

Closed Reduction of Severely Angulation Rockwood and Wilkins' Type C Thumb Metacarpal Base Fractures in Children

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Research article

Keywords: Thumb Metacarpus, Fractures, Percutaneous Leverage, Children

Posted Date: June 23rd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-36212/v1>

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Abstract

Background: Management of severely angulation Rockwood and Wilkins' type C(RW-C) thumb metacarpal base fractures in children is challenging. We report experiences of leverage reduction and dual antegrade crossing Kirschner wires (DACK-wires) fixation in these fractures, aiming to assess the results using our technique.

Methods: From October 2011 to September 2015, 17 children with severely angulation RW-C thumb metacarpal base fractures were treated at our institute. All patients underwent percutaneous leverage reduction and DACK-wires fixation in an average surgery time of 20 minutes (range 12 ~ 32minutes). The injured arm was immobilized of a thumb-spica cast including the entire first ray for 4-6 weeks, evaluated clinically and radiologically. The Cannon scoring system were used to evaluate the results. Percutaneous leverage and DACK-wires fixation were performed for 17 patients. No patients were treated with open reduction. 16 patients were followed up for a mean of 30 months (range 12-41 months).

Results: There were 9 girls and 7 boys with ages ranging from 7.5 to 14.0 years and an average age of 10.8 years. Percutaneous leverage reduction and DACK-wires were successfully used in an average total surgery time of 20 minutes (range 12 ~ 32 minutes). Bone union was achieved in all patients within a mean time of 4.2 weeks (range 4~6 weeks). The average angulation (pre-operation; 50.5° (range 40.8°–67.0°) vs post-operation: 5.0° (range 0.0°–7.0°) was significantly different($P<0.05$). The clinical results were evaluated by the Cannon scoring system, and there were 15 excellent results and one good result. There were no refractures and no incidences of nonunion, growth arrest in the proximal epiphysis. Only one patient suffered from superficial infection which was resolved after removal of k-wires and oral antibiotics. Cosmetic results were described as good and satisfactory by all patients.

Conclusion: Our percutaneous leverage technique with DACK-wires fixation can be successfully used to these fractures. This technique is simple to learn and minimally invasive, and the results are excellent.

Background

Thumb metacarpal fractures account for 1–5% of hand fractures in children,with mostly occurring in the base[1, 2, 3]. Different from the classification of the adult thumb metacarpal base fractures [4], these fractures in children were classified into four types; type A metaphyseal fractures; type B Salter-Harris(S-H) type I physeal fractures with lateral angulation; type C S-H type II physeal fractures with medial angulation; type D S-H type III fracture (pediatric Bennett fracture) [5, 6, 7] .Very few articles have specifically reported with the treatment of these fractures especially for severely angulation type C(RW-C). The purpose of our retrospective study is to determine the safety and efficacy of our technique for the treatment of severely angulation RW-C fractures.

Methods

Patients

This study was approved by the Institutional Ethical Review Board of Dalian Children's Hospital, (approval number 20003). Written informed consent was obtained from all guardians for anonymized data analysis and publication. A total of 17 patients with severely angulation RW-C thumb metacarpal base fractures were treated at our hospital from October 2011 to September 2015. A total of 16 patients were followed up for a mean of 30 months (range 12–41 months). All cases were classified as severely angulation RW-C fractures (mean angle 50.5°; range 40.8°–67.0°). There were 9 girls and 7 boys with an average age of 10.8 years (range 7.5 to 14.0 years). The fractures were 10 patients on the right side and 6 patients on the left side. All surgery procedures were performed by the senior surgeon in an average surgery time of 20 minutes (range 12 ~ 32minutes). The injured arm was immobilized of a thumb-spica cast including the entire first ray for 4–6 weeks, evaluated radiologically and clinically.

Surgical Procedures

All patients received general anesthesia. First, with the guide of the C-arm image intensifier, a leverage K-wire with a 1.5 mm diameter was percutaneously inserted into the bone fragment from the displacement direction of the fractured thumb metacarpal base fragment (Fig. 1,2). Care must be taken not to penetrate too deeply past the dorsal cortex of the distal fragment. Once the K-wire is cross the fracture site, it is levered into position and supplementary pressure is placed on the volaris of the distal fragment to reduction. Then reduction was confirmed with an image intensifier (Fig. 3a,3b). Reduction was maintained with DACK-wires with equal diameter 1.0 mm (Fig. 3c). All fractures were reduced anatomic reduction. After successful reduction and fixation, the excessive part of the nail was bent to an angle of 90°. A 1.0–2.0 cm length of the wires were reserved outside of the shin. The injured arm was immobilized of a thumb-spica cast including the entire first ray for 4–6 weeks when the wires and cast were removed at outpatient department, then continuous passive motion (CPM) was encouraged.

Postoperative evaluation

The first clinical and radiographic review was conducted two weeks after surgery. Then, the fixation and bone union were radiographically examined at 4 weeks, 6 weeks, 8 weeks and 6 months postoperatively and thereafter at half-year intervals. The bone union was indicated by the disappearance of fracture lines in 3 of the 4 cortices on radiographs of the thumb in both the antero-posterior and lateral. Clinical control was achieved 4 or 6 weeks after surgery with the removal of the k-wires and cast, meanwhile active exercise was encouraged to recover the full range of motion of thumb. The average follow-up was 30 months (range 12–41 months). The results were assessed using Cannon scoring system [8] (Fig. 4).

Statistical analysis

SPSS v22 was used for statistical analysis. If the distribution was nonparametric, a Mann-Whitney U test for independent samples was conducted. If parametric, the Paired-Samples T test was used to analyze the difference between the pre-operation and post-operation results. Significance was set at $p < 0.05$.

Results

There were 9 girls and 7 boys with ages ranging from 7.5 to 14.0 years and an average age of 10.8 years. Percutaneous leverage reduction and DACK-wires were successfully used in an average total surgery time of 20 minutes (range 12 ~ 32minutes). Bone union was achieved in all patients within a mean time of 4.2 weeks (range 4 ~ 6 weeks). The average angulation (pre-operation; 50.5° (range $40.8^\circ - 67.0^\circ$) vs post-operation: 5° (range $0.0^\circ - 7.0^\circ$)) was significantly different ($P < 0.05$). Only one patient suffered from superficial infection which was resolved after removal of k-wires and oral antibiotics. The clinical results were evaluated by the Cannon scoring system, and there were 15 excellent results and one good result. There were no deep infection and secondary displacement, malunion, growth arrest in the proximal physis. All of 16 patients have recovered full mobility of the first ray compared to the contralateral side.

Discussion

Most of the fractures of thumb metacarpals can be treated successfully nonoperative, but a less subset, especially severely displaced RW-C requires aggressive procedures. The rupture of the periosteum makes the distal fragment unstable and immobilization with the first ray unreliable [7]. Studies on this topic are rare. The management of obviously displaced RW-C thumb metacarpal base fractures in children still is a challenge for pediatric orthopedics. Closed reduction is more difficult for severely angulation and displaced RW-C fractures.

According to some authors, RW-C fractures under 30% angulation disbalance can be treated by closed reduction and splinting. We synthesized the results of Kulus SC [9] and Kuntscher [10] Anteroposterior and lateral X-ray films and three-dimensional computerized tomography(3DCT) of the injured hand were taken for each child. the maximum angle of fracture was > 40 degrees, displacement of fracture $> 2/3$, or children with rotational deformity were conducted with aggressive procedures. All 17 cases were in accordance with these operative indications.

The mobility of the metacarpal base and the swelling make closed reduction difficult. Comminution, soft tissue interposition, or transperiosteal "buttonholing" may further complicate reduction [5, 11]. The aim of treatment of these fractures is to obtain anatomic reduction. An unsuccessful closed reduction requires open reduction and fixation [5]. For the RW-C fractures, the distal part fragment of fracture moves toward the second metacarpal and hides into thenar. Manual closed reduction of RW-C fracture needs axial traction on the thumb and pressure is placed on the base of the distal fragment [12]. Both of the second metacarpal and thenar hider impact the manual closed reduction. In our theory, these are the true reasons for the failure of closed reduction. Our leverage technique described in this study proved minimal invasive and reliable to avoid open reduction.

Although some studies reported severely displaced RW-C fractures might require open reduction to remove any interposed periosteum that blocked reduction. Open reduction is indicated for irreducible RW-C fractures [10, 13]. Jehanno et al reported open reduction is not due to interposition of tendons or of the periosteum [7]. In general, manual reduction and leverage treatment of pediatric fractures are successful in most cases with good results, including S-H type χ fractures of the distal radius, radial neck fracture, supracondylar fracture, Bennett fracture, and satisfactory results have been achieved [14–17]. We conduct leverage reduction to obtain anatomical reduction of these fractures. The attempt times of leverage manual reduction can be reduced to less than 3, meanwhile the injury of physis caused by the tip of leverage k-wire can be avoided. There was no physis premature closure, bone bridge formation and epiphyseal ischemic necrosis in our cases.

There are many options for pin configuration including pinning across the reduced carpometacarpal (CMC) joint, Iselin technique, modified Iselin technique, and direct fixation across the fracture [7, 10, 13, 18, 19, 20]. Some authors recommend that intraarticular k-wires may aggravate articular surface lesion which will cause post-traumatic arthritis. This is why the Iselin method was proposed [21]. Some researchers reported the incidence of secondary displacement because of faulty Iselin technical approach and the loss of the maintaining the quality of reduction [12]. Wiggins preferred the technique that a transfixing k-wire across the epiphyseal growth plate, which has never been reported to cause epiphysiodesis [22]. Hastings also reported the thumb base fracture fixation with the longitudinal K-wires fixation with good results [18]. We prefer DACK-wires fixation, which has been proved to be good technique in previously studies. Bone union was achieved in all 16 patients within a mean time of 4.2 (range 4 ~ 6 weeks). The clinical results were 15 excellent results and one good result, without secondary displacement of the fracture, tendinous adhesion. In our experience, the advantages of DACK-wires fixation include easy selection of needle puncturing point, stable transfixing K-wires across the epiphyseal growth plate which is more stable than Iselin technique.

In our research, most of the duration time of leverage procedures were performed within 0.29 min by 1–3 attempts of attempts. Longer duration time of leverage procedure are associated with more radiation exposure (RE). The risk of RE need to be understood and minimized in pediatric trauma theatres, which is associated with malignant diseases [23]. Ultrasonography (US) has also been used for intraoperative monitor for the treatment of radial neck fractures in children to reduce the dose of RE [24]. The US could be courageous alternative of X-ray in the near future for this kind of fractures during the intraoperative intensifier.

Our experience shows that the following key points should be mastered in the procedures: (1) According to preoperative imaging data and C-arm image intensifier, the plane with the largest displacement and angulation of fractures should be judged as the leverage plane, so as to achieve anatomical reduction and reduce times of leverage. (2) adjacency of abductor pollicis longus tendon and the first metacarpal epiphysis are tagged as the puncturing points of wires to reduce the tendinous adhesion. (3) DACK-wires fixation is reliable; (4) When leveraging, the tip of the K-wire should be moved toward the metaphyseal to

prevent the injury of physis; (5) Different from other metacarpals, AP and lateral X ray of the thumb metacarpal were available, which can show angulation and displacement more reliable.

The main limit of this study was that it is a retrospective cohort with a small size, without control group. We cannot confirm that our technique is superior than others. However, our series dose obtain satisfactory outcomes with less complains. Further studies with a large cohort would be needed.

Conclusions

Our percutaneous leverage technique with DACK-wires fixation may be successfully used to these fractures. This technique is simple to learn and minimally invasive, and the results are satisfactory. It would be one approving choice for the treatment of the severely displaced RW-C fractures.

Abbreviations

RW-C, Rockwood and Wilkins' type C

DACK-wires, dual antegrade crossing Kirschner wires

S-H, Salter-Harris

CPM, Continuous passive motion

CMC, carpometacarpal

3DCT, three-dimensional computerized tomography

US, Ultrasonography

RE, radiation exposure

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the Institutional Ethical Review Board of Dalian Children's Hospital, 154 Zhongshan Road, Dalian 116012, China (approval number 20003). Informed consent was waived due to the retrospective nature of this study.

Consent for publication

Written informed consent was obtained from all guardians for anonymized data analysis and publication.

Availability of data and materials

All data generated and/or analyzed during the current study are available in this published article. Data required that are not in the article are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

None.

Authors' contributions

FQ and FJ collected patient material, designed and drafted the manuscript. FQ and FJ collected material, advised on the main subject and worked on the manuscript, FQ was the main statistician. FQ edited manuscript and presented the concept of the study. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

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Figures

A

B



Figure 1

Typical thumb metacarpal base RW-C fracture of 10.5 years old boy. a AP X-Ray of left thumb preoperative. b lateral X-Ray of left thumb preoperative.

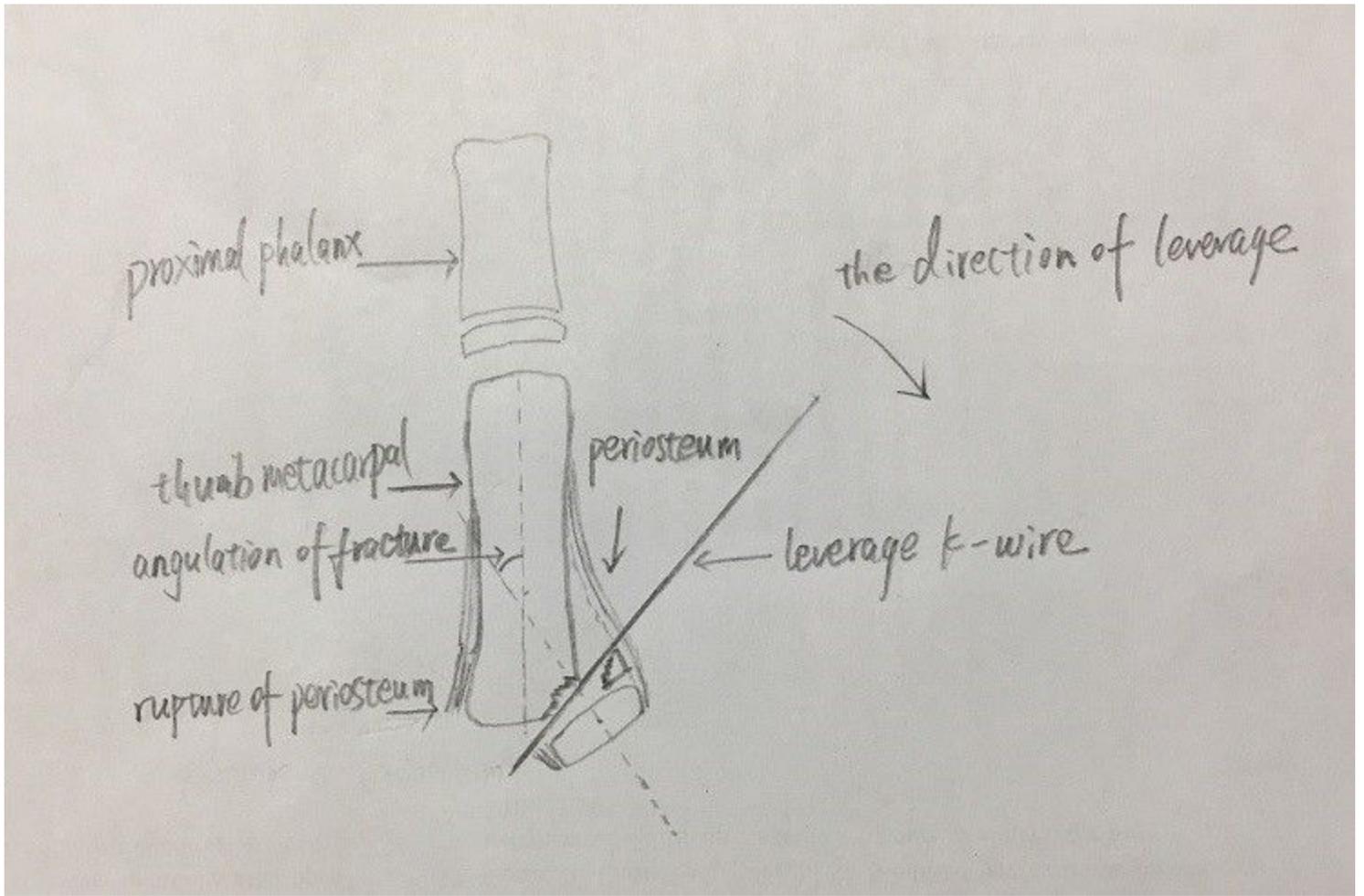


Figure 2

Diagram of percutaneous leverage of RW-C fracture of left hand (drawn by Dr. Qiao).

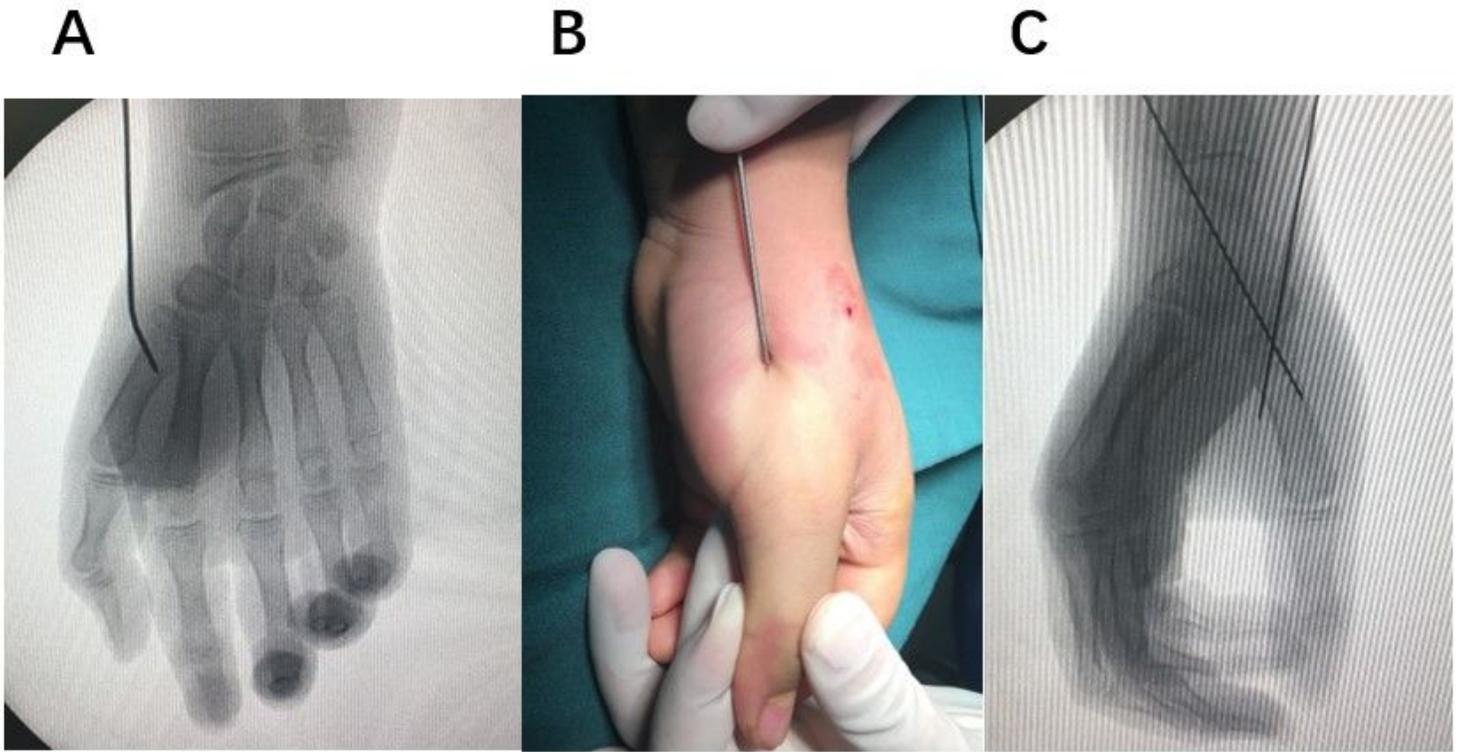


Figure 3

Typical thumb metacarpal base RW-C fracture of 10.5 years old boy. a leverage reduction of the fracture. b aspect of leverage reduction. c C-arm result after pinning fixation.

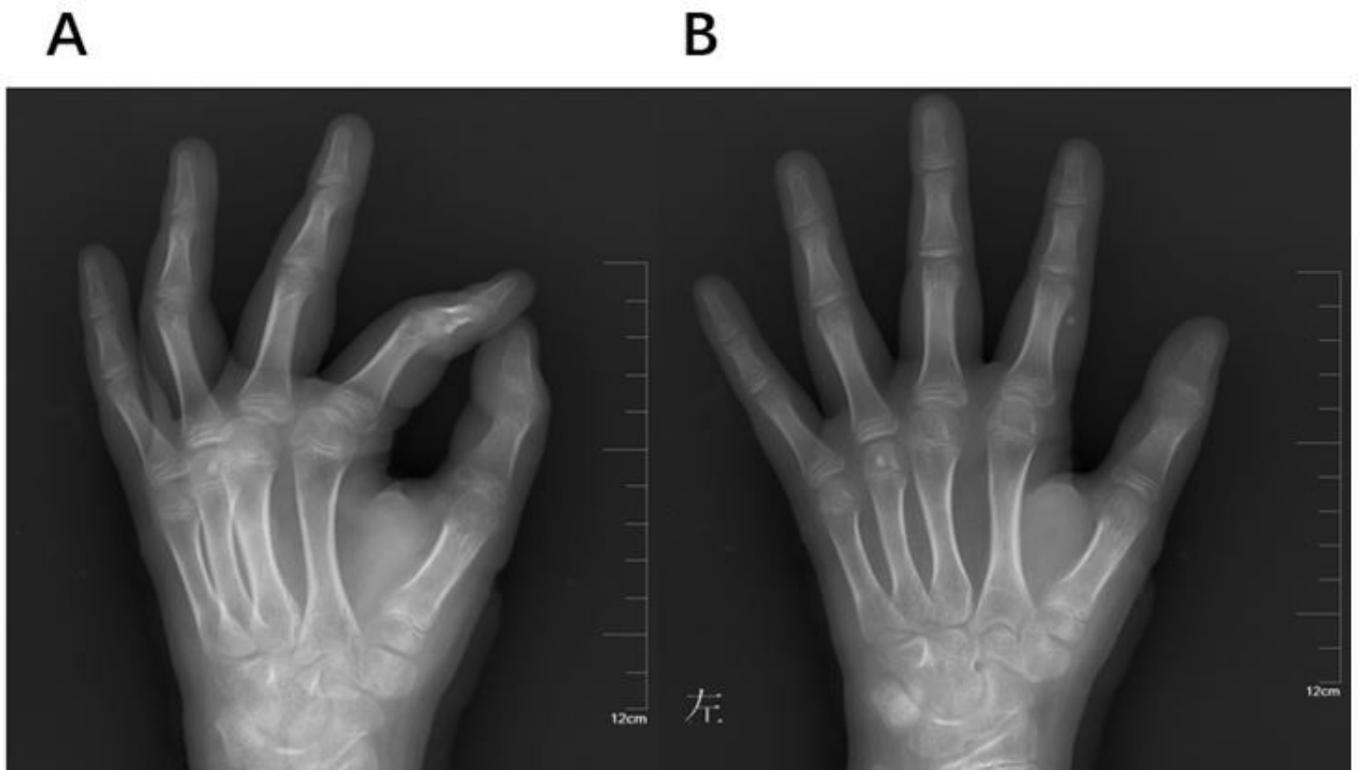


Figure 4

Typical thumb metacarpal base RW-C fracture of 10.5 years old boy.8 weeks follow-up X ray.

Supplementary Files

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