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Titanium Elastic Intramedullary Nailing in Paediatric Tibial Shaft Fractures

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Abstract

Introduction: Most of the pediatric tibial shaft fractures are treated non-operatively with close reduction and casting. Surgical indications include unstable fractures, open fracture, polytrauma patients, compartment syndrome or severe soft tissue injury. The purpose of this study was to assess the outcome of tibial shaft fracture fixation with titanium elastic intramedullary nails.

Patients and methods: The average age of the patient was 11.3 years (range 6 to 15 years) and mean follow up was 14 months (range 6 to 26 months). Patient's charts and radiographs were reviewed retrospectively. The outcomes were classified as excellent, satisfactory or poor according to Flynn's criteria for flexible nail fixation.

Results: All patients achieved union at a mean of 10.3 weeks (8 to 14 weeks). Full weight bearing was achieved at a mean of 9.2 weeks (8 to 14 weeks). At last follow-up, the result was excellent in 18 patients and satisfactory in 4 patients. Nineteen patients had less than 5-degree angulation and three patients had 5-10 degree angulation. The most common complication was irritation at nail entry site. Two cases had superficial wound infection at entry site and both healed with oral antibiotics and dressing changes.

Summary: Elastic intramedullary nailing is a safe and reliable treatment method for pediatric tibial fractures. It provides stable fixation and allows rapid healing of fractures with minimal complications.

Keywords: Tibia fracture; Paediatric; Shaft; Elastic intramedullary nails

Introduction

Tibia shaft fractures are the third most common fracture in children. They account for 10-15% of pediatric fractures [1]. Closed reduction and cast application is the main treatment modality for pediatric tibial shaft fractures. Surgical treatment is indicated in unstable fractures, failed closed reduction, open fractures, polytrauma patients, compartment syndrome or severe soft tissue injury and associated neurovascular injury [2,3]. In the past, external fixation and plate and screw fixation were used for unstable tibial shaft fracture that required surgical fixation [4-6].

Elastic nails are load sharing devices and allow early mobilization. Micromotion at the fracture site enhances the bone healing. Titanium elastic nails achieved biomechanical stability from its prebend 'C' configuration which provides stable three-point fixation and acts as an internal splint [7]. Elastic intramedullary nailing in long bone fractures in children has gained popularity because of its high effectiveness and less complication rate [8-10].

The advantages of elastic intramedullary nails include closed insertion, with preservation of fracture hematoma, minimal risk of fracture site infection, and the most importantly, a physeal sparing entry point. Other advantages are minimal soft tissue injury, early mobilization, low infection rates [8-10] and shorter hospital stays. Disadvantages include less stability compared with other fixation methods and possible need of nail removal in future [11].

Many previous studies have supported the use of elastic nails in femur fractures in children [11-13]. However, few small series have described the use of elastic intramedullary nails for pediatric tibial shaft fractures [8-10,14-19].

The purpose of this study was to assess the outcome of unstable tibial shaft fracture fixation with titanium elastic intramedullary nails.

Patients and Methods

We performed an Institutional Review Board approved retrospective review of all the children with tibial shaft fractures treated operatively at Lumbini Medical College, Tansen, Nepal. We reviewed the medical records of 22 tibial shaft fractures in children treated with titanium elastic nail from June 2014 to May 2016, at our institution. Patients with osteogenesis imperfecta, congenital pseudoarthrosis of the tibial or other skeletal dysplasias were excluded. Our indications for surgery include failed conservative management (five patients), unstable fracture pattern (nine patients), open fracture fractures (seven patients) or fractures with soft tissue injuries (one patient).

The average age of the patients in our series was 11.3 years (range 6 to 15 years). There were 14 boys and 8 girls. All patients were followed untill fracture was completely united. The average follow-up was 14 months (range 6 to 26 months).

Demographic data including the age of patients, gender, patient weight, mechanism of injury, closed or open fracture, time to weight bearing, clinical and radiological union, need for implant removal and complications of surgery were reviewed from patient charts.

The mechanism of injury was classified as i) Simple fall - fall from standing height ii) Fall from a height greater than standing iii) Sports related injury and iv) Motor vehicle accidents. Open fractures were classified according to Gustilo and Anderson classification.

Surgical technique

General anesthesia was given to all the patients. The patient was placed supine on a radiolucent table. The affected limb was then prepped and draped free. Under C-arm, the fracture site and proximal tibial physis were marked. The appropriate nail size was determined preoperatively as described by Flynn et al. (40% of the narrowest canal diameter). The nails were prebend, prior to insertion into a 'C' shaped such that it will provide three-point stability. Appropriate prebending of the nail is an important step for the success of this technique and should not be overemphasized. Adequate debridement of the wound was performed for open fractures or fracture associated with soft tissue injury. Under the C-arm guidance, the fracture was reduced in both the coronal and sagittal planes.

The medial proximal tibial was approached first through an approximately 2 cm incision distal to the proximal tibial physis. The entry point was made with a bone awl. When the nail reached far cortex, the inserter was rotated to direct the nail towards the medullary canal. The nail was advanced to the fracture site, once the nail reached the fracture site closed reduction was done and nail advanced distally. The nail position was checked under the image in both anteroposterior and lateral views. The lateral nail was inserted through similar exposure. Same size nails were used to avoid differential loading in opposite cortices that may lead to angular deformity.

C-arm was used to confirm the intramedullary location of the nail distal to the fracture site. Sufficient nail was left proximally for easy removal. Incisional wounds were closed in a layered fashion and the wound was well padded with gauze.

Postoperative management and assessment

Postoperatively, below knee splint, were given for 4 weeks. Partial weight bearing was started 4-6 weeks later when there was radiographic evidence of a bridging callus. Full weight bearing was started after clinical fracture union. Preoperative and postoperative radiographs were evaluated to determine fracture pattern, union rates, time to union and fracture alignment.

Union was defined as bridging callus at 3 cortices on anteroposterior and lateral radiographs. Delayed union was defined slower than normal progression to union (union over 6 months). Non-union was defined as no sign of union until 9 months. Malunion was defined as mal-alignment of over 10 degrees in any plane. Leg length discrepancy was defined as shortening or overgrowth over 2 cm.

The nails were routinely removed once fracture was united clinically and radiologically. The angular deformity was assessed on anteroposterior and lateral X-rays that were taken immediately after surgery and at the last follow-up. Knee range of motion (ROM), angular deformity, alignment, and signs of nail irritation were assessed in each follow-up. At the last follow-up, leg length discrepancies (LLD) between the injured and uninjured sides were assessed clinically as well as radiologically. Clinical outcomes were evaluated using modified Flynn criteria [13].

Results

There were 14 boys and 8 girls in the study, with an average age of 11.3 (range 6 to 14 years). The average hospital stay of the patient was 5.3 days (range 3 to 14 days). The longer stay was for a patient with open fractures and had intravenous antibiotics for 14 days. There were more right-sided (thirteen patients) than left-sided (nine patients) fractures. Average follow-up was 14 months. There were 15 closed and 7 open fractures.

The most common mode of injury was fall from height (mainly tree), and it was seen in nine patients (40.9%). Seven patients (31.81%) had fractures caused by motor vehicle accidents. Five patients (22.72%) had sports injury related to football and one fracture was caused by simple fall. There were two proximal shafts, 17 mid-shaft, and 3 distal shaft fractures.

All patients achieved union at a mean of 10.3 weeks (6 to 16 weeks) (Table 1). The mean time to full weight bearing was 9.1 weeks (8 to 14 weeks). No case of a delayed union, malunion, and non-union were seen. All patients had their nail removed at an average of 25.2 weeks (range 20 to 36 weeks) after surgery. The mean weight of the patients in our series was 29.8 kg (range 18 to 39 kg).

Study	Year	Weeks
Wiss et al.	1986	17
Vallamshetla et al. [15]	2006	10 (7-18)
Sankar WN et al. [10]	2007	11 (6-18)
Onta et al. [18]	2015	13.3 (12-18)
Heo J et al. [19]	2016	16.1 (11-26)
Our study	2016	10.3 (6-16)

Table 1: Union time.

Retrograde nails were inserted for distal third fracture of tibia in two patients. No case of compartment syndrome were seen. The most common complication was irritation at the nail entry site, seen in five patients (22.72%). At final follow-up, twenty patients had an angulation of fewer than 5 degrees. Two patients had an angulation of 50 to 100. None of the patients had an angulation of more than 10 degrees. Two patients had superficial wound infection at the entry side. And both healed with oral antibiotics and dressing changes.

The final outcome based on titanium elastic nailing outcome scoring system by Flynn et al. [13] are as follows. All patients had a full range of motion at knee and ankle joint. We had 18 excellent results, 4 satisfactory results, and no poor results (Table 2). Satisfactory results were due to leg length discrepancy, malalignment and minor complication like irritation at the nail entry site (Figures 1-5).

	Excellent	Satisfactory	Poor
Leg length discrepancy	<1 cm	<2 cm	>2 cm
Malalignment	50	100	>100
Pain	None	None	Present
Complications	None	Minor and Resolved	Major/Lasting morbidity
Patient Results (n=22)	18 (81%)	4 (19%)	

Table 2: Flynn scoring criteria.

Figure 1: Pre-operative.

Figure 2: Post-operative X-rays.

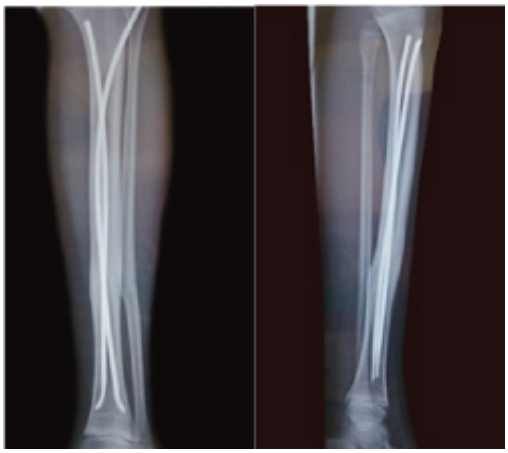

Figure 3: 6 months follow up.

Figure 4: 6 years old girl standing on the fractured leg 6 months post op.

Figure 5: Sitting crossed leg at 6 months.

Discussion

Tibial shaft fractures are the third most common fractures in children, after fractures of the femur and forearm. More than 20% of tibia fracture requires hospitalization. Closed reduction and casting is still a gold standard treatment for pediatric tibial shaft fractures. Nonoperative treatment requires prolonged immobilization and regular follow up which is very difficult in our setup. Operative treatment is beneficial particularly for children with open fractures, fractures with soft tissue injuries and associated fractures or injuries necessitating procedures.

Since 1995, titanium elastic intramedullary nails have been used increasingly to stabilize pediatric long bone fracture where surgery is indicated. The advantages of elastic intramedullary nailing include immediate fracture stabilization, minimal soft tissue disruption, lower infection and refracture rates, early mobilization and more rapid return to daily function than conservative treatment with immobilization alone. Good results with elastic stable intramedullary nailing (ESIN) in femur and forearm fracture in children has been reported.

The ideal device to treat pediatric tibial fractures should be a load sharing device. It should maintain alignment, allow early mobilization and should not cross the physis. Elastic intramedullary nail provides stable and elastic fixation that allow micromotion at fracture site when the load is applied. This facilitates bridging callus formation and early union. Both nails should be of equal diameter otherwise this may lead to an angular deformity due to differential loading of opposite cortices.

Brian O et al. [8] reported sixteen pediatric tibia fractures fixed with ESIN which achieved a very good functional outcome. They stated that ESIN is an effective treatment to obtain and maintain alignment and stability. Kubiak et al. [9] retrospectively compared flexible nailing with external fixation for treating the pediatric tibia fractures. They found that the union time was significantly shorter in ESIN group (seven weeks) compared to the external fixation group (eighteen weeks). The authors recommended that ESIN for tibial fracture in skeletally immature patients that require surgical stabilization.

Sanker WN et al. [10] reviewed 19 pediatric tibial shaft fracture. All patient achieved bony union at a mean time of 11.0 weeks (range 6-18 weeks). Five patients (26%) had irritation at the nail entry site. There were no leg length discrepancies or physeal arrests. Two patients required manipulation after the index procedure to maintain adequate alignment. According to Flynn classification, they had Twelve excellent, six satisfactory and one poor result.

More recently, Onta PR et al. [18] prospectively studied 18 children with tibial shaft fracture. The average age of the patient was 8.2 years (range 6-12 years). The time of fracture healing was 13.3 weeks and the average time for full weight bearing was 8.8 weeks. Sixteen children had an angulation of fewer than 5 degrees and 2 children had an angulation of 5 to 10 degrees which was acceptable for the age group. They recommended ESIN in diaphyseal fracture of the tibia. It is a simple, effective, minimally invasive procedure with short hospital stay and has a good outcome. The short hospital stay (5.3 days) in our study is comparable with Onta et al. (5.7 days).

Early weight bearing is an important factor in promoting union. Kubiak et al. [9] allowed immediate partial weight bearing postoperatively if there was more than 50% bone contact. The amount of weight-bearing is self-evaluated by the patients themselves according to the pain that it produces. The average union time in our study was 10.2 weeks (13.3 weeks, Onta PR et al. [18], 11 weeks Sanker WN et al. [10], 16 weeks Heo J et al. [19]) with closed and open fractures healing at an average of 9.4 and 12.2 weeks respectively. Most of the studies have shown irritation at the nail entry site as the most common complication following ESIN in the femur, ranging in incidence from 7 to 40%. Our series had similar results, where 22% of our patient complained of pain over the proximal insertion site. This study shows the superiority of the ESIN technique over other fixation techniques, such as locking compression plate and percutaneous plating in terms of post-operative complications. No case of compartment syndrome were seen. Also, eighteen patients had an angulation of fewer than 5 degrees, four patients had angulation of 5-10 degrees and none of the patients had an angulation of more than 10 degrees. There were no cases of a delayed union, malunion, and non-union. There was no rotational deformity and no shortening greater than 1 cm occurred.

Final assessment in our series was done at 6 months using modified Flynn's criteria. In this series, 82% (18 patients) had excellent results, 18% (4 patients) had satisfactory results, no patients had poor results. Ahmed et al. [17] reported 75% excellent and 25% satisfactory with no poor results. The better functional outcome may be due to early fracture union leading to an early return to activities. Early mobility also reduces school absenteeism. There were some limitations to our study. This includes retrospective nature with a small number of patients. We did not have a control group.

Conclusion

Elastic intramedullary nailing is a safe and reliable treatment method for pediatric tibial fractures. It provides stable fixation and allows rapid healing of fractures with minimal complications.

Conflict of Interests

The authors declare that there are no potential conflicts of interest with respect to the research, authorship and / or publication of this article.

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