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Original Article *Özgün Araştırma*

LOW LOSS OF REDUCTION RATES IN PEDIATRIC DISTAL RADIUS FRACTURES WITH CONSERVATIVE TREATMENT

Konservatif Tedavi ile Pediatrik Radius Distal Uç Kırıklarında Düşük Redüksiyon Kaybı

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ABSTRACT

Objective: We aimed to assess the outcomes of conservative treatment (closed reduction and cast immobilization) in the management of pediatric distal radius fractures.

Material and Methods: A total of 138 pediatric patients aged 3 to 16 years who sustained a distal radius fracture and underwent closed reduction and cast immobilization in emergency department were included in this retrospective study. The mean age of patients at the time of close reduction was 11.47 ± 3.60 (range, 3-16) years. Age, gender, classification of fracture, side, and mechanism of injury were documented. In addition, displacement and angulation data were recorded from PACS integrated hospital information management system. We evaluated demographic characteristics of patients and radiographic loss of reduction.

Results: A total of 50 patients were female, whereas 88 patients were male. Thirty-one patients (22.5%) had loss of reduction. Colles fractures had significantly higher varus-valgus deformity (p<0.001; <0.001; <0.001 and <0.001, respectively) and AP angulation (p=0.013; <0.001; <0.001 and <0.001, respectively) than SH type-2 and Torus/Buckle fractures at the first, second, 4th, and 6th weeks follow-up views. There is no significant difference in terms of varus-valgus deformity (p=0.160; 0.283; 0.263 and 0.744, respectively) and AP angulation (p=0.996, 0.943, 0.816 and 0.237, respectively) at each follow-up period between female and male patients. We did not find any correlation between age and varus-valgus and AP angulation at the follow-up views.

Conclusion: We demonstrated that closed reduction and cast immobilization is an effective treatment method for colles, SH type II, and Torus/Buckle distal radius fractures.

***Keywords**: Pediatric distal radius fractures, Colles fractures, Torus/Buckle fractures, SH type II fractures.*

ÖZ

Amaç: Pediatrik distal radius kırıklarında konservatif tedavinin (kapalı redüksiyon ve alçı immobilizasyonu) sonuçlarını değerlendirmeyi amaçladık.

Gereç ve Yöntemler: Bu retrospektif çalışmaya distal radius kırığı olan ve acil servis şartlarında kapalı redüksiyon ve alçı immobilizasyonu uygulanan, yaşları 3 ila 16 arasında olan toplam 138 pediatrik hasta dahil edildi. Kapalı redüksiyon sırasında hastaların ortalama yaşı 11.47 ± 3.60 (aralık: 3-16) yıl idi. Hastaların yaş, cinsiyet, kırık sınıflandırması, taraf ve yaralanma mekanizmaları tarandı. Ayrıca, radius distal uç kırığı olan pediatrik hastaların 1., 2., 4. ve 6. hafta takiplerindeki deplasman ve açılanma verileri PACS entegre hastane bilgi yönetim sisteminden kaydedildi. Hastaların demografik özellikleri ve radyografik redüksiyon kaybı değerlendirildi.

Bulgular: Elli hasta kadın, seksen sekiz hasta erkekti. Otuz bir hastada (%22.5) redüksiyon kaybı vardı. 1., 2., 4. ve 6. hafta takip görüntülemelerinde Colles kırıklarının; SH Tip-2 ve Torus/Buckle kırıklarına göre AP (Sırasıyla p<0.001; <0.001; <0.001 ve <0.001) ve lateral plandaki (Sırasıyla p=0.013; <0.001; <0.001 ve <0.001) açılanmaları anlamlı olarak daha yüksekti. Tüm takip döneminde kadın ve erkek hastalar arasındaki varus-valgus deformitesi (Sırasıyla p=0.160; 0.283; 0.263 ve 0.744) ve AP angulasyonu (Sırasıyla p=0.996; 0.943; 0.816 ve 0.237) açısından anlamlı bir fark yoktu. Takip görüntülemelerinde yaş ile varus-valgus ve AP angulasyonu arasında bir korelasyon yoktu.

Sonuç: Kapalı redüksiyon ve alçı immobilizasyonunun, Colles, SH Tip II ve Torus/Buckle distal radius kırıkları için etkili bir tedavi yöntemi olduğunu gösterdik.

***Anahtar Kelimeler**: Pediatrik radius distal uç kırıkları, Colles kırıkları, Torus/Buckle kırıkları, SH tip II kırıkları.*

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INTRODUCTION

Fractures involving the distal radius are commonly seen in children (1). Treatment of these injuries may vary from simple casting and radiographic follow-up to urgent reduction and surgical fixation. Generally, these fractures can be successfully managed with closed reduction and short arm casting. However, surgical fixation may also be required. Many studies have investigated optimal treatment methods concerning these fracture patterns (2-4). Nonetheless, the management of these injuries tends to differ quite significantly among clinicians. Recently published data question long-held principles of non-operative management for distal radius fractures in children (5, 6). Higher displacement degrees and angulations are more tolerable in pediatric patients due to the higher ability of remodeling in younger patients and the proximity of the fracture line to distal radial physis (7). The management of these fractures depends on the age of patients, degree of displacement, and type of fracture (8). However, treatment of these injuries differs significantly among clinicians. Closed reduction and cast immobilization has high success rate in pediatric distal radius fractures is our hypothesis.

We evaluated our outcomes of closed reduction and cast immobilization in the pediatric distal radius fractures. We performed immediate closed reduction and cast immobilization for pediatric patients with distal radius fractures. We aimed to assess the outcomes of conservative treatment (closed reduction and cast immobilization) in the management of pediatric distal radius fractures.

MATERIALS AND METHODS

This study was approved by the local ethics committee (*Kırıkkale University Non-Interventional Research Ethics Committee, 10.06.2020-2020.06.07*). Two hundred ten pediatric radial fractures were admitted to our clinic between October 2015 and March 2020. A total of 138 pediatric patients aged 3 to 16 years who sustained a Colles fracture, distal radius Salter Harris type II fracture (SH type II), and distal radius Torus/Buckle fracture and underwent closed reduction and cast immobilization were included in this retrospective study (Figure 1, 2 and 3). Patients with open fractures, pathological fractures, fractures requiring acute surgical intervention, and inadequate or absent of radiological data were excluded.

Patients' data were obtained from hospital information management system. Age, gender, classification of fracture, side, and mechanism of injury were documented. In addition, displacement and angulation data were recorded from PACS integrated hospital information management system. We evaluated demographic characteristics of patients and radiographic loss of reduction. Loss of reduction was defined as a change of more than 10° of angulation on anteroposterior (AP) or lateral views of follow-up X-rays (9). All radiographic measurements were performed on the PACS system by the same expert.

Statistical Analysis

Statistical Package for Social Sciences (SPSS) version 23.0 (IBM Corp., Armonk, NY, USA) for Windows was used for the statistical analysis of the research data. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Simirnov/Shapiro-Wilk's test) to determine whether they were normally distributed. Descriptive statistics related to categorical variables were shown as numbers and percentages, and those associated with numerical variables were presented as mean, standard deviation, median, minimum, and maximum values. As varus-valgus and anteroposterior angulation

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degrees were not normally distributed, the Kruskal-Wallis tests were conducted to compare these parameters and the ordinal variables among fracture types. The Mann-Whitney U test was used to compare the mean deformity angles at each follow-up period by gender. The pearson Chi-square test was used to compare loss of reduction by fracture type, gender, and mechansim of injury. A significance level of 0.05 was set (p<0.05 if there was a significant difference; p>0.05 if no significant difference was stated).

RESULTS

The mean age of patients at the time of close reduction was 11.47±3.60 (range, 3-16) years. A total of 50 patients were female, whereas 88 patients were male. Overall, 132 patients (95.7%) presented with fall from a standing height as the mechanism of injury. Thirty-one patients (22.5%) had loss of reduction. Details of patients' characterictics are summarized in Table 1.

The mean varus-valgus angulation was 1.71±3.27 at the first week, 2.17±3.96 at the second week, 1.95±3.79 at the fourth week, and 6.65±5.97 at the sixth week. In addition, the mean AP angulation was 6.54±7.87, 6.89±5.17, 7.05±5.56, and 1.61±3.37, respectively. There was no significant difference between female and male patients in terms of varus-valgus deformity at each follow-up period (p=0.160, 0.283, 0.263, and 0.744, respectively). The difference of AP angulation between female and male patients was also not significant at each follow-up period (p=0.996; 0.943; 0.816 and 0.237, respectively). Details of deformity by gender are given in Table 2.

Colles fractures had significantly higher varus-valgus deformity than SH type-2 and Torus/Buckle fractures at the first, second, fourth, and sixth weeks follow-up views (p<0.001; <0.001; <0.001 and <0.001, respectively). Colles fractures had also significantly higher AP angulation than SH type-2 and Torus/Buckle fractures at each follow-up views (p=0.013; <0.001; <0.001 and <0.001, respectively).

Table 1: Demographic characteristics of patients

	n (%)*
Sex	
Male	88 (63.8)
Female	50 (36.2)
Age, n=138	
Mean ±SD	11.47 ± 3.60
Median (Min-Max)	13 (3-16)
Classification	
Colles	33 (23.9)
SH-Type 2	27 (19.6)
Torus/Buckle	78 (56.5)
Side, n=65 n (%)	
Right	60 (43.5)
Left	78 (56.5)
Loss of reduction	
No	107 (77.5)
Yes	31 (22.5)
Etiology	
Fall from standing height	132 (95.7)
Motor vehicle accident	4 (2.9)
Fall from bicycle	1 (0.7)
Crush injury	1 (0.7)
Total	138 (100)

(*Column Percentage, Salter Harris; SH, Closed reduction; CR)

There was no significant difference between SH type-2 and Torus/Buckle fractures in terms of varus-valgus deformity (p=0.457; 0,212; 0.280; 0.106, respectively) and AP angulation (p=0.432; 0.482; 0.281; 0.113, respectively). Details of mean angulation degrees by fracture type are given in Table 3. Colles fractures had higher loss of reduction rates than SH type-2 and Torus/Buckle

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fractures at the sixth week follow-up views. Details of loss of reduction are summarized in Table 4.

We did not find any correlation between age and varus-valgus angulation at the follow-up views (p=0.756; 0.898; 0.701 and 0.261, respectively). There was also no correlation between age and AP angulation at each follow-up views (p=0.108; 0.060; 0.210 and 0.656, respectively).

Table 2: The mean deformity angles at each follow-up period by gender

	Mean ±SD	Median (Min-Max)	Mean ±SD	Median (Min-Max)	*p*
1st week, n=138					
Varus-valgus	2.01 ± 3.47	0 (0 – 13.8)	1.16 ± 2.86	0 (0 - 13.9)	0.160
Antero-posterior angulation	6.85 ± 9.29	5.83 (0 - 80)	5.99 ± 4.4	5.95 (0 – 16.9)	0.996
2nd week, n=138					
Varus-valgus	2.61 ± 4.48	0 (0 - 16.9)	1.41 ± 2.69	0 (0 - 12.3)	0.283
Antero-posterior angulation	6.94 ± 5.42	6.05 (0 - 23)	6.81 ± 4.76	6.3 (0 – 19.7)	0.943
4th week, n=138					
Varus-valgus	2.35 ± 4.35	0 (0 - 16)	1.25 ± 2.43	0 (0 - 9.8)	0.263
Antero-posterior angulation	7.21 ± 5.77	5.7 (0 – 26.6)	6.77 ± 5.22	5.85 (0 – 19.8)	0.816
6th week, n=138					
Varus-valgus	6.76 ± 5.99	5 (0 – 27.2)	6.45 ± 5.97	5 (0 - 25.8)	0.744
Antero-posterior angulation	1.84 ± 3.67	0 (0 – 15.6)	1.21 ± 2.74	0 (0 - 14)	0.237

[1]Mann-Whitney U Test

Table 4: Details of loss of reduction by fracture type, gender and mechanism of injury

Loss of Reduction			
	Yes n (%)*	No n (%)*	p value
Classification			
Colles	17 (51.5)	16 (48.5)	
SH-Type 2	4 (14.8)	23 (85.2)	<0,001
Torus/Buckle	10 (12.8)	68 (87.2)	
Gender			
Male	20(22,7)	68(77,3)	0,922
Female	11(22)	39(78)	
Mechanism of Injury			
Fall from standing height	30(22,7)	102(77,3)	
Motor vehicle accident	1(25)	3(75)	
Fall from bicycle	0(0)	1(100)	0,897
Crush injury	0(0)	1(100)	

[3]Pearson Chi-Square, *Row percentage

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Table 3: Details of deformity angles at each follow-up period by fracture types

	Colles n=33		SH-Type 2 n=27		Torus/Buc n=78
	Mean ±SD	Median (Min-Max)	Mean ±SD	Median (Min-Max)	Mean ±SD
1st week, n=138					
Varus-valgus	4,82±4,39	4,3(0-13,9)	0,49±1,66	0(0-8,2)	0,81±2,16
Antero-posterior angulation	8,32±5,46	7,6(0-25,1)	5,15±5,1	4(0-17,8)	6,27±9,32
2nd week, n=138					
Varus-valgus	5,52±4,76	4,8(0-15,2)	0,91±3,36	0(0-16,9)	1,2±2,89
Antero-posterior angulation	10,64±5,76	9,8(0-23)	5,46±5,37	4,4(0-20,5)	5,8±4,02
4th week, n=138					
Varus-valgus	5,57±5,31	4,5(0-16)	0,65±2,21	0(0-10,7)	0,88±2,21
Antero-posterior angulation	12,17±6,52	12,9(0-26,6)	5,02±4,81	4,6(0-16,3)	5,59±3,82
6th week, n=138					
Varus-valgus	11,82±7,42	11,3(0-27,2)	4,28±4,79	3(0-15,8)	5,28±4,17
Antero-posterior angulation	4,63±4,58	3,2(0-15,6)	0,45±1,99	0(0-10,2)	0,73±2,23

(Salter Harris; SH, [2]Kruskall Wallis Test)

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Figure 1: Pre- and post-reduction Colles fracture

Figure 2: Pre- and post-reduction Salter Harris type II fracture

Figure 3: Pre- and post-reduction Torus/Buckle fracture

DISCUSSION

Pediatric distal radius fractures have a substantial capacity to remodel due to proximity to the distal radial physis. Thus, conservative treatment of pediatric distal radius fractures is reported to have low rates of nonunion. However, loss of reduction remains one of the major complications of these fractures (10,11). The majority of the studies have assessed immobilization methods of distal radius fractures; however, there are few studies evaluating loss of reduction (12,13). Therefore, the treatment of pediatric distal radius fractures is still controversial. In this study, we demonstrated that closed reduction and cast immobilization is a viable option for initial management of pediatric distal radius fractures with an overall 23.9%loss of reduction.

The purpose of treatment is to provide adequate immobilization to maintain the reduction within acceptable degrees until the child's bone can heal and remodel (14). There are guidelines that have been set for acceptable postreduction angulation and displacement that can be corrected by remodeling (11). Crawford et al. demonstrated that a short arm fiberglass cast gently molded to correct only angulation is an adequate and effective method of treatment in overriding pediatric distal radial fractures. It is well documented that these fractures have a substantial capacity to remodel due to proximity to the physis (15-17). Dittmer et al. reported that the sugar-tong splint is a viable option for initial immobilization of pediatric forearm fractures with an overall 38%loss of reduction. Similarly, we found that closed reduction and cast immobilization had lower rates (23.9%) of loss of reduction. However, none of them underwent surgical treatment.

Nietosvaara et al. stated that 14%patients with SH type I and SH type II fractures healed with at least 10° angulation (18). In another study, Houshian et al.

reported that 63 patients (74%) who underwent an initial closed reduction had 10° (range, 2°-22°) median angulation at time of healing. Yet, 86%of fractures in this study had completely remodeled (19). However, Luscombe et al. reported that each of the 22 SH type II fractures was anatomically reduced without the use of K-wires, and no displacement occurred during the healing period (20). We also found that 8 patients (29.6%) with SH type II fracture had at least 10° angulation at the first week views, while 4 patients with SH type II fracture had loss of reduction at sixth week follow-up views and 4 fractures were remodeled. There was also no significant difference between SH type II fractures and Torus/Buckle fractures in terms of loss of reduction. This difference may result from the accuracy of the initial reduction and initial complete displacement of the radius.

The limitations of this study include its retrospective nature, which has an increased possibility that some episodes might have been missed. The sample size was small. However, we are confident that it is representative of the population of pediatric patients with distal radial fractures. A 3-point index could be used to assess the molding of our sugar-tong splints, which has been associated with possible loss of reduction (14). Finally, further studies with larger participants are needed to support qualification of conservative treatment in the management of pediatric distal radius fractures.

We demonstrated that closed reduction and cast immobilization is a viable option for initial management of pediatric distal radius fractures with an overall 23.9%loss of reduction. We highly recommend conservative treatment as initial treatment option for Colles, SH type II, and Torus/Buckle distal radius fractures.

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Availability of Data and Materials: The data and materials are available from the medical records department of the research hospital of our University. The datasets used during the current study are available from the corresponding author on reasonable request.

Ethics Committe Aproval: Kırıkkale University Non-Interventional Research Ethics Committee, 10.06.2020-2020.06.07.

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