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ORIGINAL ARTICLE

Use of external fixator combined with titanium elastic nails in the treatment of tibia shaft fractures in children

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Abstract

Tibia shaft fractures are common in all age groups. For these fractures; Conservative and surgical treatment methods are available. In surgical treatment, numerous surgical methods such as plate screw fixation, external fixator, and titanium elastic nail and K-wire fixation have been defined. The aim of the present study was to present the results of patients for whom external fixator combined with titanium elastic nails or titanium elastic nails alone were applied due to tibia shaft fractures. The study included 40 patients treated for tibia shaft fracture in our clinic between January 2016 and January 2019. Combined external fixator (EF) fixation was applied to patients who were found to be instable after Titanium elastic nail (TEN) application during the surgery. In clinical evaluation, Flynn classification, time to fracture union, fluoroscopy count, reoperation and time to full weight bearing were used. The results of patients for whom EF combined with TEN were applied were compared with the patients who had only TEN. Thirty patients were treated using TEN and 10 patients using EF combined with TEN. After 12 months of follow-ups, fracture union was achieved in all patients. There were 5% sagittal and 2.5% coronal plane angulation. Patients developed angular deformity of an average of 2.43 ± 1.9 degrees in the coronal plane and 2.65 ± 1.9 degrees in sagittal plane. Lower percentages of angular and rotational deformity were observed compared to the literature. Despite the disadvantages of using a greater number of fluoroscopy and longer operation periods in patients who underwent TEN+EF, these patients were mobilized earlier. It was concluded that combined EF application is a more feasible method in patients with pediatric tibia shaft fracture for whom stable fixation cannot be achieved with TEN.

Keywords: Tibia fracture, child, external fixator, elastic nail

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Introduction

Tibia shaft fractures are common in all age groups [1,2]. They account for almost 15% of fractures in children [3]. For these fractures, plaster splints are preferred in children after closed reduction, and most patients can be successfully treated without the need for surgery. Unfortunately, in some patients, sliding or fracture non-union could be observed after splints and surgery is preferred in these patients. Surgical methods are also preferred in cases of instable fractures, open fractures, multiple trauma patients, in patients with compartment syndrome or neurovascular damage, surrounding soft tissue damage, firearm injury and in open fractures [4,5].

In surgical treatment, numerous surgical methods such as plate screw fixation, external fixator (EF), intramedullary nail, titanium elastic nail (TEN) and K-wire fixation have been defined. These treatments have advantages and disadvantages compared to each other. Especially in pediatric patients, open or major surgeries have been replaced by closed or minor surgeries due to the complications such as infection, growth problems and refracture [4,5].

TEN is one of the most popular methods today due to its advantages such as closed fixation, minimal infection rate, minimal soft tissue damage and early mobilization [6,7]. Despite these advantages, the technique is also known to have less stability in some types of fractures such as segmentary fracture, multiple or defective fracture [8].

External fixator applications are used for all fracture areas of all ages in combination with applications for open fractures, extensive tissue damage, intra-joint fractures, instable fractures and limited stabilizing applications [9]. There are numerous publications in the literature on pediatric patients who underwent TEN or EF for the treatment of tibia shaft fractures. However, there are only a limited number of publications related to patients with complex fractures treated with combined TEN and EF applications. Therefore, new studies are needed to find the right indication.

The aim of the present study was to present the results of the patients who were treated with TEN or TEN + EF methods for tibia shaft fractures.

Material and Methods

The study received ethical committee approval from Malatya Turgut Özal University Clinical Research Ethics Committee (approval no: 2021/19). Our study was retrospectively planned. The study included 40 patients treated with TEN or TEN + EF for tibia shaft fractures in our clinic between January 2016 and January 2019.

The inclusion criteria for this study were:

- 0-18 years of age
- Tibia shaft fractures
- Minimum follow-up period of 12 months

Exclusion criteria were:

- Adult patients
- Pathological fractures
- Patients with metabolic bone disease
- Patients with less than 12 months of follow-up period
- Cases with systemic diseases such as diabetes, hypertension.

Surgical Method

Patients were operated in supine position under general anesthesia. Two mini-incisions, one medial and the other lateral, were made at 2 cm distal of tibia epiphysis and TEN entry points were determined. First through lateral and then medial, a 2-4 mm TEN was sent towards the distal through the help of the guide accompanied by fluoroscopy, and the fracture line was passed.

In multiple fracture or segmentary fracture cases or in cases where effective stabilization could not be achieved with two TENs, two 3-mm pins were placed through tibia medial to the distal of fracture line, and two 3-mm pins were placed to the proximal of fracture line with the help of a drill. The axial external fixator device was placed on top of these four pins, and was fixed through achieving effective reduction and stabilization as accompanied with fluoroscopy. After the operation, both groups of patients were

immobilized with long leg splint for two weeks.

Post-Operation Evaluation

The patients were asked to move ankle and knee joints two days after the operation and to perform joint-range of motion exercises on the 15th post-operative day. Partial load mobilization was recommended when signs of fracture union were observed in X-rays taken for control purposes (six weeks on average). In the last follow-up examination, treatment results were classified as excellent, satisfactory and poor according to the TEN result scoring system developed by Flynn et al. [10].

IBM SPSS 19 software (IBM SPSS Statistics 19, SPSS Inc., an IBM Co., Somers, NY) was used in statistical analyses. Clinical data were expressed in number, percentage, or mean ± SD. The two-way Chi-square ($\chi 2$) test was used to evaluate the relationship between two categorical variables. Student's *t* test was used for continuous variables. $p \leq 0.05$ was considered statistically significant.

Results

The results of 40 patients were included in the study. Thirty patients were treated using TEN and 10 patients using EF combined with TEN. Demographic data of the patients included in the study are given in Table 1.

Data are given as mean ± standard deviation / Median / Minimum-Maximum or frequency, percentage *p:* Independent samples *t* test or Chi-square test were used.

After 12 months of follow-ups, 87.5% of patients had excellent and 12.5% had satisfactory outcomes. The mean duration of surgery and fluoroscopy counts was higher in patients treated using EF combined with TEN. However, time to full weight bearing was shorter in these patients. There was 5% sagittal and 2.5% coronal plane angulation. Patients developed angular deformity of an average of 2.43 ± 1.9 degrees in the coronal plane and 2.65 ± 1.9 degrees in sagittal plane. Two patients treated with TEN alone and one patient treated with TEN + EF combination developed superficial infections that were healed with a one-week oral antibiotic therapy.

Data are shown as mean ± standard deviation / Median / Minimum-Maximum or frequency, percentage *p:* Independent samples *t* test or Chi-square test were used. *p:* Between-subject comparison.

Discussion

Many methods have been used for the treatment of tibia shaft fractures in children. These fractures are first treated with closed reduction and casting fixation. When the successful fracture union is not achieved, surgical methods are used. TEN is one of the most popular surgical methods today. In the present study, we achieved successful outcomes with TEN methods in patients with tibia shaft fractures. Since we could not obtain stable fixation with TEN applications alone in 25% of the patients, we combined TEN with axial fixator to achieve 100% fracture union without experiencing any major complications.

Table 1. General characteristics of study groups.

	TOTAL	TEN	TEN+EF
n	40	30	10
GENDER (Male/Female)	22/18	15/15	7/3
SIDE (Right/Left)	19/21	14/16	5/5
AGE	11±2.6	10.5±2.5	12.4±2.5
Fracture type Short oblique Long oblique Transverse Spiral	6, 15% 15, 37.5% 14, 35% 5, 12.5%	5, 16.7% 11, 36.7% 10, 33.3% 4, 13.3%	1, 10% 4, 40% 4, 40% 1, 10%

Although some studies argued otherwise, TEN is still one of the best methods for pediatric tibia shaft fractures [7,11]. TEN which is applied as intramedullary provides a strong grip on the bone due to its Divergent C configuration [12]. Thus, contact is formed at six points on tibia medulla. Through allowing controlled movement in the fracture area, this method provides fracture union with the formation of external callus. It results in a more flexible fixation compared to plate-screw application. Therefore, there are risks of angulation, rotation, shortening and fracture malunion formation. O'Brien et al., [13] reported angulations more than 5° in 12.5% of the patients. Similarly, Sankar et al., [7] reported angulation in 25.2% of the patients (6.3% of the patients had 5-10% angulation in sagittal plane, and 18.9% of the patients had 5-10% angulation in coronal plane). In the present study, 5 and 2.5% angulations were observed in sagittal and coronal plans, respectively, which were considerably lower than those reported in other studies. During the surgery, we tested the reduction stability in all patients after TEN applications with rotational movements made in coronal and sagittal planes. We applied axial external fixators to patients who had poor stability. That's why the patients in our study had almost no rotation, shortening or fracture malunion. The angulation rates were very low in both sagittal and coronal planes. Therefore, we believe that supportive fixation methods can reduce such alignment problems by applying stability tests in these patients.

Li et al., [14] compared TEN combined with EF treatment and intramedullary nail treatment in 23-55-year-old patients with tibia shaft fractures. They found no difference in ankle functional scores and fracture union rates. They observed that blood loss and knee pain were less in patients treated with TEN combined with EF. In the present study, we treated 25% of the child patients using EF as a combination for the treatment because intraoperative stability was low with TEN only application. The patients for whom we practiced this approach were the children between the age of 10 and 16, who were taller and who had more developed bone structure than their peers. In these patients, we increased stability with less tissue damage and

Table 2. General characteristics of the study groups.

Variables	Total	TEN	TEN+EF	*p*
Flynn classification score	Excellent: n: 35, 87.5% Satisfactory: n: 6, 12.5% Poor: n: 0.0%	Excellent: n: 27, 87.5% Satisfactory: n: 3, 12.5% Poor: n: 0.0%	Excellent: n: 8, 87.5 % Satisfactory: n: 2, 12.5% Poor: n: 0.0%	<0.001
Time to fracture union (weeks)	16.6±2	15.9±1.8	18.5±1.6	<0.001
Fluoroscopy counts	9.7±2.6	8.7±2.1	12.9±1.1	<0.001
Reoperation	None	None	None	
Time to full weight bearing (weeks)	7.9±1.6	8.4±1.3	6.4±1.6	<0.001
Duration of the operation (min.)	30.7±7.6	27.4±8	40.2±7.1	<0.001
Coronal angular deformity (°)	2.43±1.9	2.07±1.8	3.5±1.6	0.016
Sagittal angular deformity (°)	2.65±1.9	2.23±1.9	3.9±1.1	0.006

in a shorter time using an additional surgical procedure without any incision. Our clinical outcomes were similar to those reported by Li et al [14]. As a result, we think that combined EF application could provide effective stability in a shorter time with less tissue damage and complications in children who are taller, who have better developed bone structures and who have less intraoperative stability than their peers. Sankar et al., reported the need to repeat the reduction under anesthesia in two patients treated with TEN due to loss of postoperative reduction [7]. A secondary anesthesia was needed in these patients because these patients weighed 39 and 55 kg and had more developed body structure compared to other patients. In the present study, the patients for whom an effective intraoperative stability could not be achieved were the ones who were well-built or overweight such as those in the study of Sankar et al. Thanks to the combined EF method we performed in these patients, a second surgical or anesthesia procedure was not required.

Pennock et al., compared the results of patients treated with TEN or plate-screw fixation method for pediatric tibia shaft fractures [15]. There was difference between the groups for fracture union rates. The plate-screw group had less casting time (an average of seven weeks), better anatomical reduction and lower second surgical requirement rate. In the TEN group, on the other hand, shorter surgical time and lower scarring problems were observed. In our study, we used shorter casting periods in patients treated with TEN+EF (two weeks) compared to the period used for plate-screw group by Pennock et al. Considering all patients in the study (EF+TEN and TEN groups), no patients required a second surgical procedure. Very few patients (n: 3, 7.5%) had wound problems. The results of our study showed that the need for major surgeries such as plate-screw fixation could be eliminated with the use of TEN method in patients with pediatric tibia shaft fractures and use of combined EF method in patients for whom stable fixation cannot be achieved.

Retrospective design of the study, limited number of patients and short follow-up periods were among the limitations of the study. More efficient studies with larger patient populations are needed.

Conclusion

In conclusion, TEN is a successful method in pediatric patients with tibia fractures. However, we believe that in patients for whom stable fixation be cannot achieved by applying TEN alone, combined EF application is a more viable method in pediatric patients with tibia shaft fracture.

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Conflict of interest

There are no conflicts of interest to declare.

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