

Efficacy of Titanium Elastic Intramedullary Nailing System (TENS) in the treatment of Paediatric Tibial Shaft Fractures

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ABSTRACT

Background: Closed reduction and casting is the standard treatment in paediatric tibial shaft fractures. However, in unstable and open fractures surgery may be needed.

Aim: To evaluate results after operative fixation in tibial shaft fractures of age group between 6 to 16 years using titanium elastic nails (TENS).

Methods: Thirty eight patients, who had unstable tibial shaft fractures, were treated with titanium elastic intramedullary nailing system (TENS) under fluoroscopy in Department of Orthopaedic Unit-1 from January 2019 to September 2020 prospectively. The average age of the patients in our study was 9.2 years (range 6– 12 years). 6(15.79%) out of 38 patients had open fracture that were Grade I in 3 patients, II Grade in one patient and Grade IIIA in two patients.

Results: All patients achieved union radiological as well as clinical with a mean of 8.5 weeks. No patient developed Leg length discrepancy. No patient developed angulation in coronal or sagittal plane more than 6 degrees with mean angulation in coronal plane of 4 degrees and sagittal plane 3 degrees. Pin site irritation and infection developed in 9 patients that resolved completely at final follow up. Superficial infection developed in 3 patients who had open fracture and one patient developed deep infection.

Conclusion: Intramedullary TENS fixation provides excellent outcome with acceptable complication in Close Unstable and Open tibial fractures in which closed reduction is not possible due to stability, edema or wound.

Keywords: Paediatric Tibial Shaft Fracture, titanium elastic intramedullary nailing system (TENS), union

INTRODUCTION

Tibial shaft fractures are the second most common fractures after femoral fractures in the pediatric age group having an incidence of 15%^{1,2}. A closed reduction followed by casting is the mainstay of treatment in these fractures except with open fractures, neurovascular injury, polytrauma, and fractures with unacceptable angulation^{2,3}. Since Métaizeau with his team from Nancy, France, developed the technique of flexible stable intramedullary pinning using titanium pins in 1982, the treatment modalities have changed dramatically^{1,4}. Over the last decades an increased interest in the operative treatment of paediatric tibial shaft fractures is in debate, with no defined guidelines^{4,5}.

Different surgical methods to treat unstable paediatric tibial fractures exists including intramedullary fixation, crossed Kirschner wires (K-wires)^{1,4,5,6}, or external fixators with the treatment goals of stabilising the fracture, maintaining length and alignment with minimising the complications. External fixators have been associated with several complications such as delayed union, malunion, high incidence of pin tract infections, and leg-length inequality^{5,6,7}.

Even after efforts of French surgeons initially, and recently by the Paediatric Orthopaedic Society of North America (POSNA) clear guidelines to treat these Paediatric tibial shaft fractures haven't been established^{7,8}. Titanium elastic nail (TEN) fixation was originally used as an ideal treatment method for femoral fractures in this age group with minimal complications and desired results^{8,9,10}, however gradually the use has been increasing in other long bone fractures like tibial shaft fractures^{10,11,12}. The aim of our study was to evaluate results after operative fixation in tibial shaft fractures of age group between 6 to 16 years using titanium elastic nails (TENS).

MATERIALS AND METHODS

This prospective clinical case series was conducted to assess the results of operative treatment of paediatric tibial fractures treated in Department of Orthopaedic Unit-I, Mayo Hospital, Lahore from January 2019 to December 2019 with the final follow up of patients till September 2020. The study included Paediatric tibial shaft fractures in 6 to 12 years population that are unstable close fractures (complete displacement, comminution unstable fracture pattern), open fractures up to Gustilo anderson III A, fractures that were managed with closed reduction but failed. Patients with tibial fractures closer to the epiphyseal plate and patients with open fracture having grade more than Gustilo Anderson Grade III B & C, pathological

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fracture, and patients with follow-up less than one year were also excluded from the study. Thirty eight patients were included in the study. There were 30 males (78.9%) and 08 female (21.1%) patients. Mean age at the time of injury was 9.2 years (range 6– 12 years). Out of 38 patients 6(15.79%) had open fracture including Grade I Gustilo anderson three patients, Grade II Gustilo anderson one patient and Grade IIIA Gustilo anderson two patients. Postoperative angulation (Coronal & sagittal plane), time to bear weight, time to radiological union (three cortices bridging on radiograph) and clinical union (movement at fracture site), range of motion (Knee & ankle) were recorded for each patient. Flynn et al criteria was utilized to assess final outcome.

Surgical Technique: All cases were operated in general anesthesia in supine position on standard operating table with image intensifier. Closed reduction was first achieved under image intensifier and then 1 cm small stab incisions were used on each side of proximal tibia 2 cm distal to proximal tibial physis. Two TENS nails with a diameter of 2-4 mm according to age and bone size of patient were used in Antegrade way in all patients from medial and lateral side. After confirming reduction and correct length of TENS in image intensifier, tip of TENS was cut and bent outside the skin. Above knee back slab was applied post operatively for four weeks minimum to six weeks maximum. Once clinical and radiological union achieved TENS were removed under sedation. Data was evaluated using SPSS 22.0 for windows

8 year Old boy with closed tibial shaft fracture



Unacceptable reduction due to unstable fracture



Postoperative radiograph with long back slab



Union at 7 weeks



Unstable tibial shaft fracture in 11 years old boy treated with TEN



RESULTS

The 38 patients 30 males (78.9%) 08 female (21.1%) with a mean age at injury of (range 6– 12 years) with average 9.2 years. Out of 38 patients 15(39.47%) patients were with unstable fracture pattern, 17(44.73%) patients were with failed attempt of closed reduction and 6(15.79%) had open fracture that were Grade I in 3 patients, II Grade in one patient and Grade IIIA in two patients based on the Gustilo–Anderson open fracture classification. The mean follow-up was 12.4 months. No patient developed angulation in coronal or sagittal plane more than 6 degrees with mean angulation in coronal plane of 4 degrees and sagittal plane 3 degrees. No patient had a leg-length discrepancy. Pin site irritation and infection developed in 7(18.42%) patients that resolved completely at final follow up. Superficial infection developed in 3(7.8%) patients who had open fracture and one (2.6%) patient developed deep infection. All the infections were successfully treated with appropriate antibiotic therapies. The mean time to partial weight bearing was 3.2 weeks (2.5 weeks to 3.7 weeks). Mean time to union was 10.02 weeks (range of 8–17 weeks). Four patients developed only mild restriction of range of motion at knee joint at initial follow up and regained full range of motion at final follow up. 28 (73.68%) patients out of 38 had excellent result according to Flynn's Criteria and 10(26.31%) patients had satisfactory results.

Patients	n=38
Age	(range 6– 12 years) with average 9.2 years
Gender	30 males (78.9%) 08 female (21.1%)
Open Vs Closed	32 Closed (84.21%) 06 Open (15.79%)
Operation time	Less than 30 minutes =15 patients (39.5%) 30-60 minutes= 20 patients (52.63%) 60-90 minutes= 03 patients (7.89%)
Weight bearing	2.5 to 3.7 weeks with mean of 3.2 weeks

Angulation	Coronal plane= mean angulation of 4 degrees valgus Sagittal plane = mean angulation of 3 degrees of procarvatum
Range of Motion	Full ROM= 34 patients (89.47%) Mild restriction = 05 patients (10.52%) Moderate restriction = Nil Severe restriction= Nil
Time to Union	Less than 10 weeks= 32 patients (84.21%) 10-14 weeks = 05 patients (13.15%) More than 14 weeks = 01 patient (2.63%)
Complications	Minor complications= 06 patients (15.78%) Major complications = Nil

TENS Outcome scoring

	Excellent Results	Satisfactory Results	Poor Results
Leg Length inequality	Less than 1cm	Less than 2cm	More than 2cm
Malalignment	5 degrees	10 degrees	More than 10 degrees
Pain	None	None	None
Complication	None	Minor and resolved	Major lasting morbidity
Patient Results	28(73.68%)	10(26.31%)	0

DISCUSSION

Traditionally majority of tibial fractures are managed by closed reduction and casting, and surgical intervention is rarely required unless it is open fracture, unstable fracture, and secondary loss of reduction after manipulation and if there is neurovascular injury. Historically, external fixator includes the risks of pin track infections¹³⁻¹⁷, non-unions and breakage of pins¹⁷⁻¹⁹. Intramedullary locking nails are rarely indicated due to open physis and risk of growth arrest. Titanium elastic nails with three point fixation in 'C' configuration provides better biomechanical stability to these fractures resulting in early union and minimum complications.

Duration of surgery in our study was less than 30 minutes in 15 patients (39.5%), 30-60 minutes in 20 patients (52.63%) and 60-90 minutes in 03 patients (7.89%). All the three cases which were operated in 60-90 minutes were communitated open fractures. Average duration of surgery was 45.9 minutes. In a study by Khurram Barlas et al¹⁴, the average duration was 70 minutes. In Patel et al study, average duration of surgery was 60 minutes. Full weight bearing was started between 2.5 to 3.7 weeks with mean of 3.2 weeks. In Uludağ et al¹⁵ study the mean time to partial weight bearing was 2.1 weeks mean with (range of 1–3) weeks.

In our study time to union was assessed radiologically and clinically, union was achieved in less than 10 weeks in 32 patients (84.21%) and in 10-14 weeks in 05 patients (13.15%) and 01 patient (2.63%) achieved union in 14 weeks that was an open fracture in 12 years old boy, over all in our study mean time to union was 10.02 weeks (range of 8–17 weeks). In Oh C.W et al. study average time for union as 10.5 weeks. In Uludağ et al¹⁵ the mean time to union was 10.85 weeks with (range of 6–20) weeks. In paediatric tibial shaft fractures, union time depends on age and is prolonged in advanced age group and in open fractures as well. In Gordon et al study of 50 tibial fractures,

union achieved in 8-10 weeks with mean age of 11.7 years but delayed union was observed in patients with mean age of 14.

Titanium elastic nails (TENs) can cause angulation problems when compared to rigid fixation like compression plating and External fixators. In a study by Brien et al.¹⁶ more than 5 degree angulation was reported in two cases (12.5%), one patient having more 6 degree coronal plane angulation and the other having 10 degree angulation in sagittal plane. In Sankar et al¹⁷ study reported more than 5 degree angulation in coronal plane in 3(18.9%) patients, and more than 5 degree angulation in sagittal plane in 1(6.3%) patient. In Uludağ et al¹⁵, 9(45%) patients had angulation of more than 5 degrees but none had angulation more than 10 degrees, the study stated that the higher angulation could be due to high remodeling potential in this age group. In our study no patient developed angulation in coronal or sagittal plane more than 6 degrees with mean angulation in coronal plane of 4 degrees and sagittal plane 3 degrees, three patients developed 6 degree angulation in coronal plane one patient developed 6 degree angulation in sagittal plane, they were followed up for 12 months and we believe that with further follow up we may be able to see this angulation remodeled.

Pin tract infection or pin site irritation can be a complication with TENS. We have reviewed multiple studies and the number of pin tract infections have been significant. In Onta et al¹⁸ 22% pin tract irritation was documented, Mani et al reported 13.3% pin tract irritation along with 4.4% of superficial infection at the pin site. Sankar et al¹⁷ reported 26% of pin tract irritation. 20% pin tract irritation developed in Uludağ et al¹⁵ study along with superficial pin tract infection in 10% of cases was reported. J.M. Flynn et al¹⁹ reported in a series of 234 cases treated by TENS reported pin site irritation and superficial infection in 38(16.2%) and 4(1.7%) respectively. In our study these patients pin site irritation and infection developed in 7(18.42%) patients that resolved completely at final follow up. Superficial infection developed in 3(7.8%) patients who had open fracture and one (2.6%) patient developed deep infection. All the infections were successfully treated with appropriate antibiotic therapy without any further intervention needed. In our study method we leave the TENS ends on top outside the skin that may be cause of pin site irritation, but we believe that follow up and patient education can reduce this complication. Ligier et al²⁰ advocated that TENS ends should be placed under the skin but we believe that as compared to Femur, tibia is subcutaneous bone and skin necrosis can occur in some cases. Pin site infection in TENS is far less than fractures treated with External fixator, multiple studies have reported pin site infection after paediatric fractures treated by External fixators²⁰⁻²³. 100 percent infection rate reported by Hosny et al²¹ and Dahl et al²² studies. 56% reported in Gregory et al study²³, 52% reported in Schalamon et al²² and 50% reported by Mason et al²¹.

Leg length discrepancy can be observed after tibial fractures due to high remodeling potential in paediatric age group^{24,25,26}. In Walamastha et al study¹⁵ 3.6% patients developed less than 15 mm LLD. In our study no patient developed LLD.

We believe that there are few limitations of the study including shorter follow up time, less number of open fractures, age group diversity and comparative modalities to our treatment method with TENS.

CONCLUSION

In conclusion, an intra-medullary TENS fixation provides excellent results in unstable, open tibial fracture and those with failed closed reduction patients. Moreover the early weight bearing, early union time and acceptable complication makes it ideal treatment option.

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