



Treatment of paediatric unstable displaced distal radius fractures using Kapandji technique: a case series

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Abstract

Background The technique of intra-focal pinning described by Kapandji is seldom used in paediatric patients. We present our series of paediatric patients treated with Kapandji technique for unstable displaced distal radius fractures.

Methods We retrospectively reviewed medical records and radiographs of a consecutive series of 56 paediatric patients who underwent closed reduction and fixation with Kapandji technique for unstable displaced metaphyseal and Salter Harris 2 distal radius fractures, from 2008 to March 2018. One or two percutaneous K-wires were inserted intra-focally without crossing the physis to lever out, reduce and stabilize the distal fragment. The arm was immobilized with an above-elbow cast, and radiographic controls were scheduled at 1, 4, 8 weeks, at least.

Results The mean age at the time of the trauma was 10.5 years. The K-wires were removed at a mean of 6.4 post-operative weeks. An above-elbow cast was used for the first 4 weeks, afterwards a below-elbow cast for 2 weeks and a short-arm brace until the full recovery of motion. The mean follow-up was 18 months (range 1.5–108 months). No pin-related complications were found. All fractures showed good healing, and the full function of the wrist was achieved in every case.

Conclusion Kapandji pinning is a reliable technique in paediatric patients with unstable displaced distal radius fractures. It shows a lower complication rate compared to other techniques. For these reasons, we suggest implementing its use in clinical practice.

Keywords Paediatric · Distal radius · Fracture · Kapandji

Introduction

The distal radius is the most common site of paediatric fracture, accounting for 20–30% of all fractures [1]. The choice of treatment for distal radius fractures is based on the instability of the fracture and consequently on the risk of redisplacement. Eighty-five percent of displaced distal radius fractures (including not only displaced metaphyseal fractures but also Salter Harris 1-2 and greenstick fractures) can be successfully managed with conservative treatment [2]. In

case of fractures of the distal radius and ulna, an angulation inferior to 20° is acceptable in children younger than 10 years, whereas an angulation inferior to 10° is acceptable for older children [3]. In one-third of distal radius fractures, the loss of fracture reduction and redisplacement is reported [4]. The main risk factors for redisplacement are as follows: completely displaced fracture, > 11° angulation in the coronal plane and an intact ulna [5, 6].

Surgery plays a role in the treatment of unstable and redisplaced fractures [7–12]. Surgical treatment options for unstable displaced distal radius fractures mainly consist of K-wire pinning [7–16]. Some authors also used elastic stable intra-medullary nails for unstable displaced distal metaphyseal and metadiaphyseal radius fractures [17, 18].

Various techniques exist for K-wire fixation. In conventional pinning, K-wires are not directly inserted into the fracture site (extra-focal) and do not cross the physis. The insertion points are on the distal lateral edge of the metaphysis of the radius and on Lister's tubercle [7, 9, 10, 19]. Other

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authors inserted two extra-physeal K-wires, one retrograde and intra-focal, the other anterograde and extra-focal [12]. In some cases, one K-wire is inserted into the styloid instead of on the lateral edge of the distal metaphysis, thus crossing the physis [8]. K-wires can also be placed intra-physeally and extra-focally with a funnel orientation, as in the Py-Desmanet technique [20]. Intra-focal pinning as described in Kapandji technique is seldom used in paediatric patients with unstable displaced distal radius fractures. This is also demonstrated by the fact that only five studies reporting its use for distal radius fractures in children are available in the literature [13–16, 21]. Two of them describe variants of this technique for volarly displaced distal radius fractures [15, 16]. The original technique was described by Kapandji in 1976 for the treatment of distal radius fractures in adult patients [22]. It consists in levering out, reducing and stabilizing the distal fragment by means of intra-focal K-wires inserted from the radial styloid and from the dorsal aspect of the distal radius. The stability allowed via this technique carries the advantages of early rehabilitation and rapid restoration of motion in adults [23].

We present our series of paediatric patients treated with Kapandji technique for unstable displaced distal radius fractures and discuss its application and outcomes in clinical practice.

Materials and methods

We retrospectively reviewed the medical records and radiographs of a consecutive series of paediatric patients treated in our institution for unstable displaced distal radius fractures with the Kapandji technique from 2008 and followed up until March 2018.

In our centre, the Kapandji technique was indicated for unstable displaced metaphyseal and Salter Harris 2 fractures of the distal radius in paediatric patients with an open distal radius physis, as a primary or secondary treatment, as described by Guichet et al. [15].

It was used as a primary treatment when, after closed reduction under general anaesthesia, a post-reduction stability test demonstrated redisplacement of the fragments. The stability was assessed with maximal flexion and extension of the wrist, under radiographic control [15]. The Kapandji technique was also indicated as a primary treatment to aid reduction in the case of irreducible fracture at closed manipulation.

It was indicated as a secondary treatment in the case of failure of the initial conservative management with secondary redisplacement of the fracture fragments.

All skeletally immature patients treated in our institution with Kapandji technique as a primary or secondary treatment of unstable displaced metaphyseal and Salter Harris 2

fractures of the distal radius were considered eligible for this study. Exclusion criteria included the closure of the distal radial physis at diagnosis.

All the patients were treated by the same team of surgeons who used the same surgical technique and post-operative protocol.

Surgical technique

The insertion sites were on the dorsal aspect and on the lateral edge of the distal radial metaphysis. A 10-mm incision was performed at each insertion site, followed by dissection to avoid tendon and neurovascular lesions. We used K-wires with 2 mm and 2.5 mm diameter in smaller and larger children, respectively.

A dorsal K-wire was used to reduce the dorsal or volar tilt. The K-wire was manually inserted in the fracture site, without crossing the physis, to lever out and reduce the distal fragment of the radius in the sagittal plane. Then, it was drilled forward, to penetrate the volar cortex to stabilize the fracture. After wiring, the stability test was performed with maximal flexion and extension of the wrist under radiographic control, to assess the stability and the necessity of an additional wire. If necessary, to achieve the reduction in the coronal plane, the same procedure was performed with a second K-wire intra-focally and extra-physeally inserted from the lateral incision.

When radiographs and the stability test revealed good reduction and fixation, the K-wires were bent and cut, leaving the extremity exposed. In case of open fractures or when regular pin tract care could not be assured by parents, K-wires were cut shorter and buried.

In case of diaphyseal ulnar fracture, an elastic stable intramedullary nail was anterogradely inserted. In case of unstable metaphyseal ulnar fracture, the Kapandji technique was carried out in the ulna with a single K-wire.

At the end of the operation, the arm was immobilized with an above-elbow cast.

Post-operative protocol

In our post-operative protocol, during the first 4 weeks, the arm was immobilized with an above-elbow cast and afterwards, if the K-wires were not removed, in a below-elbow cast until K-wires removal.

The radiological evaluation was carried out at the first, fourth and eighth post-operative weeks to assess the bone healing. Depending on the development of a callus, unburied K-wires were removed in office between the fourth and eighth post-operative weeks. Buried K-wires were removed under general anaesthesia within the third post-operative month. Once the K-wires were removed, the patient used a short-arm brace until restoration of motion. Physiotherapy was

prescribed only when patients showed a delayed recovery of range of motion. Patients began sports without limitations within the third post-operative month.

In our centre, in case of Salter Harris 2 fractures a long-term follow-up until the end of the growth was indicated to evaluate the occurrence of epiphysiodesis. Very young children were followed up until complete remodelling of the fracture, if feasible.

Figure 1 shows the preoperative, intra-operative and last follow-up radiographs of one of our patients, as an example.

Results

We reviewed a consecutive series of 56 paediatric patients who underwent closed reduction and fixation with the Kapandji technique for unstable displaced metaphyseal and Salter Harris 2 fractures of the distal radius (Table 1).

The age at the time of the trauma ranged from 5 to 15 years, with a mean age of 10.5 years.

Forty-two patients underwent Kapandji technique as a primary treatment, whereas 14 were operated after the secondary displacement of distal radius fractures. There were six Salter Harris 2 distal radius fractures, and the others were metaphyseal fractures. Two K-wires were required for distal radius fixation in 24 cases.

As for the ulnar fractures are concerned, 14 patients had an ulnar styloid fracture that was treated conservatively. Twenty-eight patients had a distal metaphyseal ulnar fracture, surgically treated with Kapandji technique with a single K-wire in 5 cases, whereas the others were treated

conservatively. Three patients had an ulnar diaphysis fracture that underwent elastic stable intra-medullary nailing. Sixteen patients had an intact ulna. Among patients operated after failure of an initial conservative treatment, 7 had an intact ulna and 6 had an ulnar metaphyseal fracture that was treated conservatively. The mean duration of the operation was 26 min (range 10–55). When feasible, patients were discharged on the same day of the operation or the following morning, when operated overnight.

Two patients had a Gustilo I open fracture that required the irrigation and debridement of the wound, with good soft tissue healing. The K-wires were buried in patients with open fracture and in other 6 patients because parents could not assure regular pin tract care.

The K-wires were removed at a mean of 6.4 post-operative weeks, according to the development of a callus. Unburied K-wires were removed in office, whereas buried K-wires were removed under general anaesthesia at the ninth post-operative week on average.

The mean follow-up was 18 months (range 1.5–108 months). In our series, an above-elbow cast was used for the first 4 weeks, followed by the use of a below-elbow cast for 2–4 weeks and then a short-arm brace until the full recovery of range of motion. No pin-related complications were found. All fractures were healed, and the full function of the wrist and forearm was achieved in every case. One patient developed a keloid. One patient with Salter Harris 2 distal radius fracture developed epiphysiodesis even if the K-wires were placed extra-physeally (Fig. 2). This patient was 15 year-old at the time of trauma, and the epiphysiodesis was radiologically diagnosed when he was

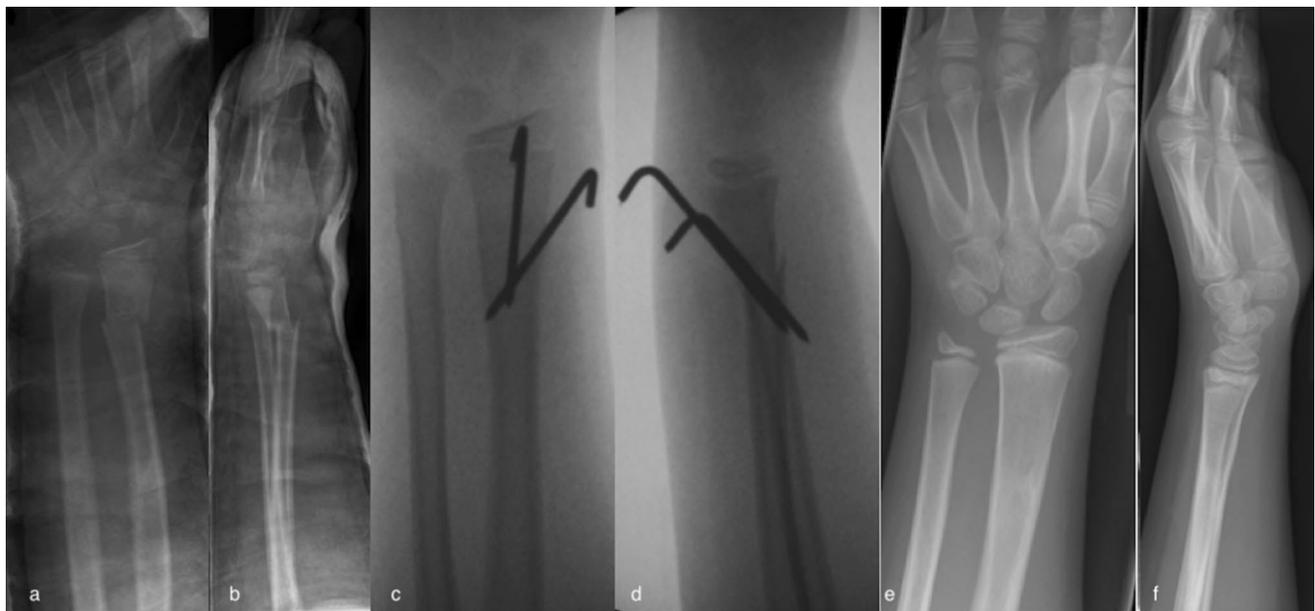


Fig. 1 **a, b** Preoperative radiographs, antero-posterior and lateral views; **c, d** intra-operative radiographs; **e, f** final follow-up radiographs

Table 1 Clinical data

Pt	Age (years)	Date of trauma	Paediatric AO (side)	Date of operation	Surgery	Length of the operation (min)	Follow-up (months)	K-wire removal (post-operative week)	Complications
1	8	10/09/08	23-M/3.1 dorsal and lateral tilt (L)	11/09/08	Kapandji (2 K-wires, radius)	39	96	5	None
2	8	08/10/08	23-M/3.1 volar tilt, SD (R)	20/10/08	Kapandji (1 K-wire, radius)	30	108	5	None
3	12	01/06/09	23r-M/3.1 volar tilt (L)	01/06/09	Kapandji (1 K-wire, radius)	25	12	4	None
4	8	05/06/09	23r-M/3.1 dorsal tilt, SD (L)	17/06/09	Kapandji (1 K-wire, radius)	20	104	6	None
5	10	18/06/09	23r-M/3.1, ulna diaphysis, dorsal and lateral tilt (R)	18/06/09	Kapandji (1 K-wire, radius) and ESIN (ulna)	20	2	6	None
6	15	14/09/09	23r-E/2.2, 23u-M/3.1, 23u-E/7, dorsal and lateral tilt (L)	14/09/09	Kapandji (1 K-wire, radius)	15	22	8	Epiphysiodesis
7	11	30/10/09	23-M/3.2, 23u-E/7, dorsal tilt (R)	30/10/09	Kapandji (1 K-wire, radius)	15	12	6	None
8	14	27/12/09	23r-M/3.1 + 23u-E/7, dorsal tilt (L)	28/12/09	Kapandji (2 K-wires, radius)	40	5	5	None
9	13	29/12/09	23r-E/2.1, 23u-E/7, dorsal tilt (L)	29/12/09	Kapandji (1 K-wire, radius)	20	12	5	None
10	14	12/01/10	23r-M/3.1, ulna diaphysis, dorsal and lateral tilt (R)	13/01/10	Kapandji (2 K-wires, radius) and ESIN (ulna)	45	12	8	None
11	13	22/02/10	23r-M/3.1, dorsal tilt (R)	22/02/10	Kapandji (1 K-wire, radius)	24	3	8	None
12	9	30/06/10	23-M/3.1 dorsal tilt (R)	30/06/10	Kapandji (1 K-wire, radius)	45	4	8	None
13	10	02/09/10	23-M/3.1 volar and lateral tilt (R)	02/09/10	Kapandji (2 K-wires, radius)	50	10	8	None
14	14	29/09/10	23r-M/3.1 volar and lateral tilt (R)	29/09/10	Kapandji (2 K-wires, radius)	15	21	8	None
15	12	28/12/10	23r-M/3.1 + 23u-E/7, dorsal and lateral tilt (R)	29/12/10	Kapandji (1 K-wire, radius)	25	3	4	None
16	12	30/12/10	23-M/3.1, dorsal tilt (L)	30/12/10	Kapandji (1 K-wire, radius)	24	1.5	4	None
17	12	07/09/11	23r-E/2.2 dorsal tilt, SD (L)	21/09/11	Kapandji (2 K-wires, radius)	25	11	8	None
18	5	09/09/11	23r-E/2.2 + 23u-M/3.1, dorsal tilt, SD (R)	22/09/11	Kapandji (1 K-wire, radius)	14	4.5	5	None
19	14	05/10/11	23r-M/3.1, ulna diaphysis, dorsal and medial tilt (L)	05/10/11	Kapandji (1 K-wire, radius) and ESIN (ulna)	55	36	6	None
20	10	31/10/11	23r-M/3.1, dorsal tilt (L)	31/10/11	Kapandji (2 K-wires, radius)	26	3	6	None
21	12	09/12/11	23r-M/3.1, 23u-E/7, dorsal and lateral tilt, SD (R)	21/12/11	Kapandji (2 K-wires, radius)	40	12	5	None
22	11	30/01/12	23r-M/3.1 dorsal tilt (L)	30/01/12	Kapandji (1 K-wire, radius)	22	18	5	None
23	8	13/06/12	23-M/3.1 dorsal and lateral tilt (R)	13/06/12	Kapandji (2 k-wires, radius)	39	52	5	None
24	15	18/08/12	23r-M/3.2 + 23u-E/7 dorsal tilt (L)	18/08/12	Kapandji (2 K-wires, radius)	20	5	8	None
25	8	12/10/12	23-M/3.1, dorsal and lateral tilt (R)	12/10/12	Kapandji (1 K-wire, radius) ^a	28	3	7	None
26	13	05/12/12	23r-M/3.1, 23u-E/7, volar tilt (R)	10/12/12	Kapandji (2 K-wires, radius)	n.a.	22	6	Keloid
27	14	23/03/13	23r-M/3.1, dorsal tilt (R)	23/03/13	Kapandji (2 K-wires, radius)	13	3	6	None
28	13	17/12/13	23-M/3.1, 23u-E/7, dorsal and lateral tilt (R)	17/12/13	Kapandji (3 K-wires, radius) ^a	44	10	12	None
29	9	02/01/14	23r-M/3.1 dorsal tilt, SD (R)	21/01/14	Kapandji (2 K-wires, radius)	20	12	8	None

Table 1 (continued)

Pt	Age (years)	Date of trauma	Paediatric AO (side)	Date of operation	Surgery	Length of the operation (min)	Follow-up (months)	K-wire removal (post-operative week)	Complications
30	7	02/06/14	Gustilo 1, 23-M/3.1 dorsal tilt (L)	02/06/14	Kapandji for radius and ulna (1 K-wire each) ^a	30	30	8	None
31	11	05/06/14	23r-M/3.1 dorsal and lateral tilt (R)	05/06/14	Kapandji (2 K-wires, radius)	25	33	9	None
32	9	26/06/14	Gustilo 1, 23-M/3.1 dorsal tilt (L)	26/06/14	Kapandji for radius and ulna (1 K-wire each) ^a	32	24	8	None
33	8	27/06/14	23r-M/3.1 dorsal and lateral tilt, SD (R)	14/07/14	Kapandji (1 k-wire, radius)	14	12	7	None
34	9	06/07/14	23-M/3.1 dorsal tilt, SD (R)	16/07/14	Kapandji (1 K-wire, radius)	28	24	7	None
35	9	09/09/14	23-M/3.1 volar and lateral tilt (L)	09/09/14	Kapandji (2 K-wires, radius) ^a	34	8	12	None
36	8	21/09/14	23r-M/3.1 dorsal tilt (L)	21/09/14	Kapandji (2 K-wires, radius)	n.a.	12	4	None
37	8	26/09/14	23r-M/3.1 dorsal tilt, SD (L)	06/10/14	Kapandji (1 K-wire, radius)	20	12	4	None
38	7	04/10/14	23-M/3.1, dorsal and lateral tilt (L)	04/10/14	Kapandji (2 K-wires, radius) ^a	n.a.	5	8	None
39	6	12/10/14	23-M/3.1 dorsal tilt, SD (L)	23/10/14	Kapandji (2 K-wires, radius)	17	14	4	None
40	12	13/11/14	23-M/3.1, dorsal tilt and lateral, SD (L)	26/11/2014	Kapandji (2 k-wires, radius) ^a	20	3.5	10	None
41	8	02/12/14	23-M/3.1, 23u-E/7, dorsal tilt and lateral, SD (L)	18/12/14	Kapandji (2 K-wires, radius)	36	40	4	None
42	10	03/12/14	23-M/3.1 dorsal tilt (L)	04/12/14	Kapandji for radius and ulna (1 K-wire each)	10	12	5	None
43	12	16/02/15	23r-M/3.1 dorsal tilt (L)	16/02/15	Kapandji (1 K-wire, radius)	15	13	8	None
44	11	10/03/15	23-M/3.1 dorsal and lateral tilt (L)	10/03/15	Kapandji for radius and ulna (1 K-wire each)	20	30	10	None
45	14	24/04/15	23r-M/3.1, 23u-E/7, dorsal tilt (R)	24/04/15	Kapandji (1 k-wire, radius)	38	12	6	None
46	12	11/05/15	23-M/3.1 dorsal tilt (L)	11/05/15	Kapandji for radius and ulna (1 K-wire for ulna, 2 for radius) ^a	40	12	10	None
47	14	04/06/15	23r-E/2.1, 23u-E/7, dorsal tilt (L)	04/06/15	Kapandji (1 k-wire, radius)	14	14	4	None
48	6	20/06/15	23r-M/3.1 dorsal tilt, SD (R)	03/07/15	Kapandji (1 K-wire, radius)	25	14	5	None
49	10	17/09/15	23r-E/2.2 + 23u-M/3.1, dorsal tilt, scaphoid fracture (L)	17/09/15	Kapandji (2 K-wires, radius)	21	1.5	6	None
50	7	11/10/15	23-M/3.1, dorsal tilt (L)	11/10/15	Kapandji (1 k-wire, radius)	20	2	6	None
51	15	14/11/15	23r-M/3.1 + 23u-E/7, dorsal and lateral tilt (L)	14/11/15	Kapandji (2 K-wires, radius)	30	1.5	6	None
52	11	27/11/15	23r-M/3.1, 23u-M/2.1, dorsal tilt (R)	27/11/15	Kapandji (2 K-wires, radius)	35	11	4	None
53	5	28/04/16	23r-M/3.1 dorsal tilt, SD (L)	04/05/16	Kapandji (1 K-wire, radius)	27	18	6	None
54	10	28/05/16	23-M/3.1 dorsal and lateral tilt (R)	28/05/16	Kapandji (1 K-wire, radius)	25	16	6	None

Table 1 (continued)

Pt	Age (years)	Date of trauma	Paediatric AO (side)	Date of operation	Surgery	Length of the operation (min)	Follow-up (months)	K-wire removal (post-operative week)	Complications
55	15	10/06/16	23-M/3.1 volar tilt (L)	11/06/16	Kapandji (1 K-wire, radius)	n.a.	21	4	None
56	11	03/06/17	23-M/3.1 + 23u-E/7, dorsal tilt (R)	03/06/17	Kapandji (1 K-wire, radius)	n.a.	3	4	None

ES/N elastic stable intra-medullary nail, L left arm, R right arm, SD secondarily displaced after initial conservative treatment

^aThe K-wire was buried

still asymptomatic at the age of 17. He was then referred to the hand surgeon for evaluation and continuation of the follow-up.

Discussion

Intra-focal Kapandji pinning is one of the surgical treatments available in the case of unstable displaced distal radius fractures or in the case of failure of the conservative treatment in children. Only five studies reported the outcome of Kapandji technique in paediatric patients with metaphyseal or Salter Harris 2 fractures of the distal radius [13–16, 21].

In a comparison of our protocol and outcome with those of the other studies on Kapandji technique in children, some differences exist. Our sample is the largest available. The study by Rubin et al. [16] represents a modification of the technique with volar approach for volarly displaced fractures. In two studies, an additional extra-focal K-wire can be inserted [13, 21]. Some authors use K-wires with a diameter of 1.4–1.6 mm [13, 14, 16], and the others use 2–2.8 mm K-wires [15, 21]. In all studies on Kapandji technique in children, the arm is immobilized in a below-elbow cast for the first 4–6 weeks, and K-wires are removed within the eighth post-operative week, followed by the use of short-arm brace in some cases [13–16, 21]. We preferred the use of an above-elbow cast for the first four post-operative weeks. Nevertheless, the literature shows that after percutaneous K-wire fixation above- and below-elbow cast are used according to the preference of the surgeon [7, 9, 10]. Moreover, differences in fracture redisplacement were not demonstrated when using above- or below-elbow casts after pinning [7]. As far as the outcome of Kapandji technique in children is concerned, the only complication reported in the literature was a single superficial pin site infection [13]. In our series, there were no pin site infections. To reduce the risk of infection, we buried the K-wires in patients with Gustilo 1 open fracture and when parents could not assure regular pin site care. Despite this, the literature on closed and open (Gustilo 1–2) fractures of the forearm in children did not show an increased risk of pin site infection when wires were not buried [24, 25]. As far as the length of the follow-up is concerned, we performed a much longer follow-up (mean of 18 months) compared to the available literature on the same technique (mean of 3–8 months). It is known that in case of Salter Harris 1 or 2 fractures, the epiphysiodesis can occur in 1–7% of patients [26]. The advantage of a long follow-up is early detection of epiphysiodesis in patients operated for Salter Harris 2 fractures, in asymptomatic patients, allowing the planning of future management.

Compared with conventional K-wire pinning, Kapandji technique offers the advantages of aiding in the reduction and stabilization of fractures and of a very low rate



Fig. 2 **a, b** Preoperative radiographs, antero-posterior and lateral views; **c, d** intra-operative radiographs; **e, f** final follow-up radiographs, epiphysiodesis of the distal radius

of complications. The literature shows that the main complications of conventional K-wire pinning and its variants for metaphyseal fractures involved pin track infections, pin migration and hypertrophic scars, with an overall complication rate ranging from 0 to 38% [7]. Some authors reported a 6–8% loss of reduction [10, 19], superficial pin track infection ranging from very few cases to 5.7% [10, 19] and a 1.4% rate of neuroapraxia [10]. Complications with a lower incidence included pin migration, re-fracture and wound over-granulation [7, 9, 19].

Study designs with a higher level of evidence are required to confirm the good outcome of the intra-focal pinning according to Kapandji technique for unstable displaced distal radius fractures in children.

Conclusion

Intra-focal Kapandji pinning for the treatment of unstable displaced metaphyseal and Salter Harris 2 fractures of the distal radius is seldom used in children. Available studies allowed for the evaluation of short-term outcomes of Kapandji technique in children due to the brevity of their follow-up. Our case series is the first to allow for the evaluation of both long-term and short-term outcomes, thanks to a mean follow-up of 18 months. We had only one procedure-related complication (keloid) and one epiphysiodesis in a patient who had a Salter Harris 2 fracture. In comparing our results with those of conventional pinning, we had a remarkably lower rate of complications. For these reasons, we suggest implementing the use of this technique in clinical practice. Further studies with a higher level of evidence are required to confirm our results.

Compliance with ethical standards

Conflict of interest All the authors have no conflict of interest.

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