Outcome of tibial fractures in children managed by titanium elastic nailing system (TENS)

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ABSTRACT

Introduction

Fractures of the tibia are among the most common fractures of the long bone in children and adolescents. Although the most common method of management of tibial shaft is through closed reduction and cast application, operative management may be required in cases such as unstable tibia fractures in which adequate reduction cannot be achieved, loss of reduction of the fracture, fractures associated with other injuries and open fractures. Titanium elastic nailing system (TENS) can be a good option for fractures that are displaced, unstable and difficult to manage in plaster cast. TENS is a simple, minimally invasive, stable and effective method with excellent outcome and minimal complications.

Methods

This was a prospective study in which children between the ages of 6 to 14 years with diaphyseal fracture tibia treated with intramedullary fixation with TENS. All the patients were followed up for period of at least 6 months. The alignment of fracture, range of motion of knee joint and complications were evaluated during follow-up examinations. The time taken for the union of the fracture was evaluated with the help of the RUST criteria and final outcome was measured by Flynn's criteria[1].

Results

A total of 33 patients (22 were males) with the mean age of 9.51 years were studied. The mean duration of surgery was about 44 minutes. Oblique pattern of fracture was the most common type while middle third of the diaphysis was most commonly involved. The average duration of hospital stay was 7.8 days with average time of union being 11.39 weeks (range: 6-22 weeks). The most common complication seen in 2 patients was skin irritation due to prominence of the implant. None of the fracture had angulation greater than 10 degrees in coronal or sagittal planes and 1 cm of leg length discrepancy (shortening) was seen in a case of comminuted fracture. The outcome according to Flynn's criteria was excellent in 28 cases, good in 4 cases and fair in 1 case.

Conclusions

TENS is an effective method that for the treatment of tibial shaft fractures in children in preventing damage to the epiphysis without interfering with fracture hematoma, while avoiding stiffness of the knee and limb length discrepancies and thereby decreasing the morbidity of the patient. The operative procedure is simple, has a low rate of complication, and prevents damage to the growing physis. It allows for early mobilization and decreases the duration of hospital stay.

Keywords: **Pediatric fractures of Tibia, Elastic Intramedullary Nailing, Titanium Elastic Nailing System, Fracture**

Introduction

Tibia fractures have been reported as the third most common pediatric long bone injuries (15%), after radial/ulnar and femoral fractures[2,3]. Pediatric tibia fractures are the second most common cause of pediatric admissions following trauma.

For the majority of cases of tibial shaft fractures in children, closed reduction and casting is considered as an effective form of treatment. However, operative intervention becomes necessary when reduction cannot be achieved as in cases of mal-rotation, angulation, or excessive shortening due to overlap, at the fracture site.

Operative treatment for tibia and fibula fracture has been advocated when the fractures cannot be reduced, are open, or occasionally, when they occur in the proximal or distal third shaft of tibia. Some patterns may not be controlled in the casts like those with more than 10 degrees of valgus deformity with an intact fibula[4]. In addition to these conditions, poly-trauma, compartment syndrome, or severe soft tissue compromise are other indications of surgical treatment[5, 6].

The aim of this study was to evaluate the functional and radiological outcome of treatment of displaced tibial shaft fractures in children and adolescents when treated with Titanium Elastic Nailing System.

Methods

This was a prospective study conducted at Department of Orthopaedics, College of Medical Sciences-Teaching Hospital, Bharatpur, Nepal from October 2014 to September 2016. Informed consent was taken from the guardians of all the patients and ethical approval was taken from the Institutional Review Board of our Institution.

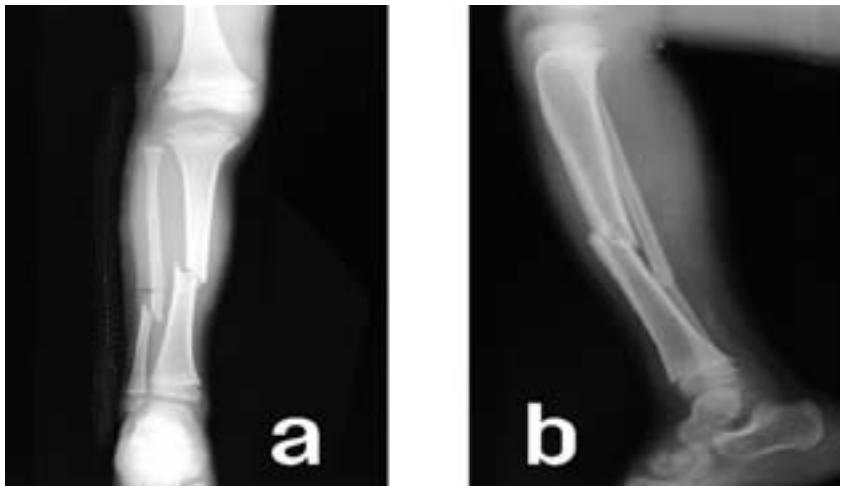

Figure 1: a, b – X-ray image of pre-operative antero-posterior and lateral view

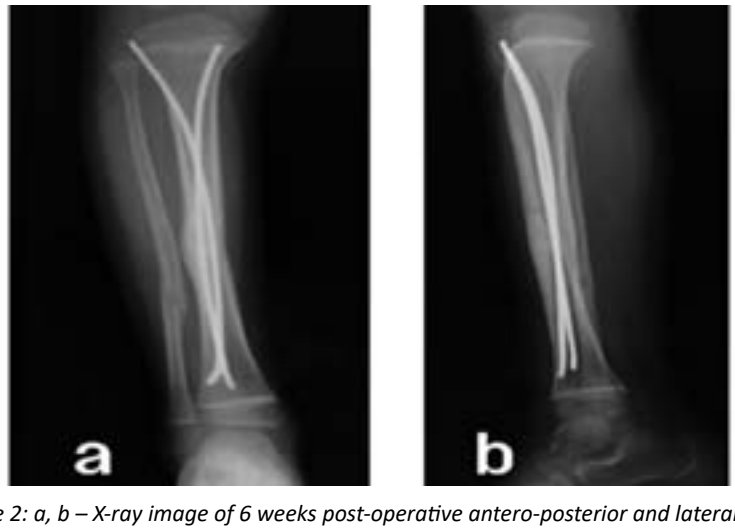

Figure 2: a, b – X-ray image of 6 weeks post-operative antero-posterior and lateral view

Figure 3: Postoperative scar mark on proximal part of left leg

Inclusion criteria

1. Children between ages 5- 15 years with traumatic closed or open tibial shaft fractures (grade I, II and III A)
2. Inability to achieve stable initial reduction with closed treatment.
3. Loss of reduction after closed treatment and casting.
4. Impending compartment syndrome.

Exclusion criteria

1. Patients with extreme proximal or distal tibia fractures closer to the epiphyseal plate and patients with grade III B, and C open tibia fractures.
2. Patients with pathological fracture
3. Patients unfit for surgery

Thirty-three cases were included in the study. AO Classification was used to classify the tibia fractures. Demographic data was recorded along with information regarding mode of injury, side of injury and other associated injuries. Preoperatively, the diameter of the individual nail was selected as per Flynn's formula i.e. diameter of nail = width of the narrowest point of the medullary canal on AP and lateral view X 0.4mm[1].

The cases were operated under general anaesthesia or spinal anaesthesia depending upon the condition and compliance of the patient. Two titanium elastic nails were inserted in antegrade fashion across the fracture site to stabilize the fracture and the sizes of the nails were chosen depending upon the canal diameter of the tibia.

The patients were re-evaluated at two weeks, six weeks, twelve weeks, eighteen weeks and 6 months after surgery to observe the outcomes. The medical records and radiographs of all the patients were reviewed in detail during the follow up. The functional outcome was evaluated on the basis of Flynn's criteria at the end of 6 months. Data was entered in Excel master-sheet with coding of the variables. Data analysis was done using SPSS 23.

Table 1: TENS scoring system (Flynn et al.)

Results	Excellent	Good	Fair
Inequality of leg length	< 1 cm	< 2 cm	>2 cm
Angular deformity	5°	10°	>10°
Pain	No	No	Diffuse
Complication	No	Minor and treatable	Major with remaining morbidity

Radiological grading was made based on angulation, shortening and union of fracture. The union of fracture was decided by RUST Score[7]. Minimum score of 4 suggests definitely not healed, while maximum score of 12 suggests fracture has healed completely.

Score Per Cortex	Callus	Fracture Line
1	Absent	Visible
2	Present	Visible
3	Present	Invisible

Results

Out of the total 33 patients in this study, there were 22 male (66.7%) and 11 female (33.3%). with average age of 9.51±2.68. The major cause of fracture was road traffic accident (63.6%) followed by fall from tree (33.3%) and a case of sports related injury (3.0%).

Table 2: Mode of injury

Mode of injury	Frequency	Percent
Fall from height	11	33.3
Road traffic accident	21	63.6
Sport related injury	1	3
Total	33	100

Seventeen (51.5%) were of the right side and 16 (48.5%) were of left side. Thirty (90.9 %) patients

presented with closed fractures while 3 cases of open fractures up to grade Gustilo Anderson III A (9.1%) were also operated. Seven fractures (21%) involved proximal third of tibial diaphysis, 25 (75.8%) involved the middle third of the diaphysis and one (3%) which involved the distal third of tibia.

There were no cases of severely comminuted (42-C) type fractures in the study. Associated fibula fracture was present in 16 cases (48.5%) while isolated tibial fractures were present in 17 cases (51.5 %).

Table 3: Pattern of fracture

Pattern of fracture	Frequency	Percent
Comminuted (42-B1)	2	6.1
Oblique (42-A2)	24	72.6
Spiral (42-A1)	2	6.1
Transverse (42-A3)	5	15.2
Total	33	100

Table 4: Associated injuries

Associated injury	Frequency	Percent
None	26	78.8
Head injury	4	12.1
Rib fracture	2	6.1
Fracture shaft of humerus	1	3
Total	33	100

In this study the maximum day of interval between injury and surgery was 6 days and minimum day is 1. Eighty One percent of the cases were operated within two days if the injury. The long duration of interval before surgery was due to associated head or other injuries which required the surgery to be delayed.

Table 5: Classification of motion loss of the knee based on deviation from full flexion and extension

Group	Extension in degrees	Flexion in degrees	Severity
1	<5	>110	Mild
2	5-10	90-100	Moderate
3	>10	<90	Severe

Table 6: Knee range of movement

Restriction of knee range of movement	Frequency	Percentage
No restriction	31	93.93
Mild restriction	2	6.06
Moderate restriction	0	0
Severe restriction	0	0
Total	33	100

The maximum duration of surgery was 80 minutes and minimum duration was 40 minutes. Most of the surgeries (93.9%) were completed within 60 minutes. The mean duration of surgery was 43.93± 9.58 minutes. Maximum number of days of hospital stay was 18 days and minimum was 4 days. The increase in duration of hospital stays were due to the presence of associated injuries which either delayed the duration before operation or needed additional hospital care or in cases of open fractures in which the wound was not adequately healed.

Partial weight bearing was started from 6 weeks from post-operative day (60.6%) but by the 8th week most of the cases (93.9%) partial weight bearing had begun. Fractures with transverse pattern were allowed partial weight bearing earlier than spiral and comminuted type of f

Complications

We found a total of 3 minor complications in which 2 implants were prominent and one case of implant back out which required early removal of the TENS. There were no major complications in 33 cases. One case had 10mm of shortening which was a case of open fracture. None of the other cases involved significant shortening at the end of 6 month follow up. Ten patients showed no varus or valgus angulation while 21 patients had angulation of less than 5 degrees and 2 patients had angulation between 5 and 10 degrees. None of the patients had angulation more than 10 degrees.

The range of movement was measured with the help of goniometer. At 6 months follow up the loss of range of motion of the knee was categorized mild, moderate and severe according to the classification by Del Pizzo W. et al.(8)

At 6 months follow up and the loss of ankle range of motion was categorized mild,

moderate and severe according to the degree of restriction. There was no restriction in 32 cases while 1 patient had mild restriction of movement in the ankle joint.

Table 7: Ankle range of motion

Ankle joint movements	Dorsiflexion (degrees)	Plantar flexion (degrees)
Full range (No restriction)	0-35	0-45
Mild restriction	0-30	0-35
Moderate restriction	0-20	0-25
Severe restriction	<20	<25

Table 8: Restriction of ankle range of motion

Restriction of ankle range of movement	Frequency	Percentage
No restriction	30	96.96
Mild restriction	1	3.33
Moderate restriction	0	0
Severe restriction	0	0
Total	33	33

The extent of union was measured according the RUST criteria. By the end of 12 weeks 90.9% of the cases were united. Three cases took more than 12 weeks for union which were both cases of open fractures which might have been the reason for the delay in union. The mean of time taken for union was 11.39 weeks ± 2.76.

Outcome

We evaluated the outcome according to Flynn's Criteria for TENS and found excellent result in 28 cases (84.8%), good in 4 (12.1%) and fair in 1 cases (3.0%).

Table 9: Outcome

Outcome	Frequency	Percent
Excellent	28	84.8
Good	4	12.1
Fair	1	3
Total	33	100

Discussion

Stabilization of fractures through the use of intramedullary devices has been practiced as early as in the mid-19th century, when ivory pegs were used, which was then gradually replaced by various metallic devices. The Küntscher nail popularized rigid intramedullary fixation, as it occupied entire medullary cross-sectional area of the bone, and thus achieved great stability in all planes[9].

In the early 1980s, Métaizeau and his team of surgeons in Nancy, France, developed an elastic stable intramedullary nail based on a theoretical concept by Firica. These surgeons dramatically changed the concept of treatment of paediatric fractures using titanium nails[10]. They were able to show that titanium nails when accurately contoured and properly inserted, could impart excellent axial and lateral stability to diaphyseal fractures in long bones. Additionally, the rotational stability was also better than had previously been experienced, even though this was initially thought to remain the weakest point of the technique. The use of titanium nails has allowed greater elasticity than was available in the steel nails of the Ender system[11].

The use of intramedullary fixation with elastic nails placed percutaneously through the proximal tibial metaphysis without violating the proximal physis has become a popular technique for the treatment of pediatric tibia fractures[11-16]. In this method of treatment, two flexible intramedullary nails are introduced in an antegrade fashion, which cross the fracture site and act as internal splints to maintain length and alignment, and at the same time, allow sufficient fracture micro motion to generate callus formation[17,18]. Initially majority of the studies involved the use of TENS in closed fractures. The more recent studies have also reported good outcome in open fractures as well[14].

The mean duration of surgery was about 44 minutes and average post-operative hospital stay was 7.88 days. The average union time was 11.39 weeks (range 6-22 weeks) in 33 cases. Delayed union and non-union are uncommon in fractures managed by TENS in long bones, however they can occur in severely comminuted fractures and open fractures[19,20].

The most common complication seen in 2 patients was skin irritation due to prominent implant. Implant end seemed to back out in 1 case which needed early removal of the implant. Nail prominence and irritation at the entry site or bursa formation may lead to

serious complications such as superficial or deep infection[21]. There were no significant major complications encountered in our study. None of the fracture had angulation greater than 10 degrees in coronal or sagittal planes and 1 cm of leg length discrepancy was seen in a case of comminuted fracture. Goodwin et al reported two cases with angular deformity of 10 degrees each, although angular deformity is uncommon in cases managed with TENS[13]. In our study the outcome according to Flynn's criteria was excellent in 28 cases, good in 4 cases and fair in 1 case.

Conclusions

Over the years, different treatment options like POP cast application has been an acceptable method of treatment of diaphyseal fractures in children, but recently it has been found, specially in the older children and adolescent groups, that the remodeling of the tibia is not very significant. The parents of the children are less tolerant towards mal-union and long duration of immobilization, which tends to hamper the schooling of the child as well as the psychology of the child.

Titanium Elastic Nailing System has a very good outcome in children with displaced and unstable pattern as well as cases of open fractures up to Gustilo Anderson grade III A tibial shaft fractures with a very low rate of complication. It is minimally invasive and the operative time is comparatively short, with minimal scar formation. It helps the child start range of motion earlier thus decreasing the chance of stiffness of the knee and ankle joints.

Limitations

- Our study was conducted in a single institution with a small sample size.
- Duration of follow-up was only 6 months, so long term outcome could not be assessed.
- The follow up of all the patients until the removal of the implants were not done due to the irregularity of the follow up after the child had returned to his or her normal activity.

Conflict of interest

None

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