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**A Clinical Study of Flexible Intramedullary Nailing in Management of Diaphyseal Fractures of Femur in Children and Adolescents (6-16 years of age)**

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**KEYWORDS**

Pediatric femur neck fracture, Avascular necrosis, Open reduction and internal fixation

**A B S T R A C T**

Femoral neck fractures are rare injuries in children, but the high incidence of long term complications make it an important clinical entity. The aim of this retrospective study was to analyze the clinical outcomes of pediatric femur neck fractures that we managed over a 10 year period. The study included 20 cases that sustained femoral neck fractures and completed a minimum follow-up of three months. The children were treated either conservatively, or by open reduction and internal fixation (ORIF), or closed reduction and internal fixation (CRIF). Maximum number of cases are with middle 3<sup>rd</sup> fracture, least were distal 3<sup>rd</sup> fracture. There were total 20 cases, of which 19 were reduced by close method successfully, 1 case had to be open. In all the cases union of fracture occurred within 3 months. We believe that internal fixation of pediatric femoral neck fractures is preferred whenever feasible because conservative treatment carries a high risk of failure of reduction.

**Introduction**

Paediatric diaphyseal femoral fractures are common injuries which comprise a sizable number of cases among hospital admissions for trauma leaving no doubt about the high prevalence of this type of injury and account for approximately 1.6% of all fractures seen in this population (Kregor *et al.*, 1993). A successful outcome of fracture management depend not just on achieving bone union, but also on the time the patient took to return to

full function in the community. The exact type of treatment is largely dictated by patient age, size, site of the fracture, and the treating surgeon's preference (Canale Beaty, 2008). A spica cast applied early is a very effective treatment for most children who are less than six years old. A skeletally mature teenager is best managed as an adult, with an antegrade interlocked intramedullary

nail. The best treatment for children between six and sixteen years of age is still debated, who present the most difficult challenges in decision-making (John M. Flynn *et al.*, 2004). For generations, such children were managed with a period of traction followed by application of a spica cast. In the last two decades, there has been a strong trend toward treatment methods that allow rapid mobilization. Moreover, there is adverse impact of prolonged hospitalization and spica cast immobilization on children and their families. In many cases, both parents work outside the home; thus, the burden of home tutoring, nursing care, and transportation can be substantial. These social factors, along with the increasing emphasis toward minimizing hospital stay and complications, have generated enthusiasm for internal and external fixation of paediatric femoral fractures, despite the fact that the combination of traction and cast immobilization yields good results (John M. Flynn *et al.*, 2002). Moreover near the end of skeletal maturity, accurate reduction is necessary as angular deformity is no longer correctable by growth (Metaizeau, 2004).

Flexible intramedullary nail fixation can be thought of as an internal splint that maintains length and alignment but permits sufficient motion at the fracture site to generate excellent callus formation. Because flexible intramedullary nailing allows rapid mobilization of children with little risk as seen in other form of surgical intervention like rigid nailing, plating of avascular necrosis, physeal injury, or refracture, there has been a recent surge in its popularity (Mazda *et al.*, 1997).

Femoral nailing with titanium nail is more stable under compressive and torsional loading than with stainless steel nail. Given the nature of titanium, it is likely that this nail can conform to the inner wall of medullary canal to a greater degree once the

precourtred nail is inserted (Mahar Andrew *et al.*, 2004). Moreover, introduction of the nails is usually easy to perform in the femur because the medullary canal is wide.

The main aim of this study to evaluate the result of flexible intramedullary nailing in the management of such injuries in our setup and groups of patients.

## **Materials and Methods**

This prospective study is based on consecutive 20 cases of fracture shaft of femur who were treated in Department of Orthopedic surgery, Basaveshwara Medical college, Chitradurga between 1<sup>st</sup> October 2012 and 31<sup>st</sup> September 2013. All patients were in the age range of 6–16 yrs. Minimum follow up was 3 months.

## **Criteria of inclusion**

1. Only those who give consent for operation and willingness for follow-up will be considered for the study
2. Age group 6–16yrs
3. Transverse, short oblique, spiral, long oblique, minimally comminuted diaphyseal fracture of femur.
4. Fresh (<21 days) fractures.
5. Closed and Type I open fracture

## **Criteria of exclusion**

1. Patients who do not give consent or not willing to visit OPD for follow up.
2. Inability to take part in post operative rehabilitation
3. Definite major illness like malignancy, chronic liver or renal disease, heart failure etc.
4. Type II and III open fracture
5. Metaphyseal fractures
6. Pathological fracture
7. Multifragmentary fractures

### **Initial work-up**

All patients admitted were evaluated and treated for life and limb threatening injuries, splinted in the interim with Thomas splint. Fractures with severe displacement were put on skin traction. Adequate analgesic was given and splinted limb was kept elevated and distal neurovascular status was monitored clinically at frequent interval. Patient with multiple injuries including head injuries were managed in collaboration with specialized departments. Various demographic, clinical investigation and operative findings were recorded as per the Proforma and the results were evaluated according to Flynn scoring system of TENS

### **Criteria of union**

Union was defined clinically by absence of bony tenderness and abnormal mobility at the fracture site, and no pain at the fracture site on weight bearing. Radiological fracture union was defined by the presence or callus bridging the fracture and partial obliteration of fracture line in two perpendicular views.

### **Criteria of malunion**

Malunion was considered to have occurred when there was  $\geq 10$  degree valgus or varus angulations or  $\geq 20$  degree of anterior or posterior angulations.

### **Criteria of limb length discrepancy**

Limb length discrepancy was said to be present if inequalities of the length between two lower extremities was  $> 2$  cm clinically at 6 months post surgery.

### **Results and Discussion**

Diaphysis of femur was divided in 3 equal zone proximal  $1/3^{\text{rd}}$ , middle  $1/3^{\text{rd}}$ , and distal  $1/3^{\text{rd}}$ .

Maximum number of cases are with middle  $3^{\text{rd}}$  fracture, least were distal  $3^{\text{rd}}$  fracture.

There are total 5 number of patient were having associated injuries, of which 4 were of head injury and 1 with faciomaxillary injury. No patient with Thoracic, cardiac or abdominal injury was encountered in our study.

All fractures were stabilized with two flexible titanium elastic nails of various diameters as shown in the table 2. Length of the nail is 45cm in built, which was cut to required length accordingly during operation.

In 6 cases 3mm diameter nail were used, 5 cases equally 2.5mm and 3.5mm nails are used. In only 1 case 4.5 mm nail were used.

### **Method of reduction**

Reductions of fracture were done before introduction of the nail under IITV guidance. Those not possible, opening of the fracture is done with minimal incision.

There were total 20 cases, of which 19 were reduced by close method successfully, 1 case had to be open

Out of 20 cases, 19 cases we had introduced the nail by retrograde method. 1 nail was introduced antegrade because in the distal  $3^{\text{rd}}$ .

All patients were mobilized as soon as post operative edema and pain subsided. Isometric exercises were started from very first post operative day. Between  $3^{\text{rd}}$  and  $5^{\text{th}}$  day active hip, knee flexion and extension was encouraged. Mobilization was then begun with partial weight bearing with support started after 1week. Full weight was started after  $3^{\text{rd}}$  week depending on child tolerance of pain.

The time to union is defined as the period between injury and weight bearing without external support and radiologically healed fracture. (Wiss and Stetson et al 1995)

In all the cases union of fracture occurred within 3 months.

Results were evaluated using Flynn Criteria of titanium Elastic Nailing

There were 13 cases of excellent results, 5 cases of successful result and 2 cases had poor.

This present study consists of 20 patients of which all in the age group of 6–16 years (mean 9 yrs) stabilized with titanium elastic nail and studied in the Department of Orthopaedics, Basaveshwara Medical College, Chitradurga between 1<sup>st</sup> October 2012 and 31<sup>st</sup> September 2013 with a minimum of 3 months post operative follow up.

Ligier *et al.* (1988) used 3mm, 3.5mm, or 4mm elastic stable intramedullary nail depending on patient's age and weight.

Heinrich *et al.* (1994) used ender nail of 3mm to 4.5 mm depending on fracture pattern, patient's age and weight.

Zehtab *et al.* (1974) used 4 to 4.5 mm ender nails and 2 to 3 nails in his series.

Metaizeau (2004) recommended use of flexible nail made of steel (Ender) of 4mm diameter near skeletal maturity and 2.5 mm for lighter children under 10 years of age. He also emphasized that diameter of titanium nail must be larger than stainless steel.

Goodwin *et al.* (2005) used two 4mm TEN in his study of torsional stability of Transverse, oblique, spiral and comminuted

pediatrics femoral fracture in synthetically created pediatrics femoral.

AO/ASIF recommends use of 3–4mm nail in femoral fracture and depending on patient's anatomy.

In our study we used 2mm nails in 1 case, 2.5mm diameter nail in 5 fracture of femur. Nail diameter of 3 mm used in 6 patients. 5 of fractures were stabilized with two 3.5mm TEN. 4mm of two nails were used in 3 cases. Since our study excludes any unstable fractures and built of patients and population as a whole in our region does not accommodate larger sizes of nail, maximum number of cases was stabilized with two 2.5mm, 3mm and 3.5mm nails.

### **Open reduction**

Table 8 depicts the comparison of incidence of open reduction in our study with other studies.

Open reduction was carried out in patient with failed closed reduction where difficulty was encountered during nail negotiation to the proximal fragment. In our series open reduction was necessary in 1 patient where closed reduction was not achieved despite repeated trial.

### **Mode of nail insertion**

Ligier and metaizeau *et al.* (1985) treated 123 femoral fractures with titanium elastic nail by retrograde insertion.

Heinrich et al (1994) treated 78 femoral fractures by flexible ender nailing, of which 64 were treated by retrograde mode and 12 were by antegrade mode.

Carey and Galpin *et al.* (1996) treated 25 femoral fractures using antegrade technique.

Houshian *et al.* (2004) treated 31 femoral fractures by titanium elastic nail using retrograde technique.

We treated 19 fractures using retrograde technique and 1 fracture by antegrade technique as the fracture was in the quiet distal 3<sup>rd</sup>.

**Duration of operation**

Table 9 shows the comparison of duration of operation in our study with that of other studies.

Duration of operation in our study is comparable to other studies.

**Type and period of post operative immobilization**

Post operative immobilization in flexible intramedullary nailing is not generally used unless fixation is highly unstable and in case of unstable fractures.

Heinrich *et al.* (1994) recommended that postoperatively, children with comminuted fractures be kept non weight bearing in a bent -knee cylindrical cast with a pelvic band fixing the hip at 45 degree.

Buckley in 1997 observed that postoperative cast immobilization was usually not necessary; however in the presence of comminuted fracture, a single hip spica of long leg cast might be necessary.

In 1988, Moehring opined that flexible intramedullary nail cannot be used in unstable comminuted fracture without unsupported. Flynn in 2002 advised use of spica for patients with unstable fracture pattern. Narayanan and Flynn in 2004 used knee brace for a week post operatively to avoid pain in the knee.

In our study 2 cases of femoral fractures was immobilized with Thomas splint due to unstable fracture configuration and suboptimal fixation.

**Radiological union**

Table 10 compares radiological period union of our study with the other studies.

In our study radiological union was seen in 6-8 weeks postoperatively in maximum number of cases. We observed that children with older age (> 10 years) comparatively took longer time than younger children (10 years).

**Results in terms of union**

Table 11 shows a comparative study of union rate in our study with that of other studies.

Fractures in children usually unite well because of thick periosteal, high remodeling potential. Using titanium elastic nail allows micro motion as well as biological fixation which augment the healing process.

**Table.1 Site of fracture**

Site	Cases no.	Percentage
Proximal 1/3 <sup>rd</sup>	5	25%
Middle 1/3 <sup>rd</sup>	13	65%
Distal 1/3 <sup>rd</sup>	2	10%
Total	20	100%

**Table.2** Diameters of nail used

Nail Diameter(mm)	No. of cases
2	1 (5%)
2.5	5 (25%)
3	6 (30%)
3.5	5 (25%)
4	3 (15%)
4.5	---
Total	20 (100%)

**Table.3** Method of reduction

Method of reduction	No. of cases	Percentage
Close	19	95%
Open	1	5%
Total	20	100%

**Table.4** Mode of insertion

Mode of insertion	No. of cases	Percentage
Retrograde	19	95%
Antegrade	1	5%
Total	20	100%

**Table.5** Mobilization

Type	Cases no.	Weeks
Non weight bearing crutches	18 (90%)	<1
Partial weight bearing	18 (90%)	2
	2 (10%)	4
Full weight bearing	15(75%)	6
	4 (20%)	8
	1 (5%)	10
Total	20(100%)	

**Table.6** Results in terms of union

Time of union	Cases no.	Percentage
Union within 3 months	20	100%
Delayed union 6-9 months	---	--
Non union more than 9 months	---	--

**Table.7** Results of union of fracture

Results	No. of cases	Percentage
Excellent	13	65%
Satisfactory	5	25%
Poor	2	10%
Total	20	100%

**Table.8** Comparison of incidence of open reduction in our study with other studies

Study year	Type of nail used	Total no of fractures	Total no of cases requiring open reduction
Heinrich <i>et al.</i> (1994)	Enders nail	78	5
Bar On <i>et al.</i> (1997)	TEN	10	1
Heybeli <i>et al.</i> (2004)	TEN	35	10
Houshian <i>et al.</i> (2004)	TEN	31	3
Luhmann <i>et al.</i> (2003)	TEN	118	4
<b>Present Study</b>	TEN	20	1

**Table.9** The comparison of duration of operation in our study with other studies

Study year	Type of nail used	Average Duration of operation (Minutes)
Heirich <i>et al.</i> (1994)	Ender	86 (50-140)
Bar-On <i>et al.</i> (1997)	TEN	74 (50-135)
Houshian <i>et al.</i> (2004)	TEN	60 (40- 100)
Heybeli <i>et al.</i> (2004)	TEN	55 (25-100)
<b>Present study</b>	TEN	82 (52-120)

**Table.10** Comparison of radiological period union of our study with the other studies

Study year	Type of nail used	Average period of radiological union (weeks)
Heinrich <i>et al.</i> (1994)	Ender	8.3
Naraynan <i>et al.</i> (2004)	TEN	10
Houshian <i>et al.</i> (2004)	TEN	7
Heybeli <i>et al.</i> (2004)	TEN	7.4
<b>Present Study</b>	TEN	8.2

**Table.11** The comparative study of union rate in our study with that of other studies

Study year	Type of nail used	Total no of case	Union
Heinrich <i>et al.</i> (1994)	Ender	78	100%
Houshian <i>et al.</i> (2004)	TEN	31	100%
Narayanan <i>et al.</i> (2004)	TEN	79	100%
<b>Present study</b>	TEN	20	100%

**Table.12** The period of Weight bearing

Study year	Non weight bearing crutch waking (days)	Partial weight bearing (weeks)	Full weight bearing (weeks)
Ligier <i>et al.</i> (1985)	5-7	3	6 (mean)
Flynn <i>et al.</i> (2002)	9	2	8.5(mean)
Metaizeau <i>et al.</i> (2004)	3-5	2	6(mean)
Houshian <i>et al.</i> (2004)	1-4	3	6-8
Heybeli <i>et al.</i> (2004)	5-7	5	6.8(mean)
Narayanan <i>et al.</i> (2004)	---	---	7.2(mean)
<b>Present Study</b>	5-7	2	6.6(mean)

### Mobilization

Table 12 shows the period of Weight bearing. In our study with other studies

Mobilization in our study was dictated by patient overall condition and fracture pattern and fixation. Non weight crutch walking was encouraged within a week in majority of the cases.

Partial weight bearing was given at 2 weeks. Two cases were allowed partial weight bearing at 6 weeks because of immobilization with spica cast. Maximum cases were allowed to bear full weight at 6-8 weeks. Results were evaluated using Flynn's (Flynn *et al.* 2001) criteria of scoring. Flynn *et al.* (2002) found 57 cases either excellent or satisfactory out of 58 patients with femoral fractures. Heybeli *et al.* (2004) found excellent in 25 (71.4%) cases, satisfactory in 9 (25.7%) cases and poor in 1 case (2.9%).

Moroz *et al.* (2006) found excellent in 150 (65%) cases, satisfactory in 57 (25%) and poor in 23 (10%) cases.

We achieved excellent results in 13 cases (65%), successful in 5 cases (25%), and poor in 2 cases (10 %). Poor results were due to angulations >10° in 2 cases.

### Conclusions

Though we never deny the usefulness and good results of conservative treatment in younger children under 6 years of age and effectiveness of inter locking nailing in skeletally matured children, we believe that titanium elastic nailing of diaphyseal fractures of long bones of lower extremity in children of 6–16 years of age is a viable and effective treatment if appropriately done in properly selected patients.



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