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Research Article

Radiological Outcome Following Percutaneous Pinning of Distal Radius Fractures: 2-Wire Versus 3-Wire Techniques

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Abstract

Introduction: Manipulation under anaesthesia and percutaneous pinning remains a well-established technique in the surgical treatment of distal radius fractures. The optimal pin position and number of pins is not established from clinical trials, although there is biomechanical data favouring a 3-wire technique with a crossed wire configuration. This study evaluates the radiological outcome of distal radius fractures after extra-focal percutaneous pinning comparing 2-wire and 3-wire techniques.

Methods: All distal radius fractures treated with extra-focal percutaneous pinning at a single District General Hospital over a 2.5 year period were retrospectively analysed. Pre-operative, post-manipulation and follow up radiographs were evaluated for radial inclination, volar inclination and ulnar variance. The radius was defined as short with a positive ulnar variance >2 mm.

Results: A total of 70 patients were included, 52 in the 2-wire group and 18 in the 3-wire group. Initial volar inclination was -15.9° in the 2-wire group versus -11.6° in the 3-wire group ($p = 0.048$) and after fixation were -0.6° versus +4.5° respectively ($p = 0.034$). However, there was no significant difference in the improvement in volar inclination between the two groups (15.3° versus 16.1°) or at final follow-up (-3.4° versus -0.4°). There were no significant differences in radial inclination between the two groups pre-operatively, after reduction or at follow up. In both groups, of the patients that gained more than 2 mm of radial length after reduction and fixation, over 50% subsequently lost this reduction by final follow-up.

Conclusions: This study has not been able to show any differences in the radiological outcomes between 2-wire and 3-wire pinning techniques. It was able to show that percutaneous pinning does appear to be able to hold the improvements made in radial inclination and volar tilt angle after manipulation, but is an unreliable method of maintaining improvements in radial length.

Keywords: *Distal Radius; Fractures; Wire; Fixation*

Introduction

Fractures of the distal radius are commonly encountered in acute hospitals with around 70,000 cases per year in the UK [1]. The incidence of these fractures increases with age [1], and there is an established relationship between age, distal radius fractures and osteoporosis [2]. They are an important cause of morbidity and demand a significant amount of patient contact time and use of resources in both management and social sequelae.

Since the introduction of volar locking plates an increasing number of distal radius fractures are being treated by open reduction and internal fixation (ORIF) [3,5,7]. Historically studies have shown a polarising consensus to whether there is a difference in outcome between ORIF with volar locking plates and closed reduction and Kirschner-wire (K-wire) fixation [3-10], with some studies showing

advantages, such as earlier return to function and better range of motion, in the short-term for ORIF [4,11], the long-term outcomes are similar with no clear advantage of ORIF over K-wire fixation [3,6,7,9,10]. Recently the UK DRAFFT [2] trail concluded that there was no difference between K-wire and locking plate fixation for dorsally displaced fractures, at least in the short. Recent studies have shown no cost effectiveness in the use of distal volar locking plates over percutaneous fixation [5].

As a result, manipulation under anaesthesia and extra-focal percutaneous pinning with K-wires remains a well-established technique for the management of unstable distal radius fractures [12]. Although optimal pin positioning has not been established from clinical trials, there is some biomechanical data favouring a 3-wire technique over a 2-wire technique, using two radial styloid wires and a crossed wire from the dorsal-ulnar corner of the radius [13].

There is evidence that radiological malunion post-fixation leads to a poor functional outcome for the patient long-term [14-16], and management decisions often concentrate on improving radiological position in an attempt to give the best functional outcome. In particular the two radiological parameters that have been shown to be most associated with poor clinical outcome are radial shortening [17] and volar angulation [16].

The aim of this study was to evaluate the radiological outcome of distal radius fractures treated with extra-focal K-wire fixation, examining the techniques utility as a whole and comparing patients treated with 2-wire and 3-wire techniques.

Methods

The authors conducted a retrospective analysis of all patients aged 18 years and over, treated for distal radius fractures by percutaneous extra-focal K-wire fixation, at a single District General Hospital over a 2.5 year period. Dorsally angulated fracture patterns, classified as AO types A2 and A3 (extra-articular fractures), and AO C1 (simple intra-articular fractures) [18] were included. Volar displaced fractures and AO type B, C2 and C3 fracture patterns were excluded from the study, along with ulnar fractures, other than ulna styloid fractures, and any facture requiring additional external fixation.

At the time of operation, all cases were first treated with closed reduction under anaesthesia via manual traction, with the quality of reduction checked intra-operatively using fluoroscopy using both AP and lateral projections. In all cases standard 1.6 mm diameter K-wires were used, introduced via small stab incisions. Five different wire configurations were used, as shown in figure 1, with two configurations in the 2-wire group (Configurations A and B) and three configurations in the 3-wire group (Configurations C, D and E).

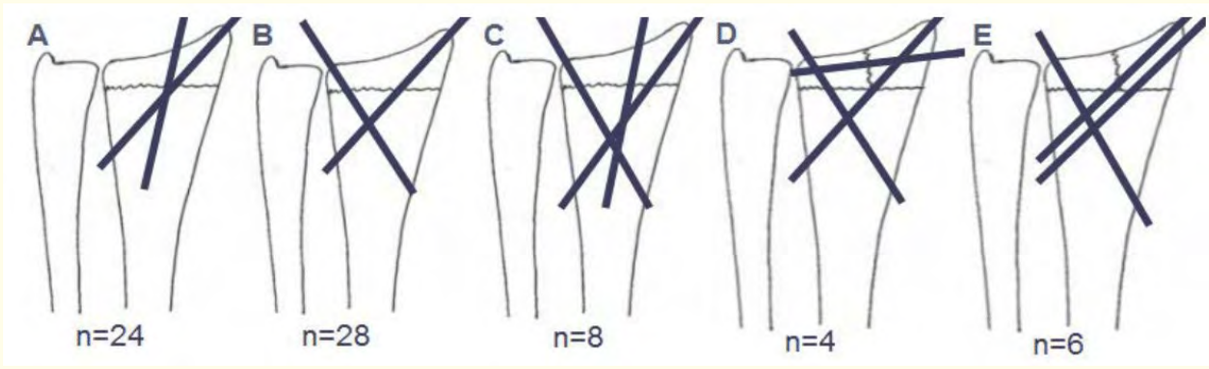

Figure 1: *K-wire configurations: A demonstrates one wire through the radial styloid and one through Lister's tubercle; B demonstrates two cross-K-wires, one through the radial styloid and one through the dorsal-ulnar corner of the radius; C demonstrates two cross-K-wires with a third wire through Lister's tubercle; D demonstrates two cross-K-wires with a third transverse wire across the fracture fragments; E demonstrates two wires through the radial styloid and one through the dorsal-ulnar corner of the radius.*

Radiographs for all cases were assessed at three different time points: the latest pre-operative radiograph available, post-operative check films, and the longest follow-up radiograph available. For each patient, standard AP and lateral view radiographs were viewed on the local computerised viewing system, IMPAX (Agfa Healthcare, Belgium). The radiographs were evaluated for radial inclination, dor-

sal/volar inclination and ulnar variance. Measurement of ulnar variance was used as a marker of radial length [19], with a loss of ulnar positive variance of > 2 mm post-fixation being defined as an increase in radial length, and a gain of ulnar positive variance of > 2 mm on follow-up radiographs defined as a loss of radial length.

All radiographs were taken according to a standard protocol and a 'phantom' hand was used to calibrate and check the magnification, which was consistent at a 1.1:1 ratio. Previous studies have attempted to measure ulnar variance to an accuracy of 0.1 mm and calculate mean changes in length [11,12,16]. The authors feel that this level of accuracy is not feasible using plain radiographs and therefore opted for the more reproducible value of 2 mm gain or loss of length.

Basic characteristics between datasets have been expressed using simple descriptive statistics. Data for radial inclination and volar inclination angles between the two groups were compared using 2-tailed un-paired students t-test, with differences considered significant at $p < 0.05$.

Results

A total of 70 cases were identified, 52 treated with a 2-wire technique and 18 with a 3-wire technique. The average age of all patients was 60.8 years, with an average age of 59.4 years in the 2-wire group and 64.8 years in the 3-wire group. The average time from injury to fixation across all 70 cases was 6.5 days (5.9 days in the 2-wire group, 8.3 days in the 3-wire group), with a mean follow-up of 55 days. 44 of the 70 patients (63%) had an extra-articular fracture pattern, with 34 patients (65%) in the 2-wire group and 10 patients (56%) in the 3-wire group (Table 1).

	All Patients	2-wire Technique	3-wire Technique
Number of patients	70	52	18
Mean age (years)	60.8	59.4	64.8
Mean time to Theatre (days)	6.5	5.9	8.3
Mean follow-up (days)	55	57	48
Fracture pattern:			
- Extra-articular (%)	44 (63%)	34 (65%)	10 (56%)
- Intra-articular (%)	26 (37%)	18 (35%)	8 (44%)

Table 1: *Basic demographics of both 2-wire and 3-wire patient groups.*

Volar Inclination (Figure 2)

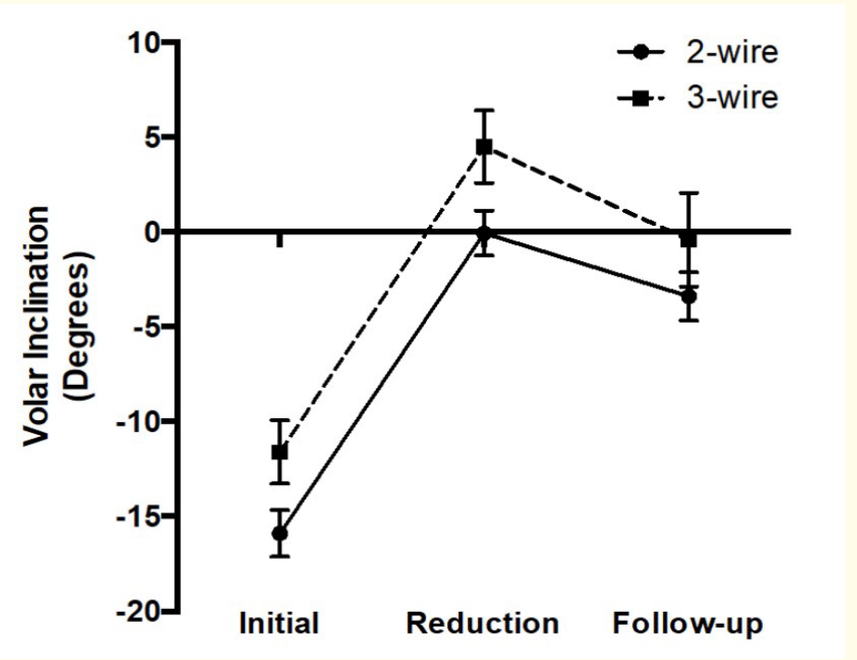

Figure 2: *Mean volar inclination (with 95% CI), measured pre-operatively, post-operatively, and at follow-up.*

Mean volar inclination pre-operatively between the two groups was -15.9° (± 1.23, 95% CI) in the 2-wire group versus -11.6° (± 1.68) in the 3-wire group ($p = 0.048$). This was improved to -0.6° in the 2-wire group and +4.5° in the 3-wire group, with a mean improvement

of 15.3° (± 1.34) and 16.1° (± 3.92) respectively (p = 0.751). There was no significant difference in volar inclination between the groups at follow-up, with a mean of -3.4° (± 1.27) in the 2-wire group and -0.4° (± 2.47) in the 3-wire group (p = 0.295). For both groups there was no significant loss of position from the post-operative radiograph to final follow up for volar inclination. With the 2-wire technique there was a mean loss of 2.8° (-0.6° to -3.4°; p = 0.430). With the 3-wire technique the mean loss was 4.9° (+ 4.5° to -0.4°; p = 0.430).

Radial Inclination (Figure 3)

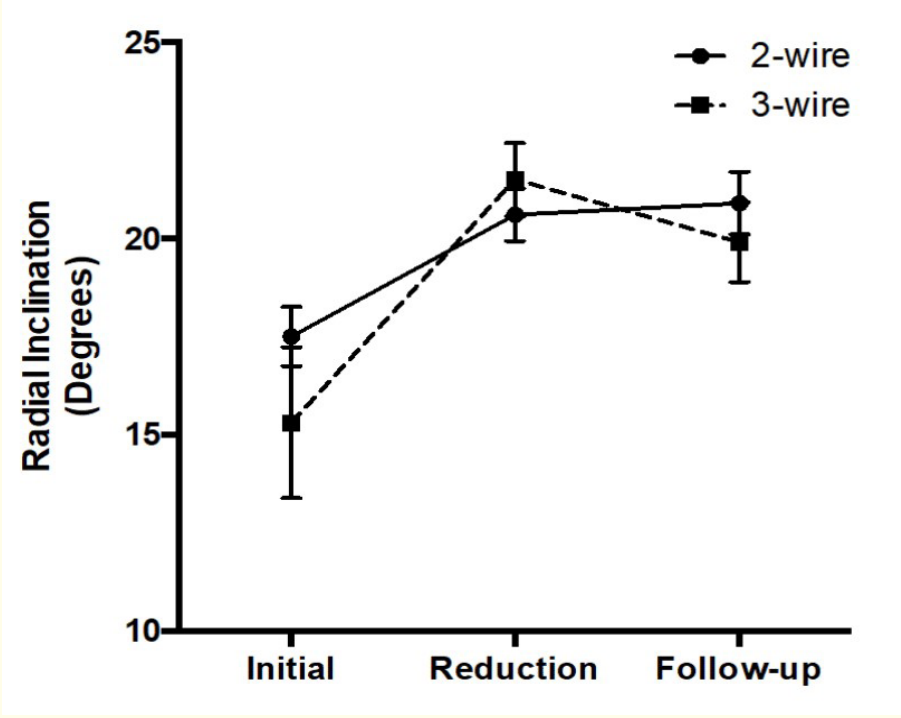

Figure 3: *Mean radial inclination (with 95% CI), measured pre-operatively, post-operatively, and at follow-up.*

Mean radial inclination pre-operatively was not significantly different between the two groups, with a mean of +17.5° in the 2-wire group and +15.3° in the 3-wire group (p = 0.317). This was improved to +20.6° in the 2-wire group and +21.5° in the 3-wire group, with an average improvement in inclination of 3.1° (± 0.66, 95% CI) and 6.2° (± 1.75) respectively (p = 0.122). Both groups were found to have maintained radial inclination at follow-up (+20.9° versus +19.9°), with no significant difference between the two (p = 0.443).

Radial Length

In the 2-wire fixation group, 22 of the 52 patients had a > 2 mm gain in radial length following reduction and fixation. However, 12 of these 22 (54.5%) patients were found to have lost this gain in radial length and had fallen back to their pre-operative length on follow-up radiographs. Similarly, in the 3-wire fixation group, 13 of the 18 gained > 2 mm of radial length after reduction and fixation, with 7 of those 13 (53.8%) subsequently falling back to their pre-operative length by follow-up.

	2-wire Technique	3-wire Technique	p value
Volar Inclination (in Degrees with 95% CI)			
- Initial radiograph	-15.90 (±1.23)	-11.60 (±1.68)	0.048
- Post-reduction	-0.06 (±1.19)	+4.50 (±1.91)	0.034
- Follow-up	-3.40 (±1.27)	-0.40 (±2.47)	0.295
Radial Inclination (in Degrees with 95% CI)			
- Initial radiograph	+17.50 (±0.76)	+15.30 (±1.92)	0.317
- Post-reduction	+20.60 (±0.67)	+21.50 (±0.93)	0.444
- Follow-up	+20.90 (±0.80)	+19.90 (±1.01)	0.443
Radial Length			
> 2 mm gain post-operatively	22/52 (42.3%)	13/18 (72.2%)	-
> 2 mm gain maintained at follow-up	10/22 (45.5%)	6/13 (46.2%)	-

Table 2: *Comparison of measured radiographic parameters between the 2-wire and 3-wire groups across the three measures time points.*

Discussion

This study compared the radiological outcomes between 2-wire and 3-wire pinning techniques for surgical management of dorsally angulated distal radius fractures, and found no significant difference between the two groups in any of the three radiological variables measured; volar inclination, radial inclination, radial length. Despite a reasonable number of patients, the study was disadvantaged by the difference in size between the 2-wire group and 3-wire group (52 versus 18 patients). The preponderance of the 2-wire technique was due to surgeon preference. The patients in the two groups were well matched otherwise, including for age, time to treatment, and percentage of extra-articular fractures, as summarised in table 1. It is likely that gaining a good reduction and placing wires in good positions is more important than the number of wires employed.

There is little evidence with regards to the optimal number and placement of K-wires in pinning distal radius fractures. However, there is some biomechanical data which suggests that a cross-pin configuration is best for engagement of all major fragments, and that a 3-wire technique, with two radial styloid pins and a crossed dorsal-ulnar corner wire, is preferred over a crossed 2-wire technique [13]. We have not been able to validate these findings based on the radiographic criteria used in this study.

Kennedy., *et al*. have examined radiological outcomes in female patients with fragility fractures of the distal radius treated with percutaneous pinning [20]. Although their study was not designed to specifically look at different pinning techniques, they also compared the results for the main techniques used in their study population and found no significant difference between outcomes, in keeping with our findings.

The data presented in this study suggests that percutaneous pinning is able to hold the improvements made in radial inclination and volar inclination after manipulation. There was no significant difference between the two groups post-operatively with both techniques maintaining acceptable improvements in volar inclination at final follow up (-3.4° for 2 wire versus -0.4 for 3 wire), and acceptable outcomes for radial inclination at final follow-up (+20.9° for 2-wire and +19.9° for 3-wire). This is in keeping with the current published literature, where extra-focal pinning has been shown to improve and maintain anatomical reduction in unstable distal radius fractures [21-23].

With regards radial length the data presented in this study suggests that percutaneous pinning is not a reliable method for maintaining any improvement in radial length gained following manipulation, with over 50% of patients that gained saw improvements > 2 mm losing this by final follow-up. This is of significance, as clinical and biomechanical studies comparing radiological outcomes with functional outcome have shown radial length to be the most important parameter [17,24]. Leung., *et al*. reported that in their study radial shortening of > 2 mm was directly related to a worse functional outcome [14], and McQueen., *et al*. showed that malunited Colles' fractures in the elderly population resulted in a weak and painful wrist [15].

A study by Barton., *et al*. in 2005 retrospectively reviewed post-manipulation and follow-up radiographs from initial manipulation and percutaneous extra-focal pinning through to fracture union [25]. As reported in this study, they found that improvements in volar and radial inclination at initial manipulation and pinning were maintained through to fracture union and follow-up at 6 months. They did, however, find that K-wire fixation was unable to prevent radial shortening after manipulation and pinning, with a mean radial shortening of 1.3 mm by the time of fracture union, and a greater loss of radial length in intra-articular fractures compared to extra-articular fractures. This again is supported by the results presented in this study. Barton., *et al*. suggest that a degree of radial shortening by fracture union should be anticipated and that surgeons should aim for 0 mm of radial shortening at the time of pinning to allow for this [25].

Percutaneous pinning of distal radius fractures remains a valuable treatment modality for maintaining improvements in volar and radial inclination after closed manipulation, with both 2-wire and 3-wire techniques proving to be equally effective. If there has been a significant loss of radial length, percutaneous pinning often fails to hold the reduction achieved. On this basis percutaneous pinning can be recommended for extra-articular or simple intra-articular patterns, with a loss of volar and/or radial inclination but without significant shortening. If there is significant shortening then an alternative technique, such as open reduction and internal fixation with a locked plate, should be contemplated, although there is still no Level 1 evidence to definitively support this.

Conclusions

This study has not been able to show any differences in the radiological outcomes between 2-wire and 3-wire pinning techniques. It was able to show that percutaneous pinning does appear to be able to hold the improvements made in radial inclination and volar tilt angle after manipulation, but is an unreliable method of maintaining improvements in radial length.

Conflicts of Interests

All authors declare no conflicts of interest. No grants, sponsorship or funding were received for this study or any associated works.

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