Original Article

Outcome of Titanium Elastic Nailing System in Diaphyseal Femoral Fractures of Children in the Age Group of 4-12 years

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Abstract

Background: *Femoral shaft fractures are the most common major pediatric injuries treated by orthopedic surgeons. Management of femoral diaphyseal fracture in the age group of 4-12 years is controversial. The purpose of this study is to demonstrate the effectiveness of intramedullary fixation of femoral shaft fractures by using Titanium Elastic Nailing System (TENS).* ***Materials and Methods:*** *Twenty-six (26) children in the range of 4-12 years with recent (<3 days) femoral shaft fracture (24 closed, 02 Grade-I compound) were stabilized with TEN, between January 2019 and June 2022 in Eastern Medical College Hospital, Cumilla and Cumilla Trauma Centre. The diameter of the individual nail was selected as per Flynn's formula and the results were evaluated by Flynn's criteria. All patients were followed radiologically as well as clinically until fractures healed and for any complications.* ***Results:*** *Among the twenty-six (26) cases 18 were boys and 8 were girls. Twenty-three (23) cases were managed by closed reduction while three (3) cases required open reduction. The time duration of surgery ranged 20-45 minutes. The hospital stay ranged between 5 to 8 days (mean 6.5 days). The mean duration of follow-up was 21 months (range: 3 - 39 months). All fractures were radiologically united at 8-12 weeks (mean 10 weeks) and full weight bearing was possible in a meantime of 9.5 weeks. According to Flynn's criteria, excellent results were found in 24 (92.3%) cases and satisfactory in 2 (7.7%) cases. Limb lengthening was noticed in 6 cases and rotational mal alignment was seen in 1 case.* ***Conclusion:*** *Intramedullary fixation with Titanium Elastic Nail may be the preferred method for the treatment of femoral fractures in children aged 4-12 years. As it is a safe, minimally invasive, surgeon-friendly technique and shows very good functional and cosmetic results.*

Key words: Pediatric Femoral Fracture, Intramedullary Fixation, Titanium Elastic Nail
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Introduction

Femoral shaft fractures are one of the most common major pediatric injuries treated by orthopedic surgeons[1]. They represent about 1-2% of all fractures in the pediatric group of population[2]. Seventy percent (70%) of femoral fractures involve the shaft of the femur[1].

The treatment of choice in these cases is typically based on patient's age, fracture type, associated injuries and the physical characteristics of the child[3]. Because of the rapid healing and spontaneous correction of the angulation, most of the femoral shaft fracture in the children younger than four years of age can be treated conservatively. Such fractures after the age of four years of the children, when treated by non-operative method may develop the loss of reduction, malunion, intolerance and plaster associated complications[4,5]. Availability of locked intra medullary nail has made the treatment of femoral shaft fractures in skeletally matured children well established[6]. However, the best treatment of femoral shaft fractures between four to twelve years of age of children is a matter of debate[7]. Since the last two decades, there has been a growing tendency towards a more operative approach in patients over four years of age[8].

Titanium Elastic Nailing (TEN), which is variously known as Elastic Stable Intramedullary Nailing, has become the choice of stabilization in pediatric long bone fractures, particularly the femoral shaft fractures[8]. The apparent advantage of this technique includes early union due to the repeated micromotion at the fracture site, biology of the fracture haematoma is intact due to close reduction, early mobilization, early weight bearing, scar acceptance, easy implant removal and the high patient satisfaction rate[1,9,10].

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Materials and Methods

In this research we report a prospective study with the objectives of evaluating the role and efficacy of Titanium Elastic Nail in femoral diaphyseal fractures in the age group of 4-12 years. Ethical approval was received from IERB of Eastern Medical College and Cumilla Trauma Center.

Twenty-six (26) children (18 boys, 8 girls) in the range of 4-12 years with recent (<3 days) femoral shaft fracture (24 closed, 02 Grade-I compound) stabilized with Titanium Elastic Nail (TEN), between January 2019 and June 2022 in Eastern Medical College Hospital, Cumilla and Cumilla Trauma Centre. Most of the fractures were due to road traffic accidents (n = 20, 76.9 %) and the rest are due to fall from height (n = 6, 23.1%). The right sided involvement was seen in 15 cases (57.7%) and associated injuries were seen in 05 cases (19.2%). There were four fractures in the proximal third, seventeen in the middle third and five in the distal third of the femur.

Most of the patients (n=22) were underwent surgery within 7 days of their injury. The surgeries were performed under general anesthesia with the patients on the fracture table in supine position. The diameter of the individual nail (2 nails with equal size) was selected as per Flynn JM, et al. formula[11] (Diameter of Nail = Width of the narrowest point of the medullary canal on Anteroposterior and Lateral view × 0.4 mm) and intraoperative assessment. The diameter of the nail was chosen so that each nail occupies at least one-third to 40% of the medullary cavity. Fractures were reduced using fluoroscopic guidance. Nails were inserted in retrograde fashion with medial and lateral incision 2.5-3.5 cm above the physis. The nails were pre-bent sufficiently so that the apex of the bowed nails rested at the same level on the fracture site to ensure a good equal recoil force.

Open reduction was required in 3 cases due to soft tissue interposition and failure to negotiate one nail to the proximal fragment. The nails were driven proximally so that both were divergent, and the tips got anchored minimum 1 cm distal to the physis. Postoperatively patients were nursed in supine position with the operated leg elevated on a pillow. A long knee brace was used in three cases of distal third fractures, where fixation was not adequate. Patients were mobilized without weight bearing on the fifth to seventh day postoperatively. Partial weight bearing started at three weeks and full weight bearing by 6-8 weeks depending on the fracture configuration, callus response and associated injuries. All patients were followed radiologically as well as clinically until fractures healed and for any complications. The summarized data was presented in the forms of figures and tables.

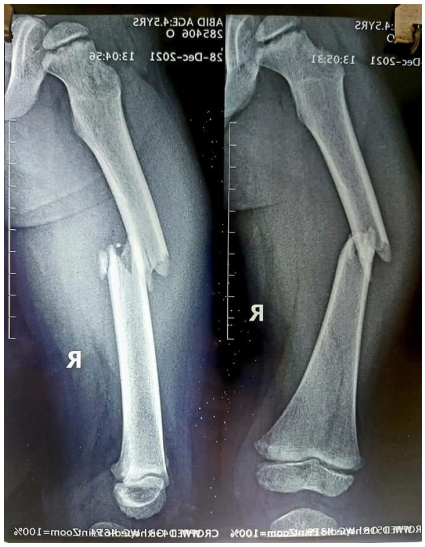

Fig. 1(a)

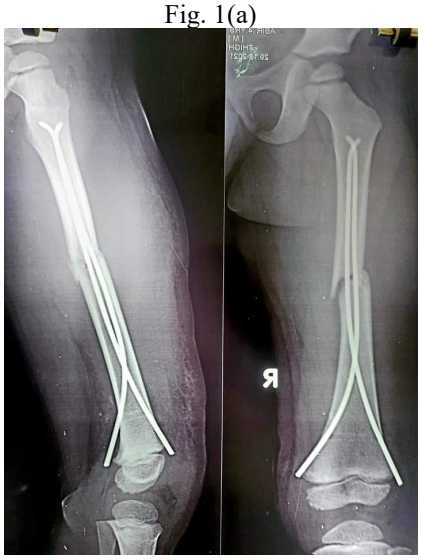

Fig. 1(b)

Fig. 1(c)

Figure-1: a) 4.5 years old baby with fracture shaft of femur, b) Close reduction and internal fixation was done with TENS and c) 6 months post-operative follow up x-ray.

Results

Among the twenty-six (26) cases 18 were boys and 8 were girls. (Figure-2) Twenty-three (23) cases were managed by closed reduction while three (3) cases required open reduction. (Figure-3) Minimum nail size used was 2.5 mm while maximum nail size used was 4 mm. The time duration of surgery ranged 20-45 minutes. The hospital stay ranged between 5 and 12 days (mean 8.1 days). In 24 cases (92.3%), no post-operative immobilizer was used, while in 2 cases (7.7%) hip spica was applied. The union of fracture was assessed by standard clinical and radiological criteria.

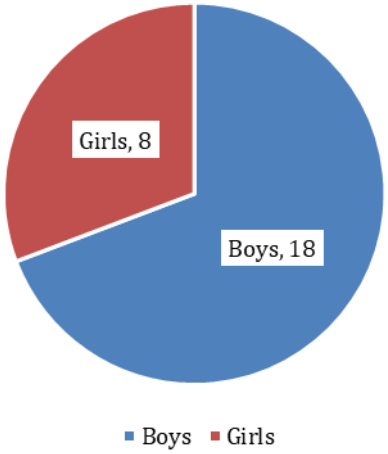

Figure-2: Pie chart showing gender distribution in study subjects (n=26)

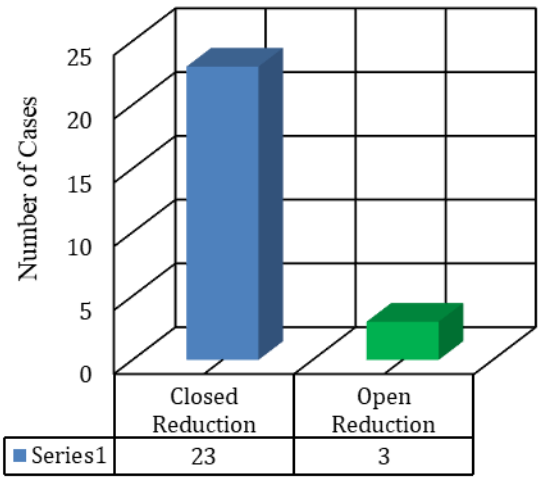

Figure-3: Bar diagram showing the types of surgery in study subjects (n=26)

The duration of follow-up ranged from 3 months to 37 months (mean 21 months). Absence of pain on walking was the clinical indicator of union. Radiological criteria for fracture union were assessed by using Anthony, et al.[12] scale of grading callus formation. (Table-I) Bridging callus was first noted on follow-up radiograph at an average of 3.5 weeks at which time partial weight bearing was started. All fractures in this series are united with grade 3 callus formation in a duration ranging between 8 and 10 weeks (mean 9 weeks). Fourteen (14) patients were found to achieve union at 8 weeks, 10 patients at 9 weeks and one patient at 10 weeks duration. The average time of the full weight-bearing ranged from 8 to 11 weeks (mean 9.5 weeks) (Table-II).

Table-I: Anthony's scale for grading callus formation

Grade	Description
Grade 0	No identifiable fracture healing
Grade 1	Primary bone healing with little or no periosteal new bone formation
Grade 2	Periosteal new bone formation on two sides of the femur
Grade 3	Periosteal new bone formation on three or four sides of the femur

Table-II: Duration of achievement of fracture union with number of the cases (n=26)

Duration of fracture union	Number of cases	Percentage (%)
8 weeks	14	53.8
9 weeks	10	38.5
10 weeks	02	7.7

Table-III: Flynn's classification method and outcome scoring (n = 26)

Criteria	Excellent	Satisfactory	Poor
Leg length inequality	<1 cm	<2 cm	>2 cm
Mal-alignment	5°	10°	>10°
Pain	Absent	Absent	Present
Compli-cation	Absent	Minor and resolved	Major and/ or lasting morbidity
Patients result	20	06	00

Functional outcome of patients was evaluated by Flynn JM, et al.[13] scoring system. The results were excellent in 24 (92.3%) and satisfactory in 2 (7.7%) cases. No patient had poor results (Table-III). Patients started full weight bearing at 6-9 weeks. The functional outcome was noted as patient was having good amount of flexion and extension at hip and knee joint, was able to squat and sit cross legged. There was no case of neuro-vascular deficit or death.

Per-operative technical difficulties encountered during close reduction due to soft tissue interposition at fracture site which requires open reduction in 3 cases.

Limb length discrepancy was noticed in 6 cases where all cases showed lengthening. Out of six cases 3 showed lengthening of 1.5 cm and the rest 3 showed less than 1 cm lengthening. Varus angulation of 5 degrees has occurred in 2 cases and 10 degrees in 2 cases. Rotational alignment was measured by the foot progression angle which was symmetrical in 1 case. Out toeing mal alignment of the injured extremity of 5° has occurred in 1 and 10° has occurred in 2 cases. There was no implant failure or refracture in this series. Superficial skin infection was found at nail entry site in 2 cases which were healed by dressing and oral antibiotic. One (1) patient developed ulceration due to entry site irritation of the nail.

The pre-injury level of activity was restored in all cases after an average of 6.5 months (range 5-8 months). The nails were removed after an average of 22 weeks (range 12-32 weeks). No complications were associated with the nail removal procedure and no refractures were observed after nail removal.

Discussion

Although femoral shaft fractures constitute fewer than 2% of all pediatric fractures, the choice of treatment has remained a constant challenge to the orthopedic surgeons[2]. Conservative treatment was the preferred method for the treatment of diaphyseal fractures in children and young adolescents. However, to avoid the effects of prolonged immobilization, to reduce the loss of school days and for better nursing care, the operative approach has been gaining popularity for the last two decades[14].

Recent studies have also increased awareness of the psychological and economic effects of spica casting on children and their families[1,15]. A variety of therapeutic alternatives such as external fixator, compression plating, rigid intramedullary nailing and flexible intramedullary nailing are being used for femoral shaft fractures in children. External fixator provides good stability and early mobilization, but it is associated with the risk of pin tract infections, and it takes a longer time for weight bearing[1,15]. Plate osteosynthesis is associated with extensive soft tissue dissection, greater blood loss, relatively longer duration of immobilization, risks of infection and hardware failure[16]. Solid intramedullary nails are ideal for skeletally mature children but when attempted in skeletally immature patients it is associated with avascular necrosis of the femoral head, thinning of femoral neck and growth arrest of greater trochanter with secondary coxa valga deformity[17-19].

Titanium elastic nail has an advantage over other methods of fracture stabilization in children because it is a simple load-sharing internal splint that doesn't violate open physis and allows early mobilization and maintains alignment[20]. Ligier and colleagues were the first to report beneficial use of titanium elastic nails (TENS) in the treatment of femur fractures in children[21]. In their 5-year study of 118 children (123 fractures) ranging in age from 5 to 16 years, they found only 1 case of infection and 13 cases of skin irritation/ulceration from the nail tip near the insertion site[21]. Similarly, Narayanan UG, et al.[22] found a good outcome in 79 femoral fractures stabilized with TEN. These authors also recommended that transverse, short oblique and short spiral fractures with minimum comminution within 5 to 12 years were the best indications of TEN[22]. Reeves RB, et al.[23] reported a higher rate of complications in the traction and casting group (41 patients with shaft fractures) as compared to the group undergoing intramedullary nailing surgery (49 patients).

In shaft fractures of the upper limbs, surgical procedures are increasing to prevent functional deformity of the forearm and cosmetic deformity of the humerus[24]. Sahu et al.[25] have reported 35 out of 40 patients with excellent results in both pediatric bone forearm fractures managed with TEN. Good results have also been reported by Kapila et al.[26] in both pediatric bone fractures treated with the titanium elastic nailing system (TENS).

The TEN approaches have some complications which are minor, and many are preventable. The most common complication of Titanium elastic nail is entry site irritation and pain[13,22]. Pain at the insertion site was significantly associated with bent or prominent nail ends[2]. These complications are minimized by advancing the nail ends till they lie against the supracondylar flare of the femur[2]. Other complications include limb length discrepancy, angulation of fractures, refractures and infection[13,22]. Limb length discrepancy has been reported and is more often associated with femur fractures. On end-to-end alignment, overgrowth is still a potential problem when using TEN. These patients must be followed up until they attain skeletal maturity[9,27]. In a study by Sarkar S, et al.[28] found Varus angulation in the fracture site in some cases which was probably due to early weight bearing in oblique fractures following elastic nailing.

Conclusion

The intramedullary fixation by TEN is a simple, easy, rapid, reliable, and effective method for management of pediatric femoral and tibial fractures between the age of 4 to 12 years, with shorter operative time, lesser blood loss, lesser radiation exposure, shorter hospital stays and reasonable time for bone healing. However, the surgeon must be

sound with technique as well as the limitations of these devices. Using an accurate technique and paying attention to the principles of fracture fixation methods with these elastic intramedullary nails, we can achieve good results and avoid common complications.

Conflict of interest

The authors declared that they have no conflict of interest.

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