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Original research article

Study of outcome of titanium elastic nails fixation in tibial diaphyseal fracture among children

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Abstract

Background and Objectives: Tibial fractures are the second most common reason for orthopaedic inpatient admission to children hospital. Nearly all diaphyseal fractures of the tibia in children can be successfully treated using closed methods and cast immobilization; others have proposed pins in plaster, external fixation, open reduction with internal fixation, or intramedullary stabilization for unstable fractures. Recently, titanium elastic nails have gained popularity for the stabilization of femoral and tibial shaft fractures and other long bone fractures in the paediatric population. This study is intended to assess the complications and outcome following treatment of shaft of tibia by titanium elastic nails.

Methods: A prospective observational study was done with 23 children in the age group of 5 to 15 years admitted with a diaphyseal fracture of tibia to hospital. They were all treated with fracture reduction and internal fixation with titanium elastic nails and followed up until fracture union (ranging between 3 to 6 months). The functional outcome was assessed using Flynn scoring system.

Results: according to Flynn scoring system, we got excellent results in 20 cases, satisfactory results in 3 cases and no poor results. Nail tip irritation in 3 cases, bursa at nail tip in one case, nail back out in one case after 7 months of index surgery, and superficial infection in one case, no significant malalignment ($>10^0$), no significant limb length discrepancy (>2cm), no delayed or non-union and no deep infection.

Conclusion: We concluded that TENS fixation for paediatric tibial diaphyseal fractures was an easy, safe and effective method that provides alignment and rotational stability with minimal complication and good union rates.

Keywords: Paediatric, diaphyseal, tibial shaft, flexible nail, TENS nail, elastic nails

Introduction

Tibial fractures are the second most common reason for orthopaedic inpatient admission to children hospitals. Tibial and fibular fractures are the third most common pediatric long bone injuries (15%) after radial/ulnar and femoral fractures. The prevalence of tibial fractures in both boys and girls has increased since 1950. Seventy percent of pediatric tibial fractures are isolated injuries; ipsilateral fibular fractures occur with 30% of tibial fractures. Tibia is the second most commonly fractured bone in abused children [1].

The fracture can be incomplete (torus, green stick) or complete. Most tibial fractures in children under 11 years of age are caused by torsional force and occur in the distal of the tibial diaphysis. If there is not an associated fibula fracture the intact fibula prevents significant shortening of the tibia; however, varus angulation develops in approximately 60% of isolated tibial fractures within the first two weeks of injury. A tibial diaphyseal fracture with an associated complete fracture of fibula usually results in valgus malalignment because of the action of muscles in antero lateral aspect of leg. In infants and young children, the tibial shaft is relatively porous and is more likely to bend, buckle, or sustain a nondisplaced spiral fracture than to fracture completely [2]. The surrounding periosteum is strong and imparts stability to the fracture site, this limits displacement and shortening. In contrast, the adolescent tibial shaft is composed of more dense cortical bone and a thinner, weaker periosteum. Fractures in the adolescent age group are more often the result of high energy trauma and are associated with greater fracture displacement, comminution, and slower healing rates than in younger children. The remodeling potential of the tibia is limited [3]. Infants and toddlers can correct approximately 50% of residual angulation with growth. In children older than 10 years, only 25% of the axial malalignment improves. Hansen and Grieff, reported only 13.5% correction of angular deformity with subsequent growth, but Shannak demonstrated that one-third of children with more than 10 degrees of angulation at healing had persistence of the angulation at final follow-up assessment. In general, varus malalignment seems to

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remodel more completely than valgus deformity. Although long-term studies show that moderate angulation is well tolerated. The authors recommend that attempts should be made to maintain alignment within 10 degrees of angulation in any direction for children older than 6 years and within 15 degrees of angulation for younger children [4]. Rotational deformity may not remodel, although external rotation deformity is better tolerated than internal rotation deformity. Some shortening at the fracture site can remodel, but the ability to compensate for shortening decreases with age. Children younger than 5 years show the greatest capacity. However, growth acceleration greater than 5 to 7mm is unusual. In a review of 142 tibial fractures, Shannak reported an average of only 4.35 mm of growth acceleration. Comminuted and long spiral fractures displayed the greatest amount of overgrowth, including those that were treated with anatomic reduction and internal or external fixation. Overgrowth is not routinely seen in girls older than 8 years or boys older than 10 years. Treatment of pediatric fractures dramatically changed in 1982, when Métaizeau and the team from Nancy, France, developed the technique of elastic stable intramedullary nailing (ESIN) using titanium nails. In the last two decades there was an increased interest in the operative treatment of paediatric fractures, although debate persisted over its indications. There is a little disagreement concerning the treatment of long bone fractures in children less than 6 years (POP cast) and adolescents older than 16 years (locked intramedullary nailing). Controversy persists regarding the age between 6 to 16 years, with several available options: external fixation, flexible stable intramedullary nails, plate fixation, and locked intramedullary nailing. Whatever the method of treatment, the goals should be to stabilize the fracture, to control length and alignment, to promote bone healing, and to minimize the morbidity and complications for the child and his/her family [5]. Orthopaedic surgeons will continue to be challenged to treat this age group with less morbidity at a lower cost, as no clear guidelines have been available until now despite efforts done initially by French surgeons, later on by European surgeons and recently by the Paediatric Orthopaedic Society of North America (POSNA). Titanium elastic nail (TEN) fixation was originally meant as an ideal treatment method for femoral fractures, but was gradually applied to other long bone fractures in children, as it represents a compromise between conservative and surgical therapeutic approaches with satisfactory results and minimal complications [6].

Methodology

All children's between 5 to 15 years of age with diaphyseal fractures of tibia admitted at hospital included in the study during the study period.

Type of study: prospective, observational study.

Statistical methods

Sample size estimation: Sample size (ref 3 and ref 4).
P (prevalence) = 15%.
Alpha (level of significance) = 5%.
d (absolute error) = 15%.
Estimated sample size is 23.
study size calculated using estimation technique after taking prevalence of tibial fracture in children's 15% (P=0.015) alpha = 5% (level of significance), 15% absolute error, sample size is 23, as per the information provided by me, statistical technique provided based on the objectives given.

Statistical technique: Frequency, proportion, chi-square test for proportion, pie chart, line chart, and related statically technique using R software.

Inclusion criteria

1) 5-15 years of age.
2) Diaphyseal fractures of tibia.
3) Closed fractures.
4) Open fractures in gustilo Anderson type 1 and type 2.
5) Tibial fracture with polytrauma.

Exclusion criteria

1) Metaphyseal fractures.
2) Open fractures gustilo Anderson type 3.
3) Pathological fractures.
4) Parents not willing for operative treatment.
5) Segmental and comminuted fractures.

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Method of collecting data

Data will be collected from patients who are attended in orthopaedics OPD and casualty and admitted to orthopaedics ward of KRH attached to MMCRI.

Clinical study will be through questionnaire, interview, radiological assessment and clinical examination.

All patients underwent preoperative and post-operative x-ray investigations.

Surgical management of the fracture by closed reduction and internal fixation with titanium elastic nails.

Post-operative observation of patients at 3, 6, 9, 12 weeks and 6 months until signs of complete union were seen on x-ray.

Patients were assessed for pain, limb length discrepancy, varus/valgus malalignment, surgical wound complications, nail prominence and range of movements at knee joint. Regular follow up and physiotherapy for the patients treated to study functional outcome.

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 leg including knee and ankle to assess the extent of fracture comminution, the geometry and the dimensions of the fracture. On admission to ward, a detailed history was taken, relating to the age, sex, and occupation, mode of injury, past and associated medical illness. Routine investigations were done for all patients.

Preoperative planning

Patients were operated as early as possible once the general condition of the patient was stable and patient was fit for surgery. After prior informed consent, a pre-operative anesthetic evaluation is done. Pre-op planning of fixation is made.

Results

All patients in this study were operated on an average of 3.8 days following admission to our hospital. A maximum delay of 6 days was recorded and the earliest was 2 days.

Most patients were operated between 2 to 4 days following admission.

Table 1: Admission to surgery interval

Duration in Minutes	Number	Percentage
2-4 Days	15	65.2%
5-7 Days	8	34.8%
Total	23	100%

Average time of surgery 68 minutes, Minimum time taken 50 minutes and maximum 90 minutes.

Table 2: Duration of surgery

Duration of Surgery	Number	Percentage
<30 Minutes	00	00
30-60 Minutes	12	52.2%
>60 Minutes	11	47.8%
Total	23	100%

Table 3: Duration of hospital stay

Days	Number	Percentage
5-7 Days	14	60.9%
8-10 Days	9	30.1%
>10 Days	-	-
Total	23	100%

Table 4: Post-Operative Immobilization

Time in Weeks	Number	Percentage
5-6 Weeks	8	34.8%
7-8 Weeks	12	52.2%
>8 Weeks	3	13%
Total	23	100%

In our study all patients were able to perform full ROM at the knee without any restriction.

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Table 5: Range of movements

Range of Movements	Number	Percentage
Full Range	23	100%
Mild Restriction	-	-
Moderate Restriction	-	-
Severe Restriction	-	-
Total	23	100%

All the patients in this study achieved union of the fracture. There were no cases of delayed Union or non-union observed. Most of the patients achieved radiological union between 10to 14 weeks.
In our study average time for radiological union was 12.5 weeks.

Table 6: Time for radiological union

Time in Weeks	Number	Percentage
10-12 Weeks	11	47.8%
13-14 Weeks	11	47.8%
>14 Weeks	1	4.4%
Total	23	100%

Average time of full weight bearing was found to be 13.2 weeks. The patients were allowed full weight bearing once adequate callus was seen on x-rays, the patient was pain free and could tolerate standing without support.

Table 7: Time of full weight bearing

Time in Weeks	Number	Percentage
10-12 Weeks	8	34.8%
13-15 Weeks	12	52.2%
>15 Weeks	3	13%
Total	23	100%

In our study after regular follow up we found following complications.

Table 8: Complications

Complications	Number	Percentage
Pain	1	4.3%
Infection		
a) Superficial	1	4.3%
b) Deep	-	-
Nail entry site irritation	3	13%
Coronal malalignment	1	4.3%
Sagittal malalignment	-	-
Rotational malalignment	-	-
Limb shortening		
a) <2cm	1	4.3%
b) >2cm	-	-
Limb Lengthening		
a) <2cm	-	-
b) >2cm	-	-
Nail Back Out	1	4.3%
Sinking Nail in medullary Cavity	0	-
Bursa at Nail Tip	1	4.3%

Functional results were graded by the criteria of Flynn. The functional outcome was graded excellent, satisfactory or poor depending upon the presence or absence of pain, complications, limb length discrepancy and angle of malalignment.
Out of the total of 23 patients, 20 patients in our study had an excellent outcome, 3 had a satisfactory outcome and no patient had a poor functional outcome. Of those with a satisfactory outcome, one patient had nail irritation and one more patient had mild pain and nail irritation.

Table 9: Functional outcome

Outcome According to Flynn Criteria	Number	Percentage
Excellent	20	87%
Satisfactory	3	13%
Poor	-	-
Total 23		100%

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Discussion

In our study 65.2% cases were operated within the first four days, while the remaining 34.8% were operated within 7 days.

According to Jeong *et al*. [7], mean time from injury to operation was 0.4 days (range 1-2 days) K.C. Saika *et al*. [8] operated 77.27% within 7 days.

In our study, average duration of surgery was 68 minutes and range a from 50-90 minutes.

In Khurram Barlas *et al*. [9]. Study, the average duration of surgery was 70 minutes.

In a study by K C Saikia *et al*. [8]., the duration of surgery ranged from 50-120 Minutes with a median of 70 minutes.

In our study the mean time of post-operative immobilization was 7.2 weeks ranging from 6-9 weeks.

The average length of immobilization in plaster was 9.6 weeks in Gross R.H. *et al.* [10] study.

The advantage of the present study was early mobilization of the patients.

The average duration of hospital stay in the present study is 6.6 days.

The mean hospital stay was 12 days in Kalenderer O *et al*. [11] study. Compared to the above study conducted on conservative methods and cast.

Bracing, the average duration of hospital stay was less in our study i.e. 6.6 days. The Reduced hospital stay in our series is because of priority given to paediatric age group while preparing to list and lesser incidence of complications.

In our study we did not witness any delayed union or non-union, achieved 100% union in all patients in the present study the mean time of union was 12.5 weeks and range from 10 to 15 weeks.

Wudbhav N. Shankar *et al*. [12] study shows mean time 11 week and range 6-18 weeks.

V.R.P Vallamshelta *et al*. [13] study shows mean time of union was 10 weeks and range 7-18 weeks.

Jeong Heo *et al*. [7] study shows mean time of union was 16.1 week and range 11-26 weeks.

Kapil Manil K.C *et al*. [14] study shows mean time of union 11.17±2.81 week.

Aksoy C, *et al*. [15] 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.

Union will be early because fracture site was not disturbed and hematoma was preserved, blood supply of endosteum preserved as TENS, because of its elastic property allows micromotion at fracture site and stimulates callus formation.

In our study the average time for full weight bearing was 13.2 weeks ranging from 12-16 weeks.

Wudbhav N. Sankar *et al*. [12]. In their study allowed full weight bearing between 5.7-11.6 weeks an average of 8.65 weeks.

In present study out of 23 patients, most common complication found was nail irritation at entry site in 3 patients (13%), followed by superficial infection in one patient, mild pain in one patient and which it subsided by 4 months with analgesics, bursa at nail tip in one patient and one patient had nail back out after 7 months of index surgery.

No significant malalignment was not found in our study, one case had $<5^0$ varus angulation but no sagittal and rotational malalignment.

No significant limb length shortening was found in our study, one case shows <1cm shortening.

No delayed union or non-union. Bone over growth over nail tip was found in one patient because patient came for implant removal after one year.

We did not come across any complications such as deep infection, neurovascular compromise, compartment syndrome, reduction loss.

We did not find difficulty in reduction in any case as there was early intervention and tibia is sub cutaneous bone as compare to femur, which helps in manipulation and reduction. we not opened fracture site in any case in our study.

Wudbhav N. Shankar *et al*. [12] study shows 5 patients developed nail entry site irritation (26%), for this reason one child required early removal of nails. no patient developed obvious rotational abnormalities, leg length discrepancies or physeal arrest as result of treatment. Two patients required repeat manipulation under anesthesia to maintain adequate reduction following index operation.

O'brien *et al*. [16] study shows no angular deformity greater than 10^0 at final follow up and no significant limb length limb length discrepancy.

Goodwin *et al*. [17] study shows two patients had angular deformity in excess of 10 degree and one child developed a clinical insignificant physeal arrest.

Jeong Heo *et al*. [7] study shows. At the last follow-up, there were no angular or rotational deformities over 10^0 in either sagittal or coronal planes. With the exception of one case with an overgrowth of 15 mm, no patient showed shortening or overgrowth exceeding 10 mm at the last follow-ups. There were four minor complications, but no major complications. A superficial wound infection in a patient with a type III open fracture resolved with oral antibiotic administration. No deep infections or osteomyelitis were reported. The other three patients experienced soft tissue irritation due to prominent nail tips at the proximal entries. All three required additional procedures; two to cut the tips at 6 and 10 weeks respectively and one for nail removal at 14 weeks. No patient reported knee pain or experienced any loss of knee or ankle motion.

In our study, out of 23 cases, 20 cases shows excellent results, 3 cases satisfactory results and no poor results according to FLYNN's TENS scoring system.

Jeong Heo *et al*. [7] study of 16 cases shows 15 excellent and 1 satisfactory results.

Wudbhav N. Shankar *et al*. [12] study of 19 cases shows 12 excellent results, six satisfactory and one poor result.

Gamal Eladi *et al*. [18] in their study of 66 children with 68 femoral and 25 tibial shaft fractures reported 75.8% excellent, 24.2% satisfactory and no poor results.

Conclusion

- TENS nail acts as an internal splint, as a simple load sharing device, which would maintain alignment, allow mobilization until bridging callus formation and would not cross physis. TENS nails provides 3 point fixation that provides stable and elastic environment at fracture site allowing micro motion, and stimulating callus formation. Operative procedure is simple, of short duration, preserves fracture hematoma, doesn't disturb endosteal blood supply and it is minimally invasive with less chances of infection and non-union.
- We concluded that titanium elastic nails fixation for paediatric tibial diaphyseal fractures was an easy, safe and effective method that provides alignment and rotational stability with minimal complications and good union rates.

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