How Safe is Titanium Elastic Nail Application in the SurgicalTreatment of Tibia Fractures in Children ?

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Tibia fractures in children are generally treated successfully by conservative means. The aim of this study was to evaluate the efficacy and safety of fixation using Titanium elastic nails (TEN) in pediatric tibia fractures in which conservative measures failed or were deemed inapplicable.

In this study, 30 patients who had tibia fractures and were fixated with TEN between 2007 and 2011 were analyzed retrospectively. The procedure was performed after poly-trauma in six patients, open fracture in seven, reduction loss in twelve, and unsuccessful closed reduction in five patients. The number of girls and boys was 3 and 27, respectively, with a mean age of 9.8 years. The evaluation criteria of Flynn et al. were used in the analysis of the results.

The mean follow-up period was 18 months. The mean period of union was 8 weeks and 14 weeks in closed and open fractures, respectively. Epiphyseal damage, rotational deformity, need for reintervention, deep infection, implant failure, or recurrent fracture was not observed in any case. According to the Flynn evaluation system, 23 cases were evaluated as excellent, and 7 as good.

Fixation with TEN is an easy, effective, and safe method that can be used in tibia fractures that are open, irreducible, or with loss of reduction and in cases with accompanying trauma, such as floating knee.

Key words : Tibia fracture, TEN, surgery

INTRODUCTION

Closed reduction and casting has been the most common, most safe, and most efficient method of treatment of tibia fractures in childhood *(15)*. Due to the unique remodeling of pediatric fractures, many angle deformities and length differences heal spontaneously. There are many published reports demonstrating the success of conservative measures *(4,8,9,15)*.

Surgical stabilization may be necessary in open fractures, fractures accompanied by neurovascular injuries, multi-trauma, and serious soft tissue injuries, the presence of the inability to keep reduction and fractures with rotational deformities in spite of successful results achieved with conservative treatment *(9,15)*.

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Plate and screw, external fixator, rigid intramedullary nails, and TEN (Titanium Elastic Nail) may be used in surgical treatment. The popularity of TEN has been gradually increasing due to its ease of use and low complication rate. Closed reduction is applied in this technique, the fracture hematoma is preserved, and the tibial epiphysis is not damaged. TEN has been used successfully primarily in femur fractures and in various long bone fractures with many published reports in the literature (3,5,10,12,17). However, though it has been used in pediatric fractures for a long time, only a few published reports exist (2,6,7,13,18). The aim of this study was to evaluate the efficacy and safety of fixation with TEN in pediatric tibia fractures in which conservative measures failed or were deemed inapplicable.

MATERIALS AND METHODS

Pediatric cases operated for tibia fractures, applying TEN for treatment, in the Diyarbakır Training and Research Hospital , between 2008 and 2012 ,were retrospectively analyzed. Patients with any skeletal dysplasia were excluded. Thirty-four patients who met the criteria were analyzed. Four patients were excluded due to inadequate follow-up. Indications for surgery were: poly-traumatized patient (6 patients), open fracture (7 patients), reduction loss after angulation (12 patients), and failure of achieving reduction with closed methods (5 patients).

The mean age of the 30 patients was 9.8 years (5-14 years), with a mean follow-up period of 18 months (6-40 months). The number of boys and girls was 27 and 3, respectively.

All patient records were evaluated for the mechanism of injury, type of fracture, presence of additional injuries, time of full weight bearing, time of union, time of implant extraction, and accompanying complications. Preoperative and postoperative radiological views of the fractures were analyzed to define the type of fracture, time of union (union seen in three cortices), and the amount of residual angulation in the bone.

Tibia fracture occurred due to motor vehicle accidents in 7 patients, sports injury in 8, fall from a height in 3, and simple fall in the remaining 12 patients. Femur fractures were present in addition to tibia fracture in three patients, distal radius fracture in one, and clavicle and supracondylar humerus fracture in one patient. Five of the seven open fractures were type 1 and two were type 2. Four of the fractures were 1/3 distal diaphyseal fractures, and the remaining 26 were shaft fractures. Twenty-six patients had simultaneous fibula fractures.

Technique of operation

All patients were operated on under general anesthesia in the supine position on a radiolucent operating table. Tourniquets were not applied on any patient. Wound debridement was performed on open fractures and the accompanying soft tissue injuries. The fracture line was visualized under fluoroscopy. The entry site was determined to be 2 cm distal to the proximal physis of the tibia and caution was exerted not to injure the tibial apophysis. Two longitudinal incisions measuring 2 cm on the medial and lateral sites of the tibia were performed. The fracture was reached bluntly with the aid of a haemostatic clamp.

Two TEN's of equal thickness were selected to occupy 40% of the medulla that was defined preoperatively. The cortex was penetrated with a drill 0.5 cm thicker than the selected implants. Both wires were forwarded until they reached the fracture line. Following reduction, which was performed under fluoroscopy, the first wire was forwarded to pass beyond the fracture line. After checking the distal tibia by fluoroscopy in the lateral and anteroposterior plane for the first wire, the second wire was introduced similarly if the position of the first one was deemed appropriate. Afterwards, fluoroscopy controls were performed in both planes again. Open reduction was not performed on any patient. Wires were cut 1.5 cm away from the bone surface. Long leg splints were applied, which stayed in place for 2 weeks postoperatively.

All patients were encouraged to walk on the first postoperative day without weight bearing. Full weight bearing was postponed until full union ((when the bridge formed by callus tissue in all three cortices was observed). TEN's were removed after six month in most cases (Fig. 1).

RESULTS

In all patients radiological full union was achieved in an average of 9.4 weeks (7-18 weeks) after treatment. The mean duration to union was 8 weeks (7-14 weeks) and 14 weeks (10-21 weeks) after closed and open fractures, respectively. TEN's were removed at a mean of 32 weeks (24-52 week).

Fig. 1. – A 9 year-old patient with tibia fracture. A : preoperative anterior and posterior radiographs., B : postoperative anterior and posterior radiographies. C : anterior and posterior radiographs after TEN removal.

Table I. – Flynn et al. TEN scoring system

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

At the last follow-up the mean degree of angulation was 4° in the sagittal and 5° in the coronal plane. One patient had 8° of recurvate deformity. Valgus angulation of 4° and varus angulation of 5° was recorded in one and four patients, respectively.

Skin irritation due to perforating wires was the most commonly encountered complication, which was present in seven cases. However, it was serious enough as to require early removal of the wires in any patient. In one case a superficial infection was seen which was treated with antibiotics. No deep infection or angulations or unequal leg length necessitating reintervention or early epiphyseal closure were seen in any of the patients.

The results of the patients were classified according to the scoring system of Flynn *et al* (5). in excellent, good and fair (Table I). According to the Flynn scoring system, 23 patients were scored as excellent and 7 as good due to wire irritation.

In the study, descriptive statistic methods (average, standard deviation, frequency) were applied using the SPSS15.0 for Windows 7 package program.

DISCUSSION

Tibia fractures in children are generally treated successfully with conservative measures. Success with splint treatment is directly related to the amount of damage of muscle tissue, periosteum, and other soft tissues. The success rate with conservative treatment is decreased in patients who have severe soft tissue injury.

Although surgical treatment is commonly required in open fractures and fractures with presence of ipsilateral femur fractures, it has also been used in fractures with accompanying neurovascular injury, compartment syndrome, multi-trauma, serious soft tissue injury, and rotational deformities, and fractures in which closed reduction cannot be maintained (7). Plate and screws, external fixators, rigid intramedullary nails, and TEN can be used in surgical treatment.

The most commonly used method in surgical treatment was the external fixator, despite its high rates of infection at the base of the wires, nonunion and refractures (16,20). In addition, plate and screws and locked intramedullary nails, for patients with closed epiphysis, were also used (8). Due to the potential problems that these implants may cause, new types of implants that would provide the continuity of alignment and allow early mobilization have been attempted to treat these fractures.

Titanium elastic nails have been used to successfully treat fractures of many long bones in the body, especially in femur fractures (5). These nails facilitate callus production by decreasing shear forces and allowing micro movements (5,12). They stimulate union by converting their traction forces to compression forces trough the three points' fixation that is provided. Other significant advantages of stabilization with TEN are immediate mobilization, lower rate of infection, limited soft tissue damage, and very rapid return to normal daily activities (11, 13).

TEN is a relatively new technique used in tibia fractures, which has had an increased popularity in the last decades, and there are few publications on this technique (2,6,7,13,18). O'Brien et al (13) in their series of 16 patients who were monitored for a mean of 17 months, reported a mean duration of radiological union of 9 weeks. They reported no angular deformity of more than 10° and no inequality of the leg length. Goodwin et al (6) reported a group of 19 patients with a mean duration of follow-up of 13 months, in which two patients had more than 10° angulation and one had epiphyseal growth disturbance. Vallamshetla et al (21) reported a series of 54 patients with 56 fractures, 13 of which were open fractures. The mean duration of union was reported to be 10 weeks and one patient had delayed union. Two patients had malunion, three patients had infections that were superficial in one and deep in two, and two patients had unequal leg lengths. Gordon et al (7) reported a series of 50 patients (26 open and 24 closed fractures) with a mean duration of union of 8 weeks in 45 patients. Five patients had delayed union and two underwent a second surgery. Delayed union was attributed to the advanced age of the patients (mean age : 14.1 years). One patient had angled union and one osteomyelitis. Srivastavaet et al (18) reported the results of 24 patients that were treated using TEN. The fractures were composed of 8 closed and 16 open fractures. While the mean duration of union was reported to be 20.4 weeks, two patients were both reported to have infection and malunion, and one patient was reported to have unequal leg length. Despite these complications, the authors suggested TEN to be used in pediatric tibia fractures. Sankar et al (8) reported a series of 19 patients with a mean 11 weeks of duration of union. The most frequent problem encountered in the study was the irritation of the entry site of the wires. Recurrent manipulation was performed in two patients due to reduction loss and four patients had rotational deformities of 5°.

Floating knee results from high-energy trauma. Fractures due to these injuries are generally unstable with open fractures seen in 40% of cases. Therefore, tibia fractures with floating knee require surgical treatment more frequently. Surgical treatment is recommended in this type of injury, especially in children who are 6 years of age or older. In this study, two such cases had good outcomes following treatment. We suggest that TEN treatment is appropriate in tibia fractures accompanied by floating knee (1).

The mean duration of union in closed and open-fractures was 8 weeks (7-14 weeks) and 14 weeks (10-21 weeks), respectively, in our patients ,comparable to the previous reports.

No deep infections occurred in our patients. This might be due to the small number of open fractures in this series and to the fact that no patient underwent open reduction. The frequency of compartment syndrome after tibia fracture in patients who underwent TEN application was reported to be 2-32% (6,8,14). Although the exact incidence of compartment syndrome after pediatric tibia fractures is unknown, it has been reported to be indirectly correlated with age (6). No compartment syndrome was encountered in the patients in this study.

Inequality of extremities is a common complication after tibia fracture due to overgrowth or epiphyseal damage (19). It is reported that overgrowth after closed tibia fractures should not be more than 0.5 cm (4,15). Some authors reported that unequal leg length was seen more frequently after open tibial fractures and could be more than 1 cm (2,11). Difference in leg length did not develop in any of the patients in this study. This may be because the majority were closed fractures.

Angulation deformities of more than 10°, developing after pediatric tibia fractures are found in 33% of cases (15). Factors resulting in a decreased amount of angulation were reported to be young age, spiral fracture, and anterior and varus angulations (2,15). No angular deformities of more than 10° were present in any of our patients ; four of the patients had a varus angulations and the mean age was low. Furthermore, a lower amount of angulation may be due to the fact that weight bearing was not allowed until the detection of union. This might explain the absence of angular deformity necessitating surgical treatment in this series.

The most common complication in pediatric patients with femur fractures treated with TEN was reported to be skin irritation at the end of the wire with reported rates of 7-40% (10,17). This rate was reported to be 26% for tibia fractures (14). The rate of skin irritation in our series was found to be 23% and no patient was required to have early removal of the wires.

Although tibia fractures in children have been treated very successfully using conservative methods, TEN has become popular for patients in whom surgical treatment is to be applied, due to its easy use, limited soft tissue intervention, application without opening the fracture line in a majority of cases, and easy removal. We suggest that the application of titanium elastic nails is one of the most efficient, easy and safe methods in the treatment of pediatric tibia fractures.

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