Original Article

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Angle Measurement in Critical Forearm Radiography in Pediatric Patients with Forearm Fractures Undergoing Conservative Treatment: Interobserver and Intraobserver Correlation Study

Konservatif Tedavi Uygulanan Önkol Kırıklı Pediyatrik Hastalarda Kritik Önkol Radyografisinde Açı Ölçümü: Gözlemciler Arası ve Gözlemciler İçi Korelasyon Çalışması

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ABSTRACT

Objective: *Forearm fractures account for approximately 40% of child fractures. The elbow is treated conservatively with a 90° flexion cast. The aim of this study was to determine whether patients with forearm fractures who underwent open or closed reduction and fixation after loss of reduction in plaster follow-up is to make interobserver, and intraobserver comparisons of the radiological measurements of fracture angulations and to investigate the effect of these measurements on surgical decision.*

Method: *In the medical records of our clinic between 2013 and 2014, 36 forearm fractures were detected in 35 patients aged 10-15 years who had undergone open reduction, and fixation because of loss of reduction. Patients who had a 1/3 mid-diaphyseal fracture of the radia and ulna and whose radiological controls on days 5, 10, 15 and 31 revealed displacement fractures were retrospectively included in the study.*

Results: *Twenty –two patients who underwent open reduction and fixation were evaluated in terms of concordance between preoperative radiological measurements. ICC (Intraclass correlation coefficient) coefficients were 0.84 (0.69-0.92) for AP radius, 0.95 (0.91-0.97) for AP ulna, and 0.89 (0.80-0.95) for lateral radius, and 0.79 (0.60-0.90) for lateral ulna. According to this, there was a high level of concordance between these four parameters.*

Conclusion: *The decision for surgical treatment of the patients made by different surgeons who are responsible for the treatment is based on the evaluation of the patients as a whole, but not based on measurement of radiological parameters. Although it is considered that the measurement technique may change by experience, there is no statistical difference between the measurements performed by the same person at different times.*

Keywords: *forearm fractures, child, radiological, interobserver*

ÖZ

Amaç: *Önkol kırıkları çocuk kırıklarının yaklaşık %40'ını oluşturmaktadır. Genel olarak dirsek 90° fleksiyonda alçılama yapılarak konservatif tedavi edilir. Bu çalışmanın amacı, alçı ile takiplerinde redüksiyon kaybı sonrası açık veya kapalı redüksiyon ve tespit uygulanan önkol kırıklı çocuk hastaların, radyolojik kırık açılanması ölçümlerini gözlemciler arası ve gözlemciler içi olarak karşılaştırmak ve bunun cerrahi karara etkisini araştırmaktı.*

Yöntem: *Kliniğimizin 2013-2014 yılları arasındaki tıbbi kayıtlarında önkol kırıklarına redüksiyon kaybı nedeni ile açık redüksiyon ve tespit yapılan 10-15 yaş arası 35 hastanın 36 ön kol kırığı saptandı. Radius ve ulnanın 1/3 orta diafiz kırığı olan ve 5, 10, 15 ve 31'inci günlerdeki radyolojik kontrolleri sırasında kayma saptanarak operasyon kararı alınan hastalar retrospektif olarak çalışmaya dahil edildi.*

Bulgular: *Açık redüksiyon ve tespit yapılan 22 hasta ameliyat öncesi grafilerdeki radyolojik ölçüm sonuçları arasındaki uyumları değerlendirildiğinde; ICC (Intraclass correlation coefficient) katsayıları: AP radius için 0.84 (0.69-0.92), AP ulna için 0.95 (0.91-0.97) lateral radius için 0.89 (0.80-0.95), lateral ulna için 0.79 (0.60-0.90) hesaplandı. Buna göre değerlendirmeciler arasında 4 parametre için de yüksek uyum olduğu görüldü.*

Sonuç: *Tedavinin sorumluğunu yüklenen farklı cerrahlar tarafından hastaların cerrahi tedavisine karar verilmesi, hastaların sadece grafi üzerinden değerlendirilmeyip bütün olarak değerlendirilmesinden kaynaklanmaktadır. Ölçüm tekniğinin tecrübeyle değişebileceği düşünülmekle birlikte, aynı kişi tarafından farklı zamanlardaki ölçümler istatiksel olarak fark yoktur.*

Anahtar kelimeler: *çocuk, önkol kırığı, radyoloji, gözlemciler içi*

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INTRODUCTION

Forearm fractures constitute approximately 40% of child fractures. Generally, elbow is fixated conservatively by plastering at 90° flexion [1,2]. The successful treatment is possible by maintaining the reduction in the correct position and ending the plastering at the appropriate time [3,4]. Failure, the risk of opening, depends on the movement in the plaster [5]. There was no relationship between the type, and location of the fracture and treatment failure. The general approach of pediatric orthopedics to pediatric forearm fractures is the application of surgical treatment in patients with a fracture displacement angle of 10° -15° or more than 50% [6].

The aim of this study was to compare the measurements of anterior or closed reduction and fixation of the forearm fractures in children based on interobserver measurements of traumatology residents and radiology specialists with different experiences between the observers and the effects of these measurements on the surgical decision.

MATERIAL and METHOD

Ethics committee decision was taken. Our study was planned retrospectively. In the medical records of our clinic between 2013 and 2014, 36 forearm fractures of 35 patients aged 10-15 years, who had undergone reduction and fixation due to fracture displacement were detected (Table 1). Patients who had 1/3 middiaphyseal fracture of the radius and ulna with a shift detected during their radiological controls on days 5, 10, and 31 were included in the study retrospectively. For 5 patients whose reduction was not considered adequate, immediately decision of surgical treatment was made Two patients with open fractures, 1 patient with fractures in both arms, 3 patients who could not be followed up properly, 1 patient with multiple organ injuries and 1 patient with metabolic bone disease were excluded from the study.

Table 1. Age, gender and location of fractures of the patients.

Variables	Mean±SD / Range
Age (years)	12.3±1.7 (10-15)
Gender	1female (4.5%) / 21 males (95.5%)
Location of the fracture	Middle right 16 (72.7%)
	Middle left 6 (27.3%)

Fractures were analyzed, and evaluated in AP and lateral radiograms. Angulations between 60 and 90 degrees in cortex are considered as transverse fractures, and less than 60 degrees were considered an oblique fracture. There were transverse fractures in 18 and oblique fractures in 4 patients. Spiral oblique and fragmented complex fractures were absent in our study.

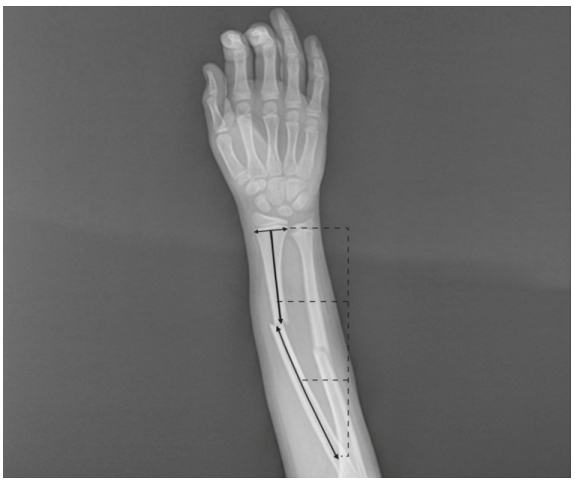
At their first admissions, closed reduction and circular cast were applied to all patients and reduction was evaluated with control radiographs. Long-arm circular cast was applied in all patients with elbow at 90° flexion, forearm at neutral position and wrist at 10° extension in closed reduction. No patient's full cast was replaced with splint to relieve swelling.

Follow-ups were made on the 5th, 10th, and 15th days after reduction. On the 30th day, a short arm circular cast was applied. After reduction, AP and lateral radiograms showed that the reduction was sufficient if the angles were less than 10° and the translation was less than 50% in both radius and ulna.

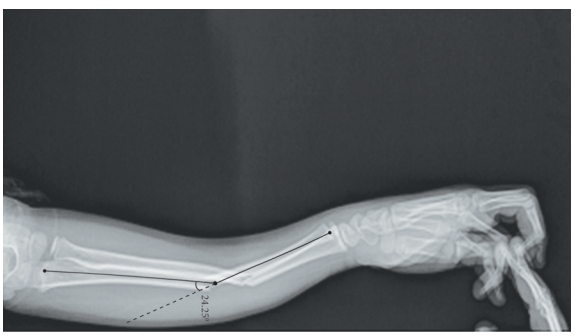
During the follow-up of the cast, in two patients the cast became loosei So it was reconstructed on the 5th day, and a plaster replacement was performed without loss of reduction These two patients had union in the control radiograms obtained 20 days later.

When the reduction loss was observed in the patients, surgical treatment was applied within 15 (5-31) days. Surgical treatment was performed in three patients due to a shift of 12° (10°-14°) on day 5, 15° (11°-20°) on day 10, and 17° (16°-18°) on day 15 of 2 patients. On the 10th day, two patients who had translation were found to have an angle of 15°.

Evaluations were made by a specialist in orthopedics and traumatology with 10 year experience, and a resident in the clinic of orthopedics and traumatology by examining the latest digital radiograms before surgery. On the PACS (Picture archiving and communication system), the proximal of the radius is the middle of the bicipital tuberosity, the distal of the radius; was defined as the middle of the distal radius fiz line. The distance of these two points was divided into 3 identical parts and evaluated as middle third



Graph 1. Evaluation of fracture site on AP forearm x-ray.



Graph 2. Measurement of fracture angulation on lateral forearm x-ray.

shaft fractures and included in our study. Ulna fractures were also identified by associating them with the radius (Graph 1).

The opening of both bones (radius and ulna) was defined as the angle between the lines drawn from the above-mentioned starting points to the midpoint of the fracture line in the radioulnar and dorsoventral plan (Graph 2). Inter-, and intra-observer measurements were made on the PACS system.

Angles were measured separately by the radiology, orthopedics and traumatology specialists in the same patients on the last digital radiograms before the operation and on the PACS system 6 weeks later.

For data analysis, 16.0 computerized version of the statistical program "SPSS (Statistical Package for Social Science) for Windows" was used. Descriptive methods were used to analyze the demographic and clinical features of the subjects at the beginning of the study. The agreement between the observers' evaluations was evaluated with "Intraclass Correlation Coefficient (ICC)"within the 95% confidence interval.

RESULTS

The BMIs of 3 female and 19 male patients were between 15-20 kg/m^2 (Table 1). There was no patient with excess swelling accompanying fractures. The reasons for the fracture in terms of fracture mechanism and energy included falling from a bicycle, or a ladder and falling while running.

When the compliance between the results of radiological measurements based on preoperative radiograms performed by radiologists, 10-year orthopedist, first year orthopedist and orthopedic surgery resident was evaluated. ICC (Intraclass correlation coefficient) coefficients: 0.84 (0.69-0.92) for AP radius, 0.95 (0.91-0.97) for AP ulna, 0.89 (0.80-0.95) for lateral radius, 0.79 (0.60-0.90) for lateral ulna were estimated. Accordingly, it was observed that there was a high agreement among the evaluators for all 4 parameters (Table 2).

In the evaluation of preoperative radiograms of the patients according to the radiologist, there were 16 patients with at least one angle above 10° and 11 patients with angle above 15°. According to the evaluation of the radiologist 6 weeks later, there were

Table 2. Conformity between observers in angle measurements.

	Experienced orthopedist Mean±SD (min-max)	Experienced radiologist Mean±SD (min-max)	One-year orthopedist Mean±SD (min-max)	First-year resident in orthopedics Mean±SD (min-max)	ICC** coefficients (within 95 confidence interval)
AP* radius°	10.1±8.2 (0-25)	7.5± 7.9 (0-30)	5±7.8 (0-30)	9.5±8.2 (0-30)	0.84 (0.69-0.92)
AP* ulna°	6.7±7.6 (0-27)	6.5±6.9 (0-23)	6.1±7.3 (0-25)	6.6±7.7 (0-27)	0.95 (0.91-0.97)
Lateral radius°	14.1±11 (0-35)	13.8±9.6 (0-33)	13.8±9.7 (0-37)	13.9±10.1 (0-35)	0.89 (0.80-0.95)
Lateral ulna°	6±8.3 (0-35)	6.4±7.5 (0-26)	3.6±4.7 (0-15)	6.1±7.3 (0-25)	0.79 (0.60-0.90)

Table 3. Measurements of the observer (orthopedist) and the intra-observer consistency in the decision for surgery.

	1. Measurement	2. Measurement	ICC** coefficient (95% confidence interval)
AP* radius°	10.1±8.2 (0-25)	8.4±7.6 (0-25)	0.89 (0.73-0.95)
AP* ulna°	6.7±7.6 (0-27)	7.3±7.7 (0-25)	0.97 (0.93-0.98)
Lateral radius°	14.1±11 (0-35)	13.9±12.4 (0-36)	0.95 (0.89-0.98)
Lateral ulna°	6±8.3 (0-35)	6.4 8.2 (0-36)	0.97 (0.92-0.98)

** AP: anterio-posterior, **ICC: Intraclass correlation coefficient*

17 patients with an angle of 10° and 11 patients with an angle of 15°.

According to the evaluation of preoperative AP and lateral radiograms of 16 patients after 6 weeks by the senior orthopedic specialist, operation decision was taken for 16 patients. According to the evaluation of the orthopedist; operation decision was taken for 16 patients (Table 3).

DISCUSSION

In this study, it was investigated whether the measurement of fracture angles on plain AP and lateral X-ray in forearm fractures, which were previously scheduled for surgery, was performed properly. This measurement is important because the fracture is operated in consideration of the measured angles.

The characteristics of displacement effects the surgical decision Angle of displacement is just one of the factors that is effective in decision-making process. Besides the angle, factors such as translation, rotation, shortening and elongation, number of parts and shape of the fracture line should be also evaluated.

There is no inter-observer and intra-observer study in the literature on this subject. In a study of 38 diseases related to medial epicondyle fractures in children with comparable demographic characteristics, though at a low level, inter-, and intra-observer differences were noted [7].

In a similar study, in the evaluation of cast index (CI), which is suggested as a factor in reduction loss, inter-observer and intra-observer differences were observed. Ten radiograms were randomly selected by two authors to measure CI, and for each intra-observer variability, each author re-evaluated the same radiograms for CI after a 6-week interval. When they used Pearson correlation, they found that CI showed good correlation between 0.61 and 0.80 and excellent correlation after 0.81 [8].

Many treatment algorithms have been proposed for forearm fractures. While many authors accept the opening up to 10° for forearm fractures as a limit for conservative treatment [9,10], some accept the opening up to 20° as the surgical limit [11,12]. There is consensus that rotation incompatibility should not be accepted for surgical treatment [9]. In patients with narrowed interosseous distance, significant rotational loss [13] or angular deformities [9,14] can be seen in the forearm. In a cadaver study, it was revealed that the 20° opening in the forearm fractures of the forearm caused a significant loss in the pronation-supination of the forearm [9]. The authors suggested that the decision of surgical treatment in 22 patients was based on 10° fracture opening by different surgeons who were responsible for the treatment.

When the reduction loss is seen, surgical decision is made within 15 (5-31) days in accordance with the literature [15].

The limitations of the study were its retrospective design, evaluation of angular deformity in only 2 plans, and the failure to measure the natural inclination of the radial bone on the intact side. The maximum angle shown in the accepted radioulnar and dorsoventral plan was excluded. However, real size can be approximated with the geometry used [10]. Translation was considered acceptable based on previous studies, and rotation was not evaluated [16,17].

In conclusion, it was determined that measurement of the fracture angles observed on plain AP and lateral radiograms was performed in pediatric forearm fractures. Although the compatibility between the mean of the interpersonal fracture angles is good,

the experienced orthopedic surgeon made the surgical decision in 16 patients.

It was thought that the decision to operate was made according to the 10° tilt rather than 15° tilt which is accepted as the general principle. Again, during the follow-ups, it was observed that a surgical approach was made due to the high possibility of shifting to the acceptable reduction limits. Another reason for this may be the increase of self-confidence of surgeons with the advancement of surgical techniques. The specialist in orthopedics and traumatology may have been affected by the anxiety of the parents and decided on surgery.

The decision of surgical treatment of patients by different surgeons who are responsible for the treatment is due to the fact that the patients are not only radiologically evaluated but rather as a whole. Although the measurement technique is thought to change and improve with experience, measurements at different times by the same person are not statistically significantly different.

Ethics Committee Approval: Ethics Committee Approval Ministry of Health Kartal Dr. Lütfi Kırdar Training and Research Hospital Ethical Committee. Decision no: 2017/514/113/5.
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