Original Article

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A prospective study of management of pediatric femoral diaphyseal fractures using intramedullary titanium elastic nails

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Abstract:

Background and Objective: Femoral shaft fractures account for 1.6% of all Pediatric bony injuries. Angulation, malrotation and shortening are not always corrected effectively. Fixation of femur fractures in children and adolescents by elastic stable intramedullary nailing is becoming widely accepted because of the lower chance of iatrogenic infection and prohibitive cost of in-hospital traction and spica cast care. The objective of the study was to study the functional outcome, duration of union and the complications following the use of elastic nail for femoral shaft fractures in children & adolescents. **Method:** Children and adolescents between the age group of 5-16 years with Femoral shaft fractures were admitted to Navodaya Medical College and Research, Raichur from August 2011 to August 2012. All patients underwent elastic stable intramedullary nailing fixation for the sustained fracture. Patients were followed up from 3 weeks to 6 months after surgery. A minimum of 30 cases were studied without any sampling procedure. **Result:** The study comprised 19 male patients and 11 female patients aged from 5 to 16years with mean of 10.5 years. The commonest duration from date of injury to date of surgery was 2 to 4 days. The follow-up ranged from 3 weeks to 6 months. **Interpretation and Conclusion:** Elastic stable intramedullary nail leads to rapid fracture union by preservation of fracture hematoma and limited soft tissue exposure. It also helps in preventing damage to the distal femoral physis. Hence we conclude that flexible intramedullary nailing is an excellent technique for the treatment of diaphyseal fractures of the femur in children and adolescents aged 5 to 16 years.

Key words: Diaphyseal; Elastic stable; Femoral shaft; Flexible nail; Intra medullary.

Introduction:

Femoral shaft fractures account for 1.6% of all pediatric bony injuries [1].There is little controversy over the treatment of adult femoral shaft fractures with intramedullary nail fixation [2]. Similarly, 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 5 to 16 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 treatment with a reamed nail. Current treatment options include early spica casting, traction, external fixation, ORIF with plating, elastic stable intramedullary nails and reamed intramedullary nails [3]. In children, fractures of the femoral shaft are commonly treated by various types of traction for about 3 weeks, followed by plaster cast immobilization. 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[4].Time and experience of many clinicians have shown that children with diaphyseal femur fractures do not always recover with conservative treatment. Angulation, malrotation and shortening are not always corrected effectively [5].

The management of paediatric femoral shaft fractures gradually has evolved towards a more operative approach in the past decade. This is because of a more rapid recovery and reintegration of the patients and a recognition that prolonged immobilization can have a negative effect even in children [6].

Plating of femoral shaft fracture offers rigid fixation, it requires a larger exposure with the potential for increased blood loss and scarring. It is a load bearing device and refracture is a risk. Antegrade nailing techniques have shown a risk of proximal femoral deformities and avascular necrosis of the femoral head [7-9]. Elastic stable intramedullary nail fixation provides a healthy environment for fracture healing with some motion leading to increased callus formation [9]. Elastic stable intramedullary nail fixation in the paediatric population is simple, effective and minimally invasive. It allows stable fixation, rapid healing and a prompt return of the child to normal activity. Functional results are excellent and complications are minor [9].

Materials and Methods

In this study 30 patients, aged 5 to 16 years, with fracture shaft of the femur were treated with retrograde Elastic stable intramedullary nailing at Navodaya Medical College Hospital and Research Centre, Raichur from 2012 to 2014.

Method of data collection: The study includes patients with Femoral shaft fractures admitted and examined according to protocol. Associated injuries were noted. Clinical and radiological investigations were carried out and medical fitness for surgery to undergo flexible nailing fixation for the sustained fracture was taken. Patients were followed up at 3 weeks, 6 weeks, 12 weeks, and at 6 months interval. A total of 30 cases were studied without any sampling procedure.

Inclusion criteria:

- Children and adolescent patients between 5 to 16 years of age.
- Patients fit for surgery.
- Stable diaphyseal femoral shaft fractures.
- Type I and II compound fractures.

Exclusion criteria:

- Patients aged less than 5 years and more than 16 years of age.
- Patients medically unfit for surgery.
- Comminuted and segmental fractures.
- Type III Compound fractures.
- Very distal (or) very proximal fractures that precludes nail insertion.
- Patients not willing for surgery.

As soon as the patient was brought to casualty, patient's airway, breathing and circulation were assessed. Then a complete survey was carried out to rule out other significant injuries. 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. Diagnostic radiographs were of sufficient quality including whole length of femur with knee and hip joints to avoid missing of associated fractures of the trochanter and neck of femur. On admission to ward, a detailed history was taken, relating to the age, sex, occupation, mode of injury, past and associated medical illness. Patients were then put through a thorough clinical examination and general condition was assessed regarding hypovolemia, associated orthopaedic or other systemic injuries and resuscitative measures were taken accordingly. Wounds when present were cleaned thoroughly and the limb was immobilized either in a Thomas splint or in skin traction. Analgesics, antibiotics, tetanus toxoid, tetanus immunoglobulins and blood transfusions were given as needed. Routine investigations were done for all patients. Patients were operated as early as possible once the general condition of the patient was stable and patient was fit for surgery.

Results

All the patients were followed until fracture union occurred. The followup period ranged from 3 weeks to 6 months. Results were analyzed both clinically and radiologically. Majority of the patients i.e., 15 (50%) were in the age group of 9-12 years, followed by 8 (26.66%) patients in 13 to 16 years. The youngest patient was 5 years and oldest patient was 15 years. The mean age in our study was 10.5 years.

The major cause of the fracture in our study was RTA in 21 (70%) patients and fall while playing in 7 (23.33%) patients. Right femur was involved in 13 (65%) patients and left femur in 7 (35%) patients, right : left ratio is 16 :14. In the present series, 17 (56.66%) were transverse fractures, 5 (16.66%) were oblique and 8 (26.66%) were spiral fractures. Middle 1/3rd of the shaft was involved in 25 (83.33%) cases and proximal 1/3rd in 5(16.66%) cases. 27 (90%) were closed fractures and 3 (10%) were open fractures. Both open fractures belonged to Gustilo Type I. 24 (80%) patients were operated between 2 to 4 days and 2 (6.66%) patients were operated within 24 hours. The commonest time interval between trauma and surgery was 2 to 4 days. 25 (83.33%) patients had closed reduction and in 5 (16.66%) patients, fracture site had to be opened to achieve reduction. In 13 (43.33%) patients, 2.5 mm nail was used followed by 3 mm nail in 8 (26.66%) patients. Fracture union was defined as the period between operation and full weight bearing without external support and a radiographically healed fracture. In our series, time to union ranged from 10 to 12 weeks average being 10.53 weeks. Post operative immobilization was not done in all cases. All patients were allowed to walk with the help of walker from the 1st post operative day, not bearing weight on the operated limb.

Discussion

The treatment of femoral shaft fractures in children, particularly those who are between 5 to 16 years of age is controversial. Operative treatment is becoming more well accepted. Each of the surgical methods described have specific advantages and potential complications that must be appreciated by the treating surgeon. The present study was conducted to assess the results of elastic stable intramedullary nail fixation of femoral shaft fractures 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 have become increasingly popular.

Recognizing the relative safety and efficacy of the femoral shaft fracture fixation with flexible intramedullary nails, several large medical centres in the United States and Europe have reported on series of femoral fractures in children and adolescents, proving the value of this method. In the present study 15 (50%) of the patients were 9-12 years old, the average age being 10.5 years. **Fabiano Prata Nascimento, et al**[10], treated femoral shaft fractures in age range 5 to14 yrs with average age being 9.6 yrs.

Alenjandro Uribe Rios, et al[11], conducted a prospective study regarding effects of stainless steel flexible nails in children aged between 5 and 12 yrs, in a study group of 48 patients. The average age was 8.6 years. There were 11 (36.66%) girls and 19 (63.33%) boys in the present study. The sex incidence is comparable to other studies in the literature. **Fabiano Prata Nascimento, et al**[10], reported that there were 16 (53.3%) male patients and 14 (46.66%) female patients. There were 40 boys and 8 female in the study conducted by **Alenjandro Uribe Rios, et al**[11].This male preponderance can be explained as boys are more active and are more prone for accidents and falls. In the present study RTA was the most common mode of injury accounting for 21 (70%) cases and fall while playing accounted for 7 (23.33%)cases. **Bar-on E, et al**[12], conducted study on 20 femoral shaft fractures. Motor vehicle accident was the cause of injury in 15 (75%) cases. In the study conducted by **Alenjandro Uribe Rios, et al** [11], the commonest mechanism of injury was road traffic accidents in 37 (77%) patients and 8 (16.7%) patients had fall from height. In the study conducted by **Fabiano Prata Nascimento, et al** [10], RTA was the most common mechanism and was seen in 19 (63.3%) patients. In our study, Transverse fractures accounted for 17 (56.66%) cases, Oblique fractures accounted for 5 (16.66%) cases and spiral fractures accounted for 8 (26.66%) cases. **Heinrich SD, et al**[5], noted 35 (44.87%) transverse fractures and 14 (17.94%) oblique fractures in their study while **Cramer KE, et al**[7], noted 35 (61.4%) transverse fractures and 16 (28.07%) spiral fractures. In the study conducted by **Fabiano Prata Nascimento, et al**[10], they noted transverse fracture in 18 patients, oblique fracture in 8 patients, spiral fracture in 2 patients and comminuted fracture in 2 patients. Fractures involving the middle 1/3rd of the femoral shaft accounted for 25 (83.33%) cases and those involving the proximal 1/3rd accounted for 5 (16.66%) cases in our study. **Ozturkman Y, et al**[13], noted 18 (69.23%) fractures in the middle 1/3rd and 3 (11.53%) fractures in the proximal 1/3rd of

the shaft, whereas **Heinrich SD, et al**[5], noted 54 (69.23%) fractures in the middle 1/3rd and 10 (12.82%) fractures in the proximal 1/3rd of the shaft. **Cramer KE, et al**[7], 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 27 (90%) cases were closed fractures and 3 (10%) cases were open fractures of Gustilo type I.**Fabiano Prata Nascimento, et al**[10], reported 28 (93.3%) closed and 2 (6.7%)open fractures.In the study conducted by **Alenjandro Uribe Rios, et al**[11], 42 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. 24 (80%) 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**[14].In our study 2 (6.66%) patients were operated within 24 hours.23 (40.35%) patients were operated within 24 hours in **Cramer KE, et al**[7] study.In the study conducted by **Alenjandrouribe Rios, et al** [11], the average time elapsed from initial injury to surgery was 4 days.

Type of Reduction:

In our study, closed reduction was done in 25 (83.33%) cases and open reduction was done in 5 (16.66%) cases.In 5 (6.41%) fractures, open reduction was done to facilitate passing the nail across the fracture site by **Heinrich SD, et al**[5].Closed nailing was done in all cases in a study conducted by **Fabiano Prata Nascimento, et al**[10].In the study conducted by **Alenjandro Uribe Rios, et al** [11], the fracture site had to be opened to perform the reduction in 11 (21.5%) fractures.

Nail size used:

In most of the cases (43.33%), 2.5 mm diameter nails were used. 3 mm nails were used in 26.66%, 2 mm nails were used in 16.66% of the cases and in other 13.33% cases 3.5 mm nails were used.

Post operative mobilization/immobilization:

In our study, no post operative immobilization was done in most of the cases, however above knee slab was applied in 3 patients. **Infante AF, et al**[15] treated 190 children with immediate hip spica casting, The average duration of immobilization in their study was 7 weeks. **John Ferguson, et al**[16], 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 the study by **Gross R.H, et al**[17].In the study conducted by **Alenjandro Uribe Rios, et al**[11], no other immobilization treatments like plaster or orthosis were used. In the study conducted by **Fabiano Prata Nascimento, et al**[10], 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 11.73 days.The mean hospital stay was 12 days in **Kalenderer O, et al**[14], study.In a study conducted by **Alenjandro Uribe Rios, et al**[11], the average length of hospital stay was 7.8 days. After surgery, the average length was 2.1 days for the group of patients with no associated injuries.**Greisberg J, et al**[18], compared the study of flexible intramedullary nailing with hip spica casting. They noted average hospital stay of 6 days in flexible intramedullary nail versus 29 days in hip spica casting group.Average hospitalization time was 11.4 days in the study conducted by **Mann DC, et al.[19]Gross RH, et al**[17], 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**[10], was 9.43 days.Compared to the above studies conducted on conservative methods and cast bracing, the average duration of hospital stay was less in our study i.e., 11.73 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 10.53 weeks.

Oh C.W, et al[20], reported average time for union as 10.5 weeks. **Aksoy C, et al**[21], 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 al**[10], 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 (10%) patients had 10 degree restriction of knee movements (flexion) which was corrected by rigrous physiotherapy, while 1

(3.33%) patient had terminal 45°restriction in knee flexion at 2 months, but normal range of knee flexion was achieved at six months.Loss of motion at the knee was seen in 14 (53.84%) patients in **Herscovici, et al,**[22]study.**Bar-On E, et al**[12], noted 20° loss of internal rotation at the hip in one patient treated with external fixation. **Flynn J M, et al**[23], 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 sequelae after femoral shaft fractures in children and adolescents.In the present study, average limb lengthening was 0.5 cm and average limb shortening was also 0.5 cm. No patient in our study had significant limb length discrepancy (i.e. > ±2 cm). **Beaty, et al**[24], reported that two patients had overgrowth of more than 2.5 cm necessitating epiphysiodesis, after conservative treatment. The mean limb length shortening was 0.35 cm in **Kalenderer O, et al[14]. Ozturkman Y, et al**[13], observed mean leg lengthening of 7 mm in 4 patients and mean shortening of 6 mm in two children. **Cramer KE, et al**[7], 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 al**[25], noted children with femoral shaft fractures had a median difference in length compared with the other side of 0.5 cm. **Gonzalez-Herranz P,et al**[26], observed mean shortening of 32 mm (5 to 65 mm) and average over growth of 11.4mm (5 to 20 mm) in their study conducted on spica casting of the femur in children. **John Ferguson, et al**[27], noted more than 2 cm shortening in 4 children after spica treatment for paediatric femoral shaft fractures. In the study conducted by **Alenjandro uribe Rios, et al**[11], there were five cases of length discrepancy, two cases of 1 cm lengthening, and three cases of shortening (two of 1.5 cm, one of 1 cm).**Fabiano Prata Nascimento, et al**[10], showed the final shortening of the limb, after a follow-up period of at least 24 months, occurred in 6.7% of the cases(two patients), with 0.25 cm on average.**Mazda K, et al**[16], noted limb length discrepancy of more than 10 mm in 3 (8%) of cases.**Herndon WA, et al**[28], noticed limb length shortening ranging from 1to 4 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 seen in 5 of the cases which was controlled by antibiotics. Pin tract infection is a major disadvantage of external fixation application. **Bar-on E, et al**[12], 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 al** observed that the risk of pin tract infection ranges from 36% to 62% and the risk of re-fracture or fracture through a pin tract ranges from 0% to 36%. **Alenjandro Uribe Rios,et al**[11], 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 the insertion site: In the present series, nail impingement was seen in 5 (16.66%) patients.In the study conducted by **Fabiano Prata Nascimento, et al**[10], 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 **Alenjandro, et al**[11] 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 weeks) 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.

Heinrich SD, et al[5], reported 5° of varus angulation in one child in their study and 11% of fractures had an average valgus malalignment of 6°.**John Ferguson MB, et al**[27], noticed 7° varus angulation in one patient in their study.**Herndon WA, et al**[28], compared the results of femoral shaft fractures by spica casting and intramedullary nailing in adolescents. They noticed varus angulation ranging from 7 to 25° in 4 patients treated with spica casting and no varus angulation in surgical group.**Herndon WA, et al**[28], noticed 12° valgus angulation in one patient treated with spica casting.**Alenjandro Uribe Rios, et al**[11], observed two angular deformities in the valgus.**Fabiano Prata Nascimento, et al**[10], noticed valgus in 12 (40%) and varus in 3 (10%) patients.The varus and valgus malalignments that occurred in our study are within the acceptable limits.

Antero posterior angulation: In the present study, there were no antero posterior angulations.Anteroposterior angulation ranged from

5.6° to 7.6° in children treated with immediate spica casting in **Infante AF, et al**[15], study.**Ozturkman Y, et al**[13], noted an anterior angulation of 7° and a posterior angulation of 6° in 2 patients respectively.**Herndon WA, et al**[28], noticed anterior angulation ranging from 8° to 35° in patients treated with traction and spica casting. 8% of the patients had an average anterior or posterior angulation of 8° in **Heinrich SD, et al**[6] study. **Bar-on E, et al**[12], noticed one case of posterior angulation treated by external fixation.**Fabiano Prata Nascimento, et al**[10], noticed anterior angulation in 23 (76.7%) patients and posterior angulation in 5 (16.6%) patients.

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

Other complications: In our study no proximal migration of nails was seen in any of the cases.**Bar-on E, et al**[12], noticed proximal migration of the nail in one case.**Kregor PJ, et al**[29], 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 al**[30], 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. The advantages of the present study include minimal scarring, closed reduction. The device being a load sharing one, fracture heals by secondary callus formation which is more stronger and re-fracture is not a risk. Rigid intramedullary nailing is also described in the management of femoral shaft fractures. **Raney EM, et al**[31], noticed premature closure of the greater trochanteric physis consequent to intramedullary nailing.

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