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TRAUMA SURGERY

Treatment of physeal fractures of the distal radius by volar intrafocal Kapandji method: surgical technique

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Abstract
Background Distal radial physeal fractures with volar displacement are rare. Several methods of operative treatment include volar plate without inserting distal screws, percutaneous technique using two anterior skin incisions and reversed Kapandji technique with pins introduced through a posterior approach and locked at the anterior cortex of the fracture.
Methods We report three cases along with a literature review of the surgical techniques described in the past and a novel surgical technique for this uncommon fracture termed "Volar Kapandji".
Results All patients had anatomic reduction at the last follow-up radiography, and all patients had a full range of motion and VAS 0 at the last follow-up. No complications were recorded.
Conclusions This case study presents the minimally invasive option for treating rare cases of physeal distal radius fractures with volar displacement.
Level of evidence V.

Keywords Child · Distal radius fracture · Intra focal pinning · Kapandji · Pediatric · Physeal fractures · Surgical technique

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Introduction

Distal radial physeal fractures represent approximately 20% of all growth plate fractures in children, second in frequency only to those of the phalanges [1]. Fractures with less than 15° of angulation and up to 1 cm of shortening will demonstrate complete remodeling without functional impairment in skeletally immature patients [2].

Most of the cases are the result of a fall on a hyperextended wrist, resulting in displacement of the fracture dorsally. A rare type of injury in which the fracture displaces vollarly (Fig. 1) occurs in less than 5% of distal radius physeal fractures [3, 4]. Tredwell et al. described only six cases of 72 (8%) distal radius physeal fractures [5], while Cannata et al. described only five cases of 157 (3%) distal radius physeal fractures [6].

The fracture can be treated operatively by several methods. Seriat-Gautier and Jouve used a plate without inserting the distal screws [7]. Hoël and Kapandji described a percutaneous technique using two anterior skin incisions, 5 mm medial to the radial artery and lateral to the ulnar artery, to pass Kirschner wires into the fracture site before reducing the fracture (Fig. 2). The wires were then advanced into the posterior cortex at an angle of 45° [8]. Guichet et al. described a reversed Kapandji technique with the pins introduced through a posterior approach and locked at the anterior cortex at the fracture site after reduction (Fig. 3) [9].

We describe a surgical technique termed "Volar Kapandji" that we previously described for intra-articular distal radius fractures in adults [10].

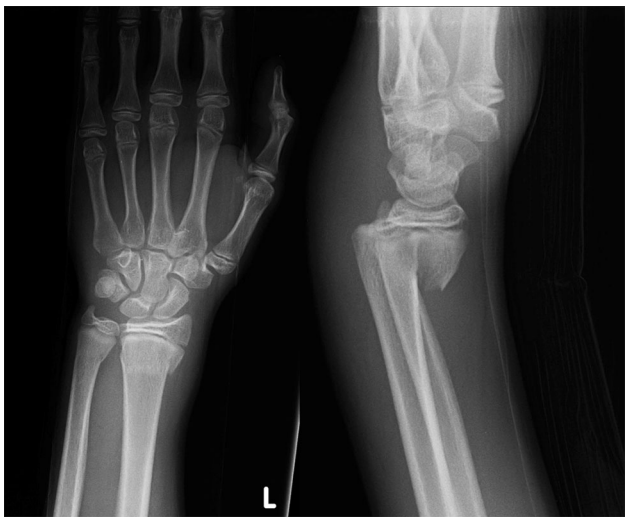

Fig. 1 Preoperative radiographs of a distal radius fracture

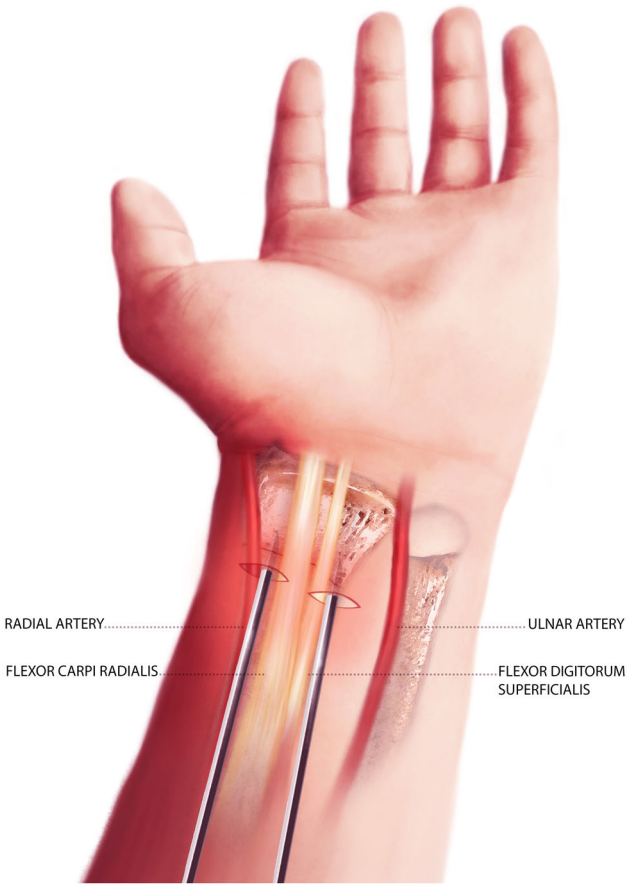

Fig. 2 Hoël and Kapandji described a percutaneous technique using two anterior skin incisions, 5 mm medial to the radial artery and lateral to the ulnar artery, to pass Kirschner wires into the fracture site

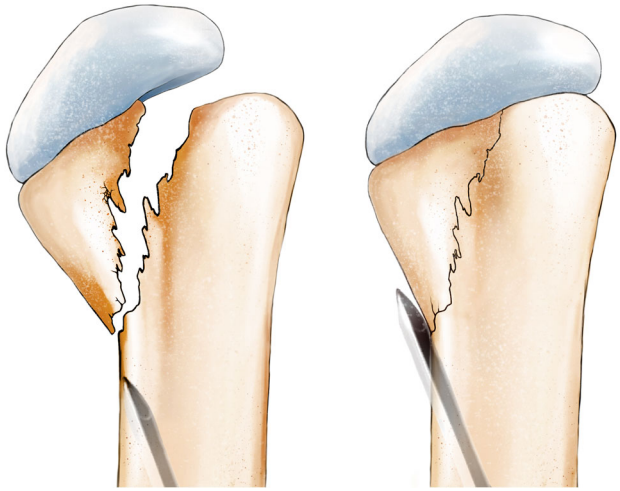

Fig. 3 Guichet et al. described reversed Kapandji technique with the pins introduced through a posterior approach and locked at the anterior cortex at the fracture site after reduction

Patients and methods

Subjects

Three patients with distal radial physeal fractures with anterior displacement were treated with the "Volar Kapandji technique". The follow-up evaluations, which were conducted for three months from the injury, included assessments of wrist motion, standard wrist radiographs and visual analog scores (VAS).

Surgical technique

Surgery was performed with the patient under general anesthetic. We inserted smooth K-wires [1.4/1.6 mm (0.054/0.062 in.) diameter] into the fracture site of the radius with fracture reduction according to the fracture pattern. The K-wires were well padded, and a below-elbow plaster cast was applied for 4 weeks following surgery. The K-wires were removed 4 weeks' post-surgery. Active finger motion was encouraged early after surgery. Active and active-assisted motion of the wrist joint was started according to patient tolerance, following removal of the plaster cast.

Volar K-wire insertion technique

We used a technique similar to volar radial arthroscopic portal placement [11]. Under a fluoroscopic intensifier of the fracture site, the joint line and the flexor carpi radialis tendon (FCR) were marked on the skin (Fig. 4a). A 1 cm longitudinal incision was made over the FCR. The tendon

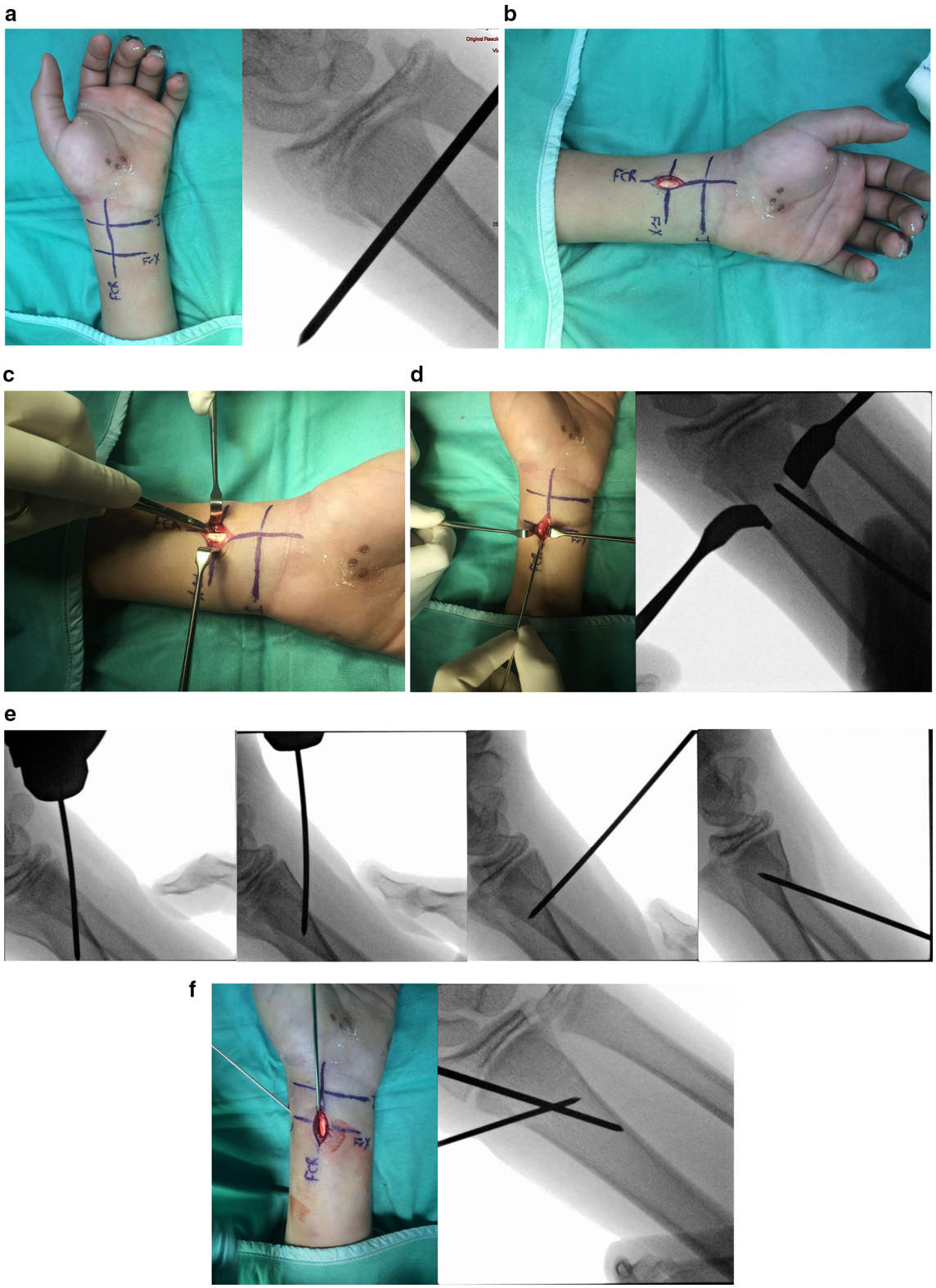

Fig. 4 **a** Under fluoroscopic intensifier, the fracture site, joint line and flexor carpi radialis tendon are marked on the skin. **b** A 1 cm longitudinal incision was made over the FCR and the tendon sheath is divided. **c** The FCR tendon retracted ulnarly and a mosquito point into the fracture site. **d** K-wire being introduced into the fracture site with the drill at oscillating mode. **e** Inserting the K-wire into the fracture site, levering to restore anatomy and driving the wire into the distal cortex. f Additional K-wire added from the radial styloid

Table 1 Demographic radiographic and clinical variables of patients

Case	Gender	Age	Side	Injury	Primary treatment	Indication for operation	Follow-up (months)	Result
1	Male	8	Right	Fall	Reduction and cast	Loss of reduction	3	Full ROM, VAS 0
2	Male	15	Left		Reduction and cast	Loss of reduction	3	Full ROM, VAS 0
3	Male	17	Left	Fall from bicycle	Reduction and cast	Loss of reduction	3	Full ROM, VAS 0

ROM range of motion, *VAS* visual analog scale

Fig. 5 One month postoperative radiographs of the distal radius fracture

sheath was divided (Fig. 4b) and the FCR tendon retracted ulnarly with a K-wire being introduced through a mosquito point into the fracture site, with the drill at oscillating mode to avoid any unnecessary damage (Fig. 4c–e). Additional K-wires were added from the radial styloid (Fig. 4f).

Anatomy

The volar radial arthroscopic portal was studied in several articles, regarding its safety and proximity to the radial artery and the palmar cutaneous branch. Rees et al. performed arterial injection studies to investigate the vascular anatomy surrounding the volar radial portal, using a gelatin and lead oxide mixture or India ink in five fresh frozen cadaver arms. Measurements taken from the area surrounding the volar radial portal showed a "safe zone", free of any neurovascular structures, that consisted of the width of the FCR tendon plus at least 3 mm or more in all directions [12]. The palmar cutaneous branch is closest in proximity but always lies to the ulnar side of the FCR [13, 14].

Fig. 6 Three-month postoperative wrist ranges of motion of patient number 1 involving the *right hand*

The portal for the entry of the K-wire is proximal to the volar radial arthroscopic portal which can be even safer regarding the palmar cutaneous branch.

Results

Three patients (Table 1) completed follow-up of three months. All patients had reduction and casting on the day of arrival and a loss of reduction in the next follow-up appointment. All patients had anatomic reduction at the last follow-up radiography (Fig. 5), and all patients had a full range of motion and VAS 0 at the last follow-up (Fig. 6). No complications were recorded.

Discussion

Surgical treatment for the rare cases of volar displaced physeal distal radius fractures is described in very few articles so far. Plate fixation was described in seven patients [7]. When considering this technique, we should keep in mind the high complication rate of this procedure [15, 16] and the need for another operation to remove the pates.

Guichet et al. described a technique of inserting K-wires from the posterior approach to avoid neurovascular damage. They treated six patients with good results [9]. The disadvantage of the technique is the difficulty in buttressing the fracture from the dorsal approach.

Hoël and Kapandji described volar insertion of two pins and found it to be safe and effective [8]. The disadvantage of the technique is the risk to neurovascular structures with the use of two K-wires. We used only one volar K-wire. The major concern in this minimally invasive technique concerns safety while inserting a K-wire in the volar aspect of the wrist. The anatomy of this region can jeopardize the median nerve and its palmar cutaneous branch and the radial artery; however, several investigations addressing the volar radial arthroscopic portal found it to be safe [12–14].

Slutsky et al. [11, 17] described their results with the volar radial portal in cadavers and patients. They found a safe zone greater than 3 mm surrounding the portal that was free of any neurovascular structures, with no complications being recorded from the use of the portal in 30 patients. We also used the drill in an oscillating mode when inserting the K-wire to ensure no possibility of damaging a neurovascular structure.

The limitations of this study are the small group of patients and its retrospective nature. Nevertheless, this case study presents the minimally invasive option for treating rare cases of physeal distal radius fractures with volar displacement.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Peterson HA, Madhok R, Benson JT, Ilstrup DM, Melton LJ 3rd (1994) Physeal fractures: part 1. Epidemiology in Olmsted County, Minnesota, 1979-1988. J Pediatr Orthop 14(4):423–430
2. Do TT, Strub WM, Foad SL, Mehlman CT, Crawford AH (2003) Reduction versus remodeling in pediatric distal forearm fractures: a preliminary cost analysis. J Pediatr Orthop B 12(2):109–115
3. Schoenecker JG, Bae DS (2015) Fractures of the Distal Radius and Ulna. In: In Rockwood and Wilkins' fractures in children. Eighth edition. edn. Wolters Kluwer Health, Philadelphia, 356
4. Wilkins KE, Beaty JH (1994) Operative management of upper extremity fractures in children. American Academy of Orthopaedic Surgeons monograph series, American Academy of Orthopaedic Surgeons, Rosemont
5. Tredwell SJ, Van Peteghem K, Clough M (1984) Pattern of forearm fractures in children. J Pediatr Orthop 4(5):604–608
6. Cannata G, De Maio F, Mancini F, Ippolito E (2003) Physeal fractures of the distal radius and ulna: long-term prognosis. J Orthop Trauma 17(3):172–179
7. Seriat-Gautier B, Jouve JL (1988) Avulsion fractures of the distal part of the radius with anterior displacement in children. Chir Pediatr 29(5):265–268
8. Hoel G, Kapandji AI (1995) Osteosynthesis using intra-focal pins of anteriorly dislocated fractures of the inferior radial epiphysis. Ann Chir Main Memb Super 14(3):142–156
9. Guichet JM, Moller CC, Dautel G, Lascombes P (1997) A modified Kapandji procedure for Smith's fracture in children. J Bone Joint Surg Br 79(5):734–737
10. Rubin G, Chezar A, Rinott M, Bor N, Rozen N (2013) Treatment of intra-articular distal radius fractures by the volar intrafocal Kapandji method: a case series. Tech Hand Up Extrem Surg 17(2):91–98
11. Slutsky DJ (2002) Wrist arthroscopy through a volar radial portal. Arthroscopy 18(6):624–630
12. Rees MJ, Taylor GI (1986) A simplified lead oxide cadaver injection technique. Plast Reconstr Surg 77(1):141–145
13. DaSilva MF, Moore DC, Weiss AP, Akelman E, Sikirica M (1996) Anatomy of the palmar cutaneous branch of the median nerve: clinical significance. J Hand Surg Am 21(4):639–643
14. Martin CH, Seiler JG III, Lesesne JS (1996) The cutaneous innervation of the palm: an anatomic study of the ulnar and median nerves. J Hand Surg Am 21(4):634–638
15. Arora R, Lutz M, Hennerbichler A, Krappinger D, Espen D, Gabl M (2007) Complications following internal fixation of

unstable distal radius fracture with a palmar locking-plate. J Orthop Trauma 21(5):316–322
16. Jupiter JB, Marent-Huber M (2010) Operative management of distal radial fractures with 2.4-millimeter locking plates: a multicenter prospective case series. Surgical technique. J Bone Joint Surg Am 92(Suppl 1 Pt 1):96–106
17. Slutsky DJ (2004) Clinical applications of volar portals in wrist arthroscopy. Tech Hand Up Extrem Surg 8(4):229–238