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REVIEW

Displaced distal end radius fractures in children treated with Kirschner wires - A systematic review

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This study was carried out in Al Ahli Hospital, Doha, Qatar

The indications for Kirschner wiring, the technique of wiring, type of cast immobilization, period of immobilization and complications of K wires are unclear. We conducted a systematic review of the literature on Kirschner wiring of distal radius fractures in children.

A total of 4263 articles were identified. The full text of the remaining 78 articles was reviewed. 64 articles were finally excluded because of incomplete data leaving 14 for analysis.

Complete fracture displacement and translation more than 50% are the commonest indications for Kirschner wiring of these fractures with 2 retrograde wires in non-Kapandji fashion being the commonest technique. Long arm casts are the favored modality of immobilization with superficial infection being the commonest complication. Re-displacement rates are low after Kirschner wiring.

Most studies were retrospective and there is the need for a multicenter randomized controlled trial to define protocols for management of displaced distal radius fractures in children.

INTRODUCTION

Fractures of the distal radius in children are common injuries and account for 20 percent of all childhood fractures. 62 percent of these are radial metaphyseal fractures. (*1*)

More than 70 percent of these fractures occur in boys and they are more common in the summer months.

Un-displaced fractures are generally treated in a splint or cast whilst displaced fractures require manipulation under anaesthesia and immobilization in a cast. (*6*) It is important to maintain reduction of the fracture as re-displacement will compromise the outcome.

Re-displacement following manipulation of displaced distal radius fractures has been reported to range from 7-91 % (*4,22,28,29*). Various factor including patient age, fracture morphology, presence of concomitant ulnar fracture, complete initial displacement, skill of the surgeon, cast padding and technique have been observed to predispose to re-displacement.(*24*)

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Fractures that re-displace may require further surgery or be allowed to heal and may either remodel or mal-unite with reduced functional and poor cosmetic outcomes. This is often a dilemma for the treating physician.

Percutaneous Kirschner (K) wire fixation has been recommended to prevent re-displacement but the indications vary and the technique is not without complications (*26*).

Whereas Zamzam (*30*) et al advocate primary K-wire fixation for all displaced distal radius fractures even when a satisfactory closed reduction has been achieved, others such as Proctor et al (*22*) advocate fixation in all cases when a perfect reduction cannot be achieved whilst Prevot et al (*20*) recommend it for instability and irreducibility.

Complication rates following treatment of distal radius fractures in adults range between 6 - 80%. (*27*). The most common complications following K-wire fixation are pin tract infections, buried K wires, neuropraxia and tendon irritation. However the data in children is sparse.

In the face of uncertainty when considering what the most appropriate treatment choice is, a systematic review is helpful to synthesize the best evidence when randomized controlled data is insufficient or not available (*25*).

Aims: The aim of this study was to establish the indications for K- wiring of distal radius fractures in children, the technique of wiring, re-displacement rates, type of cast immobilization, period of immobilization and complications of K wiring following a review of the most recent evidence.

MATERIALS AND METHODS

Two reviewers (SK,SJ) undertook a literature search in the databases Medline(Medical literature analysis and retrieval system online),CINAHL(Cumulative index to nursing and allied health literature),OvidSp, Cochrane Library from inception to December 2013 using the subject headings(MESH terms) 'distal radius fractures','p(a)ediatric','children','Kirschner(K) wire(s)','cast', 'deformity' and 'displacement.'

Our primary literature search was without language restrictions to capture all possible information available.

A manual reference check of all the retrieved articles was performed to identify additional references not captured by the original search.

Inclusion and exclusion criteria

The inclusion criteria were:

1) Literature style-Original articles, human subjects
2) Children less than 16 years of age
3) Fractures involving the distal radius with or without an ulnar fracture
4) Treated by an above or below elbow cast with K wire/s
5) Reported outcomes both clinical and radiological
6) Randomized control trials, non-randomized or quasi randomized controlled trials, prospective or retrospective case reports

The inclusion criteria meant that in some studies part of the data could not be used. For example, patients treated by K wire fixation and open reduction were excluded.

The exclusion criteria were:

1) Re-fractures
2) Pathological fractures
3) Biomechanical or animal studies
4) Follow up less than 6 weeks
5) Sample size less than 5 patients
6) Review studies
7) Complications not reported
8) Multiple fractures

Non -standard treatment options like functional casting and intramedullary K wires were excluded. Fractures with vascular injury were also excluded.

The two reviewers (SK and SJ) independently reviewed all the titles and abstracts of citations identified by the electronic search and narrowed the list using the inclusion and exclusion criteria.

The full text of the short list were then reviewed and analyzed for eligibility. The reference lists of all the articles were also reviewed and any relevant articles were screened similarly.

The two reviewers strictly followed the methods set out in the Cochrane handbook for systematic reviews of Interventions(*5*) and evaluated each ar-

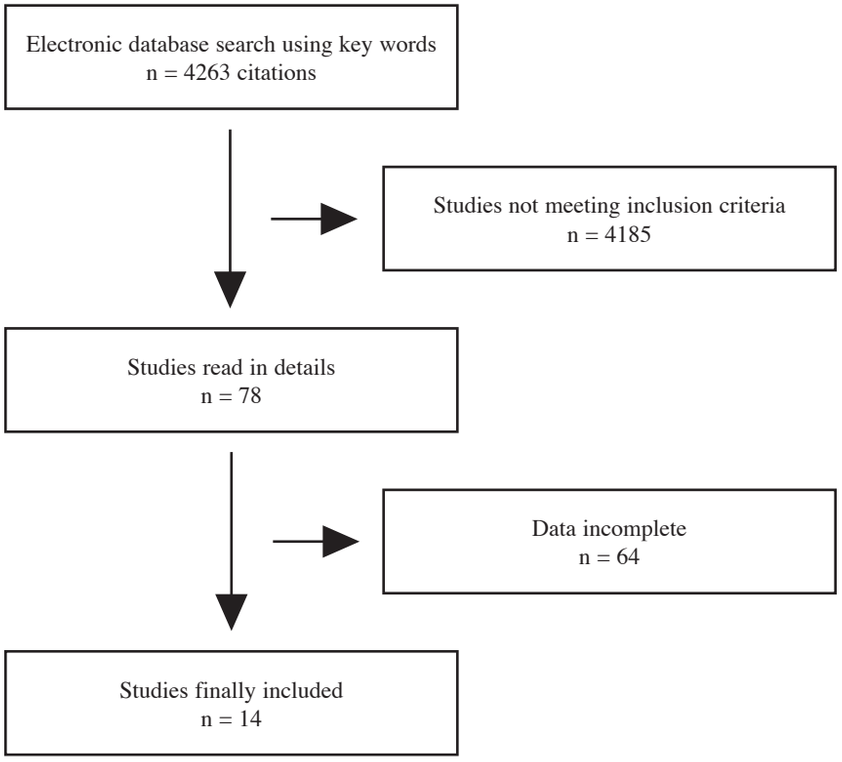

Fig. 1. — Identification of relevant articles

ticle using both the Structured Effectiveness Quality Evaluation Scale (SEQES) and Sackett's Level of Evidence (LOE) .(*9,16*) The SEQES appraises the quality of a study based on study design, subject acrual, intervention, outcomes, analysis and recommendations. The SEQES scores varied from 17 - 37 (mean score of 23.4).This indicates our stringent inclusion and exclusion criteria in including only valid qualitative studies.

The data extracted included patient demo-graphics (age, gender, sample size), fracture mor-phology (associated ulnar fractures), treatment modality (plaster of Paris cast with or without K- wires),type of cast (above or below elbow),timing of treatment-initial or delayed, follow-up, reported outcomes and complications.

Statistical analysis

To facilitate analysis of the data we calculated the mean of the age distributions of the children. This enabled us make comparisons for indications of K-wiring of distal radial fractures in children below and above 10 years of age. The frequencies of the various techniques of K- wiring and time to removal of K- wires were also calculated.

Re-displacement was analyzed as an outcome measure for the 3 randomized control trials due to homogeneity of data. Risk ratios and 95% confidence intervals were calculated using Revman 5.2 software.

RESULTS

The literature search yielded 4263 articles. 4185 were excluded because they did not fulfill the inclusion criteria .The full texts of the remaining 78 articles were reviewed.

64 articles were finally excluded because of incomplete data leaving 14 for analysis (Fig. 1).

There were 3 prospective randomized controlled trials, (*3,13,14*) 1 prospective cohort study (*15*) and 10 retrospective cohort studies. Out of the 3 randomized control trials one was a multi-center study (*3*).

Table I. — Patient and fracture characteristics along with rates of re-displacement.

Author	Year	Type of study and Level of evidence	SEQES score	Patients (n)	Age range (years) (mean)	Reasons for K wiring	Re-displace -ment
Colaris	2013	Prospective randomized controlled trial I	37	61	6-12	>15° angulation <10 years >10° angulation 10-16 years and /or translation>50% bone diameter	8%
Miller	2005	Prospective randomized controlled trial I	36	16	10-14	>30°angulation or complete displacement in >10 years	None
McLauchlan	2002	Prospective randomized controlled trial I	35	35	(8.1)	Complete displacement +/- ulnar fracture	2.8%
Parikh	2013	Retrospective IV	26	36	(9.7)	Dorsally angulated fractures	3%
Mustafa	2009	Prospective III	20	32	4-16	>15° angulation <10 years >10° angulation >10 years With /without translation >50% bone diameter	12.5%
Muratli	2002	Retrospective IV	22	43	8.6-16	Translation > 50% bone diameter	6.8%
Choi	1995	Retrospective IV	17	140	8 and 12 (bimodal)	Translation >50% bone diameter	6.4%
Gibbons	1994	Retrospective IV	21	12	5-13	>15° angulation <10 years >10° angulation >10 years With/without complete displacement	None
Luscombe	2009	Retrospective IV	17	7	5-16	Complete displacement	42.9%
Jordan	2012	Retrospective IV	21	17	(9.7)	Complete displacement	None
Sharma	2010	Retrospective IV	17	26	(10.6)	Not clear	24%
Van Leemput	2002	Retrospective IV	20	15	(9.7)	Complete displacement and angulation more than 37°	None
Schneider	2007	Retrospective IV	17	67	3-16	If unstable after reduction->20° angulation <10 years Any angulation in older child	None
Ozcan	2010	Retrospective IV	22	20	5-15	>30° angulation <10 years >20° angulation >10 years With/without translation >50%of bone diameter	10%

Indication for K- wiring:

The total number of children who underwent K-wire fixation of distal radius fractures in the studies analyzed was 527 with an average age of 9.7 years.

The indication for K- wiring of distal radius fractures in children vary significantly from no clear indication to complete fracture displacement (Table I). In the majority of reports more than one indication for K-wiring was used. To enable meaningful comparisons and conclusions we summarized the data based on the mean age of the children as de-

picted in Table II. Complete fracture displacement and translation >50% of the diameter of the radius appear to be the commonest indications for K-wiring of distal radius fractures in children less than 16 years of age and account for 90% of all k-wiring in the studies analyzed (*2,3,4,7,11,13,14,15,17,18,28*).

Technique of K wiring

The techniques of K-wiring used are depicted in figure 2 and the commonest technique is retrograde percutaneous K-wiring using 2 wires in a non-Kapandji fashion (*28,24,3,23,11,17*).

Following closed reduction, a 5 mm skin incision is made over the radial styloid and blunt dissection of soft tissues is made down to the bone. The superficial branch of the radial nerve is protected.

A 1.6mm K- wire is usually used and directed proximally and ulnarly across the fracture site under image intensifier control to engage the opposite cortex. In younger children a 1.4 mm wire is used instead.

The second wire is inserted from dorsal to volar through a 5 mm skin incision in the interval between the 4th and 5th extensor compartment. The ends of the wires are bent and cut and kept external to the skin.

In the reports (*14,15,2,18*) that used 1 - 2 wires a second wire was inserted if after inserting the first wire the surgeon felt that fracture stability was not adequate. The definition of fracture stability was not clear.

In 2 of the 14 studies, the Kapandji *(8)* technique was used (*19,24*).

Removal of K wires

The time to removal of K-wires depended to a great deal on whether the wires were buried under the skin or exposed.

If the wires were not buried most were removed at 3 or 4 weeks after insertion (Fig. 3). In a few patients the wires were removed close to 6 weeks because of reasons such as lack of radiological union.

Table II. — Indications for K wiring

Children less than 10 years of age		Children greater than 10 years of age	
	Frequency(%)		Frequency(%)
Translation more than 50%	50	Translation more than 50%	45
Complete displacement	40	Complete displacement	45
Angulation>15°	30	Angulation >10°	27
Angulation >20°	10	Angulation >20°	9
Angulation >30°	10	Angulation >30°	9
		Any angulation	9

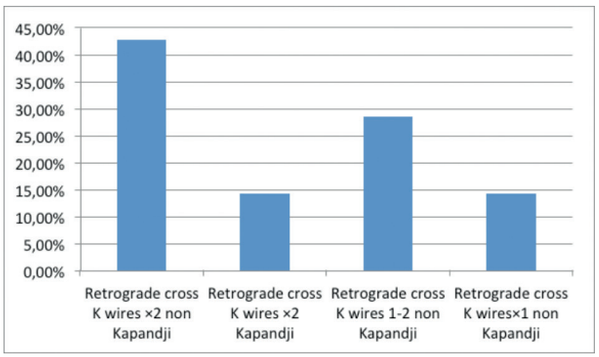

Fig. 2. — Identification of relevant articles

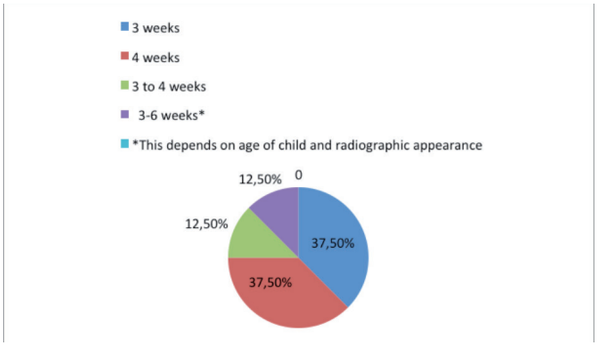

Fig. 3. — Time to removal of K wires that were not buried

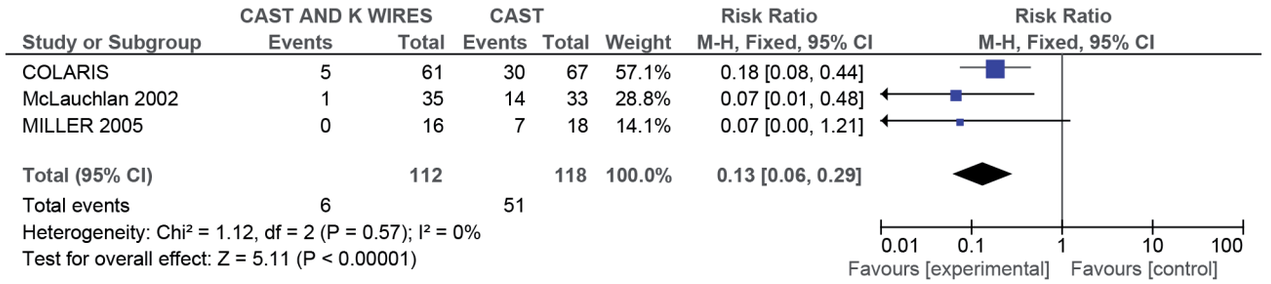

Fig. 4. — Risk of redisplacement-Forest plot

In most reports the wires were removed in the outpatient clinic without the need for sedation. However general anaesthesia was administered for wire removal if they became buried inadvertently.

The wires were deliberately buried under the skin in only one report (*15*). In this report the buried wires were removed 8-21 weeks after insertion and this was done under general anaesthesia.

Type of cast immobilization

Above elbow casts are the predominant mode of immobilization after K-wiring (78.5%).Below elbow casts were only used in 3 reports (*29,29,11*). Time to fracture union or re-displacement was not influenced by the type of cast used.

Re-displacement

The rate of re-displacement after k-wiring of distal radius fractures ranged between 0-42.9 percent.

A high rate of re-displacement (42.9%) was reported in one study (*11*). The authors believed this was due to intrinsic instability of the respective fractures.

5 studies reported no fracture re-displacement after K- wire fixation (*4,28,14,23,7*).

It was difficult to analyze the factors that predispose to re-displacement because the definition of re-displacement varies greatly and includes:
1) Loss of any reduction after initial surgery
2) Loss of reduction by >10° in any one plane
3) Loss of reduction by >20° angulation

We were however able to analyze the data on re-displacement for the 3 randomized controlled trials due to homogeneity of the data and comparison with a suitable control (above elbow cast alone).

The forest plot in Fig. 4 shows that the risk of re-displacement is statistically lower in the cast plus K- wire group. There were only 6 events of re-displacement out of 112 in the cast and K- wire group as compared to 51 out of 118 in the above elbow cast only group. Risk ratio of 0.13,(95 % confidence interval 0.06 - 0.29.)

Complications

The analyzed studies reported complication rates varying from 0-38% (median 8.3%). Table III shows the reported complications and the incidence of each complication in relation to the total number of complications.

Superficial pin site infection is the most common complication and resolved with antibiotics and after wire removal in the reported cases. There were

Table III. — Complications

Complications	***Incidence (%)****
Superficial infection	52
K wires buried	30
Neuropraxia	9
Prominent scars	7
Tendon irritation	2

*Values were calculated using studies that provided adequate information to produce overall figures

no reported cases of osteomyelitis although this is known to occur.

Non-union, growth arrest, compartment syndrome or permanent nerve damage were not reported.

DISCUSSION

This paper presents a comprehensive systematic review of the evidence in the literature on the treatment of displaced distal radius fractures in children using Kirschner wires.

Though this systematic review revealed a plethora of indications for K -wiring of distal radius fractures in children less than 16 years of age complete fracture displacement and translation more than 50% of the diameter of the radius are the commonest indications.

The technical challenges in wiring these fractures are the presence of the physis, the small size of the bone and the required obliquity of the wire (*10*). Transphyseal pinning may be done as reported in many studies but carries the risk of growth arrest (*21*). This risk is negligible if smooth wires are used and multiple wire passes are avoided. Threaded wires are never to be used.

The commonest wiring technique is retrograde percutaneous K-wiring using 2 cross wires in non-Kapandji fashion with the wire ends outside the skin.

Intra-focal wiring using the Kapandji technique as advocated by Parikh et al (*19*) has the advantage of sparing the physis however this is at the expense of maintaining fracture stability in the presence of dorsal comminution at the fracture site (*24*).

A single wire has been used in very few studies (*4,13*). This is not advisable as stability is compromised in fractures that are unstable.

Though above elbow casts are the preferred mode of immobilization after K-wiring (78.5%) they are not superior to below elbow casts in terms of time to fracture healing and the re-displacement rate. Below elbow casts would be more appealing to patients as they are not as disabling as above elbow cast.

Time to wire removal varies between 3-6 weeks when the wires are not buried under the skin. Most wires were removed 3 or 4 weeks after surgery.

Due to the heterogeneity of the data it was not possible to undertake statistical analysis to compare the outcome and complications when the wires were removed at 3 or 4 weeks. On the evidence available we would not advocate burial of the K-wires.

The analyzed studies revealed complication rates varying from 0-38% (median 8.3%).This compares favorably to the rates reported in the adult population (6-80%) (*27*). The reported complications were all classed as minor. In addition none of the complications led to long term disability.

Only one study (*14*) looked at the cost implications of using K wires versus casts alone. The authors concluded that there were no significant differences between the overall costs of using casts alone versus K wires. However as the cast only group had higher re-displacement rates further interventions meant a trend towards greater costs.

McLauchlan et al (*13*) in a prospective randomized trial have suggested that the benefit of K-wiring is that fewer radiographs are required in the follow up period.

The definition of re-displacement in the various studies is not consistent with some studies using a definition like “the need for a secondary reposition and consecutive operation.”*(23)* We believe the reported rates would be lower if the definition of re-displacement was standardized.

Statistical analysis of the 3 RCT’s in this study confirmed that K wires and above elbow cast significantly reduces the risk of re-displacement as compared to above elbow casts alone. (RR 0.13, 95%CI 0.06, 0.29)

Though the present analysis utilized all available evidence (no language restriction) in the literature with average SEQES score of 23.4 reflecting good quality studies considerable heterogeneity existed with the patients and the data collected making a meta-analysis impossible.

Another limitation is that we included 10 retrospective studies in this review. A systematic review of randomized control trials or cohort study is ranked as a higher level of evidence. However, the importance of a systematic review relies on the methodological search for the underlying causes of heterogeneity, which allows the authors to make evidence based recommendations for future investigations (*12*).

In conclusion this systematic review revealed that K-wiring of distal radius fractures in children is commonly used for completely displaced fractures and those with translation more than 50 percent of the radius. 2 retrograde K-wires in non-Kapandji fashion is the most commonly used technique. Above elbow casts are favored over below elbow casts after K-wiring though below elbow cast do not seem to increase the risk of re-displacement or malunion. The risk of fracture re-displacement is minimal after K-wiring. Superficial pin tract infection is the commonest complication after K-wire fixation and resolves once the wires are removed.

We would however recommend the need for a multicenter randomized controlled trial to define protocols for management of displaced distal radius fractures in children.

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