

ENDERS NAILING IN PEDIATRICS SHAFT FEMUR FRACTURE

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INTRODUCTION: Femoral shaft fractures are the most common major pediatric injuries managed by the Orthopaedics surgeon. They represent approximately 1.6% of all bony injuries in children. Males are affected more frequently than females with regards to age; the distribution is bimodal with peaks at age of 2 and 12 years.

Advancement in mechanization, increasing number of fast moving vehicles has been accompanied by an increase in the number and severity of fractures in the paediatric age group. The incidence of femoral fractures in children comprises 20 per 100,000 yearly in the United States and Europe.¹ The treatment of femoral shaft fractures in the pediatric population remains controversial. The child age often directs the management. Non operative treatment options include functional treatment for the very young, pavlic harness, skin or skeletal traction, and spica casting. Operative treatment options include closed reduction and external fixation, open reduction and internal plate fixation, closed reduction and minimally invasive plate osteosynthesis (MIPO), and closed reduction and intramedullary nailing with either flexible or rigid nails. Intramedullary nail fixation of pediatric long bone fracture, particularly femoral shaft fracture, has revolutionized the care and outcome of these complex injuries. Nailing is associated with a high rate of union and a low rate of complications. Traditional management of paediatric femoral shaft fractures has been in the form of traction and casting and immobilization in spica cast as a standard treatment for all femoral shaft fractures in children, and femoral fractures ranked high in terms of duration of hospitalization. Indications for surgical management were few and included children with associated injuries like head injury, abdominal injury or compound fracture with extensive soft tissue trauma. The aversion to treat femoral shaft fractures in paediatric age group patients operatively is aptly reflected in statement given by Blount "the operation is unnecessary, however and as such must be condemned. It introduces the hazard of an unnecessary anesthetic, unnecessary exposure of bone ends, and trauma to the entire marrow cavity of the femur. There is no reason for doing it. Moreover one postoperative osteomyelitis in a lifetime is enough to cure a surgeon of a casual attitude toward open reduction." Complications such as limb length discrepancy, torsional angular deformities, pressure sores, nerve palsies, soiling of the skin and, breakage of the plaster, joint stiffness were noticed with spica cast management even after proper precautions to add to these were the psychosocial implications of spica cast treatment and its complications, with separation of child from his environment and the difficulties in taking care of a child in spica. On account of the above complications, in the last few decades, the trend worldwide has been towards some form of fixation for children's fractures, especially the femoral shaft, and the indications for operative management have widened. Various fixation devices have

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been advocated by many authors and these include external fixators, compression plating devices, intramedullary fixation devices such as rigid or flexible nails.

MATERIAL AND METHOD: This was non-randomized prospective clinical study carried out in PEOPLES COLLEGE OF MEDICAL SCIENCES & RESEARCH CENTRE HOSPITAL (PCMS&RC), BHOPAL from 15 September 10 to October 12. Forty children between the age of 3 to 15 years who were clinically and radiologically proven to be fresh fracture shaft femur and were treated with Ender's nailing were included in this study. Prior approval of Institutional Ethics Committee of (PCMS & RC) was taken. The present study comprised of analysis of a total of 40 cases of diaphyseal shaft femur fractures in children.

The statistical analysis of the data was done using Chi-square test.

INCLUSION CRITERIA:

1. Closed, Simple or comminuted fractures involving the diaphysis of femur.
2. Fractures in patients who presented with multi-system trauma.
3. Multi skeletal trauma.

EXCLUSION CRITERIA:

1. Radiological signs of skeletal maturity.
2. Open fractures.
3. Infected fractures.
4. Pathological fractures.

Functional evaluation of each patient was done as per TEN (Titanium elastic Nails) outcome scoring system.

OPERATIVE TECHNIQUE: The length of the medial nail is determined by measuring the distance between tip of greater trochanter and a point at the junction of a line at mid lateral aspect of femur and the line drawn perpendicular from upper pole of patella joining the former. Similarly the length of the lateral nail is determined by subtracting 2 cm from the length of medial nail. In all patients both the ends of the epiphysis was preserved.

Diameter of nail was determined by measuring the inner diameter at the isthmus and calculating 40% of it.

The patient is placed on the radiolucent fracture table.

DISCUSSION: In most of the studies femoral shaft fracture in 4 to 17 years have been treated surgically of which 90% were treated with Elastic Stable Intramedullary Nailing (E.S.I.N) Other operative treatment options include CRIF or ORIF with MIPO, Close reduction and intramedullary nail fixation (flexible or rigid nail) with their own advantages and disadvantages.

In less than 4 years age E.S.I.N is not indicated for the fear of bone overgrowth. Conservative treatment is indicated in younger children (<4 years) where spontaneous bone remodeling is likely.

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The effect of Operative versus non-operative treatment has been focus of several comparative studies. It has further been noted retrograde flexible nailing resulted in more reliable outcome than conservative treatment. For femoral shaft fracture in the Intra medullary group limb length discrepancy (LLD), malunion, or loss of motion did not occur. Cramer KE et al. (2000)²

Angular deformities greater than 10 degree were observed from the conservative treatment and none from the nailing group. Conservative treatment showed a wider variance of leg length discrepancy (LLD) and the nailing group had no discrepancy. Retrograde flexible nailing may result in more reliable outcomes than conservative treatment for femoral fractures. (Song HR et al (2004)³

The mean age of the patients in this study was 8.6 years. This was lesser than the mean age of 9.5 years in study conducted by Flynn et al (2001),⁴ and in Mann et al (1986)⁵ study where the mean age was 12.7 years. In Shashank et al⁶ study the mean age was 7.6 years. This could be attributed to the age group of the patients in the above studies.

The patients between the age 03 to15 years were included in this study which was very similar to the age 2 to15 years of patients in the study done by Shashank Chitgopkar (2005).⁶ The patients included in study by Flynn et al (2001)⁴ were in the age 4 to 16 years. However in Mann's study (1985)⁵ the age of the patients was 9 to 15 yrs. on the assumption that - problems like knee stiffness, shortening occurred in children above 8 years who were treated with conservative methods (Mann et al, 1986)⁵ further children below age of 8 years tolerated traction or functional sequelae better. Also anatomical reduction below 8 yrs was usually not necessary as deformities tend to correct with growth in cases of young children. (Mann et al, 1986)⁵. Children above this age group i.e. 15 yrs were treated as adults with rigid intramedullary rod fixation (Herndon et al, 1989).⁷ The age range of patients included in this study is similar to that conducted by Flynn⁴ and Chitgopkar.⁶

Male patients dominated the series because of the nature of their outdoor activities. The male to female ratio is 9:1. This is close to the series studied by Mann et al (1986)⁵ where the male to female ratio was 13:2 however, this is in contrast to study conducted by Ligier et al (1988),⁸ who noted male to female ratio of 2:1.

In our series, fall from height, accounted for the highest incidence of these injuries (55%) followed by road traffic accidents which accounted for 40% cases. which is in contrast with the other reports of Mann 65 % and Beaty 77% cases with RTA. In our series the patients hailed from mostly rural areas and climbing trees during fruit bearing seasons was very common.

In this study there were only 05 (12.5%) cases with associated injuries. Associated injuries were noted to occur in 20% of cases in study conducted by Flynn et al (2001).⁴ This is in contrast to study conducted by Shashank Chitgopkar (2005)⁶ and Beaty et al (1994)⁹ in which there were 60% of cases with associated injuries, while 42% cases with associated injuries were reported by Ligier et al (1988).⁸ This can be accounted for by the high incidence of High energy trauma in the form of RTA in the above studies.

CONFIGURATION: In our series there were 26 (65%) transverse fracture, 7(17.5%), oblique fracture and 7 (17.5%) cases of comminuted fracture. The correlation of configuration with the

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result as shown in table No. XV was highly significant. ($P < .001$) Further the results in comminuted and non-comminuted fractures as shown in table XIII was highly significant. ($P < .001$). Comminuted fracture has more complications like shortening and mal rotation as shown by Winquist RA, Hansen ST et.al¹⁰ studies.

LEVEL OF FRACTURE (SITE): In this series the maximum fracture occurred in Middle third 19(47.5%) followed by Upper third 17(42.5). Minimum fracture occurred in Lower third 04(10%).) The correlation of Level of fracture with the result as shown in table No. XII The relationship of level of fracture with results was not significant ($P < .05$).

AGE: In our study 52.5% of the patients were between 3 to 8 years of age. More than 75% had excellent results in this age group. The correlation of Age with the result as shown in table No XIV The relationship of age groups 3 to 8 yrs and 9 to 14 years with results was not significant ($P < .05$).

The average interval between injury and definitive management in this study was 4.4 days. The average hospitalization time noted in this series was 15.37 days. We followed a policy of discharging after suture removal which was done on the 12th day post operatively. The traditional treatment of either Gallows or Thomas splint traction had a mean 29 days hospital stay while in the early intervention group consisting of flexible nails, early hip spica or external fixator the average hospital stay was 10 days (Sturdee). Average hospitalization time of 8 days was noted in the study conducted by Kissel et al (1989).¹¹ The hospitalization time was prolonged because of associated injuries as children without associated injuries were usually treated by conservative methods. Galpin et al (1994)¹² also noted hospitalization time of 5 days for isolated femoral fractures and prolonged hospitalization time for patients with associated injuries. This is in contrast to study conducted by Ligier et al (1988)⁸ who noted the average hospitalization time of 4.6 days.

Average duration of surgery was 28.37 minutes.

Blood loss was less than 15 ml. in all the cases.(since procedure was done per cutaneously & the fracture was reduced by closed reduction under image guidance.

The average time of full weight bearing was 6.82 weeks after evidence of clinical union. The average time of full weight bearing in study conducted by Shashank Chitgopkar (2005) was 7.5 weeks while that in study conducted by Mann et al (1986) was 8.6 weeks.

The average time of clinical union was 6.82 weeks in this series. The timings of fracture union reported by Shashank Chitgopkar (2005) were 8.7 weeks and Galpin et al (1994) was 9.1 weeks.

In this series none of the patient showed more than 10 degrees of angulation in any plane (one patient had angulation of less than 10 degrees). This is quite similar to study conducted by Ligier et al (1988) who also noted similar result. However Galpin et. Al (1988) who also noted similar result. However Galpin et.al (1994) observed angulation of more than 10 degrees in one case (3.3%).

All cases were assessed by TEN outcome scoring system. We noted excellent results in 28 cases (70%), satisfactory results in 12 cases (30%). This is quite similar to study conducted by

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Flynn et al (2001) who noted excellent results in 38 cases (65.5%), satisfactory results in 18 cases (31.03%), and poor results in (1.7%).

Heinrich et al (1994)¹³ reported excellent results in all 78 cases treated with Enders Nails without any significant complications. Bar-on et al (1997)¹⁴ also reported excellent results with flexible nails and reported that the results were better than those with external fixators. Kissel et al (1989)¹⁵ reported results of Enders nailing to be superior to the conventional methods of treatment.

Skin irritation at the entry portal due to prominent nail was noted in 2(5%) cases in this study. Similar result is seen in the study conducted by Fynn et al (2001)⁴ who noted this complication in 6.8% of case. Ligier et al (1988)⁸ also reported the incidence of skin irritation by prominent nails in 10.5% of cases.

One patient in this study was found to have infection at the entry portal of the nails which subsided by 4 weeks after appropriate antibiotic therapy [after pus culture & sensitivity test] and daily dressing.

Similar complication was seen in study conducted by Ligier et al (1988)⁸ who noted in one case (0.8%). No infection was reported by Mann et al (1986).⁵

Angulations of less than 10 degrees & more than 5 degree were seen in one patient (2.5%) in this study. This patient had a comminuted fracture of the lower third of femur. Similar complication rate was seen in the study conducted by Kissel et al (1989)¹⁵ who found significant angulation in one case (7.14%) and this case was reported to be fixed by one nail leading to unopposed pull by that nail resulting bending at the fracture site. Carey et al (1996) also noted this complication in 1 case (4%), and Galpin et al (1994)¹² found in 2 cases (5.7%). None of the patients in study of Ligier et al (1988)⁸ and Mann et al (1986)⁵ developed this complication.

True limb length shortening of more than one cm. was found to occur in one case (2.5%) in this series. This patient had a comminuted fracture in the lower third and also had significant angulation at the fracture site. Ligier et al (1988)⁸ reported this complication in 7 cases (5.69%) and Galpin et al (1994) in 5.7% of cases. Flynn et al (2001) noted this complication in 10.2% of cases. However Mann et al (1986) noted no such complication in their study.

Re fracture of the femur distal to the tip of enders nail was noted by Gaplin et al (1994)¹² in 1 case (4.5%), by Carey et al (1996) in one case (4%) and by Flynn et al (2001)⁴ in one (1.7%).

No such complication was noted in this study. Similarly nail back out was seen in one case (1.7%) in the study conducted by John Flynn et al (2001). No such complication was seen in this study.

The treatment of femoral shaft fractures in children with Enders nails compares favorably to many other forms of treatment options available to treat these fractures. Bar on et al (1997)¹⁴ reported pin tract infections and delayed union in cases treated with external fixators, however this complication did not occur in cases of intramedullary nail fixation. They concluded that flexible intramedullary nailing was better option than external fixators for management of these fractures. Large exposure, periosteal stripping, delayed union, plate breakage, stress fractures after the plate removal are few complications seen in cases of compression plate fixation, which are not seen in cases of intramedullary nail fixation. James Beaty et al (1994)⁹ reported excellent

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results with interlocking nailing of these fractures in adolescents but noted one case (3.3%) of avascular necrosis of femoral head. Geogry et al (1995) compared flexible intramedullary nailing with rigid nailing in these fractures and noted no statistically significant difference in final outcome. They however noted that flexible nailing required much less operative time and less fluoroscopy time. Also the estimated cost of using Ender nails is much less than using Russell Taylor interlocking nails. Galpin et al (1994) noted myositis ossificans in 6 (27.3%) cases treated by reamed nails while none of the patients treated with undreamed nails showed this complication.

Loss of alignment and fixation failure could be a problem with Enders nails due to relatively less rigid fixation, but in this study no such incidence occurred and a stable fixation was achieved. Also being a load sharing device, no risk of relative osteopenia at the ends of bones occurred, as seen in load bearing lateral fixation devices, hence no refracture which is important complication to be taken care of, occurred.

Flynn et al (2001)⁴ stated that the ideal device to treat pediatric femur fractures would be a simple, load sharing internal splint allowing mobilization and maintenance of alignment for a few weeks until bridging callus forms. The device would exploit a child's denser bone, rapid healing and ability to remodel, without risking the physis or blood supply to the femoral head.

Thus the aim to fix fractures of diaphysis of femur in children with intramedullary nails is to encourage formation of bridging periosteal callus. Flexible intramedullary nailing provides a combination of elastic mobility and stability.

Stability is provided by nails, bone and the surrounding soft tissue:

- The nails provide internal elastic support, channelling the forces and preventing excessive displacement by the automatic adjustment of the bone fragments. The double ascending nails increase the stability of fixation.
- The bone provides the axial stability, provided that there is no overlap at the fracture site. This is ensured either by cortical contact in end to end reduction or by anchoring the nails to the metaphysis. Also the cancellous bone in children is very dense, so that the nail drop seen in the elderly patients is less common.
- The muscles act as the guy ropes, so even in an irritable child or the hyperactive child, the muscle activity just compliments the fixation. Muscle action also causes spontaneous correction of any angular deformity. Also there is retention of normal bow of the femur.
- The elastic mobility provided by these nails allows micro motion thus promoting external bridging callus formation. The periosteum is not disturbed and being a closed procedure there is no evacuation of the fracture hematoma or the risk of infection. Callus formation is twice as fast as with conventional methods.

The treatment of the pediatric femur fracture, however continue to evolve. For many reasons, the adolescent group poses a great challenge to the treating surgeons. The traditional method of traction and spica casting can be effective but is more difficult in older children due to their size, slower healing rate, and limited potential for remodeling. Operative stabilization can simplify management but carries the attendant risks of surgery, particularly injury to functioning physis.

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The use of Enders nail in fracture of shaft of femur of children has expanded the treatment options for patients with multi skeletal or multisystem injuries especially head injury patients with nursing care with conservative treatment is quite cumbersome. Fry, Kirk, Hofer et al (1976)¹⁶ evaluated children with fracture shaft femur with head injury and found operative management to be safe and effective method for management of these fractures.

In patients with multiple fractures, simultaneous fracture fixation in more than one limb may be desirable. Enders nailing is done in supine position over fracture table, thus allowing simultaneous procedure for upper limb and other systems. Where there is an indication of life saving procedures, such as craniotomy or laprotomy, repositioning of the patient is not necessary for subsequent fracture fixation.

Greisberg J, Bliss MJ et al(2002)¹⁷ noted that patient treated with flexible intramedullary nails achieved earlier independent ambulation at an average of 19 days compared with 106 days in a control group treated with spica casts. They also attained earlier independent bathroom use and hospital stay was significantly shorter. The patient returned to school earlier at 28 days post injury compared with 120 days post injury for patient in spica casts. The use of flexible intramedullary nail allowed patients and their families to achieve independence months earlier than the spica casts patients. Earlier return to school, independence ambulation and independence bathroom use are advantage of this treatment modality.

CONCLUSION: Hence it can be concluded that Enders nail can be effectively used to treat fractures of diaphysis of femur in children at all levels. The relation-ship of age and results were not significant implying that Ender's nailing is an effective tool in 3 to 14 years age group. However the results were far better in non-comminuted shaft fractures. The blood loss and operative time are minimal. It leads to rapid bone healing, and non-interference of fracture hematoma and minimal periosteal stripping. The load sharing mechanism of intramedullary nailing promotes secondary bone healing. Because of the early weight bearing, rapid healing and minimal disturbance of bone growth, this may be considered to be a physiological method of treatment.

This procedure provides stable fracture fixation and allows early mobilization and early rehabilitation of patients. It reduces the hospitalization time while achieving near anatomic alignment, maintaining length and allowing early active motion at the hip and knee. The simplicity of the procedure also facilitated fracture fixation in those with multiple fractures.

We recommend this procedure in 3 to 14 years age group with closed shaft femur fracture at any level in non-comminuted fractures.

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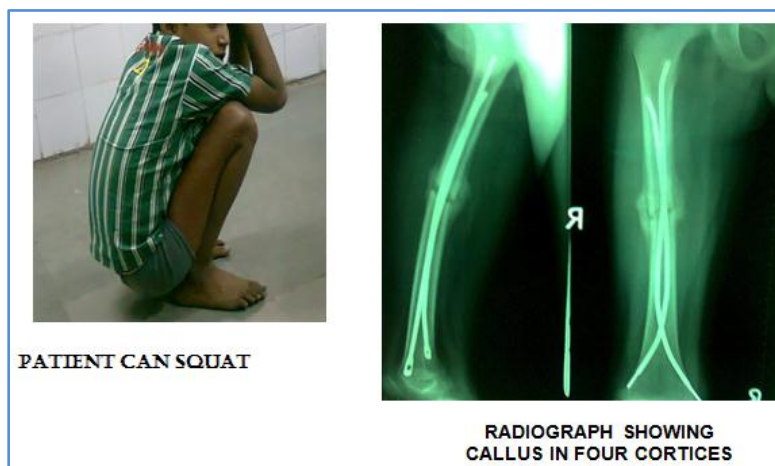
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CASE NO.1: CLINICAL PHOTOGRAPHS AFTER 4 WEEKS OF OPERATION.



CASE NO. 2: CLINICAL PHOTOGRAPHS AFTER 6 WEEKS OF OPERATION.



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CLINICAL PHOTOGRAPHS AFTER 8 WEEKS OF OPERATION.



RADIOGRAPH SHOWING UNION

STANDING ON INJURED LIMB WITHOUT SUPPORT

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