

Titanium Elastic Intramedullary Nailing in Displaced Forearm Fractures in Children: An Experience of 154 Cases

Recep DİNÇER¹, Ahmet KÖSE¹, Tuncay BARAN¹, Murat TOPAL¹, Ali AYDIN², Murat İPTEÇ²

¹ Department of Orthopedics and Traumatology, Ministry of Health Health Sciences University Erzurum Regional Education and Research Hospital, Erzurum, Turkey.

² Department of Orthopedics and Traumatology, Atatürk University Research and Application Hospital, Ankara, Turkey.

SUMMARY

Diaphyseal forearm fractures in children are extremely common. They are mostly treated by conservative methods. The elastic intramedullary nail is a good solution owing to its advantages in the cases when surgery is needed.

A total of 154 children with a forearm double fracture, who were surgically treated with the titanium elastic nail at the Department of Orthopedics, Erzurum Regional Training and Research Hospital between January 2010 and December 2015, were included in the study. Children aged more than 14 years with pathologic fractures, isolated radius, and isolated ulna fracture were excluded from the study. All cases were followed up for 1 year. All cases were treated first with closed reduction and casting. A surgical decision was taken for the cases that could not be reduced and had a shift in the fracture line in the follow-ups.

The average union was radiologically for 5.9 weeks (4-9). Pin tract infection was observed in two cases, skin irritation in seven cases, nail migration three cases, and refracture six cases. Nerve damage, tendon rupture, malunion, nonunion, and synostosis were not observed. Perfect results were obtained in 126 (82.7%) cases, and good results were obtained in 26 (15.9%) cases in the study.

Elastic intramedullary nailing is a surgical technique primarily preferred for forearm fractures in children because it is easily applicable; is associated with a small incision and no need for a secondary operation; has a low complication risk; and yields good clinical and radiological results.

Key words: Elastic intramedullary nail, forearm fractures, fracture in children

INTRODUCTION

Although diaphyseal forearm fractures in children are extremely common, the general approach is a conservative treatment (1). Despite having a high remodeling capacity, high-energy, nonreductive, and unstable fractures are treated surgically (2). Good results of open reduction and internal fixation (ORIF) with plaque have been reported in the literature (3,4). However, it has also been shown that ORIF causes complications such as soft tissue damage, infection, neurovascular damage, nonunion, malunion, and scar (5). Treatment with titanium elastic intramedullary nail (TEN) has been reported to yield better results compared with ORIF in terms of complications (6-8).

This study aimed to evaluate 154 patients treated with TEN in terms of their functional status, union status, and complications.

Correspondence:

Recep DİNÇER

Erzurum Bölge Eğitim ve Araştırma Hastanesi No: 6 25600 Erzurum, Türkiye.

e-mail: recebed@gmail.com

PATIENTS AND METHODS

A total of 154 children (aged 6–14 years; 131 males and 23 females) with a forearm double fracture, who were treated with TEN at the Department of Orthopedics, Erzurum Regional Training and Research Hospital between January 2010 and December 2015, were included in the study. The duration of follow-up was at least 1 year. The study was performed in a single center. The preoperative written consent of the patients and the approval from the Institutional Review Board were obtained prior to the retrospective evaluation. Cases with displaced forearm double fracture, cases with displaced fractures with an angulation of 150 at the age of 8 years and 100 at the age of 8 years and over after the application of closed reduction, and fracture cases with unstable reduction were included in the study (9,10). Children aged more than 14 years and less than 6 years; children with pathologic fractures, isolated radius, and isolated ulna fracture; cases meeting the acceptable conservative treatment criteria on the first application; children with different fractures in the same extremity; children with head trauma; and patients with multiple trauma and type 2–3 open fracture were excluded from the study.

All fractures were in the Type 22-D group according to the AO classification of fractures in children (11). Although 149 fractures were closed, 5 were in the Type 1 group according to the Gustilo–Anderson open fracture classification (12). Closed reduction was applied to the fractures in 109 cases, whereas minimal open reduction was applied in 45 cases. TEN tips were buried in 90 children, whereas they were exposed in 64 children (Table 1).

All cases were followed up for a minimum of 1 year. All of the cases treated surgically were first subjected to closed reduction and casting. A surgical decision was taken for the cases that could not be reduced and had a shift in the fracture line in the follow-ups. Both bones were detected with TEN in all fractures.

SURGICAL TECHNIQUE

The cases with open fractures were immediately taken for surgery after the emergency application. The cases with closed fractures were treated within the first 2 days after the application. All

cases were applied general anesthesia. All patients were given 1 g cefazolin intravenously half an hour before the operation. They were placed on the radiolucent arm table in the supine position. No tourniquet was applied to any of the cases. The surgery was started with the first bone reduced. The radius insertion site was advanced with the blunt dissection of the extensor carpi radialis brevis (ECRB) and extensor carpi radialis longus tendons from the lateral side of Lister's tubercle distally. The ECRB tendon sheath was opened longitudinally. The first entry was applied perpendicular to the radial metaphysis with an awl in the second extensor compartment. The first entry point was expanded with a curved awl by targeting the medullary cavity. The radius nail of the determined suitable size and diameter was advanced using the nail holder with partial rotational forces. When the nail tip reached the fracture line, it was checked by scopy control whether

TABLE 1: Patients' medical details and demographic distribution.

Number of patients	154
AO/OTA fracture type, <i>n</i> (%)	
Type 22-D4/1	56(33,2)
Type 22-D5/1	98(66,8)
Fractured forearm	
Right	98 (63,2)
Left	56 (36,1)
Closed fracture, <i>n</i> (%)	149 (96,8)
Type 1 Open fracture, <i>n</i> (%)	5 (3,2)
Gender distribution, <i>n</i> (%)	
Female	23 (15,4)
Male	131 (84,6)
Trauma etiology, <i>n</i> (%)	
Traffic accident	19 (12,3)
Fall	128 (82,6)
Other's	7 (4,5)
Open reduction	45 (29,2)
Closed reduction	109 (70,8)
Exposed TEN	64 (41,6)
Buried TEN	90 (58,4)
Average age	8,3 (6-14)
Follow-up period, avg. (week)	52



FIGURE 1: Ulna apophysis entrance and incision area are seen.

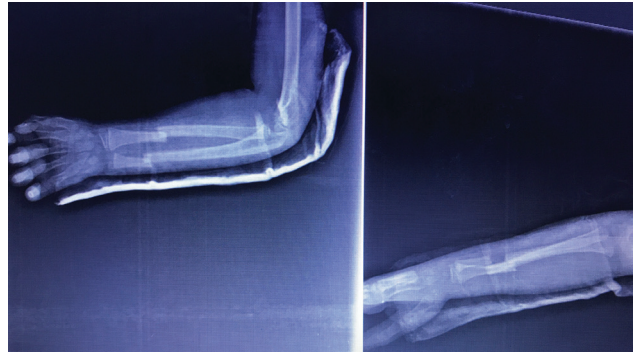


FIGURE 2a: Preoperative AP and Lateral x-ray in 8 year old child.



FIGURE 2b: Post-operative AP view after union.

the nail advanced intramedullary. The entry point of the ulna was determined to be from the apophysis tip proximally. TEN was inserted intramedullary in the fracture cases to which closed reduction was applied, and the procedure finished after the reduction was completed. In cases to which closed reduction could not be applied, TEN was inserted via mini-Thompson incision dorsally for the radius and via transcutaneous mini-incision for the ulna shaft fracture (Figure 1). In all cases, Titanium Elastic Nail T2 (Marquardt UK) was used. The diameter of the nail was determined to be at least 40% of the medulla by scopy control (13). Surgical applications were performed by two surgical teams. Leaving the nail tips inside or outside was determined according to the treatment protocol applied. No tourniquet was applied in any of the cases. The average operating time was 42.6 min, with no significant bleeding.

A long-arm splint was applied for 2 weeks during the postoperative period. The patient was then taken to a physical therapy program. The patient was called for the second-week, fourth-week, eighth-

week, sixth-month, and first-year controls. The anterior–posterior and lateral radiographs containing the wrist joint and elbow were used in the radiological follow-up of the cases. The callus was radiologically observed on the anterior–posterior and lateral radiographs. Clinically, no sensitivity with palpation on the fracture site and no pain with forearm movements were considered as union criteria. Complications such as nerve damage, tendon rupture, nonunion, malunion, osteomyelitis, and pin tract infection were noted. Wrist and elbow flexion–extension and elbow pronation–supination degrees of the cases were evaluated after the union.

RESULTS

Ninety-eight of the fractures were located on the right side and 56 on the left side. The examination of the etiology of the fractures revealed a simple fall in 82.6 and traffic accidents in 12.3% of the cases.

The union was obtained radiologically in all cases in an average of 5.9 weeks (4-9) (Figure 2). Further, 100% union was obtained in

all fractures. The Flynn criteria were used in evaluating the patients (14). Perfect results were obtained in 126 (82.7%) cases, good results in 26 (15.9%) cases, and moderate results in 2 (1.4%) cases in the study (Table 2).

No patients developed iatrogenic bone, tendon, vascular, and nerve damage during the operation. Pin tract infection, which could be reversed with antibiotic treatment, was observed in two cases, skin irritation in seven cases, and nail migration in three cases. Refracture developed in six cases within an average of 4.8 months after the implants were removed. Malunion, nonunion, and synostosis were not observed. All patients were followed up for 2 weeks with a long-arm splint during the postoperative period. According to the sociocultural level, the splint was changed to a short-arm splint and elbow exercises were started in the next 2 weeks.

The time of the removal of the implants whose ends were left outside was 6.2 weeks (5–9 weeks) on average, and that of the implants whose ends were left inside was 31.6 weeks (26–44 weeks) on average.

DISCUSSION

Forearm shaft fractures in children are usually treated by conservative methods in the case of displacement despite malunion and the limitation of function (8). The most common cause of the cases to which closed reduction cannot be applied is soft tissue interposition (15). Although the functional results of ORIF as a surgical option are good, the unacceptable scar tissue on the skin and the infection rate in some children are its disadvantages (8). The rate of forearm closed fractures operated is 5%–16% in the literature (7,15,16). In this study, the closed reduction could not be applied to the fracture in 45 cases. Hence, open reduction with a mini-incision was used.

Remodeling capacity is extremely high in children aged less than 8–10 years despite malreduction in conservative treatment (7,17,18). It is important to evaluate deformity on the anteroposterior and lateral radiographs. The angulation up to 20° in children may disappear with growth (2,17,19).

TABLE 2: TEN Results.

• Surgery period (min), average (range)	42.6 min Not reported
• Fluoroscopy period (min), average (range)	Not significant
• Bleeding	
• Union period (week), average (range)	Average 5.9 weeks (4–9 weeks)
• Post follow-up ROM (degree), average (range)	Full
• Supination	Full
• Pronation	Full
• Flexion	Full
• Extension	Full
• Flynn criteria (%)	
• Perfect	126 (82.7%)
• Good	26 (15.9%)
• Acceptable	2 (1.4%)
• Not acceptable	None
• Redisplacement	
• Ten tips exposed	5.2 weeks (4–7 weeks)
• Ten tips buried	31.6 weeks (22–46 weeks)

The surgical methods in forearm fractures in children are fixation with plaque and use of open or closed elastic intramedullary nail. The advantages of TEN are excellent cosmetics, short surgical time, minimal soft tissue dissection, easy removal of the implant, and early movement (6). The bleeding during the operation is less. Intramedullary implants generally have stress-sharing property, leading to the formation of a stronger callus tissue. Implant removal from the same incision is an important cosmetic superiority.

Angulation of more than 10° and fully displaced fractures were the surgical indications in the series in which Yung et al. applied K-wire intramedullary to 57 forearm fractures in children aged between 2 and 13 years (18). Richter et al. applied TEN to 30 children aged 4–14 years (average 9.6) (7). The lower age limit in the present study was 6 years. It was believed that the age of surgical application was extremely small in these studies.

The results of forearm fractures treated with TEN have been reported to be good in the literature. The perfect result was obtained in 92% of the patients after a 3.5-year follow-up on average in the study conducted by Lascombes et al. (15). Moreover,

10° supination limitation developed in 3 out of 30 cases in the study of Richter et al. (7). Perfect results were obtained in 26 out of 31 cases and poor results in 2 cases in the study of Küçükkaya et al. (20). Perfect results were obtained in 126 cases (82.7%) and good results in 26 cases (15.9%) in the present study.

Nonunion and delayed union in children and adolescents are rare (17,21). Sun et al. claimed that the use of the K-wire in the large canal in older children leads to union delay (22). Richter et al. detected a delayed union in a single 14-year-old case (7). No delayed union and nonunion was detected in any of the cases in the present study.

Another important complication is the development of a refracture. Although the refracture rate in conservative follow-up cases is around 6%–10% (17) in the literature, it is rarely seen in TEN-treated cases with a rate of 0.5% (23). Kelly et al. found this rate to be 4.7% (16 cases) in their large series of 339 cases (24). Martus et al. detected refracture in 9 of 205 cases (4.4%). In four of the cases, refracture developed when the nail was in the intramedullary canal; in five of the cases, it developed after the removal of the implant (25). No clear consensus exists on when implants should be removed. Initially, implants were buried under the skin and held there for 6–12 months for biomechanical support against the risk of refracture (17). In the present study, refracture was detected within an average of 4.8 months after the implant removal in six cases (3.9%), which was compatible with the data in the literature.

CONCLUSIONS

The removal of TEN requires a clinically small surgical procedure. Elastic intramedullary nailing is a surgical technique primarily preferred for forearm fractures in children because it is easily applicable; is associated with a small incision and no need for a secondary operation; has a low complication risk; and yields good clinical and radiological results.

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