

## Short-term complications of fixation of pediatric distal radius fracture by percutaneous pinning in patients referred to Shahid Madani Hospital

### Abstract

**Aims:** Distal radius fracture (DRF) has the highest rate among pediatric fractures. The management of distal radius fractures in children has to be as non-invasive as possible, which requires definitive care for proper reduction and stabilization. This study was designed to evaluate the short-term complications of pinning radius fractures in children, help the surgeon make an appropriate decision according to the situation of patients, and also look for solutions to reduce complications.

**Methods:** In this cohort study, patients diagnosed with distal radius fracture aged 3-15 years who visited Shahid Madani Hospital in Karaj were evaluated. Demographic characteristics and type of fracture of patients who underwent pinning of distal radius fractures, were collected after obtaining their consent. Then the complications of patients were evaluated based on Clavien-Dindo-Sink, and dahl scores four and five weeks, and three and six months after the surgery.

**Results:** According to the Clavien-Dindo-Sink score, 96 cases had no complications, 35 cases had complications of grade 1, 27 cases had complications of grade 2, 9 cases had complications of grade 3, and 1 patient had complications of grade 4. In the examination of the DahlPin operative site complication score, 108 cases had no operative site complications, 30 cases had complications of grade 1, 22 cases had complications of grade 2, 6 cases had complications of grade 3, and 2 cases had complications of grade 4. Four cases had transient neurapraxia and 20 cases had limited range of motion.

**Conclusion:** The results obtained from this study create a more comprehensive understanding of the complications and weaknesses of the percutaneous pinning treatment method for distal radius fracture patients.

**Keywords:** Salter-Harris Fractures, Wrist Fractures, Fracture Fixation

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### Introduction

Fractures in children are an important public health issue and one of the frequent reasons for going to the emergency room<sup>(1, 2)</sup>. DRF has the highest frequency among the fractures of children<sup>(3-5)</sup>. Radius fractures constitute 20% of pediatric fractures, of which 62% include metaphyseal involvement<sup>(6, 7)</sup>.

Pediatric distal radius fractures are often classified based on their relationship to the distal physis (growth plate). The Salter-Harris classification system is widely used. These fractures can vary in severity and potential for growth disturbance, with higher classifications (IV and V) posing greater risks. Additionally, metaphyseal fractures are common and typically stable. They can be complete fractures, such as Colles' (apex volar) or Smith's (apex dorsal), or incomplete, such as torus (buckle) fractures. Diaphyseal fractures, which involve the midshaft of the radius or ulna, can include isolated fractures or more complex injuries like both bone fractures and greenstick fractures, where only one side of the bone is fractured while the other bends. Lastly, Monteggia fractures involve an ulnar fracture with radial dislocation, and Galeazzi fractures consist of a distal radius fracture with dislocation of the distal radioulnar joint<sup>(8)</sup>.

One of the most common early complications of DRF is injury of median nerve<sup>(9, 10)</sup> which can present as carpal tunnel syndrome. The treatment of DRF in children has to be as non-invasive as possible, which requires definitive care for proper reduction and stabilization<sup>(11)</sup>. Treatment methods available for fractures of distal radius fall in two groups of conservative and non-conservative approaches. These

include closed reduction and casting as most conservative approach, and closed reduction and percutaneous pinning (CRPP), external fixation and open reduction with internal fixation (ORIF) as non-conservative approaches<sup>(12)</sup>. In children with closed fractures without any indication for referring, closed reduction and careful follow-up could be enough<sup>(12-16)</sup>. For patients with severely displaced fractures, CRPP is advised<sup>(16,17)</sup>. The advantages of this method include low cost, less invasiveness than the open method, and proven results over time, and the disadvantages include infections of the pin system and tendon irritation<sup>(18)</sup>.

Several studies have investigated the complications and outcomes associated with percutaneous fixation of pediatric distal radius fractures. Wasiak et al. (2023) conducted a prospective cohort study to evaluate the early complications of percutaneous K-wire fixation in pediatric distal radius fractures. They followed 116 patients with displaced and unstable fractures, monitoring them at 4 weeks, 5 weeks, 3 months, and 6 months post-surgery. The study found a 37% complication rate, with most being minor issues such as pin site inflammation (33.6%). Two patients required additional surgery due to deep infections and pin migration. Overall, they concluded that the procedure is safe with a low rate of major complications but highlighted the need for careful post-surgical monitoring to manage minor complications<sup>(16)</sup>.

With all due respect to its benefits, CRPP is not an easy choice as it is still an invasive approach to some levels thus comes with some complications and risks<sup>(16)</sup>. Possible treatment complications are still important issues that have to be considered when in decision making. The complications rate for pinning for these patients in distal radius fractures varies from 0 to 38%<sup>(16)</sup>. Possible complications include infection of pin site, iatrogenic injury of neurovascular components, pin dislodgement requiring re-surgery for pin removal, and ablation leading to malunion<sup>(19)</sup>. Parents want to avoid residual abnormalities and expect to have received the correct treatment in the first visit<sup>(20)</sup>. This cohort study was designed to evaluate the short-term complications of pinning radius fractures in children, help the surgeon make an appropriate decision according to the situation of patients, and also look for solutions to reduce complications.

## Methods and Material

In this study, patients diagnosed with a fracture of the distal radius aged 3-15 years who referred to Shahid Madani Hospital in Karaj were evaluated.

Inclusion criteria were displacement of distal radius fractures that were treated by pinning, age 3-15 years, and exclusion criteria included use of another treatment method, patients how refuse to co-operate, and patients refuse to for co-operate in follow-up.

Patients who visited Shahid Madani Hospital for one year from February 1402 and underwent pinning were included in the study and were followed up for 6 months. Pinning surgery was performed for fractures with more than 50% translation and volar angulation greater than 30 degrees. For each patient, two pins were placed by default, and in cases where instability was suspected, three 1.5 mm pins were inserted. Patients underwent surgery 12 hours after the fracture. Antibiotic prophylaxis was started before the surgery<sup>(21)</sup>. After obtaining closed reduction, the wires were placed under fluoroscopic control. The tips of the pins remained ten millimeters or more away from the skin and sterile gauze was used as its dressing. Right after the surgery, casting was applied and covered the tips of the pins. The patients were monitored at least 12 hours in the surgery department. After discharge, the patients were referred to the relevant doctor for follow-up.

Visits were made during four and five weeks, and three and six months post operation, and included standard history, physical examination and radiologic studies. At each visit patients were assessed for possible neurovascular, and pin site complications, and range of motion limitations of both limbs. At each visit, lateral and anteroposterior radiographs were used to evaluate displacement, osteitis, wire migration, and bone remodeling. In this study, an inability to achieve 5 degrees of flexion, 30 degrees of wrist extension, radial deviation of less than 10 degrees, and ulnar deviation of less than 15 degrees within a 2-month period after surgery was considered a limitation of motion.

Upon observing lucency around the pins in the X-ray, loosening of the pins, discharge, and the patient's fever and chills, there was suspicion of a deep infection. Additionally, with increased swelling of the wrist and fingers and a feeling of warmth in the area, there was suspicion of a superficial infection in

that region. The cast was removed, and an erythematous area was observed. Both the pins and the cast were removed six weeks later, after signs of fracture healing were observed.

Two scoring systems were used to evaluate patients' outcomes. The Clavien-Dindo classification system, originally developed by Pierre-Alain Clavien in 1992 and further refined by Dindo et al. in 2004, is widely used for grading postoperative surgical complications. This classification focuses on the severity of complications based on the interventions required to manage them, rather than subjective measures. It consists of five primary grades, ranging from minor complications that require only medication (Grade I) to life-threatening complications requiring intensive care management (Grade IV), with death being classified as Grade V<sup>(22)</sup>. The Dahl Pin-Site Complication Scoring System is used to evaluate complications at pin sites, particularly in the context of external fixation treatments. The system classifies pin-site conditions as follows:

- **Grade 0** indicates a normal pin site without any complications.
- **Grade 1** represents mild inflammation.
- **Grade 2** includes serous discharge.
- **Grade 3** is characterized by purulent discharge.
- **Grade 4** indicates bone osteolysis, and
- **Grade 5** represents sequestration of the bone around the pin.

This scoring system provides a detailed way to assess the severity of pin-site complications, which is crucial for monitoring infections and guiding further treatment. This system is particularly useful in pediatric orthopedic studies, including the assessment of complications arising from percutaneous pinning, where pin-site infections and related issues are common<sup>(23)</sup>.

Median (interquartile range) was used to express quantitative variables and qualitative variables were presented as number (percentage). The analyses were performed using SPSS software and the significance level was considered to be 0.05.

## Results

During the study period, 400 patients with distal radius fractures visited the hospital. Based on the inclusion and exclusion criteria, a total of 168 patients, including 104 boys (61.9%) and 64 girls (38.1%), were enrolled in the study. Images related to the patient before and after surgery are available in Figure 1. The patients had median age

of 13 with interquartile range of 10-14 years (patients aged 3-15 years were included in the study). (Table-1).

**Table-1 Distribution of demographic and background variables**

%	n		
61.9	104	Male	Gender
38.1	64	Female	
13 (10-14)			Age
51.8	87	Not a physal fracture	Salter Harris
6.5	11	I	
35.1	59	II	
2.4	4	III	
4.2	7	IV	
51.2	86	de Palma	Pin placement pattern
17.3	29	Kapanji	
5.4	9	intra-medullary	
26.2	44	intra-medullary single pin	
50.6	85	No	Concomitant distal ulna fracture
49.4	83	Yes	

**Table-2 Distribution of outcome measures**

%	n		
57.1	96	No complication	Clavien-Dindo-Sink
20.8	35	Grade 1	
16.1	27	Grade 2	
5.4	9	Grade 3	
0.6	1	Grade 4	
64.3	108	Grade 0	Dahl Pin-Site Complication
17.9	30	Grade 1	
13.1	22	Grade 2	
3.6	6	Grade 3	
1.2	2	Grade 4	
97.6	164	No	Transient neuropraxia
2.4	4	Yes	
88.1	148	No	Limited range of motion
11.9	20	Yes	

In terms of Salter-Harris fracture, 87 patients (51.8%) did not have a physal fracture, 11 patients (6.5%) had a Salter-Harris type I fracture, 59 patients (35.1%) had a Salter-Harris type II fracture, 4 patients (2.4%) had Salter-Harris type III fracture, 7 patients (4.2%) had Salter-Harris type IV fracture. In terms of pin placement pattern in surgery, 86 patients (51.2%) used the de Palma pattern for pin placement, 29 patients (17.3%) used the Kapanji pattern for pin placement, 9 patients (5.4%) used the intramedullary pin, and 44 patients (26.2%) used

a single intramedullary pin. Regarding the presence of distal ulna fracture, 85 patients (50.6%) did not have ulnar fracture and 83 patients (49.4%) had ulnar fracture.

According to the Clavien-Dindo-Sink score, 96 patients (57.1%) had no complications (score 0), 35 patients (20.8%) had grade 1 complications, 27 patients (16.1%) had grade 2 complications, 9 patients (5.4%) had complications They had grade 3 and 1 patient (0.6%) had grade 4 complications. (Table-2)



**Figure 1: Images before (A and B) and after (C and D) surgery of a 13-year-old boy with a distal radius and ulnar bone fracture, treated with PCP and casting.**

According to the DahlPin operative site complication score, 108 patients (64.3%) had no operative site complications (score 0), 30 patients (17.9%) had grade 1 complications, 22 patients (13.1%) had grade 2 complications, 6 patients (3.6%) had grade 3 complications and 2 patients (1.2%) had grade 4 complications.

Regarding the occurrence of transient neuropraxia, 164 patients (6.97%) did not have transient neuropraxia and 4 patients (4.2%) had transient neuropraxia.

Regarding the incidence of range of motion limitation, 148 patients (88.1%) did not have range of motion limitation and 20 patients (11.9%) had range of motion limitation.

Further, the relationship between sex, age, location of pin placement and Salter-Harris fracture classification of patients with site complications (Clavien-Dindo-Sink and Dahl Pin Site Complication), incidence of transient neuropraxia and limited range of motion were measured. Based on the obtained results, young age has a significant relationship with the incidence of neuropraxia and limited range of motion, the placement of the pin was also associated with a limitation in the range of motion, such that, in general, intramedullary pin placement was accompanied by a lower occurrence of motion limitation. (Tables 3-4).

Table-3 P-values of sub-group analysis					
Concomitant ulnar fracture	Pin placement pattern	Salter-Harris	Age	Gender	
0.886	0.117	0.086	0.563	0.288	ClavienDindoSink
0.579	0.546	0.682	0.133	0.715	DahlPinSiteComplication
0.981	0.272	0.173	0.001	0.124	Transeint Neuropraxia
0.594	0.017	0.352	0.048	0.498	Restricted Range of Motion

Table-4 Relation of pin placement pattern with restriction of range of motion							
P-value	Pin placement pattern						
	de Palma	Kapanji	intra-medullary	intra-medullary single pin			
0.017	71	25	9	43	Num	No	Restricted Range of Motion
	42.30%	14.90%	5.40%	25.60%	%		
	15	4	0	1	Num	Yes	
	8.90%	2.40%	0.00%	0.60%	%		

## Discussion

The fact that distal radius fractures are the most common fractures of pediatric population, highlights the vital importance and huge impact of initial management approaches in healthcare system. The primary aim of this study was to shed more light on the benefits and costs of closed reduction and

percutaneous pinning treatment approach. In the present study, patients with distal radius bone fractures who were treated by CRPP in Shahid Madani Hospital Karaj were examined in terms of short-term complications. Based on the obtained results, a total of 168 people, including 104 boys and 64 girls, were included in the study with the complaint of distal fracture of the radius bone. Patients had median age of 13 with interquartile range of 10-14 years.

Regarding the type of Salter-Harris fracture, 87 patients did not have a physeal fracture, 11 patients had a type I fracture, 59 patients had a type II fracture, 4 patients had a type III fracture, and 7 patients had a Salter-Harris type IV fracture. Regarding the pin placement pattern in surgery, de Palma pattern was used in 86 patients, Kapanji pattern was used in 29 cases, intramedullary pin was used in 9 patients and single intramedullary pin was used in 44 cases. 83 cases had ulnar fractures. According to the Clavien-Dindo-Sink score, 96 cases had no complications, 35 cases had complications of grade 1, 27 cases had complications of grade 2, 9 cases had complications of grade 3, and 1 patient had complications of grade 4. In the examination of the DahlPin operative site complication score, 108 cases had no operative site complications, 30 cases had complications of grade 1, 22 cases had complications of grade 2, 6 cases had complications of grade 3, and 2 cases had complications of grade 4. Four patients had transient neurapraxia and 20 cases had limited range of motion. The results of sub-group analysis indicate a significant association between younger age and the occurrence of neurapraxia and restricted range of motion. Additionally, the method of pin placement is also linked to limitations in joint mobility.

In a study, Beaty et al. (2024) compared the outcomes of single versus double percutaneous pinning in pediatric distal radius fractures. This observational study of 101 patients found no significant difference in complication rates between the two groups, although fractures stabilized with two pins showed slightly better post-operative alignment compared to those with a single pin. However, the clinical significance of this difference was minimal, suggesting that both techniques are effective if proper fracture reduction and post-operative care are ensured<sup>(24)</sup>.

Khan et al. (2021) performed a systematic review to identify risk factors for premature physeal arrest in the distal radius. Their review of 13 studies indicated that intra-articular fractures and repeated manipulations increased the risk of physeal arrest, with symptoms such as pain, deformity, and reduced range of motion being common. The authors recommended at least 18 months of radiological follow-up for all physeal injuries<sup>(25)</sup>.

In a cohort study by Michał Wasiak and his colleagues<sup>(16)</sup> in 2023 titled as “Early complications of percutaneous K-wire fixation in pediatric distal

radius fractures—a prospective cohort study”, 119 patients treated with CRPP were included. Follow-up sessions were on four and five weeks, and three and six months after operation. The data was gathered by history, physical examination and radiographic evaluations. Grade I or II CDS were observed in 42 (35.3%) cases and 2 (1.7%) had grade III complications. In total, 44 (37%) cases had complications. Re-operation was indicated in 2 patients. Inflammation of pin site (33.6%) was the most frequent minor complication.

The study design of present study was inspired by the study of Michał Wasiak et al. The results of the two studies are also in part similar, but samples of our study presented higher rates of complications. Some of the factors related to this difference are higher sample size of the present study, and differences in initial characteristics of the two population. In summary, based on results of this study, CRPP can be viewed as a safe approach for DRF in children considering its low rate of major complications.

In a cross-sectional study by Ramoutar and his colleagues in 2015<sup>(26)</sup> titled “The outcomes of displaced paediatric distal radius fractures treated with percutaneous Kirschner wire fixation: a review of 248 cases”. A total of 248 child aged 3 to 15 years old were included in the study. The patients were followed for 4-156 weeks. Mid-posterior angle between the initial postoperative and radiographs at the time of the removing of K-wire was increased significantly. Twelve cases needed to be re-operated due to displacement of the wires. Two hundred and fifteen cases showed normal function after removing K-wire. A total of 41 patients (17%) had complications related to the use of K wire.

Unlike our study, Ramoutar et al. focused on more severe cases which can explain the higher rate of serious complications. This study highlights the negative impact of CRPP that is mainly due to K-wires, which emphasizes on the importance of thinking twice before choosing more invasive approaches.

## Conclusion

This study highlights the significance of early management in pediatric distal radius fractures, particularly with closed reduction and percutaneous pinning (CRPP). Among the 168 patients studied, including both boys and girls, short-term

complications such as neurapraxia and limited range of motion were identified. Notably, younger age was significantly associated with a higher incidence of neurapraxia and restricted range of motion, while the method of pin placement also played a critical role in post-operative mobility outcomes. Despite these complications, the majority of patients experienced favorable outcomes, with only a small percentage developing severe complications as classified by the Clavien-Dindo-Sink and Dahl Pin Site Complication scoring systems. These findings underscore the importance of careful surgical technique and appropriate follow-up to minimize complications. Additionally, the study contributes valuable data to the ongoing discussion of best practices in pediatric orthopedic care, suggesting that CRPP remains an effective and safe approach when performed with attention to patient age and surgical methodology.

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#### Authors Contribution:

In this study, conceptualization by SA, AN, PR; Methodology by AN, PRA; Investigation by PY; Writing - original draft preparation by PY; Writing - review and editing by SA, AN, PR; Visualization by PY; Supervision by SA, AN, PR; and Project administration by SA, AN, PR were done.

#### Conflicts of Interests:

None declared by Authors

#### Ethical Permission:

Informed consent for study participation was obtained from all subjects. This study was approved by the ethics committee of Alborz University of Medical Sciences, Alborz, Karaj, Iran. (IR.ABZUMS.REC.1403.015)

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