

Treatment and Management of Complications in Pediatric Forearm Fractures

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BACKGROUND/AIMS

Forearm diaphyseal fractures are common in children. While closed reduction and casting are sufficient in most patients, surgical treatment is required in some cases. The aim of this study is to determine the possible causes of complications occurring in patients with intramedullary fixation with nail (IMN), as well as to evaluate the management of complications and their final results.

MATERIAL and METHODS

Between January 2017 and January 2020, 53 children under the age of 16 who had forearm fractures and surgically treated with IMN were included in the study. Demographic data of the patients, type of surgery, surgical technique, postoperative care, complications, and treatment modalities of complications were evaluated.

RESULTS

The mean age of 53 patients (41 boys and 12 girls) included in this study was 10.5 ± 2.4 years. The average follow-up period of all our patients was 23.4 months (12-34 months). Complications in our study were seen in 14 (26.4%) patients. These complications included pin-track infection in six (11.3%), refracture in four (7.5%), injury of superficial branch of radial nerve in two (3.7%), extensor pollicis longus rupture in one (1.8%), and pin migration in one (1.8%) patient.

CONCLUSION

As a result of the treatment and management of these complications, mild hypesthesia persisted along the superficial branch of the radial nerve in only one case, and all other complications were fully recovered. Successful management of complications can be achieved with close follow-up and appropriate treatment.

Keywords: Complications, forearm, pediatric fractures, surgery, treatment

INTRODUCTION

Forearm diaphyseal fractures in children are frequently seen and constitute approximately 5.4-14.9% of all childhood fractures.¹⁻³ Due to the high potential for union and remodeling in children, closed reduction and immobilization with plaster cast are considered to be the first successful treatment in most patients. Surgical treatment is recommended in cases that cannot be reduced closed, in unstable fractures, open fractures, and refractures.^{4,5} Although plate-screw and intramedullary fixation with nails (IMNs) are used in the surgical treatment of forearm fractures, intramedullary fixation is currently more often preferred in forearm fractures.⁶ Kirschner-wires (K-wires), rushrods, Steinmann pins, and elastic stable intramedullary nails (ESINs) are used in intramedullary fixation.

The incidence rates of postoperative complications for pediatric forearm fractures range from 8.9 to 67%.⁷⁻⁹ The most important of these complications are pin track infections, refracture, pin migration, extensor pollicis longus (EPL) tendon injury, radial nerve superficial branch injury, nonunion, malunion, compartment syndrome, osteomyelitis, and synovitis. Our hypothesis is that surgical complications are seen at a high rate in pediatric forearm fractures, but these complications are almost completely healed with appropriate approaches. Our aim in this study is to determine the complications

and possible causes that occur in patients who underwent IMN for forearm fractures in our clinic, as well as to evaluate the management of complications and their final results.

MATERIAL and METHODS

Patients who were operated in the clinic of our tertiary health center for forearm fractures between January 2017 and January 2020 were included in this study. The data about the patients were obtained from the automation records of our hospital using the ICD Codes (International Statistical Classification of Diseases and Related Health Problems). Patients younger than 16 years of age who underwent surgical treatment with IMN and were followed-up for at least 1 year were included in this study. Patients with pathological fractures, cases followed-up for less than 1 year, those with multiple traumas, and those previously had undergone plate-screw osteosynthesis were not included in this study. A total of 53 patients were included in this study based on inclusion and exclusion criteria.

In determining the fracture site, three regions as proximal, middle, and distal 1/3 were determined as described by Mehlman and Wall.¹⁰ In this study, in addition to the demographic data of the patients, the type of surgery, surgical technique, complications, and treatment modalities of complications were also evaluated.

Surgical Technique

After the first-generation cephalosporin was administered to all patients as surgical prophylaxis, they were placed on the table in the supine position, and a pneumatic tourniquet was wrapped around their forearms. In most of the cases, surgical intervention was primarily started from the radius. Approximately 2 cm proximal to the radial physis, a small skin incision was made on the dorsolateral aspect of the forearm to reach the distal radius by preserving the EPL and the superficial branch of the radial nerve.

Intramedullary nail was advanced through the entry hole previously opened through an appropriate site for the reduction of the fracture under the guidance of fluoroscopy. For the ulna, a mini-incision was made on the lateral edge of the olecranon, and the nail was directed from proximal to distal. Both approaches for radial and ulna fractures were performed as previously described in the literature.¹¹⁻¹³ In cases where closed reduction cannot be applied on the fracture line, the pneumatic

tourniquet was inflated, and through a mini open incision, the fracture line was reduced, and IMN was applied.

We took care not to force the pins beyond the epiphyseal lines, and we ensured that the diameter of the pin filled more than half of the diameter of the diaphysis. In some patients, the pins were bent appropriately and left buried under the skin, while in others, they were left unburied on the skin.

Postoperative Care

Postoperatively, a long-arm splint was applied for 2 weeks, and then a short arm splint for 3-6 weeks. Joint movements were initiated after the splint was removed. The patients were followed-up clinically and radiologically at 2, 4, 6, and 12 weeks. Union of the fracture was deemed to be achieved when the formation of visible callus on the fracture line was noted on radiograms, and pain, tenderness, and pathological movements disappeared.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences version 22.0 (IBM SPSS Corp.; Armonk, NY, USA). Normality of gender distribution between the two groups was assessed using two-sample proportion test, and the normality of age distribution was assessed using independent two-sample t-test.

RESULTS

The mean age of 53 patients (41 boys and 12 girls) included in this study was 10.5 ± 2.4 years. The average follow-up period of all our patients was 23.4 months, and pins were removed on an average of 126 days in those with buried pins and on 67 days in those with unburied pins. The demographic data of our patients are given in Table I. It can be seen from the table that our patients were mostly men ($n = 41, 77.4\%$) and fractures of the left extremities ($n = 30, 56.6\%$) were encountered. Mostly fractures of the middle 1/3 of the forearm were seen. In 34 of our patients, fixation with IMN was achieved using K-wires,

Table I. Demographic Data of Patients

Characteristics	n (%)
Gender	
Male	41 (77.4)
Female	12 (22.6)
Side	
Right	23 (43.4)
Left	30 (56.6)
Fracture location	
Proximal	8 (15.09)
Middle 1/3	32 (60.37)
Distal	13 (24.5)
Type of IMN	
K-wire	34 (64.2)
ESIN	19 (35.8)
Pin status	
Buried	31 (58.5)
Unburied	22 (41.5)
Complications	
Pin tract infection	6 (11.3)
Refracture	4 (7.5)
Radial nerve superficial branch injury	2 (3.7)
Ekstansör pollicis longus rupture	1 (1.8)
Pin migration	1 (1.8)

Main Points

- Forearm fractures are common in children. Nonsurgical approaches are used for most of these fractures.
- Surgical intervention is required in displaced fractures, and reduction cannot be achieved with a conservative method.
- Many surgical methods have been described in these patients. In addition to the success of these surgical methods, complications and their management are also extremely important.
- In this study, we discussed the complications of surgically treated pediatric forearm fractures and their management.



Figure 1. Pre- and postoperative radiographs of a 9-year-old patient with displaced radius fracture and nondisplaced ulna fracture.

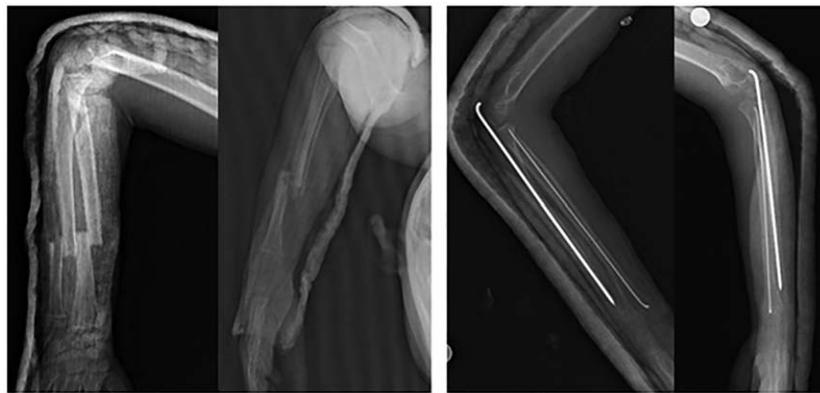


Figure 2. In the same patient, the refracture occurred 5 months later, and the IMN was applied.

and in the remaining 19 patients, ESINs method was used for fixation. The number of cases with embedded pins were more numerous than those with unburied pins. In our study, complications were seen in 14 (26.4%) patients.

The most common complication was pin track infection in six (11.3%) patients, five of which occurred in patients with unburied pin tips. Refracture, another important complication in these fractures, was seen in our four (7.5%) patients. It was found that in three of these four patients, the pinheads were unburied, and pins had been pulled out on postoperative 54, 62, and 72 days. Refractures had occurred after spontaneous fall of pins on the postoperative 8, 12, and 17 days after the pins were pulled out. In the case whose pin was buried and pulled out after the 5th month, refracture occurred after a fall from a height of about 1 m 12 days after the pin was pulled out. These refractures occurred in the middle one-third of the forearm in three and in its distal one-third in the other patient (Figures 1 and 2).

Another important complication was the injury of the superficial branch of the radial nerve in two of our patients. In their follow-up, one completely recovered in the sixth month, and in the other patient, mild hypesthesia still persisted in the postoperative 14th month.

EPL rupture was detected in one of our patients during pin removal. Tendon repair was performed in the patient with EPL

rupture, and the patient recovered completely without any sequelae. Pin migration was detected in the follow-up of a patient whose pin tip was embedded in the radius. After healing of the fracture was achieved completely, the cortical window was opened where the pin tip and the pin were removed.

DISCUSSION

In this study, different complications were observed in 14 (26.4%) cases. The most common complication was pin track infection in six (11.3%) patients. As another complication, refracture was observed in four (7.5%) patients. Three of our refractures were seen in the middle 1/3 of the forearm. In our study, EPL rupture was found in only one patient (1.8%), which occurred during the removal of IMN. In two (3.7%) patients, damage to the sensory branch of the radial nerve was detected. There are many methods for the treatment of pediatric forearm fractures, and conservative methods such as closed reduction and plaster casting often provide successful treatment outcomes. The presence of thick periosteal tissue and high potential for remodeling increase the success of conservative treatment.^{14,15}

The remodeling potential decreases as the fracture location approaches proximally and with aging.^{16,17} In cases where closed reduction cannot be achieved and reduction cannot be maintained, surgical treatment is performed. As surgical

treatment alternatives plate-screw, osteosynthesis and IMN are practiced. Recently, it has been observed that there is a trend toward surgery among the authors due to difficulties such as maintaining reduction of fracture in conservative treatments and higher refracture rates.^{6,18,19} With advantages of IMN, such as its being a mini-invasive procedure, easy applicability, lower rates of complications, and cosmetic problems, IMN has been preferred more frequently.^{6,9,20} In addition, fixation with an intramedullary nail allows micromovements in the fracture site and earlier callus formation.²¹

In our study, it was found that forearm bone fractures in children were mostly seen in males, on the left upper extremity and mostly in the middle 1/3 of the forearm. These results are similar to the literature.⁶ A wide range of complications up to 60% are seen in the surgical treatment of these fractures.⁹ The diagnosis, treatment, and management of these complications greatly affect the outcome of the treatment.

In this study, different complications were observed in 14 (26.4%) cases. The most common complication was pin track infection in six (11.3%) patients. Tsukamoto et al.⁶ reported that pin track infection rates were 11.7% in a study they conducted on fracture complications. Meriç et al.²² treated their patients using IMN treated, unlike our findings pin track infection was seen in 22.2% of their patients. In our patients who developed pin track infection, a swab sample was obtained from the pin site, and their treatments were rearranged according to the culture results. Complete healing was achieved within 2-3 weeks in five patients with unburied pin tips. In one of our patients, whose pin tip was buried under the skin, the implants were removed, and the wound debridement was performed when the infection did not regress despite 2 weeks of oral antibiotic treatment, and sufficient callus tissue was detected in the radiograms. Full recovery was achieved after 3 weeks of antibiotherapy in the patients with a long arm splint. Pin track infections seen in these patients are generally superficial, and good results can be obtained with medical treatment. However, in cases that do not respond to the treatment of infection, satisfactory results can be obtained with early intervention, removal of the pins, and debridement of the wound site.

As another complication, refracture was observed in our four (7.5%) patients. Three of our refractures were seen in the middle 1/3 of the forearm. In the literature, the rates of refracture in forearm fractures vary between 4 and 8%, and they are often seen in midshaft fractures. It has been suggested that higher muscle mass percentage in the proximal part of the forearm better protects the forearm, which explains lower rates of refractures involving these regions.^{6,9,13} Cullen et al.²³ reported only one refracture in a series of 20 cases, in which they applied intramedullary K-wires. Refractures are reported to occur mostly in males, younger ages, and thin individuals.^{9,24} Three of our four refracture cases were male, and refractures were seen in those whose pin tips were unburied. We think that unburied pin tips tend to be removed within a short time. ESIN was performed as revision surgery in the treatment of our three cases of refracture. In our fourth case, osteosynthesis with plate-screws was performed because the intramedullary region was closed, and IMN could not be sent through. In such cases of revision, it is recommended to have the plate screw set ready together with the IMN, as an implant may be required. Removal of the pins in the fracture line without

achievement of complete union was thought to play a role in the development of refractures. In the literature, refractures have been also observed more frequently in fractures whose pins were removed prematurely.^{24,25} In our study, the main reasons for the early removal of the pins were the patient's frequent requests to remove the pin due to the unburied pin irritating the area, creating a risk for infection and the uneasiness given to the patient. In these cases, we think that the application of the fracture treatment protocol and communication with the patient are important factors rather than the patient's demand.

Surgeons may have different preferences about exposing or buried the pin tips. As a matter of fact, different surgeons in our study either unburied or buried pin tips. Here, during the follow-up of our patients, we especially observed that infection occurred less frequently in patients whose pin tips were buried, and that joint movements were initiated much more earlier in these patients. Some studies have demonstrated that the burying of the pins under the skin and retaining them for at least four or six months prevents infection and reduction loss and can initiate earlier mobility of the extremity.^{4,12,13,24,25} In our study, the pin tips were left buried in 31 and unburied in 22 cases. We have observed that our tendency is to leave the pin tips under the skin at an increasing rate. In line with the data we detected in our study, we think that the buried of the pins is safer for preventing development of complications such as infection and refracture.

In forearm fractures, EPL injury is one of the complications that occur while the nail is being implanted or removed.^{26,27} In our study, EPL rupture was found in only one patient (1.8%), which occurred during the removal of IMN. In this patient, intraoperative EPL repair was performed, and by wearing a short-arm splint with thumb support for three weeks, recovery was achieved. Kruppa et al.¹³ found EPL damage at a rate of 1.5% in their study. Flynn et al.²⁸ detected tendon rupture in 1.9% of their patients. The EPL complication rate we obtained was similar to the literature findings.

Another complication is the damage to the sensory branch of the radial nerve, which is an important structure, when access through the Lister's tubercle is selected for the management of a radial bone fracture at the wrist level. In our study, this complication developed in two (3.7%) patients. While one of them recovered in the 6th month with close follow-up, the other patient still had mild hypesthesia in the postoperative 14th month. This latter case did not receive any treatment related to hypesthesia, and the patient is being followed-up. In the literature, it has been reported that most of the nerve injuries seen in the treatment of forearm fractures tend to heal spontaneously.^{18,29}

Following the treatment of all complications that developed after at least one year of, all of our patients recovered without any sequelae, except for one patient who developed mild hypoesthesia due to the injury of superficial branch of the radial nerve. As our first result in forearm fractures, despite the wide range of complications seen in patients undergoing surgical treatment with IMN, good follow-up and treatment with appropriate surgical technique seriously affect the final result of the treatment. The second result is that the buried of the pins reduces the risk of infection and indirectly prevents development of refracture from as it tendency for late removal.

Our study have some limitations. The most important of these is the small number of patients and the single-center study. Another limitation was its retrospective nature. One of the reasons for the low number of patients may be that they were operated by us and followed-up in other centers.

In conclusion, although the first treatment in pediatric forearm fractures is usually closed reduction and casting, we believe that in cases treated surgically, complications that develop in cases can be completely healed with timely and appropriate interventions.

Ethics Committee Approval: Ethical committee approval was received from local Ethics Committee (approval date: December 4, 2020, approval number: 2020/09-17).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

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Conflict of Interest: The authors have no conflicts of interest to declare.

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