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Titanium Elastic Nailing System (TENS) in Paediatric Tibia Fractures

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ABSTRACT

Background: Closed reduction and cast application is considered the first line of treatment for tibial shaft fractures in children. Over the past few decades, management of pediatric tibial shaft fractures has shifted more towards the operative intervention owing to less immobilization, faster recovery, shorter rehabilitation period, lack of adjoining joints stiffness and less psychological impact to the children. Flexible intramedullary nails have been found to fulfil all the above mentioned advantages and they also maintain a good alignment and rotation at the fracture site. **Methods:** A retrospective study was performed on pediatric tibial shaft fractures fixed with titanium elastic nailing system. We assessed the fracture alignment, delayed union, nonunion, infection, motion of the knee joint, limb length discrepancy and fracture union time at the follow-up visits. The outcomes were classified as excellent, satisfactory or poor as per the Flynn classification for flexible elastic nailing fixation. **Results:** 20 patients were included in our study which included 14 (70%) males and 6(30%) females. The average age of these patients was 10.15 years (range 7– 14 years). The average time taken for fracture union (both clinically and radiologically) was 10.6 weeks. There were 2(10%) cases of delayed union, 1(5%) of malunion, 1(5%) of limb lengthening, 1 (5%) of limb shortening, 3 (15%) of nail prominence and skin irritation and 1(5%) case of superficial infection at the nail entry site. According to the Flynn criteria, we had 14(70%) excellent and 6(30%) satisfactory results. No poor results were noted. **Conclusion:** Titanium elastic nail fixation is an effective and reliable method for management of tibial shaft fractures in children. It allows rapid healing of tibial shaft fractures with an acceptable rate of complications.

Keywords: Elastic intramedullary nail; fracture; pediatric; tibia; titanium elastic nails

INTRODUCTION

Tibial shaft fractures are the third most common long-bone fractures in children with a reported incidence of 15%. After the femoral fractures, these fractures are the second most common bony injuries which require hospitalization.[1-3] A closed reduction and cast application is the primary treatment for these injuries. Although operative treatment for these fractures is not required in most cases, it may be needed in children with open fractures, neurovascular injury, polytrauma and unstable fractures causing unacceptable angulation. Operative management can be done using various techniques like crossed Kirschner wires, intramedullary fixation, or external fixators. External fixators are the primary line of management in fractures with severe soft-tissue loss, although they are known to be associated with many complications such as malunion, delayed union, leg-length discrepancy and high incidence of pin site infections.[4-6]

Intramedullary locking nails, which are widely and effectively used for the management of such fractures in skeletally mature patients, have limited role in children with open physes, as they pose a threat to the proximal tibial growth plate.[7] Elastic stable intramedullary nailing of long bone fractures in the skeletally immature patients has gained widespread popularity because of its clinical effectiveness and low complication rates. This technique has also been supported in many studies, especially for its use in femur fractures. This is because of its many advantages like preservation of the fracture hematoma, closed insertion and a physeal-sparing entry point.[8,9] Some studies have also described its use for tibia fractures.[10-12] The purpose of our study was to present the results of unstable tibial shaft fractures fixed using titanium elastic nailing system.

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MATERIALS AND METHODS

This was a retrospective analytical study performed from April 2018 to March 2020. Consent was taken from the parents of all the patients included in our study. Ethical clearance was taken from the Ethical Committee of our hospital. Diaphyseal tibial fractures which failed closed reduction, those associated with compartment syndrome, multiple long bone fractures, floating knee, grade I or II compound fractures and multisystem injuries were included in our study. Tibial fractures in children of age less than 5 years and in those of more than 14 years, grade III compound fractures, fractures associated with infected wound, those treated with conservative treatment with acceptable alignment, fractures associated with severe comminution and massive bone loss were excluded from this study.

20 patients were included in our study. All of these patients were operated under general anesthesia. The appropriate size of the nail was calculated by using the Flynn's formula, i.e., nail diameter = 0.4 x narrowest diameter of the medullary canal. The nails were manually pre-contoured into C shape to achieve intramedullary three point fixation. A 45 degrees bent was given to the nails' tip for easy negotiation across the fracture site.

An incision of size around 2 cm was given either lateral or medial side of the proximal leg and entry point was made 1.5 to 2 cm distal to the physis using an owl. Now the pre-countered nail tip was introduced into the medullary canal and advanced upto the fracture site. Once the nail was at the fracture site, we performed closed reduction and then advanced the nail across the fracture site. The proper nail positioning was confirmed under C-arm both in antero-posterior and the lateral views. Then the second nail was inserted by similar method as described above. We advanced the nails distally till the tips were just proximal to the distal tibial physis. Proximally, around 1 cm of the nails was left outside the cortex for removal; however unburied portion of nail was not bent to prevent skin irritation and bursitis at the entry site of the nail. Special attention is to be paid to ensure that both the nails are of the same size to avoid differential loading over opposite cortices which may lead to angular deformity. An above knee posterior slab was applied at the end of the surgery. The posterior slab was removed after three weeks post-operatively and the patients were asked to walk with partial weight bearing over the affected leg.

Patients were evaluated at three weeks, six weeks, three months, six months and one year post surgery to assess the alignment at the fracture site, limb length discrepancy, any infection, knee range of motion, delayed union, non-union and the fracture union time. Final fracture alignment, limb length discrepancy and the knee range of motion were calculated when the fracture was noted to have united. We assessed the alignment at the fracture site by drawing lines on X-ray films and measuring with a goniometer. The limb length discrepancy was calculated by measuring the length of both the limbs from anterior superior iliac spine to the medial malleolus in supine position. Any difference of length in the affected limb as compared to the normal limb was considered as limb length discrepancy. As far as the knee range of motion is concerned, we assessed it by passive flexion and extension of the knee joint and the angle was measured with the help of a goniometer. The delayed union and nonunion were assessed based on the clinical and radiological union. The fracture is considered to be clinically united when there is no pain on movement of the fracture ends. On the other hand, radiological union is defined as the appearance of a mature callus over at least 3 out of the 4 planes.[13] All of the data were tabulated in Microsoft Excel Programme and the results were interpreted as mean ± standard deviation and simple percentage also.

RESULTS

The demographic data of our patients is mentioned in [Table 1], mechanism of injury in [Table 2] and the fracture pattern in [Table 3]. The average age of patients in our study was 10.15 ± 2.06 years and the average time taken for fracture union was 10.6 ± 1.11 weeks. The complications which were noted in our study are mentioned in [Table 4].

Table 1: Demographic data

Parameters	n (%)
Gender	
Male	14 (70%)
Female	6 (30%)
Side	
Right	9 (45%)
Left	11 (55%)

Table 2: Mechanism of injury

Parameters	n (%)
Motor vehicle injury	8 (40%)
Pedestrian injury	3 (15%)
Fall from height	5 (25%)
Sports related injury	4 (20%)

Table 3: Pattern of fracture

Parameters	n (%)
Transverse fracture	9 (45%)
Spiral fracture	3 (15%)
Oblique fracture	6 (30%)
Comminuted fracture	2 (10%)

Table 4: Complications after surgical intervention

Parameters	n (%)
Malunion	1 (5%)
Delayed union	2 (10%)
Nonunion	-
Limb shortening	1 (5%)
Limb lengthening	1 (5%)
Nail prominence and skin irritation	3 (15%)
Superficial infection at entry site	1 (5%)
Osteomyelitis	-
Compartment syndrome	-
Re-fracture	-

On assessing our treatment outcomes according to the Flynn et al criteria,[8] we achieved 14 (70%) excellent results, 6 (30%) satisfactory results and no poor result [Table 5]. The satisfactory results found in our study were either due to the nail entry site skin irritation, superficial infection, delayed union or malunion.

Table 5: TENS outcome scoring as per Flynn et al Criteria

Parameters	Excellent result	Satisfactory result	Poor result
Limb length inequality	<1.0 cm	<2.0 cm	>2.0 cm
Malalignment	5◦	10◦	>10◦
Pain	None	None	Present
Complications	None	Minor and resolved	Major
Patient results (n=20)	14	6	0

DISCUSSION

Closed reduction and cast application is the mainstay of treatment for most of the tibia shaft fractures in children. Operative indications include unstable fractures, secondary loss of reduction, open fractures, neurovascular injury or polytrauma. Fracture fixation can be performed by different methods like external fixators, plate and screw osteosynthesis, intramedullary nails and percutaneous pinning.[14]

Titanium elastic nails (TENs) have recently been recognized as a very important treatment option in select open fractures because of the several advantages provided by it, which include applicability in open fractures, minimal scar formation and providing excellent overall outcomes in tibia shaft fractures in the pediatric age group.[15] TENS have been shown to not only maintain the alignment at the fracture site but they are also capable of adjusting the rotation of the limb while treating these fractures. In addition to providing good stability, these nails also provide some amount of elasticity and micro-motion at the fracture site that actually stimulates formation of callus and hastens the union process. The possibility of surgical site infection is also significantly reduced because of the need for very small incisions for such surgery.[16]

Debnath et al.[17] in their study on 30 patients with midshaft fractures of the tibia achieved an excellent outcome in 50% patients, acceptable outcome in 36%, and a poor outcome in 14% patients. In a study by Pennock et al.[18] a comparison was done between the patients undergoing osteosynthesis with plate and screws with those undergoing TENS. They showed that the recovery rates were similar in 97% of them. Sankar et al.[19] reported an excellent outcome in 63% patients, an acceptable outcome in 32%, and a poor outcome in 5% of their patients in a study on 19 patients with unstable tibial shaft fractures. In our study, a complete union was seen in all the cases. There was no restriction of motion or significant pain at the end of the treatment. We could achieve an excellent outcome in 70% of our patients and an acceptable outcome in 30% of our patients. No poor result was noted.

The most common complication that has been reported with TENs or elastic stable intramedullary nail (ESIN) is nail prominence and skin irritation at the nail entry site. Nail prominence can lead to more serious complications like superficial or deep infection, bursitis, skin breakdown, effusion and stiffness of the adjacent joints, repositioning and the need for premature implant removal with subsequent risk of re-fracture.[20] The worst complication can be extension of infection to the diaphysis leading to osteomyelitis.[21] The prevalence of skin irritation by these nails varies from 3% to 52%. The previous protocol regarding the nail bending and leaving them prominent for easy future removal has now been changed.[22] For tibia fractures treated with TENS, 1.5 cm of the nail should be left outside the bone cortex, as advocated by Sanker et al.[19] They also advised that the protruding part of the nail should be left parallel to the proximal metaphysis and it should be left unbent. There were 3 (15%) cases of nail prominence and skin irritation in our study. However, none of them required any revision surgeries for the same.

Titanium elastic nails (TENs) have a higher propensity for causing malunion as some angulation can occur during the union process, unlike the plate-screw and other rigid fixations. Brien et al.[23] in a similar study on TENs, reported an angulation of over 5° in 2 (12.5%) of their patients, with one patient having an angulation of 6° in the coronal plane and the other patient having an angulation of 10° in the sagittal plane. Sankar et al.[19] in their study observed that 1 (6.3%) patient had an angulation of 5–10° in the sagittal plane and that 3 (18.9%) patients had an angulation of 5–10° in the coronal plane. In our study, no patient had an angulation of over 10° in the final examination, although 1 (5%) patient was found to have an angulation of 5–10°.

There were 2 (10%) case of delayed union and no case of nonunion in our study. We define non-union as no callus formation at 12 weeks after the surgery. Both delayed union and nonunion are found to be uncommon after ESIN in long bones of the lower limbs. However, a delayed union or a non-union can occur when tibia is fractured by severe direct injury.[21] Tibial shaft fractures treated by ESIN can sometimes develop a hypertrophic non-union, if the fibula is intact or it heels quickly leading to slight distraction at the fracture site.[21,24] This can be managed by either rigid intramedullary nailing or 1 cm of fibular resection.[24,25] Delayed union or non-union can also be caused by infection at the fracture site secondary to the open wounds. In a study by Srivastava et al,[26] 5 cases of delayed union and 2 cases of nonunion have been documented in open tibial shaft fractures operated by TENs.

Limb length discrepancy has also been reported following tibia shaft fractures. A leg-length inequality of <15 mm was noted in 3.6% patients in a study by Vallamshetla et al.[27] In our study, 2 (10%) patients were seen to have a limb length inequality of 10 mm; one had a shortening of 10 mm and the other had a lengthening of 10 mm. The patient with post-op shortening was a case of comminuted type II open fracture. Usually shortening is encountered secondary to comminution and lengthening secondary to physeal stimulation because of hypervascularity during healing of the fracture.[28]

No case of compartment syndrome was observed in our study. However, in some studies, compartment syndrome has been observed with femur or tibia fractures operated by TENs.[20] Sankar et al.[19] reported 4 cases of compartment syndromes and 3 cases of impending compartment syndromes during the course of treatment which were treated by fasciotomy at the time of index surgery. Shital N Parikh et al.[20] observed that those patients who were exposed more to fluoroscopy and had a longer operative time, were more prone to develop this complication. This has also been attributed to the repeated attempts at fracture reduction and possible soft tissue injury while negotiating the nail multiple times across the fracture site. Compartment syndrome which is diagnosed during the conservative treatment can be managed by fasciotomy and fixation of the fracture by TENs. This stabilizes the fracture and helps in wound care. When the compartment syndrome is diagnosed after the surgical fixation by TENs, nails help in protecting the fracture displacement during and after the fasciotomy.[10]

None of the patients in our series required any secondary surgical intervention or re-admission following discharge, except for nail removal.

There were some limitations in our study. It was a retrospective study and included a small number of patients. There was no control group and we did not compare other modalities of treatment.

CONCLUSION

Titanium elastic nailing system is a simple, reliable, rapid and effective method for the management of tibia shaft fractures in the age group of 5 to 14 years. It involves lesser blood loss, shorter surgical time, decreased hospitalization and reasonable time for fracture union. Though it may involve some complications, most of them are avoidable as well as manageable with careful precautions taken intra-operatively.

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