

Original research article

The use of Ender's Nail in Tibial Diaphyseal Fractures in Pediatric Patients – A Clinical Study

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Received: 20-03-2022.

Revised: 13-04-2022.

Accepted: 24-04-2022

Abstract

Background: Pediatric patient population having shaft tibia, open or closed, which couldn't reduce conservatively with traction manipulation and cast. Purpose of the study was to access the outcome of shaft tibia and femur fracture fixation with ender's nailing which is least invasive, least complications, least expensive and excellent outcome.

Materials and methods: It is a retrospective study with 11 patients with diaphyseal fracture of tibia were managed surgically with ender's nails at teaching tertiary care hospital with minimum of 6 month follows up. The demographic data, level of fracture, type of fracture, number of Ender's nails, level of entry points, the direction of nail tips and the time to union are all recorded.

Results: All patients had average clinical union start time of 10 to 14 weeks. Full weight bearing was started at 8 weeks for tibia patients. No nonunion, infection, malunion was seen. As per Flynn's criteria 64% patients with excellent and 36% patients with satisfactory outcome noted in our series.

Summary: Ender's nail is cost effective, safe, easy to use and easy to remove intramedullary nail fixation for pediatric shaft tibia fracture. It provides stable fixation and allows rapid healing of the fractures with minimal to no complications.

Key Words: Ender's Nail, Tibia fractures; elastic nailing, Outcome

Introduction

Tibial shaft fractures in pediatric age group are most common after femur and forearm representing 15 % of all pediatric fractures.[1] Conservative management by means of closed reduction and cast application consider an ideal treatment for stable fractures. However, there

is no general agreement over unstable or displaced fractures management modalities for pediatric lower limb long bone fractures. Versatile management options for such fractures are casting, Enders nailing and Titanium. Elastic Nail (TEN), external fixator depending on many factors such as polytrauma, open fractures, neurovascular injury or ipsilateral limb fractures. Flexible nailing comprises two options for pediatric fractures one is Enders nail made up of stainless steel and other one is titanium elastic nail. Superiority of one over other is still a debatable issue. Theoretically TEN is considered superior with an added advantage of MRI compatibility in polytrauma patients. These flexible nailing methods are considered relatively safer, minimally invasive, less traumatic to biology around fractures. Loss of alignment in operative patients with flexible nailing was significantly lower as compared to nonoperative management.[2] The elastic restoring force i.e. the force that reduces the fracture at the apex of the curve of the nail is twice as high for stainless steel as compared to titanium nails. For adolescent and older children near skeletal maturity with narrower medullary canal and extensive soft tissue injury steel nail is better options due to its higher restoring force.[3] We have been using Ender's nails, which are a pre-contoured, stainless steel nail for stabilization of tibial shaft fractures will continue to do so and we will report our experience in this ambidirectional study.

Pediatric Lower limb long bones shaft fractures are common injuries for orthopedic surgeons in their day to day clinical practice. These fractures usually occurs due to direct impact of external forces in traffic accidents, of fall down and hit the hard surface directly while playing. To determine demographic and epidemiological factors associated with fracture, understand the mode of injury and line of management, estimate the biomechanics of implant on fracture healing and its final result, and observe the treatment outcome.

Material and Methods:

It is a retrospective study with 11 patients with diaphyseal fracture of tibia were managed surgically at teaching tertiary care hospital with minimum of 6 month follows up from May 2019 till may 2020.

Inclusion criteria:

- Age group 6-15 years
- Fracture of Tibial diaphysis.
- Open fractures upto grade 2
- Patients with unstable, displaced fractures unable to reduce fracture and maintain the reduction after anesthesia.

Exclusion criteria:

- Skeletally matured patients
- Ipsilateral hip or ankle fractures
- Pathological Fracture.
- Malunited old shaft fractures of lower limb.

After obtaining Institutional Review Board approval, we have analyzed case records and radiographs of all children with lower limb long bone fracture who were treated with Ender's nails. All children with radiographic follow-up until complete fracture consolidation have been included in the study. Our indications for nailing are displaced or unstable, closed or type-1 and type-2 open tibial shaft fractures (Gustilo and Anderson), those with associated injuries and those with failed closed reduction. Fractures were classified based on AO pediatric fractures classification. All children with such fractures and no evidence of compartment syndrome or neurovascular injury were routinely operated after anesthetic and pediatrician's assessment. The demographic data, level of fracture, type of fracture, number of Ender's nails,

level of entry points, the direction of nail tips and the time to union are all recorded. The radiographic assessment of coronal angulation and sagittal angulation have been measured on the anteroposterior and lateral radiographs respectively at immediate post-op, six weeks follow-up and final follow-up using the mid-diaphyseal lines of the proximal and distal fragments. Union time has been assessed based on first appearance of three cortical bridging callus. An angulation of more than 10° in any plane have been considered as malunion and limb length discrepancy have been defined as shortening or lengthening of more than 1.5 cm at final follow up.

Technique

The child was positioned supine and fractured limb was elevated over a cushion. No tourniquet was used. A formal reduction of the tibia was done to gain the length, to facilitate accurate measurement of the nail. The distance between the proximal and distal physis was considered as the nail length. The entry point was made in the proximal tibial metaphysis at least 1.5 cm away from the physis. Through a 1 cm longitudinal incision the bone was reached with blunt dissection and a 3.2 mm drill was used to make the entry hole which was then widened tangentially with an awl, under fluoroscopic guidance. The proximal or distal site of entry was subject to the surgeon's discretion. Antegrade nailing was done for tibia fractures. Diameter of nail was decided by width of the narrowest point of the medullary canal on Anteroposterior and/or Lateral view multiply by 0.4 mm.^{25,26} As per our institutional protocol, two pre-bent 3 / 3.5 mm Ender's nails were used for most of the fractures. The nail was negotiated under image guidance and in case if it was found abutting against the opposite cortex, it would be withdrawn, and its curve adjusted to avoid splintering. The stability of the fixation was checked in coronal and sagittal planes after the completion of nailing. If found unstable, an additional nail would have been added either from the proximal or distal site. The eyelet was left flush with the metaphysis to avoid soft tissue irritation and for easy identification during implant removal.

For those with Tibial shaft fractures a below knee cast was given. The cast was removed at four weeks and gradual weight-bearing was started, based on fracture healing where in transverse fracture it was early about 4 weeks and spiral or long oblique fracture it was about 6-8 weeks. physical therapy curtailed to patient-to-patient basis depends on age, fracture pattern and fixation stability and advocated on post operative day 1 after adequate analgesia. Implant removal was performed after a minimum of nine months from the time of surgery.

Results

We had eleven patients with shaft tibia fracture. Out of Eleven patients treated with ender's nailing for pediatric lower limb long bone fractures, ten patients (91%) were male and one patient (09%) was female. Patients' age ranges from 6 to 12 years with mean of 9 years. Only one had bilateral shaft tibia fracture, rest ten patients had unilateral shaft tibia fracture. Out of eleven shaft tibia fracture, only one was isolated shaft tibia fracture rest ten patients had associated shaft fibula fracture (56%) as well. None of the patients needed any fixation for fibula or fibulotomy.

Regarding mode of injury six patients (55%) had history of road traffic accident, five patients (45%) had history of fall down at home while playing. None of the patients had additional fracture in body rather than shaft tibia- fibula. Only one patient (9 %) had history of head injury and CT scan head ruled out any intracranial hemorrhage, six patients (54%) had history of superficial abrasion, bruise or laceration to local site, hands or face, four patients (36.36%) didn't have any associated injury. Out of eleven patients two patients (18%) had open grade 1

fracture with puncture wound on fracture site, nine patients (82%) had closed fractures. Patients were treated within time frame of 8 - 26 hours with mean of 17.5 hours since the time of injury. We did not do open reduction for any fracture in our series. None of them needed blood transfusion or special post-operative care. After fracture fixation, Tibia patient were immobilized with Below Knee slab for 2 weeks, knee bending was started after 2 weeks of fracture fixation. Patients were kept non weight bearing for 4 weeks. Partial weight bearing was started from 4 to 8 weeks. After 8 weeks full weight bearing and gait training was started. Physiotherapy was started at 3 weeks 8 weeks in the mode of Quadriceps Drill, Quadriceps Strengthening Exercise, and Hamstring Strengthening Exercise. Out of eleven patients, only two patients (18%) had mild skin impingement; rest sixteen patient (81%) didn't have any major complication. Patients were scheduled for visit within 1 month, 2 months, 3 months, 6 months post-operative follow up. Clinical union signs were seen within 1 to 2 months of timeframe. Earliest radiological healing sign was observed at 1 month post op, late by 2 months. Radiological union has been seen earliest 8 weeks and late by 16 weeks with mean of 12 weeks. Patients were advised to schedule visit after 9 months of surgery. Results were evaluated using Flynn et al scoring criteria for Ender's Nail.[4] (Table I) Seven patients (64%) had excellent and four patients (36%) had satisfactory outcome. The criteria measured Pain/ tenderness, limb length discrepancy, any mal alignment and/or minor/ major complications at final follow up.

Table I: Flynn's Scoring Criteria outcome

Outcome	Number of patient	Percentage
Excellent	07	63.6
Satisfactory	04	36.4
Poor	00	0.0
Total	11	100

Two patients were scheduled for Enders removal due to soft tissue impingement at 9 months which impedes terminal flexion. After removal of enders, both were able to achieve complete flexion at knee joint without any residual pain. None of the patients in our series were re-operated after index surgery.

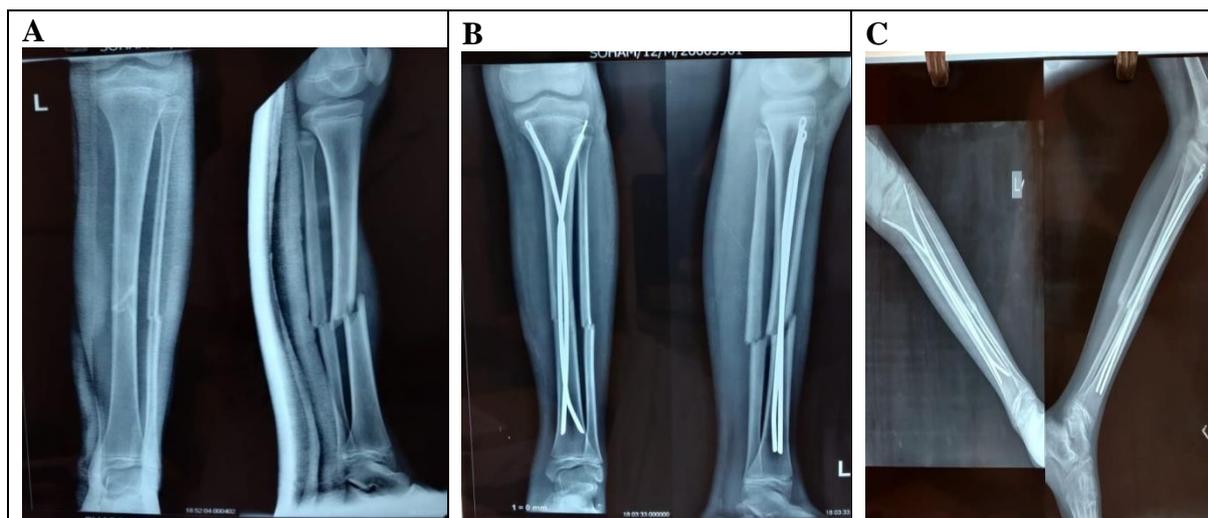


Figure 1: Radiograph of shaft tibia fracture of 7 year pediatric patient a) Pre operative b) Immediate post-operative c) Final follow up

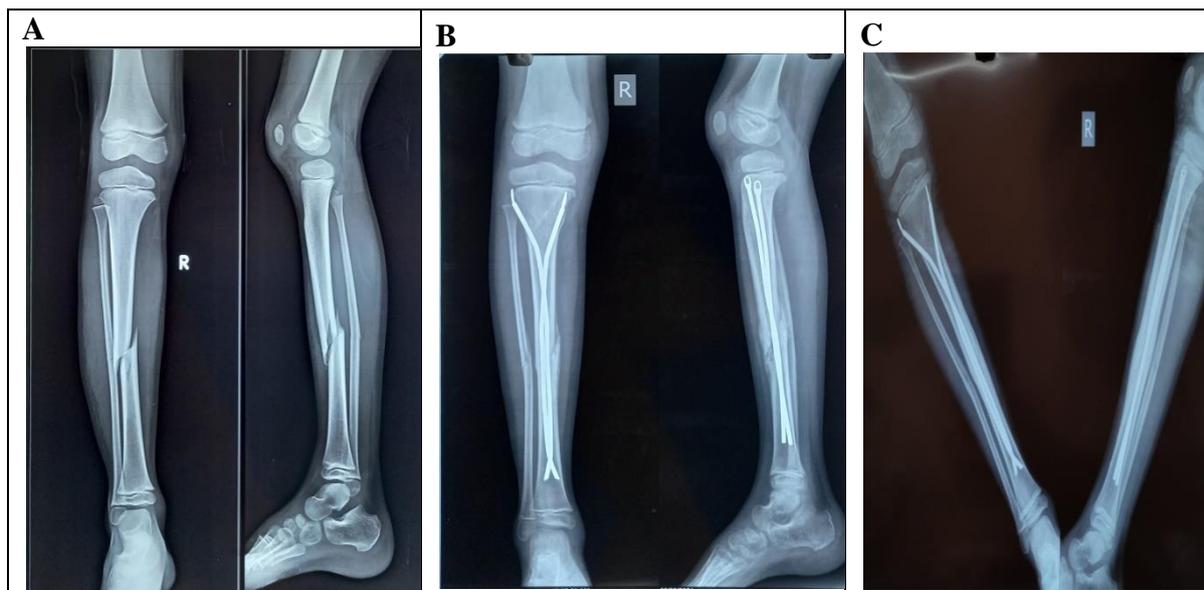


Figure 2: Radiograph for shaft tibia fracture of 9 year pediatric patient a) Pre operative b) Immediate post-operative c) Final follow up

Discussion

Today's world, children are more prone to get lower limb long bone fractures with playground injury or road traffic accidents having either displaced Tibia-Fibula or Femur fracture. It is one of the most common fractures requiring hospital admission and operation in the pediatric age group. With many articles published for different types of fixation techniques with titanium elastic nail system, newly plating / interlocking nails, but the majority of them incline towards the TEN system. There is a scarcity of literature regarding the use and outcome of Enders' nailing in pediatric lower limb long bone fractures. Flexible nailing has proven superior to plating, external fixation, or interlocking nails and conservative management. Flexible nailing has become the mainstay treatment for pediatric and adolescent long bone fractures amenable to conservative management.

The long-standing history of excellent results in fracture management with stainless steel implants cannot be overlooked. The Enders nail is one of the excellent implants with its versatility and ease of use with cost effectiveness. Although the Enders nail is not practiced by many centers, it is still in use in developing countries with limited resources and the affordability of fancy implants. With proper technique and correct principles, it is still far more superior than conventional modern commercialized implants for pediatric long bone fracture management.

During the COVID-19 pandemic across the globe in late 2019 and 2020, trauma referrals to tertiary care surprisingly increased, probably due to lockdown states, no clear guidelines for management at smaller nursing homes and small hospitals with COVID protocols, poor infrastructure to handle surgical and medical facilities to combat COVID cases with trauma, and lower affordability of private healthcare due to lost jobs as well as the shutdown of smaller businesses. To counteract these factors, the trauma unit should have its own protocol in accordance with national guidelines by the apex body as well as from expert senior pediatric orthopaedic surgeons at our institute. The use of the Enders nail not only provides excellent fixation but is seemingly more cost-effective and a widely available choice in developing countries like India. Our study seemed to be less invasive, well-equipped resources, and backed up pediatric and medical facilities to combat COVID scenarios.

Since its inception in early 1900s stainless steel implants were modified gradually from type 302 to 316L for orthopaedic surgery which contain 17-19% chromium and 14% nickel and later molybdenum with little amount of carbon was added for corrosion resistance.[5-6] More over Ender's nail has advantage of being low cost, pre countered, immediate fracture stabilization, minimal soft tissue disruption, lower infection and refractures rates, early mobilization and rapid return to normal day to day activity with minimal complication, quick removal with the help of the 'eye' in enders nail.

We have selected only Stainless still implant over titanium as formal has more benefit than later one. Stainless steel nails have better stability in torsional force, axial force and bending force.[7] Titanium nails are less stiff than steel with lower bending yield load. In adolescent and unfavorable canal diameters enders nail were considered better as compared to titanium nails.[8]

Lascombes et al advocated usage of elastic nails in upper and lower limbs with precision of entry and thorough understanding of fracture geometry with fixation techniques. Femur and tibia fracture fixation with these elastic nails with accurate diameter according to age of child and technique of insertion sequentially in proximal, transverse, distal shaft, comminuted and long oblique fractures confer a challenging task and expertise. [9] Biomechanics of fracture healing and remodeling potential of children long bone fractures are much concern as compared to adults. Three point bony fixation, prebending and negotiation of enders and elastic nails are almost comparable. Conservative management in children with lower limb fractures had negative impact in terms of prolong cast immobilization, study dropout, joint stiffness and parental psychosocial problems. [10] Kaiser studied composite femur synthetic bone models with two groups divided into fixation with steel nails and another group of bone fixation with elastic nails. Biomechanical loading successfully exhibited pristine compatibility, strength in cortical contacts with bending and shearing stiffness. [7]

In regards to steel nails, they had score over elastic nails to bring to forefront statistically. Union rate and revision incidence were less in steel intramedullary nails. [11] Stainless steel nails were excellent in healing, stability, resistant to deforming forces, less complication rate, no metal allergic reaction and cheap as compared with elastic titanium nails. [12] Merianos et al had used enders nails in proximal, distal, midshaft and segmental tibial fractures where at final follow up recorded less than 10* valgus and posterior angulation and malrotation. [13] Treatment of femoral shaft fractures with proximal entry leads to coxavalga, epiphyseal growth arrest of trochanter along with varied degree of capital femoral dysplasia.[14] Parsch et al- Ender's nails were used in all ages from three to eighteen years of age irrespective of diaphyseal long bone fractures with either direction with extended indication among children with good results. [15] One of the largest series of tibial shaft fractures treated with enders nail suggested hundred percent radiological union without any obvious coronal and sagittal plane deformity.[1] Premanandam et al. enders nails were satisfactory tool not only for pediatric femoral diaphyseal fracture stability and cost but also for versatility of technique once learned for all age group of surgeons. [16] The excellent amount of callus with bone healing where minimal telescoping with elasticity and flexibility as compared to locked nails were observed in enders nailing. [17]

No instances were observed concerning delayed union, infection, nonunion, growth arrest, injury to the femoral epiphysis, or re fractures after rod removal. Two patients had skin impingement at entry site which were removed after 9 months as full callous seen on X ray. Ender's Nails are economical, resist not only shearing/bending force but also resist rotational

force when used multiple. It can be used in open grade 1, 2, 3A fractures. We have multiple advantages like stable fracture fixation once cross fracture site, minimal telescoping at fracture end, simple to maneuver while negotiation at the insertion end, easy to remove due to eye at the end of the nail. It has also a lesser chance of migration due to its flat and broad insertion end. Enders nails are considered as best implant for polytrauma pediatric patients, severe soft tissue injuries, and combined strain pattern by Enders nails which generates in-axial directions from callus at fracture site by active physiotherapy. We don't have any evident metallurgy in any recorded data as well as in our series. Patients' had minimal to no complications at all. Although our case series comprises a relatively smaller numbers, more study regarding the use of enders nail in pediatric long bone lower limb fractures will be required to establish some more evidences for its use and its outcome.

Conclusion

There are no general agreements over implant choice or management methods to treat Long bone pediatric fractures in current era. Enders nailing is reliable and cost effective method of fixation with lesser complications in developing nations.

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