanium in bending tests. Stainless-steel nails have greater intrinsic strength and therefore are not as dependent on the opposing bend technique.

Nail size used:
In 8 cases (32%) 2.5mm diameter nails were used. 3 mm nails were used in 11 (44%) of the cases and in 5 (20%) cases 3.5 mm were used. Only in one case 2 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 treated 190 children with immediate hip spica casting. Average duration of immobilization in their study was 7 weeks.

John Ferguson et al 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 Gross
R.H. et al20 study.

In the study conducted by Alenjandro uribe Rios et al35 no other immobilization treatments like plaster or orthosis were used.

In the study conducted by Fabiano Prata Nascimento et al36 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 8.44 days.

The mean hospital stay was 12 days in Kalenderer O, et al47 study.

In a study conducted by Alenjandro Uribe Rios et al35 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 al31 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 al49.

Gross RH, et al 20 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 36 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. days. The reduced 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 al50 reported average time for union as 10.5 weeks. Aksoy C, et al32 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 et al36 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:

Range of motion:

All patients had full range of hip motion in the present study, 3 (12%) patients had 10 degree restriction of knee movements (flexion) which was corrected by rigorous physiotherapy, while 1 (4%) 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 al51 study.

Bar-On E, et al27 noted 20° loss of internal rotation at the hip in one patient treated with external fixation. Flynn J M et al52 noted one case of knee stiffness in patients treated with spica casting which required manipulation under anaesthesia.

Limb length discrepancy:

This is the most common sequel after femoral shaft fractures in children and adolescents.

In the present study, average limb lengthening was 0.6 cm, average limb shortening was 0.5 cm.

No patient in our study had significant limb length discrepancy (i.e. > ± 2 cm).

Beaty et al53 reported, two patients had overgrowth of more than 2.5 cm necessitating epiphysiodhesis, after conservative treatment.

The mean limb length shortening was 0.35 cm in Kalenderer O, et al47 Ozturkman Y. et al30 observed mean leg lengthening of 7 mm in 4 patients and mean shortening of 6mm in two children.
Cramer KE, et al10 noted average limb lengthening of 7 mm (range 1-19 mm) in their study. Clinically significant limb discrepancy (> 2 cm) did not occur in any patient in their study.

Huber RI, et al54 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 al55 observed mean shortening of 32 mm (5 to 65 mm) and average over growth of 11.4 mm (5 to 20 mm) in their study conducted on spica casting of the femur in children.

John Ferguson et al48 noted more than 2 cm shortening in 4 children after spica treatment of pediatric femoral shaft fracture.

In the study conducted by Alenjandro uribe Rios et al35 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 al36 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 al56 noted limb length discrepancy of more than 10 mm in 3 (8%) of cases. Herndon WA, et al57 noticed limb length shortening ranging from 1 to 4.6 cm in 7 patients.

Comparing to limb length discrepancy in conservative methods, limb length discrepancy in our study was within the acceptable limits.

Infection:
Superficial infection was not seen in any case of our study.

Pin tract infection is a major disadvantage of external fixation application. Bar-on E, et al27 reported 2 cases of deep pin tract infection in their patients treated with external fixation.

Blasier RD, et al, Davis TJ, et al and Fein LH, et al58 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 35 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.

Nail impingement at insertion site:
In the present series, nail impingement was seen in 3 (12%) patient. In the study conducted by Fabiano Prata Nascimento et al36 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 post-operatively and needed another surgery to correct the loss of reduction of the fracture.

In the study conducted by Alejandro et al,35 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.

Malalignment:
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.

Herndon SD, et al7 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 al48 noticed 7° varus angulation in one patient in their study.

Herndon WA, et al57 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 al57 noticed 12° valgus angulation in one patient treated with spica casting.

Alenjandro uribe Rios et al35 observed two angular deformities in the valgus.

Fabiano Prata Nascimento et al36 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 were no antero posterior angulation. Anteroposterior angulation ranged from 5.6° to 7.6° in children treated with immediate spica casting in Infante AF, et al28 study.

Ozturkman Y, et al30 noted an anterior angulation of 7° and a posterior angulation of 6° in 2 patients respectively.

Herndon WA, et al57 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 al7 study.

Bar-on E, et al27 noticed one case of posterior angulation treated by external fixation.

Fabiano Prata Nascimento et al36 noticed 23(76.7%) anterior angulation and 5 (16.6%) posterior angulation.

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 al7 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.

Other complications:

In our study no proximal migration of nails was seen in any of the cases.

Bar-on E, et al 27 noticed proximal migration of the nail in one case.

Kregor PI, et al59 reported 13° anterior angulation in one case and overgrowth of the injured femur averaging 0.9 cm in patients treated with compression plate fixation.

Ward et al60 managed 24 children between the ages of 6 and 16 years old with 4.5 mm 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.

**ADVANTAGES OF FLEXIBLE NAILING:**

- The avoidance of reaming and the use of small diameter flexible nails lessen 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.61
- Biodynamically, 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 nails, 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 nails 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 cancellous 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.2
- 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.7

**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.

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 the 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.

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 6 to 14 years.

In our study, following results were noted:

Average limb lengthening was 0.6 cm whereas average limb shortening 0.5 cm. Nail impingement was seen in 3 (12%) of cases. None of our patient had superficial skin infection, persistent pain and malunion or delayed union. According to FLYNN’S CRIETERIA, results are evaluated as excellent in 22 cases (88%) and good in 3 (12%) cases.

References

42. Loder RT. "Pediatric polytrauma: orthopedic care and hospital course". J Orthop Trauma 1987; 1: 48-54.