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Titanium Elastic Nailing (TEN) for the management of femoral diaphyseal fractures of children in 5-16 years of age and <50kg weight

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Abstract
The definitive treatment of paediatric femoral diaphyseal fractures remains controversial, although management of such fractures has gradually evolved in the past two decades towards operative approach because of a desire for more rapid recovery and reintegration of the patients. Modalities of treatment vary mostly according to age, with fracture pattern and site having a lesser impact. We used TEN (Titanium Elastic Nailing) for the management of femoral diaphyseal fractures of children in 5-16yrs age group with transverse fractures of femur and weight<50kg.

Description of Technique: Two flexible nails, made of titanium are inserted in a retrograde fashion through small incisions over the distal metaphysis, 2 cm above the physis. The size of the nails is selected based on the diameter of the patient's intramedullary canal on preoperative radiographs.

Methods: We reviewed all displaced pediatric femoral diaphyseal fractures of children in 5-16yrs age group with transese fracture of femur and weight<50kg treated at IMS&SUM Hospital, Bhubaneswar from october 2016 through September 2018.We included 54 fractures(30 boys,24 girls) meeting criteria for inclusion. These fractures were Proximal 3rd (n=6), Middle 3rd (n=45), Lower 3rd (n=3).All patients underwent surgery as early as possible with an average 3days from the day of admission. The results were evaluated using Flynn's scoring criteria.

Results: Excellent results were seen in 50 patients, good in 4 patients. All the fractures healed with average time to union of 6.5 weeks. Mean duration of hospital stay was 4.5 days. Full weight bearing was achieved in all cases in the mean time of 6.5 weeks.

Conclusions: Flexible nailing is a safe and reliable method of fixation for femoral shaft fractures of children 5-16 yrs age and weight<50kg. They do not provide rigid fixation, but allow enough stability to permit for early mobilization and fracture healing. It is safe less invasive with fewer complications and early return of children to school.

Keywords: Fracture femur, paediatric, Titanium elastic nailing

Introduction

Most femoral fractures in children are closed injuries and traditionally have been treated by closed methods [1, 2]. Management of paediatric femoral fractures has gradually evolved in the past two decades towards operative approach because of a desire for more rapid recovery and reintegration of the patients with recognition that prolonged immobilisation can have negative effects even in children. Economic pressures also are factors in selecting operative treatment [20, 21]. There is little disagreement concerning the treatment of long bone fractures in children less than 5 years (POP cast) and adolescents older than 16 years (Locked IM Nailing or Plating) [3, 4]. Younger children less than 6 years tolerate POP cast well can be easily managed at home. Mild displacement an angulation correct well by growth and remodelling. Older children more than 16 years show good response with a standard locked IM Nailing or Plating. Management of fractures in children aged between 5-16 years is controversial. An ideal fixation device for paediatric femur fractures would be a load sharing internal splint, maintain reduction for a few weeks until callus forms, more importantly implant should not damage the physis and blood supply to the femoral head. Titaniumelastic nailing [5, 6] of diaphyseal femur fractures [22, 23] in skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications. Many studies have supported the use of this technique in femur citing advantages that include closed insertion, preservation of fracture hematoma and physeal sparring entry point. Due to their elasticity, titanium nails are thought to promote callus formation by limiting stress shielding [26-28] and allow for enough movement to generate an optimum bone forming strain environment. There remains some concern regarding the level of control of length and rotation afforded by elastic nails. Pre-bending of elastic nails and the use of multiple nails are known to reduce the effect of angular and rotational forces on the fracture. There are various other methods of treatment available such as external fixation, compression plating and flexible or locked [16, 17] IM Nailing. TENs has become the choice of stabilization in paediatric long bone fractures [18, 19] especially femoral shaft fractures [7, 8]. The advantages of this procedure are early union due to repeated micro motion fracture site, early mobilization and weight baring, easy implant removal

and good scar acceptance. We conducted a prospective study on 54 patients on use of TENs in treatment of children [24, 25] of age 5-16 yrs and weight<50kg with diaphyseal femur fractures.

Materials and Methods

54 children (30 boys, 24 Girls) in the age group of 5-16 years, average 8.5 years with recent fractures were treated using TENS. Six fractures were in proximal 3rd, 45 were in middle 3rd and 3 were in the distal 3rd of this 42 were transverse fractures, 3 were minimally comminutted (Winquist-I), 9 were short oblique. Two cases had grade-I compound femur fractures. Patients with femoral metaphyseal fractures, Grade-III open fractures and Pathological fractures were excluded. Majority of patients underwent surgery as early as possible, with an average of 3 days from day of admission. Two titanium nails of similar diameter were used. The diameter of individual nail was selected as per Flynn *et al.* l formulae (Diameter of nail = width of narrowest point of medullary canal in AP and lateral X 0.4 mm) and intra operative assessment. TENs works on the basic principle of three point fixation provided by symmetrical bracing action of two elastic nails inserted in to the metaphysis each of which bears against the inner bone at three points. The prerequisites for optimum fracture stability when using TENS are 1) The nails should be pre bent in such a way that apex is located at the fracture site, 2) Diameter of the nail should be at least 40% of the internal diameter of medullary canal, 3) Both nails should be of same diameter and should be bent to same extent, 4) When inserted nails should have maximum cortical contact at the fracture site in opposite directions. All currently available elastic nails have beaked or hooked ends to allow satisfactory sliding down while inserting along inner surface of the diaphysis without impacting on opposite cortex. TENs available in standard length of 440mm were used.

Procedure

Under suitable anaesthesia (GA or Spinal),and patient in supine position, under image intensifier skin incision is given on medial and lateral aspect of distal femur 2 cms proximal to distal femoral epiphysis. Entry point is made with an awl, drill is then inclined, so that it makes an angle of 10^0 with metaphyseal cortex for easy passage of nail. Appropriate size nail inserted with the help of T handle. Nail is driven up with rotatory movements or using hammer until it reaches the fracture site. Now reduction is done under image intensifier and nail driven in to the proximal fragment. Second nail was then introduced on opposite side until it crosses the fracture site. Both nails are driven proximally till their tips became fixed in the cancellous bone of proximal femoral metaphysis. The tip of the nail that entered through lateral femoral cortex should come to rest just distal to the trochanteric epyphysis. The opposite nail (Nail inserted through the medial femoral cortex) should be at the same level towards the calcar region. The two nail construct should be in symmetrical alignment face to face with maximum curvature of nails at the fracture site. Distally nails are cut leaving 1cm outside cortex and are slightly bend for easy removal. In all cases double C construct was used to ensure three point fixations**.**Post operatively all patients were followed up at 3,6,12 weeks initially and thereafter in every three months. At every visit patients were assessed radiologically (Callus) as well as clinically until fractures healed and for any complications. The results were evaluated using Flynn's scoring criteria of TENs. Nails were removed 6 months post surgery when the fracture healed completely.

Results

Median duration of surgery was 60 Minutes (45-80), Mean hospital stay was 4.5 days. All fractures healed with average time to union 6.5 weeks (6-10weeks).Full weight bearing was achieved in all cases in a mean time of 6.5 weeks. Results were assessed using the criteria by Flynn *et al.* l.50 had excellent results and 4 good results. Entry site irritation occured in one case (Due to Leaving nail end longer than 2cms and excessive bending). One patients had varus angulation of 10^0 and 7^0, Shortening of limb was seen in one cases(Less than 2 Cms), one had posterior bowing of 10^0. All patients had full range of knee motion. 2 cases required insertion of nails with different diameter because of intra op difficulty of driving second nail in to the proximal fragment.

Conclusion

The ideal treatment of femoral shaft fractures in children is one that controls alignment and length, does not compress or elevate the extremity excessively, is comfortable for the child and convenient for the family, and causes the least negative psychological impact possible. Determining the ideal treatment for each child depends on the age of the child. The location and type of fractures, the family environment, the knowledge and ability of the surgeon, and to a lesser degree financial considerations. Immediate spica casting of femoral shaft fractures in children has been recommended by several authors. Best results with this method seem to be obtained in infants and young children. Illgen *et al.* [14] reviewed 114 children who had early spica treatment and recommended it as treatment of choice in children younger than 6 years of age. Hughes[15] *et al* reviewed 23 children treated with early spica casting to determine the effect of this treatment on family, School and other support systems. They identified patient mobility as the most difficult problem, followed by toileting, hygiene, time off work for parents, and schooling. They suggested that spica cast treatment is easier for preschool children than for school-aged children, and they recommended counselling and careful planning before spica cast application. Blasier [13], Aronson [11] and Tursky used primary external fixation with early weight-bearing for 139 femoral fractures in children. The Fixators were left in place an average of 11.4 weeks. Of those examined at 2 year follow-up, 15 of 18 had an average of 8.7 mm overgrowth and 3 had an average shortening of 7.7 mm. Refracture rate was 1.4% and although pin tract infection requiring antibiotic treatment developed in 6,osteomyolitis did not develop in any of the patients. Heinrich *et al.* in a prospective study of 78 femoral fractures in 77 children aged 2 [3, 4] years to 18 years, noted at follow up mild varus or valgus angulation (11%) and mild anterior or posterior malalignment (8%) after fixation with flexible intramedullary nails. However 68 of the children had equal leg lengths at follow up and 8 had minimal rotational malalignment of an average 8^0.They reported that stabilization of selected paediatric diaphyseal fractures with flexible intramedullary nails obtained results comparable to nonoperative treatment but with less disruption of family life and shorter hospitalization. Ligier *et al.* [17] reported the use of elastic stable intramedullary nails (ESIN) in 123 fractures of the femoral shaft in patients ranging from 5-16 years of age; all fractures united and no patient complained of disability or had gait abnormalities at follow up, most reports

recommend this technique for children ages 6-16 years in whom traction or external fixation has not been selected as an option and in whom both the proximal and distal femoral physes need to be avoided. Bar On *et al*, [12] in a prospective study comparing external fixation with flexible intramedullary nailing in children, noted that flexible intramedullary nailing had fewer complications, and the parents were more satisfied. They recommended the use of flexible nailing in the shaft fractures that require surgery and reserve external fixation for open or severely comminuted fractures. They used Kuntscher nails, Ender nails, Rush rods and interlocking nails.

Only correct tensioning of nail can fulfil the dynamic principles of this method. It is based on circular muscle mantle and restoring force of prestressed nails, which repeatedly bring the fragment back in to anatomical position.

The incorrect insertion points can have negative effects like internal tension and imbalance of fracture stability and fixation. Entry points that are too diaphyseal, damage the musculature during insertion and removal. The nails that are left too long cause severe muscle and skin irritation and breakdown. Injury to perichondrial ring and growth plates may occur at time and formation of entry point as well as nail insertion and may lead to growth arrest. Always 2 nails of same thickness should be used to avoid valgus and varus or axial deformity which may be due to different restoring forces. Difficulties with fracture reduction as well as advancing the 2nd nail may tempt the surgeon to rotate the nail more than 180 degrees. This may lead to one nail being wound around the other –The corkscrew phenomenon. In such cases it is rotationally and axially unstable.

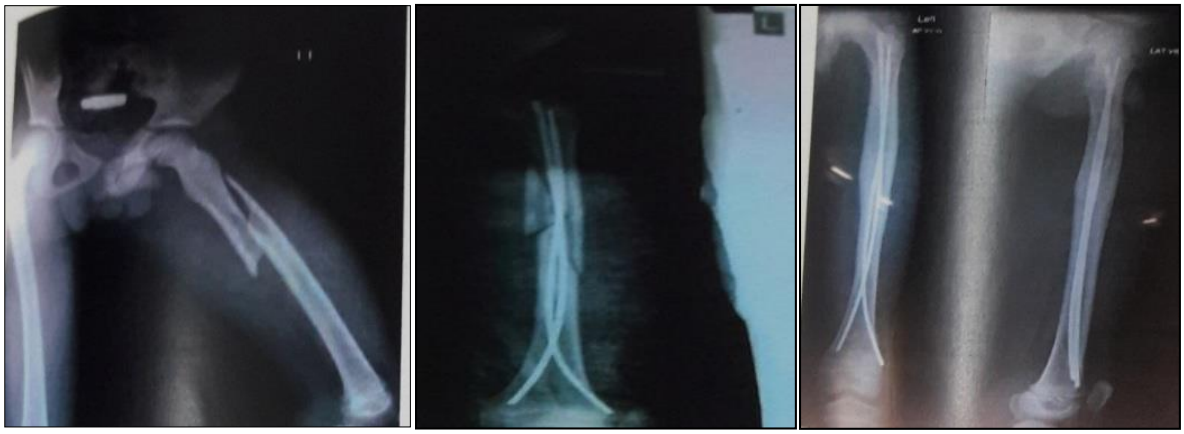

Fig 1

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