Result of the pin fixation with mini-open technique for irreducible distal radius diaphyseal metaphyseal junction fractures in child

Çocuklarda redükte edilemeyen metafizo-diyafiziel distal radius kırıklarında mini-açık teknikle yapılan pin tespiti sonuçları

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Abstract

Aim: Although conservative treatment remains the preferred choice for distal radius fracture in children, reduction losses and failure to achieve reduction remain the main problems at diaphyseal metaphyseal junctional fractures. There is no consensus on the surgical treatment of displaced metaphyseal-diaphyseal distal radius fractures. This study aims to evaluate the result of the crossed pin fixation applied with the mini-open technique at pediatric metaphyseal-diaphyseal distal radius fractures.

Methods: The radiological and clinical outcomes of pediatric distal metaphyseal diaphyseal distal radius fractures operated between 2018 and 2020 were retrospectively investigated. The clinical follow-ups of the patients were performed in the second, fourth, sixth weeks and the third month. Radiological recovery time, reduction losses during follow-up, complications, and forearm and wrist range of motion were examined.

Result: There were 13 boys and 6 girls with an average age of 10.1 (8-12 years). Radiographs taken immediately after the operation showed less than 5% translation in the coronal plane and less than 10% translation in the sagittal plane. An average of 4 degrees of change was observed in the lateral radiographs, and an average of 3 changes was detected in the anterior to posterior (AP) radiographs at the last follow-up. No limitation in the range of motion was observed in the patients.

Conclusion: Our data showed that the pin fixation with the mini-open technique was a suitable method to treat metaphyseal-diaphyseal distal radius fractures with a satisfactory alignment and achieving stable fixation.

Keywords: Fracture fixation; minimally invasive; osteosynthesis; radius fractures

Öz

Amaç: Pediatrik distal radius kırıklarının tedavisinde, konservatif tedavi genel tercih edilen tedavi olmasına karşın distal metafizodiafizier kırıklarda redüksiyon kayıpları ve redüksiyonun sağlanamaması başlıca sorun olarak karşımıza çıkmaktadır. Yer değiştirmiş metafizodiafizier distal radius kırıklarının cerrahi tedavisinde hangi tekniğin kullanılacağına dair fikir birliği bulunmamaktadır. Bu çalışmanın amacı; metafizodiafizier yerleşimli distal radius kırıklarında mini-açık teknik ile yapılan pin tespitinin sonuçlarını değerlendirmektir.

Yöntemler: 2018-2020 yılları arasında metafizodiafizier distal radius kırığı nedeni ile ameliyat edilen pediatrik vakalar geriye dönük incelenmiştir. Hastaların klinik takipleri ikinci, dördüncü, altıncı haftalarda ve üçüncü ayda yapıldı. Radyolojik iyileşme zamanı, takiplerde gelişen redüksiyon kayıpları, komplikasyonlar, el bileği ve önkol hareket açıklıkları değerlendirilmiştir.

Bulgular: Toplamda 19 hasta, 13'ü erkek ve 6'sı kız hasta olmak üzere incelemeye alınmıştır. Çalışmaya dahil edilen hastaların ortalama yaşı 10.1 (8-12 yıl) yıldır. Ameliyattan hemen sonra çekilen grafilerde koronal planda translasyon %5'in altında, sagittal planda ise %10'un altında bulunmuştur. Hastaların son takiplerindeki kırık iyileşmesine yönelik yapılan radyografik incelemelerde ön-arka grafilerde ortalama 3, yan grafilerde ise ortalama 4 derece açısal değişiklik tespit edilmiştir. Hastalarda herhangi bir hareket kısıtlılığı gözlemlenmemiştir.

Sonuç: Araştırmamız sonucunda; metafizodiafizier distal raidus kırıkların tedavisinde mini-açık teknik ile uygulanan pin tespiti yeterli stabilite ve dizilim elde edilmesi açısından uygun bir tekniktir.

Anahtar Sözcükler: Asgari invazif cerrahi; kırık tepiti; osteosentez; radius kırıkları

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INTRODUCTION

Treatment of complete displaced distal radius metaphyseal junctional fractures achieved by immobilization with a plaster cast is generally considered insufficient (1). After cast immobilization treatment, reduction losses have been reported in the literature by over 30-39% (2-4). It has been shown that the more proximal fracture line is located in distal metaphyseal fracture, the more instability increases (5). If reduction losses exceed 10 degrees, movement restrictions occur in supination and pronation (6). Surgical treatment options for displaced distal radius diaphyseal metaphyseal junctional (DRDMJ) fractures are pin fixation, intramedullary nancy nail fixation, and plate fixation for older children (7-9). There is no consensus on the surgical treatment of these fractures. DRDMJ fractures are usually located too distally to be treated by titanium elastic nail fixation and too proximal to be treated by conventional K-wires fixation (10). Although titanium elastic nail applications seem reliable for pediatric radius shaft fractures, they can cause frontal plane deformities for fractures of this region. K wire applications result in unsatisfactory fixation due to acute angle application in this region (11,12).

For this reason, we defined the mini-open technique to preserve the reduction and place the k-wire appropriately during the application of crossed-pin fixation. This study aims to investigate the clinical and radiological results of crossed-pin fixation being applied with the mini-open technique. Our hypothesis is that the mini-open technique in DRDMJ fractures will allow the application of the K-wire in a more accurate position and the reduction losses will be less in the follow-ups as a result of fixation with the appropriately placed K-wire. This retrospective article reports the results of 19 cases.

MATERIAL AND METHODS

Ethics committee approval for this study was obtained from the Kırşehir Ahi Evran University Faculty of Medicine Clinical Research Ethics Committee (date: 07.03.2023, decision no: 2023-05/31). Patients over nine years of age who operated for DRDMJ between 2018 and 2020 were included in the study. We defined the metaphyseal junction according to Lieber et al. (10) (Figure 1). We used that definition to select the study population. All patients had previously tried closed reduction under conscious sedation, and reduction parameters could not be achieved with the closed technique (>25° of angulation on the lateral radiograph, >10° of angulation on the posteroanterior radiograph, <25% apposition of the fracture on the lateral or posteroanterior radiograph)(13,14). All patients underwent surgery within two days. One experienced surgeon treated all patients. Our series evaluated patients' demographics, complications, fracture healing, and implant removal time. Preoperative radiographs of all patients were evaluated to review the measurement of angulations in the frontal and sagittal planes, translation ratio at the fracture site, and determine whether there is an accompanying ulna fracture (Figure 2). Fracture type is defined as oblique or transverse on preoperative radiographs. Direct radiographs of the patients taken immediately after surgery, at the second week, fourth week, sixth week, and third-month follow-up, were subsequently evaluated according to the defined criteria. On lateral radiographs, sagittal angulation was defined as the angle formed between the radial shaft and a line drawn to the physis. On Anterior-posterior radiographs, coronal angulation is the angle formed between the radial shaft and a line drawn to the physis (15). The number of pins and configurations were also evaluated on both AP and lateral radiographs. All implants were removed after callus formation was seen in at least three cortices. K-wires in the distal radius were removed in 4-6 weeks after adequate union was observed. After the removal of the K-wire, the patients' short arm splint treatment was terminated. The free and full-arm motion was allowed after that. In cases where the elastic nail was applied for ulna fractures, the ulna nails were removed after the third month of controls. The last control of the patients was done at 3 months and wrist range of motion and forearm rotation were evaluated and compared with the healthy side. Elastic stable intramedullary nailing (ESIN) was removed if the union was observed in the ulna fracture at the last control of the patients in the 3rd month. Angular changes during fracture healing were measured on direct radiographs at the last follow-up (Figure 3).

Operative Technique

All operations were performed under general anesthesia. The patient was placed in the supine position with the upper limb on a radiolucent side table. The fracture site was identified under C-arm fluoroscopy, and a 1 cm skin incision was applied above the fracture site. After the facia incision, dissection was continued down to the bone. A curved Kelly clamp was inserted into the fracture site and used as a lever for reduction. After the reduction was achieved under C-arm fluoroscopy, the pinning part was started. Two lateral pins were applied in divergent configurations for the oblique fracture pattern. For the transverse fracture pattern, two lateral pins were applied on both sides of the fracture in a cross configuration (Figure 4). In order to prevent reduction losses during pinning, the curved Kelly clamp used for reduction was repositioned to support the fracture line medially. In order to prevent reduction losses due to pressure from the radial side during pinning, the clamp was opened and supported from both sides of the fracture line from the ulnar side. This way, the reduction was protected against the pressure applied from the radial side. After the radius fixation was completed, the stability of the distal ulna fracture was checked under C-arm fluoroscopy with wrist movements. Titanium elastic nail was applied for ulna fracture where instability and fixation were needed. After the operation, the patient's hands were immobilized with a below-elbow cast (BEC) application for four weeks. After plaster removal, all wrist, forearm, and elbow movements were encouraged.

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences version 24.0 software in the statistical analysis of the study for Windows (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp. USA). Continuous variable statistics were summarized as mean and standard deviation, mean (Min-Max). A number of observations of categorical variables were given as n.

RESULTS

Between 2018 and 2020, 1040 pediatric distal radius fractures were admitted to our clinic. When the fracture distributions of these patients were examined, DRDMJ fractures were observed in 110 patients, and closed reduction and cast treatment were not successful in 27 patients at the first admission. Plate osteosynthesis was applied to 5 patients due to comminuted metaphyseal fractures. External fixation was applied to 1 patient due to an open fracture. In 3 patients, there was an additional injury in the ipsilateral upper extremity. We reviewed the clinical and radiological results of 19 patients who underwent pin fixation with the mini-open technique for distal radius diaphyseal metaphyseal junctional fracture. There were 13 boys and 6 girls with an average age of 10.1 (8-12 years). Demographic data, including age, sex, fractured side, and associated ulna fracture, is given in (Table 1).

Eleven patients had isolated radius fractures; eight patients had associated ulna fractures. Titanium elastic nail was applied to 5 of 8 ulna fractures. Additional fixation was not applied in the remaining three patients since the fracture movement was not observed in wrist movements under C-arm fluoroscopic controls—frac-

Table1. Patient demographics.

Patient demographics (n=19)	
Age (years; mean, range)	10.1 (range, 8-12)
Sex (Female/male)	6/13
Associated ulnar fracture	8
Fracture line (Transvers/oblique)	13/6
Side (left/right)	8/11

n: Number

Table 2. Immediate postoperative radiographic evaluation data

	Immediate postoperative
Coronal plane translation	<5%
Coronal plane angulation	<5
Sagittal plane translation	<10%
Sagittal plane angulation	< 5

%: Percent

Table 3. Radiographic changes at the last follow-up

	Radiographic changes
Coronal plane translation	0%
Coronal plane angulation	3 (range, 0-5)
Sagittal plane translation	0%
Sagittal plane angulation	4 (range, 0-6)

%: Percent

ture line-oriented transverse at 13 patients and short oblique at six patients. A lateral entry point divergent pin configuration was applied for short oblique fractures. Two lateral-sided entry point crossed pin fixations were applied for transverse fractures. Twelve patients had 100% dorsal translation on the sagittal plane, and seven patients had 0-50% dorsal translation with an average of 20 (range, 15 -30) dorsal angulation on preoperative radiographs.

Preoperative AP views detected an average angulation of 13 (8-25) degrees. Translation of less than 5% was observed in coronal and less than 10% in sagittal planes in the radiographs taken immediately after the surgery. The radiographs obtained immediately after the surgery detected an angulation of fewer than 5 degrees in the coronal plane (Table 2).

An angulation of fewer than 5 degrees was detected in evaluating postoperative lateral views. No change was observed in translation due to the examination of the lateral radiographs obtained in the last clinical follow-ups. At the last follow-up, the lateral radiograph evaluation observed an average of 4 (range, 0-6) degrees of change. While no change was observed in translation, an average of 3 changes was detected in the AP radiographs obtained in the last follow-up of the patients (Table 3).

No reduction loss was observed in the ulna. Superficial pin site infection was detected in 2 cases. It was treated with antibiotic therapy and pin removal after the union. No tendon irritation or neurovascular injury was observed. Fracture healing was observed before six weeks in all cases. Wrist flexion and extension were fully observed in all patients. No rotational restriction was observed in the forearm.

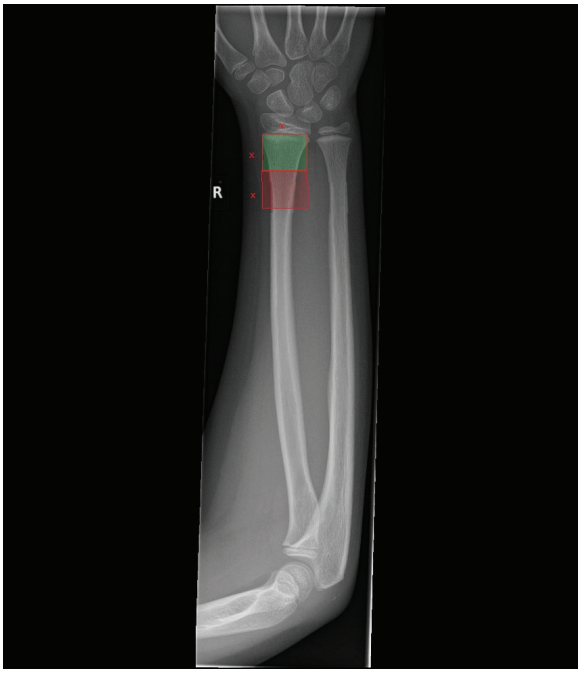

Figure 1. The metaphyseal portion of the distal radius is shown with a green square. The height of the square is equal to the width of the physis. The metaphyseal junction is shown with a red square described by Lieber et al. (10).

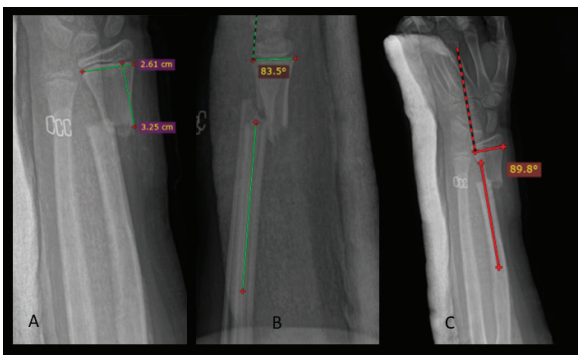

Figure 2. A. confirmation that the fracture is located in the Diaphyseal Metaphyseal Junction. B. The angle is 83° formed between the radial shaft and the line drawn to the epiphyseal plate, and 100% apposition was observed after closed reduction in the lateral radiographs. C. The angle formed between the radial shaft and the line drawn to the epiphyseal plate is 89° and 60% apposition after closed reduction in the postero-anterior radiographs.

DISCUSSION AND CONCLUSION

There is no consensus on the surgical treatment of nonreducible pediatric DRDMJ fractures. Although pin fixation gives good results in the treatment and follow-up of metaphyseal fractures, it is insufficient in fractures where the fracture line is moved proximally(5,10). Pin fixation is a reliable and adequate method for displaced distal radius fractures (15,16). Reduction losses can be seen in clinical follow-ups after pin fixation of DRDMJ fractures due to proximal placement of the fracture line (5,10). Our study used the mini-open technique to ensure adequate fixation in the K-wire application. At the same time, no nonunion or delayed union was observed in any patient due to pinning applied with the mini-open technique. No reduction loss was observed that would affect the postoperative clinical results. Due to the narrow width of the bone in the fracture region, there are inadequacies in k-wire appli-

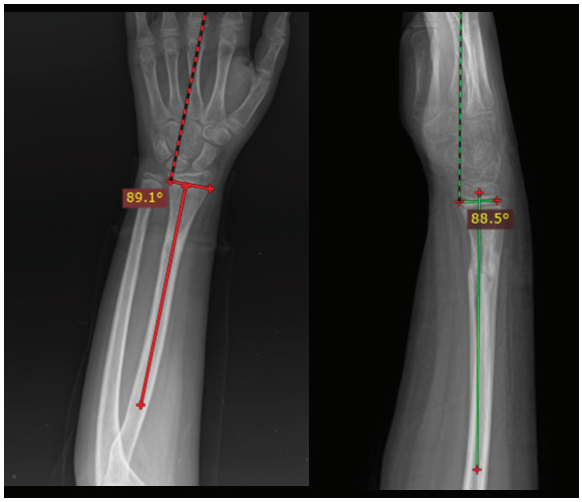

Figure 3. Measurement of angular change on final follow-up radiographs.

Figure 4. Fixation with 2 radial cross pins for radius and titanium elastic nail for ulna fractures

cations (11). As a result of application difficulties, the angulation and translation of the fracture line cannot be fully corrected (16,17). Our study's mini-open technique reduced postoperative fracture with minimal translation and angulation.

It was seen on the immediate postoperative radiographs that angulation and translation of the fracture line were corrected satisfactorily by the mini-open technique.

Reduction losses were observed during follow-up due to placing the k-wire in an inappropriate position (18,19). In our follow-ups, no translation loss was observed due to the 4-week BEC treatment with k-wire, and a change of translation of fewer than 4 degrees was observed on both AP and lateral radiographs. Intramedullary fixation methods are recommended for metaphyseal-diaphyseal distal radius fractures due to the difficulties of applying the K-wire (20). Due to the short distal fracture segment, reduction losses are observed due to the load on the medial cortex in titanium elastic nail applications (12,21). The posteromedial entry point is defined to overcome the short segment problem by applying radial titanium elastic nails (8). The short segment problem and sagittal angulation may arise because of the loading on the volar cortex. In order to eliminate the short segment problem, two short elastic nails were applied (22). Even if excellent and stable fixation results have been published after the short, double elastic nail application, there is a possibility of iatrogenic fracture during the application (22). In our series, no iatrogenic fracture was detected. In another series, pre-bending titanium elastic nails were applied for DRDMJ fractures, and it was observed that the translation could not be corrected 100% after the application (21). Complications such as injury of the growth plate, tendon irritation, and injury of the sensorial branch of the radial nerve can be seen associated with applications of titanium elastic nails (23-25). Our study observed no neurovascular injury or tendon irritation in patients. Pin site superficial infection was detected in only two patients, and they recovered after K-wire removal. There was a need for secondary surgical intervention under general anesthesia to remove titanium elastic nails. In our series, no secondary surgical intervention was performed except for patients who underwent titanium elastic nails for ulna fractures. All K-wires were removed under outpatient conditions. The trans epiphyseal intramedullary Kirschner-wire fixation to increase stability has been described (10,26). Although complete correction of fracture angulation was not observed after the application, good clinical results were obtained.

Damage to the growth plate can occur due to the k-wire applied from the epiphysis to the metaphasis. No complications associated with growth plate injury were observed in our case series. Plate osteosynthesis is recommended for older children because it provides more stable and satisfactory reduction; however, some

complications could be seen, such as more extensive skin scars, slower healing, a high rate of refractures, and physical plate injury (27,28). K-wire applications are a more minimally invasive method for DRDMJ fractures. Wide incisions are not needed during K-wire applications. There is no need for anesthesia or incision during K-wire removal. Restriction of wrist movements may be observed after malunion of forearm fractures. Restriction of supination and pronation movements are seen chiefly. A significant limitation of the movements could be seen if angular malalignment is over 20 degrees (29, 30). No limitation of movement was observed in the last follow-up in our series. Motion is not restricted because the angulation remained below 10 degrees in AP and lateral radiography in the last follow-ups.

Limitations

The most important limitation of our study is the absence of a control group and the retrospective nature of the research. The main reason for not having a control group is that fractures located in the diaphyseal metaphyseal junction constitute a very small part of the entire distal radius population in daily clinical practice. Again, because of the good response to conservative treatment in fractures of diaphyseal metaphyseal junction fractures, surgical treatment is applied to very few of them.

The mini-open technique provides an advantage in placing the k-wire in a more suitable position and preserves the reduction during the pin fixation. Our data showed that the pin fixation with the mini-open technique was a suitable method to treat irreducible DRDMJ fractures with a satisfactory alignment and achieve stable fixation.

Conflict-of-Interest And Financial Disclosure

The authors declare that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

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