

## Closed Reduction and Percutaneous Pinning in Management of Epiphyseal Injury of Distal Radius in Children

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### ABSTRACT

**Background:** The goals of management of a displaced epiphyseal fracture of distal radius are to recover full function in a cosmetically normal wrist and elbow and avoidance of complication. The commonly accepted treatment in children is fracture reduction and percutaneous pin fixation.

**Objectives:** Study of the results of treatment of displaced epiphyseal fractures of distal radius in children by closed reduction and percutaneous fixation by K-wires.

**Materials and Methods:** Twenty-five children were treated by this method. Most of them were displaced dorsal and the others were displaced volar according to the directional displacement. The cases were examined clinically and radiologically at first. Twenty cases were operated in the same day and five cases were delayed because of sever edema. **Results:** the results were assessed both functionally and cosmetically according to evaluation of elbow, wrist function, pronation and supination and residual deformity. The overall results obtained were satisfactory with treatment by closed reduction and percutaneous pinning.

**Conclusion:** we suggest that children who initially have a completely displaced fracture of the distal radius should be manipulated under general anesthesia and recommend that percutaneous K-wire fixation be used to ensure stabilization and avoid redisplacement, even when a perfect closed reduction has been achieved.

**Keywords:** Percutaneous Pinning, Epiphyseal Injury, Distal Radius.

### INTRODUCTION

Epiphyseal injuries of the distal radius are common in children, and they account for 75% to 84% of pediatric forearm fractures <sup>(1)</sup>.

Fortunately, most epiphyseal-plate injuries are not associated with any disturbance of growth. After separation of an epiphysis through its epiphyseal plate, there may be a slight and transient acceleration of growth, in which case no significant deformity ensues <sup>(2)</sup>. The radius is connected to the ulna via the proximal radioulnar articulation, the interosseous membrane, and the distal radioulnar articulation. The distal and proximal radioulnar joints are interdependent for stability. With pronation and supination, movement occurs at each of these joints <sup>(3)</sup>. Bado <sup>(4)</sup> noted that with pronation, the radius shortens and, with supination, it lengthens relative to the ulna. This interdependence may be the reason for late dislocation of the radial head in children who had significant shortening of the ulna after an injury to its distal end.

Caine classification of epiphysal injuries is based on the mechanism of injury and the relationship of the fracture line to the growing cells of the epiphyseal plate and is correlated with the prognosis for growth disturbance <sup>(5)</sup>. Epiphyseal injuries have also been classified by Poland, Aitken and Magill, and more recently by Ogden <sup>(2)</sup>. The goal of treatment is to prevent proximal migration of the distal radial fragment and to stabilize the radioulnar joint <sup>(7)</sup>.

Displaced fractures of the distal radius physis with median neuropathy and significant volar soft tissue swelling can be managed with closed reduction and percutaneous pinning <sup>(8)</sup>. The perfect anatomical reduction was the most important prognostic factor, but not for initially completely displaced fractures <sup>(9)</sup>.

Possible complications postoperatively are; edema, pin tract infection and pin migration. The major problem I faced was the difficult closed reduction in the cases presented late because of the presence of edema. The second problem was difficult insertion of the pin from dorsal to volar in these cases. Iatrogenic neurovascular injuries and other intra-operative complications are possible but rare <sup>(10)</sup>. The most commonly used treatment modality is closed reduction and immobilization in plaster. Conservative treatment is gold standard in long-term follow up of children with epiphyseal fracture of distal radius. The most important problem in this treatment is to maintain the reduction in a plaster brace. Loss of reduction and malunions are frequently seen <sup>(11)</sup>.

Fixation with percutaneous Kirschner wire (K-wire) is recommended in patients who carry high risk of reduction loss after closed treatment in order to prevent forearm rotational loss <sup>(12)</sup>.

In my study I aimed to determine the effect of percutaneous K-wire fixation after the first reduction maneuver in the patients with epiphyseal distal radius fractures who had risk of reduction loss in the plaster brace.

### AIM OF THE WORK

Proper assessment and management of epiphyseal injury of distal radius through satisfactory reduction and proper fixation by K-wires without effect on bone growth or length.

### MATERIALS AND METHODS

This prospective study was carried out from May 2017 to January 2019. Twenty five patients of recent displaced epiphyseal fractures of distal radius in

children managed by closed reduction and fixation by k-wires. **The study was approved by the Ethics Board of Al-Azhar University.**

**Table (1): Age Incidence:**

Age	Number	Percentage
< 7	5	20%
> 7	20	80%

**Table (2): Sex incidence:**

Sex	Number	Percentage
Male	19	76%
Female	6	24%

**Table (3): Affected side incidence:**

Affected side	Number	Percentage
Non dominant	18	70%
Dominant	7	30%

**Table (4): Mechanism of injury incidence:**

Mechanism of injury	Number	Percentage
Fall on outstretched hand	23	90%
Motor car accident	2	10%

**Table (5): Associated Injuries incidence:**

Associated Injuries	Number	Percentage
NO	15	60%
Distal ulnar fractures	10	40%
Humeral fracture	3	12%

**Table (7): Classification of associated fracture of ulna:**

Associated fracture ulna	Number	Percentage
Metaphyseal	9	90%
Physeal	1	10%

**Table (8): Time lag between injury and the operation:**

Time lag	Number	Percentage
Early < 24 hours	24	96%
Late > 24 hours	1	4%

**Methods**

**Inclusion criteria:**

- Children up to 12 years.
- Recent injury.
- Patient with neurovascular compromise and displaced radial physeal fractures.
- Significant volar soft-tissue swelling.

**Exclusion criteria:**

- Salter – Harris I and II fractures.(mild swelling)
- Old injury.

The patients included for this study were examined and prepared for the management in the following way:

**History:**

Full history taking including:

- Personal history.
- Present history of the trauma: mechanism of injury, symptoms and signs, associated injuries, and any interference done before his arrival.
- Past history of any medical problem.

**Clinical examination:**

Examination of the affected limb and systematic examination of the body was done to all cases stressing on:

- Vascular examination especially the distal pulse of the affected limb.
- Neurological evaluation for exclusion of associated nerve injury (median and ulnar nerve).
- Skin condition.
- Degree of edema at the fracture site.

**Radiological Examination:**

Plain x-ray (2 views) for the fracture and associated injuries.

**Laboratory Investigations:**

CBC and Coagulation Profile if doubtful history of Bleeding tendency

**Anesthesia:**

- General anesthesia was used in all cases.

**Positioning:**

The patient was positioned supine on an operating table with the image intensifier parallel to the table.

**Technique of closed reduction and percutaneous pinning:**

Under complete aseptic condition by sterilization of mid arm, elbow, forearm, and the wrist then draping

- 1) Hyper dorsiflexion maneuver.
- 2) Maintaining the reduction.
- 3) Percutaneous pinning.

**Post-operative management:**

- Antibiotics, analgesics and antiedemateus.
- Post-operative x-rays.
- The limb is elevated.
- Observation of the circulation for 24 hours.

**Post-operative follow up:**

The patient was routinely discharged 24 hours after operation. The patient was followed up clinically and radiologically after one week by A\P and lateral views. After 4 weeks of injury, the pins and the cast were removed, with encouragement for exercise. Then, the patient was followed up weekly until fracture union and complete recovery of wrist function.

**Table (9): Pin configuration:**

Pinning	No. of cases	%
Crossed pins	19	76%
2lateral pins	6	24%
Total	25	100%

**Operative time:**

The operative time ranged between 15 and 30 minutes with an average of 25 minutes. The minimal time was in cases with less edema that had early presentation and easy reduction. It increased gradually with delayed presentation of the cases with increased edema and difficult reduction.

**Intraoperative problems and complications:**

The major problem we faced was the difficult closed reduction in the cases presented late because of the presence of edema, the delayed interference and instability. The 2<sup>nd</sup> problem was difficult insertion of the pin from dorsal to volar in these cases. No iatrogenic neurovascular injuries or other intra-operative complications were encountered.

**RESULTS**

In this prospective study, we managed 25 children with displaced epiphyseal injury of distal radius by closed reduction and fixation by k-wires.

**Follow up period:**

The follow up period ranged between 2 and 4 months. The patients were followed up until they achieved complete fracture healing and normal wrist, fingers (hand) and elbow function. The longer follow up was for the cases presented late with much edema as they had delayed recovery of the wrist and elbow function. In all cases of this study, the following steps were done in the following manner:

1. The cases followed up after one week and x-ray was done (A/P and lateral views) to compare the results with the acceptable reduction.
2. The cases followed up again after 4 weeks to evaluate the results of cases according to the radiological acceptable reduction and union.
3. Four cases showed delayed union, short arm cast was done for another two weeks.
4. Redisplacement means loss of reduction if dorsal angulation more than 10 degrees, radial translation more than 20% and less than 50% opposition in sagittal plane.

The patients were evaluated clinically according to the wrist movement (flexion, extension, radial and ulnar deviation) and forearm movement (pronation and supination). They returned for a clinical examination at eight to ten weeks after the injury, at which time the ranges of motion of wrist and elbow were recorded again. Physical therapy was prescribed for patient who did not have a normal range of motion at this follow-up visit. Those patients were seen for one last clinical check up. Patients who had a normal range of motion at the eight to ten week follow-up appointment were discharged from additional follow-up visits. The results were assessed clinically and radiologically. Clinical assessment was depending on:

- A) The subjective symptoms such as pain at rest or with activities of daily living and ability to participate in physical activity and sports.

B)

The objective symptoms were made of the range of movement of the wrist and forearm.

**Criteria for evaluation of the results:** The results were graded according to the criteria into satisfactory and unsatisfactory results (table 10).

**Table (10):** The results of cases according to the age of patient:

Age of patients	No of cases	Results
<7 years	5 cases	Satisfactory: 5 case (100%) Unsatisfactory: (0%)
>7 years	20 cases	Satisfactory: 19 cases (95%) Unsatisfactory: 1 cases (5%)

**Table (11):** Healing Time:

Healing time	No of cases	percentage %
-2 months	13	52%
2-3 months	9	36%
3-4 months	3	12%
Total	25	100%

**DISCUSSION**

They had previously noted that these fractures had a high incidence of loss of position leading to mal-union. Those fractures treated by percutaneous wiring had no significant complications, and all had satisfactory result. They conclude that these fractures should be treated by stabilization with percutaneous wiring. They recommended that fracture of distal radius in the presence of an intact ulna should be wired<sup>(13)</sup>. In our study twenty-five cases were treated by closed reduction and percutaneous pinning, twenty four of them had satisfactory results (96%) and one case had unsatisfactory results (4%). The goals of management of a completely displaced fracture of distal radius in children are to recover full function in a cosmetically normal wrist and avoidance of complication.

*Armstrong et al.*<sup>(14)</sup> reported that the peak of ages occur at ages 5-14 years old. In our study, the peak of age occurred at 6 and 12 years and the mean age is 11 years old.

*Armstrong et al.*<sup>(14)</sup> reported that the ratio of male to female is 3:1 due to sports involvement<sup>(14, 15)</sup>. In our study, there were nineteen boys and six girls. The male were predominance with male to female ratio 3:1.

Satisfactory results are: no pain or clinical deformity, loss of forearm rotation < 20, loss of wrist movement < 20 and angulations on radiograph < 20 degree. Unsatisfactory results are pain or clinical deformity, loss of forearm rotation > 20, loss of wrist

movement > 20 and angulations on radiograph > 20 degree<sup>(13)</sup>. In our study, the results were satisfactory in 24 cases (96%) and unsatisfactory in 1 case (4%) due to pin loosening and migration of the distal fragment.

**Zamzam and Khoshhal** retrospectively reviewed 183 children with a simple fracture of the distal radius, with or without fracture of the ulna, treated by closed reduction and cast immobilization. The fracture redisplaced after an initial acceptable closed reduction in 46 (25%). Complete displacement at the first diagnosis was identified as the most important factor leading to redisplacement. Other contributing factors were the presence of an ipsilateral distal ulnar fracture, and the reduction of completely displaced fracture under deep sedation or local hematoma block. The recommendations were that completely displaced fractures of distal radius in children should be reduced under general anesthesia and fixed by primary percutaneous K wires even when a satisfactory closed reduction had been achieved. In our study, one case treated by percutaneous pinning redisplaced (4%), which had unsatisfactory results due to pin migration<sup>(9)</sup>.

**McLauchlan et al.**<sup>(18)</sup> in a prospective study on 68 children who had a completely displaced fracture of the distal radius were treated either by manipulation and application of an above-elbow cast alone or by additional insertion of a percutaneous Kirschner (k-wire). The follow-up radiologically and clinically was obtained in 65 children and 56 returned for clinical evaluation three months after injury. Maintenance of reduction was significantly better in the K-wire group and fewer follow-up radiographs were required. One case in the K-wire group required exploration for recovery of a migrated wire. They concluded that the use of a percutaneous K-wire to augment the reduction of the fracture in children who had a completely displaced fracture of the distal radius is a safe and reliable way of maintaining fracture alignment. In addition, they reported that closed reduction and percutaneous pin fixation decreased the incidence of these complications.

**Zeng et al.** evaluated the results of treatment with closed reduction and percutaneous Kirschner wires in childhood unstable distal radius physis fractures. 43 children (33 boys, 10 girls; mean age 11.7 years old; range 8.6 to 16 years) were treated with immediate closed reduction and percutaneous K wires. Fractures with more than fifty percent displacement were considered unstable. A satisfactory reduction was defined as the presence of 80% cortical contact on anteroposterior and lateral x-rays, an angulation of less than 20 degrees at ages below 10 years and 15 degrees at ages above 10 years, and the absence of malrotation. Clinically, the range of motion of the elbow and wrist, forearm supination and pronation and grip strength were measured and compared with those of the other side in the 12<sup>th</sup> postoperative week. They considered restriction of 10 degrees or more in relation to the

other side as failure. Radiologic indications of failure in the post operative sixth week were residual angulations of more than 15 degrees and 10 degrees at ages below and above 10 years, respectively, and malrotation. Forty-one patients (93.2%) achieved a successful outcome. Failure was encountered in two patients (6.8%). The two patients developed pin tract infection, which resolved with antibiotic therapy and wound care. Patients returned to their normal activities in a mean of ten weeks. They concluded that closed reduction and the use of percutaneous Kirschner-wires proved to be the choice of treatment in unstable distal radius fractures in children<sup>(19)</sup>.

**Choi et al.**<sup>(13)</sup> reported that distal radius fractures are common in children. Recent studies reported that treatment by closed reduction and application of plaster is doubtful. The most important risk factor about these fractures is translation of the fracture. If a distal radius fracture is displaced by more than 50% at the fracture site, it should be classified as high risk. They performed percutaneous K-wire pinning on 157 such high-risk distal radius fractures in children less than 16 years of age. The predicted early and late failure rate was reduced from 60% to 14% and only 1.5% of patients had significant limitation of forearm movement of more than 15 degrees in the final assessment. There were no cases complicated by early physeal closure or deep infection. They reported that percutaneous K wire has a place in high risk group of patient with over 50% translation of the fracture. Percutaneous pinning provided stable, anatomic reductions without the need for additional treatment; however, there was a similar rate of complications, as a result of pin-track infection, irritation of radial sensory nerve, or irritation of an extensor tendon. There were no instances of tendon disruption, permanent nerve injury, or growth arrest. In addition, there were no major differences in clinical, radiographic, or cost of treatment outcomes between these two groups at the time of final follow-up. The decision to use a cast or percutaneous pinning depends on the surgeon's preference and should be based on a thorough understanding of the risks and benefits associated with each procedure. In our study, 25 children were treated by closed reduction and percutaneous pin fixation. Fracture reduction with greater stability was achieved. Complication rate was low and the range of joint motion was excellent at 12 weeks. One case had pin tract infection which lead to pin loosening and migration, this lead to redisplacement after removal of pin and had unsatisfactory result (4%) and twenty four cases had satisfactory results with no complication (96%)<sup>(18)</sup>.

**Nwobi and Krishna** reported that the mean age of 4 years was recorded in children treated by closed reduction and cast alone. 35% needed re-manipulation from displacement during period of plaster immobilization. Mal-union was recorded and the children required additional x-ray evaluation

during follow-up. In the mean age of 7 years, they found it expedient to insert percutaneous pins. Fracture reduction with greater stability was achieved. Complication rate was low and the range of joint motion was excellent at 12 weeks. In our study, five cases fewer than seven years treated by closed reduction and percutaneous pinning due to unstable reduction, all had satisfactory results (100%) and no unsatisfactory results was recorded. Twenty cases were treated by closed reduction and percutaneous pinning due to unstable reduction in the age of seven years or more. Nineteen cases had satisfactory results (95%) and one case had unsatisfactory result (5%). Percutaneous pinning was preferred because the stability after reduction was unreliable for reasons as resolution of traumatic edema, difficulty in obtaining reduction, greater mobility of such children and bone mass<sup>(20)</sup>. Fractures at similar level of both forearm bones mostly couldn't be reduced by closed method. Management by casting alone may be inadequate because of the difficulty in maintaining alignment. The need for early reduction has long been understood. They identified two factors which increase the chance of re-displacement of distal radius fracture in children; the presence of complete displacement and failure to achieve a perfect reduction. Previously *Alemdaroglu et al.* reported that the re-displacement may be due to position of immobilization in plaster. *Malviya et al.* suggested that re-displacement may be due to loose cast and reported that re-manipulation might be safe and effective but they advised the addition of K wire percutaneously in a high risk cases. In our study twenty five cases treated by closed reduction and percutaneous pinning have no re-displacement except in one case (4%) due to pin infection<sup>(21, 22)</sup>.

## CONCLUSION

We suggest that children who initially have a completely displaced fracture of the distal radius should be manipulated under general anesthesia and recommend that percutaneous K-wire fixation is used to ensure stabilization and avoid redisplacement, even when a perfect closed reduction has been achieved.

## REFERENCES

- Carson S, Woolridge DP, Colletti J, Kilgore K (2006):** Pediatric upper extremity injuries. *Pediatric clinics of North America*, 53 (1): 41-67.
- Ogden JA (2006):** Skeletal injury in the child. <https://www.springer.com/gp/book/9780387985107>
- Shin AY, Deitch MA, Sachar K, Boyer MI (2004):** Ulnar-sided wrist pain: diagnosis and treatment. *JBJS.*, 86 (7): 1560-74.
- Bado JL (1967):** The Monteggia lesion. *Clin Orthop.*, 50: 71-86.
- Caine D, DiFiori J, Maffulli N (2006):** Physeal injuries in children's and youth sports: reasons for concern?. *British Journal of Sports Medicine*, 40 (9): 749-60.
- Shapiro F (2016):** Epiphyseal Growth Plate Fracture-Separations. In: *Pediatric Orthopedic Deformities*, Volume 1. Springer, Cham., pp: 505-612.
- Rozental TD, Beredjikian PK, Bozentka DJ (2003):** Longitudinal radioulnar dissociation. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, 11 (1): 68-73.
- Kocher MS, Waters PM, Micheli LJ (2000):** Upper extremity injuries in the pediatric athlete. *Sports Medicine*, 30 (2): 117-35.
- Zamzam MM, Khoshhal KI (2005):** Displaced fracture of the distal radius in children: factors responsible for redisplacement after closed reduction. *Bone & Joint Journal*, 87 (6): 841-3.
- Slutsk Y (2010):** External fixation of distal radius fractures. <https://www.ncbi.nlm.nih.gov/pubmed/18070654>
- Ritchie JV, Munter DW (1999):** Emergency department evaluation and treatment of wrist injuries. *Emergency Medicine Clinics*, 17 (4): 823-42.
- Ozcan M, Memisoglu S, Copuroglu C, Saridogan K (2010):** Percutaneous Kirschner Wire fixation in distal radius metaphyseal fractures in children: does it change the overall outcome?. *Hippokratia*, 14 (4): 265.
- Choi KY, Chan WS, Lam TP et al. (1995):** Percutaneous Kirschner-wire pinning for severely displaced distal radius fractures in children. A report of 157 cases. *The Journal of bone and joint surgery*, 77: 797-801.
- Armstrong N, Welsman JR, Chia M (2001):** Short term power output in relation to growth and maturation. *British Journal of Sports Medicine*, 35 (2): 118-124.
- Zimmermann R, Gschwentner M, Kralinger F et al. (2004):** Long-term results following pediatric distal forearm fractures. *Archives of Orthopaedic and Trauma Surgery*, 124 (3): 179-186.
- Peterson HA (2007):** Distal radius. Epiphyseal Growth Plate Fractures, 227:72.
- Blakemore LC, Cooperman DR, Thompson GH et al. (2000):** Compartment syndrome in ipsilateral humerus and forearm fractures in children. *Clinical Orthopaedics and Related Research*, 376: 32-8.
- McLauchlan GJ, Cowan B, Annan IH, Robb JE (2002):** Management of completely displaced metaphyseal fractures of the distal radius in children: a prospective, randomised controlled trial. *The Journal of bone and joint surgery*, 84 (3):413-7.
- Zeng ZK, Liang WD, Sun YQ et al. (2018):** Is percutaneous pinning needed for the treatment of displaced distal radius metaphyseal fractures in children?: A systematic review. *Medicine*, 97 :36.
- [https://www.researchgate.net/.../249994431\\_Fractures\\_of\\_the\\_distal\\_forearm\\_bones\\_in...](https://www.researchgate.net/.../249994431_Fractures_of_the_distal_forearm_bones_in...)**
- Alemdaroglu KB, Iltar S, Çimen O et al. (2008):** Risk factors in redisplacement of distal radius fractures in children. *JBJS.*, 90 (6): 1224-30.
- Malviya A, Tsintzas D, Mahawar K et al. (2007):** Gap index: a good predictor of failure of plaster cast in distal third radius fractures. *Journal of Pediatric Orthopaedics B.*, 16 (1): 48-52.