Medical Science and Discovery
ISSN: 2148-6832

The feasibility of closed reduction by emergency physicians with the aid of remote consultation in pediatric closed diaphyseal forearm fractures

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ABSTRACT

Objective: Still, conservative management is usually preferred for treating pediatric closed diaphyseal forearm fractures in the Emergency Department (ED). The aim of this study was to evaluate the feasibility of closed reduction by Emergency Medicine (EM) physicians with the aid of remote consultation by Orthopedic Surgeons (OS) in pediatric closed diaphyseal forearm fractures.

Material and Methods: The study was conducted as a single-center, retrospective, observational study in 112 pediatric patients (age less than 14 years) with closed diaphyseal forearm fractures at a tertiary pediatric trauma center. Patients were either treated by EM physicians with remote consultation by OS or by OS. Door-to-reduction time was calculated as the time between the ED admission time and post-reduction plain radiograph recording time.

Results: The mean age of 112 patients was 8.6 ± 3.0 years. 37 (33.0%) patients were treated by EM physicians and were discharged from ED. Orthopedic surgeons treated 75 (67.0%) patients. The angulation averages of post-reduction of all fractures were not statistically significantly different between emergency medicine physicians and orthopedic surgeons ($p > 0.05$). The average door-to-reduction time (minutes) (ADRT) for all fractures among the 8 years and the younger group was statistically significantly lower in the EM physicians (16.6*1.7) than in the OS (32.2*6.4) groups (MWU=527.5*0.001). The ADRT for all fractures in the older than 8 years group was significantly lower in the EM physicians (16.7±2.1) than in the OS (35.5±4.6) groups (MWU=406.0, $p<0.001$).

Conclusion: EM physicians are able to perform an acceptable reduction with residual angulation degrees and fracture alignment of pediatric closed diaphyseal forearm fractures with the aid of remote consultation by OS.

Keywords: Emergency Medicine physicians, Pediatric, Closed diaphyseal forearm fractures

Research Article

Received 21-03-2023

Accepted 05-04-2023

Available Online: 10-04-2023

Published 30-04-2023

INTRODUCTION

Pediatric forearm fractures are the most widespread fractures, representing 40% to 50% of all childhood fractures (1-3). Any type of accident that causes a person to lie on the ground or at a lower level without intention has been linked to forearm fractures. Also, falls and fractures in pediatric patients are serious and often preventable public health problems (4).

Pediatric closed diaphyseal forearm fractures (CDFF) are a very common type of fracture in the pediatric population admitted to the emergency department, and there is not much consensus about management, treatment, and follow-up protocols for these injuries (5,6). Still, conservative management is usually preferred for treating pediatric CDFF in the Emergency Department (ED). Conservative management with urgent reduction and cast immobilization is a safe and successful treatment option for pediatric CDFF (5,7).

Anteroposterior (AP) and Lateral radiographic images of the forearm are typically adequate to diagnose a forearm fracture (8). AP and Lateral Radiographs performed in the emergency department confirm the fracture type and identify the degree of deformity and angulation, and AP and Lateral Radiographs are also useful for assessing the necessity for reduction prior to cast immobilization (7).

http://dx.doi.org/10.36472/msd.v10i4.921

The acceptable level of angulation, and the necessity for a reduction before cast immobilization, varies by the age of the patient, fracture type, and location (7,9). After urgent reduction, pediatric CDFF may recover with an angular deformity though the deformity may reduce over time because of angular correction caused by remodelling associated with growth (9). Remodelling will improve if CDFF is manipulated with complete displacement. But angulation might be more crucial for protecting and maintaining forearm rotation. In the literature, a general guideline for closed reduction and percutaneous pinning in pediatric patients is to limit post-reduction angulation to a maximum of 15 degrees in patients younger than 8 years old, while a maximum angulation of 10 degrees is recommended in patients older than 8 years old (7).

Many studies have shown that emergency physicians manage pediatric CDFF with conservative management, reducing the need for urgent orthopedic consultation and hospital admissions (10-14). This study aimed to evaluate the feasibility of closed reduction by EM physicians with the aid of remote consultation by Orthopedic Surgeons in Pediatric CDFF.

MATERIAL and METHODs

The study was conducted as a single-center, retrospective, observational study between 01.06. 2017, and 01.06.2019 in pediatric patients (age less than 14 years) with CDFF (including both radius and ulna, isolated radius/ulna fractures, and injuries limited to the diaphysis zone of bone) at a tertiary pediatric trauma center. Ethics committee approval and institutional permission in accordance with the Helsinki Declaration were obtained.

AP and Lateral radiographs were performed in the emergency department to diagnose, confirm the fracture type, and identify the degree of deformity and angulation in pediatric patients with forearm trauma. Also, in cases with CDFF, orthopedic surgeons (OS) are consulted over the phone using the Picture Archiving and Communication System (PACS) for the necessity and suitability of closed reduction by EM physicians. Pediatric patients with CDFF were treated with conservative management (including closed manipulation and casting) by EM physicians or OS. Closed manipulations (the standard technique of axial traction) were performed by EM physicians or OS assisted by cast technicians, with sedation provided by EM physicians. The arm was immobilized in neutral prono-supination with the elbow flexed at 90 degrees with casting. In the immediate post-reduction period, AP and Lateral radiographs were performed to evaluate fracture alignment. EM physicians and OS reviewed the post-reduction AP and Lateral radiographs to determine the success of the reduction in PACS. If the reduction was deemed satisfactory based on AP and lateral radiographs, with post-reduction angulation within the recommended limits of 15 degrees for patients younger than 8 years old and 10 degrees for patients older than 8 years old, they were discharged from the ED. However, if the fracture alignment was deemed unacceptable after closed reduction, the patients were admitted to the ward for subsequent surgical treatment.

Retrospectively, on PACS, an independent OS reviewed AP and Lateral radiographs, evaluated the success of reduction, and evaluated whether operative treatment was indicated after post-reduction.

Patients were separated into two groups: conservatively treated by EM physicians with the aid of remote consultation by OS and conservatively treated by only OS. Also, all study patients were divided into 2 groups: those 8 years or younger and those older than 8 years.

Demographical-clinical characteristics, plain radiographs, and electronic medical records of the patients included in the study were recorded. Door-to-reduction time (ADRT) was calculated as the time between the ED admission time and post-reduction plain radiograph recording time. Patients with ages more than 14 years, children with open diaphyseal fractures of the forearm, and children with pathological fractures were excluded. Trained physicians primarily analyzed all data.

Statistical Analysis

Categorical data were expressed as frequency(n) and percentage(%) and numerical data as the arithmetic mean, and standard deviation(SD). SPSS version 26.0 (IBM SPSS Statistics for Windows, version 26.0. Armonk, United States of America) was used for the analysis. In categorical data, Fisher's exact test was performed for analysis if 1 cell has an expected count of less than 5%. The conformity of the numerical data determined by measurement to the normal distribution was checked with the Shapiro-Wilks test. The Mann-Whitney U test was used to compare the means of 2 independent groups when the assumptions of normal distribution have not been met. A p-value <0.05 was considered statistically significant.

RESULTs

112 pediatric patients with CDFF were included in the study. The mean age of patients was 8.6 ± 3.0 years. There were 87 cases of boys (77.7%). Right-sided CDFF was detected in 60 (53.6%) cases. Both radius and ulna bone fractures were noticed in 93 (83.1%) cases. Demographic characteristics are displayed in table 1.

Table 2 displays the average angulation of both radius and ulna fractures before and after reduction at the initial ED.. In all age groups, the angulation averages of post-reduction of all fractures with both radius and ulna after reduction on AP and Lateral radiographs were not statistically significantly different between EM physician and OS (Table 2).

Figure 1 shows that 37 out of the total number of patients (33.0%) were treated by emergency medicine physicians with the assistance of remote consultation by orthopedic specialists in the ED, and all of these patients were discharged from the ED.75 (67.0%) patients were treated by OS in the ED (**Figure 2**). However, 12 (16.0%) of patients managed by OS had an ineffective closed reduction and were admitted to the ward to be operated on surgically subsequently (**Figure 3**).

http://dx.doi.org/10.36472/msd.v10i4.921

The rate of conservative treatment success (acceptable residual angulation degrees and fracture alignment) was statistically significantly different between EM physicians and OS (Fisher's exact test, p=0.008).

The means of the age of all fractures including both radius and ulna were statistically significantly different between conservative treatment (8.1±2.8) and surgical treatment (11.5±2.5) groups (Mann-Whitney U(MWU)=155, p=0.001). Only 2 cases had isolated radius and ulna fractures in surgical treatment groups. 12 patients were observed to have had the following surgical treatment techniques: 5 (42.6%) cases of plate fixation, 5 (42.6%) cases of titanium elastic nails, and 2 (16.8%) cases of an intramedullary nail.

The average door-to-reduction time (minutes) (ADRT) for all fractures among the 8 years and younger group was statistically significantly lower in the EM physicians (16.6*1.7) than in the OS (32.2*6.4) groups (MWU=527.5*0.001).

The ADRT for all fractures in the older than 8 years group was significantly lower in the EM physicians (16.7±2.1) than in the OS (35.5±4.6) groups (MWU=406.0, p<0.001). The ADRT for fractures with both radius and ulna were statistically significantly different between conservative treatment (27.3±9.5) and surgical treatment (36.1±4.5) groups (MWU=204.5, p=0.009).

Table 1: Demographic features of all patients.

	n	%
Age Groups (years)		
≤ 8	58	51.8
>8	54	48.2
Sex		
Boy	87	77.7
Girl	25	22.3
Fracture Occurred		
At school	24	21.4
At Playground	56	50.0
At home	19	17.0
In vehicle accident	13	11.6
Side of fractures		
Right	60	53.6
Left	52	46.4
Bones involved		
Radius	11	9.8
Ulna	8	7.1
Radius and ulna	93	83.1
Time to admission emergency department		
08:00-16:00	51	45.5
17:00-07:00	61	54.5
Performing Closed Reduction		
Emergency Medicine physician	37	33.0
Orthopedic surgeon	75	67.0
Treatment		
Conservative	100	89.2
Surgical	12	9.8
Total	**112**	**100.0**

Table 2: The mean angulations of pre- and post-reduction of all fractures with both radius and ulna at the initial emergency department.

Age groups (years)	Bone	Reduction	X-Ray	EM physician (Mean±SD)*	OS (Mean±SD)*	MWU	P Value
≤ 8	**Radius**	**Pre**	AP	7.1 ± 7.7	18.6±17.7	388.0	**0.01****
			Lateral	19.1±12.5	27.4±17.0	359.0	0.07
		Post	AP	0.4±1.5	1.6±4.0	310.5	0.21
			Lateral	3.3±3.4	3.7±5.1	266.0	0.89
	Ulna	**Pre**	AP	6.3±6.2	18.2±17.9	379.0	**0.02****
			Lateral	14.1±9.9	25.1±17.0	397.5	**0.01****
		Post	AP	0.3±1.0	0.9±2.5	295.5	0.39
			Lateral	2.1±2.5	1.9±3.3	236.5	0,39
>8	**Radius**	**Pre**	AP	8.2±9.2	18.7±14.5	285.0	**0.03****
			Lateral	22.1±9.0	22.9±11.0	205.0	0.95
		Post	AP	0.9±2.2	3.6±7.7	237.0	0.25
			Lateral	3.0±4.0	7.2±8.9	249.0	0.20
	Ulna	**Pre**	AP	6.4±5.4	15.5±14.1	274.5	0.06
			Lateral	21.6±12.3	18.6±11.7	166.5	0,34
		Post	AP	0.7±2.7	1.8±4.1	235.0	0.22
			Lateral	1.1±2.3	3.7±6.0	251.5	0.14

Abbreviations: MWU:Mann-Whitney U test, EM:Emergency Medicine , OS:Orthopedist Surgeon, AP:Antero Posterior, SD:Standart Deviation *:average degrees of angulation, **:p<0.05 significantly

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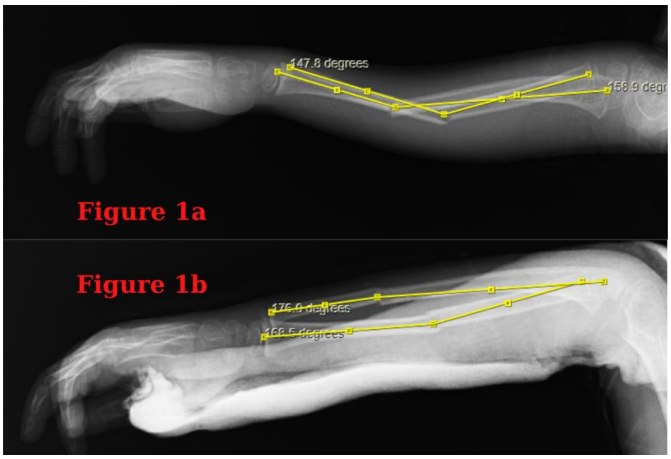

Figure 1: Pre-reduction (**Figure 1a**) and Post-reduction (**Figure 1b**) Lateral Radiographs of 7 years old boy with both radius and ulna diaphyseal forearm fractures were treated by Emergency Physician.

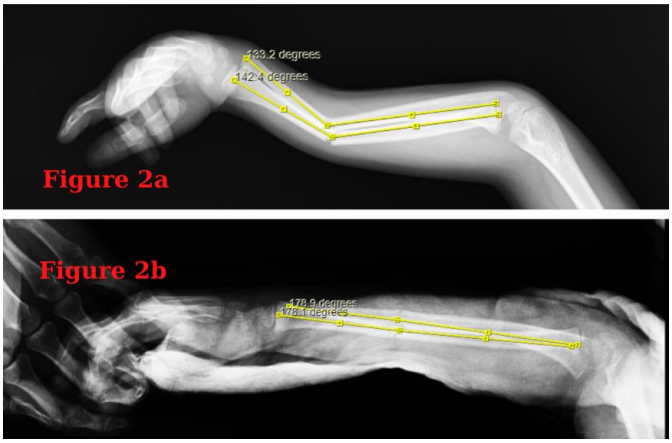

Figure 2: Pre-reduction (**Figure 2a**) and Post-reduction (**Figure 2b**) Lateral Radiographs of 6 years old boy with both radius and ulna diaphyseal forearm fractures were treated by Orthopedic Surgeon.

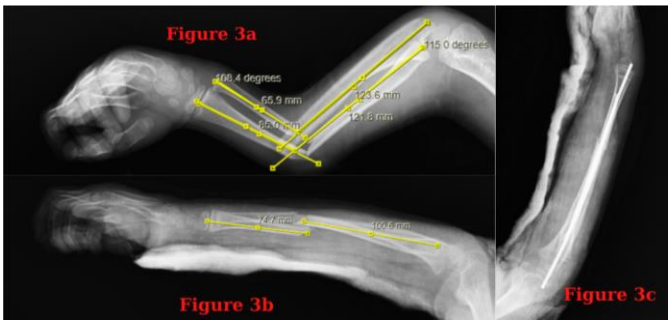

Figure 3: Pre-reduction (**Figure 3a**) and Post-reduction (**Figure 3b**) Lateral Radiographs of 8 years old boy with both radius and ulna diaphyseal forearm fractures were treated surgically(titanium elastic nail)(3c) by Orthopedic Surgeon.

DISCUSSION

The treatment of pediatric CDFF is controversial (8). In the pediatric population (especially younger than 14 years), conservative treatment (closed reduction and casting) performed with acceptable residual angulation, is still safe, successful, and the first recommended treatment option according to the literature (5,7). Closed reduction in forearm fractures provides satisfactory alignment in most pediatric cases. Recent studies show that EM physicians can perform closed reductions to obtain adequate reductions in forearm fractures without orthopedic surgeon intervention or consultation (10,13,15-17). Post-reduction angulations for all children younger than 14 years of age were similar and acceptable fracture alignment between EM physicians and OS groups in this study. In the groups treated by emergency medicine physicians with the aid of remote consultation by orthopedic specialists, there was no requirement for bedside consultation or intervention by the orthopedic specialists. Also, all of the cases were treated conservatively in the EM groups. The rate of conservative treatment success (acceptable residual angulation degrees and fracture alignment) was statistically significantly different between EM physicians and OS in this study (Fisher's exact test, p=0.008). This difference was caused by OS's preference to attempt closed reduction for fractures with a high angulation or high risk of surgical intervention. EM physicians successfully performed closed reduction in CDFF with remote consultation from OS. With the aid of remote consultation from OS, we demonstrated that pediatric closed reduction in CDFF may be a skill that EM physicians can perform appropriately.

The indication for surgical treatment varies depending on the patient's age, fracture type, and post-reduction angulation degrees in pediatric CDFF (7,8). In a recent review of the literature on pediatric forearm fractures, an angulation angle of 15 degrees or greater is considered acceptable for conservative treatment post-reduction in children younger than 8 years old, whereas an angle of 10 degrees is considered acceptable in children older than 8 years old (7). In this study, in all age groups, closed reduction done by the EM physicians' group was deemed acceptable in terms of angulation degrees and fracture alignment in accordance with the literature on after-reduction radiographs. In addition, post-reduction angulation degrees were similar between EM physicians and OS groups. In accordance with the literature, we suggest that EM physicians have achieved success in fracture reduction and fracture alignment in groups aged 8 years and younger and above 8 years old. In recent years, CDFF surgical treatment has increased dramatically in cases older than 8 years according to the literature (7,8,18). In this study, the means of the age of the conservative treatment groups were lower than the surgical treatment groups (8.1vs11.5, p=0.001). In accordance with the literature, the averages of ages were higher (11.5 years) in cases treated with operative techniques in this study.

Some recent studies conducted on pediatric forearm fractures showed that closed reduction by EM physicians had agreeable fracture alignment and beneficial decreased length of ED stays (10,12,13,17). As there were no orthopedic specialists present in our ED, on-call consultations were required to bring them to the ED. Therefore, the door-to-reduction time of the patients was analyzed for each group. However, the duration of casting, and control radiograph evaluation of post-reduction was not taken into account, because these durations are standard for the physicians in both groups. In this study, the average door-to-reduction times (ADRT) of EM physicians were significantly different from OS groups.

The ADRT of EM physicians' groups (16.6*1.7) was significantly lower than OS groups (32.2*6.4) in 8 years and younger (MWU = 527.5, p<0.001). Similarly, in the older than 8 years group, the ADRT for the EM physicians (16.7*2.1) was significantly lower than that for the OS groups (35.5*4.6) (MWU=406.0, p0.001). We observed that closed reduction performed by EM physicians could both reduce the need for OS consultation and shorten the time it takes patients from the door to the reduction room, thus greatly reducing the length of stay in the ED.

Limitations: There are some limitations. First, the study was retrospective and conducted with a relatively small number of patients in a single center. Second, patients diagnosed with CDFF were consulted by phone to OS before closed reduction and OS reviewed radiographs in PACS. As a result, the cases were subjected to selection bias by OS. Also, OS preferred to attempt closed reduction for fractures with a high risk of surgical intervention. This study only measured residual angulation, and did not assess displacement or malrotation, which are other factors that can impact treatment outcomes. Because OS prefers to attempt a closed reduction on completely displaced CDFF, we suggest to EM physicians that only angulated fractures should be treated in our hospital. Further prospective, large-scale studies with longer-term follow-up are required to confirm the success rate of closed reduction of pediatric distal forearm fractures by emergency medicine physicians.

CONCLUSION

EM physicians can perform an acceptable reduction with residual angulation degrees and fracture alignment of pediatric CDFF with the aid of remote consultation by OS. As a result of the closed reductions, EM physicians' groups were able to shorten the ADRTs of patients, thereby significantly reducing the duration of time spent in the ED.

Acknowledgments: None

Conflict of interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. This research did not receive and a specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Contributions: MÖ, MA, MŞ, HS, SA: Project design, literature review, Data collection and analyzes. **MÖ:** Manuscript preparation and revisions.

Ethical approval: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and/or with the Helsinki Declaration of 1964 and later versions. Informed consent or substitute for it was obtained from all patients for being included in the study. Written consent was obtained from each patient to use their hospital data.

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