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# Closed reduction of distal radius fractures: a systematic review and meta-analysis

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- Distal radius fractures (DRF) are a common injury, especially in the elderly.
- Displaced fractures can be reduced by closed reduction through several techniques, two of which are compared in this systematic review and meta-analysis.
- Closed reduction by finger-trap traction (FTT) seems to offer better correction of radial shortening. Additionally, there may be less pain and fewer complications associated with this technique.
- Closed reduction by manual traction seems to offer better correction of the dorsal tilt.
- Further research is needed to fully determine the optimal method of closed reduction.

**Keywords:** closed reduction; conservative treatment; distal radius fracture; finger-trap traction; manual traction

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## Introduction

The topic of this article is distal radius fractures and the treatment of these, specifically closed reduction of displaced fractures. Over recent decades, surgical approaches such as open reduction and internal fixation have seen increasing use, but recent studies with one-year follow-up show no significant differences between surgical intervention and closed reduction with cast immobilization in terms of functional outcome.[1,2] Additionally, complications such as tendon afflictions and further surgery can arise from surgical intervention.[1] Therefore, closed reduction and cast immobilization remains an important treatment option in a majority of cases. However, the optimal method of closed reduction remains to be determined.

A very commonly used method of closed reduction is manual traction (MT). An assistant provides counter-traction while the operator provides traction and manipulates the bone fragments into position.[3,4] Even though it has been the most commonly used method for at least the better part of a century,[3] the evidence of its effectiveness is ambiguous, and by the 1950s it was already being postulated that the method might damage the soft tissues surrounding the fracture.[5]

Another method is mechanical reduction by finger-trap traction (FTT) which dispenses with the need for an assistant as the forearm is suspended by finger-traps in the radial fingers. Counter-traction is provided by weights suspended on the arm near the elbow joint. This restores the longitudinal axis without further actions, and the operator can then apply manual dorsal pressure to the fragments, if necessary, to restore the volar tilt of the wrist.[6] Several study authors have recommended this procedure as a more gentle method of reduction.[5,7,8] A Cochrane Review from 2003, updated in 2007, found insufficient evidence to recommend one type of reduction over the other.[9]

The aim of this article is to perform a systematic review and meta-analysis of the current literature that compares closed reduction by MT to FTT with radiographic measures and pain assessment in the treatment of distal radial fractures in adults.

## Methods

### *Protocol and registration*

This systematic review and meta-analysis was planned, conducted, and reported according to the guidelines of the PRISMA statement.[10] A study protocol was registered with the PROSPERO register of systematic reviews prior to data abstraction and analysis with the registration number CRD42016036274.[11]

### *Eligibility criteria*

We considered studies featuring an adult population with a dislocated distal radial fracture who had undergone

closed reduction by either MT or FTT and measured radiographic outcomes.
Inclusion criteria:

1. Articles involving distal radius fractures.
2. Articles written in English, French, German or a Scandinavian language.
3. Randomized controlled trials (RCTs), including abstracts.
4. Report of the sought outcome of interest: radiographic evaluation.

Exclusion criteria:

1. Articles including patients under 18 years of age.
2. Systematic reviews.
3. Studies with a focus on any type of surgical intervention, such as open reduction and internal fixation (ORIF), pinning and external fixation.

Primary outcome: Radiographic measurements of angulation and radial length.

Secondary outcomes: Pain during reduction, difficulty of reduction, success rate of reduction.

Randomized controlled trials evaluating the use of fluoroscopy during closed reduction on adult patients were also sought, but none were found.

### *Information sources*

Studies were identified by using electronic databases and by scanning the reference lists of articles. This search was applied to PUBMED/Medline, EMBASE and COCHRANE Central database and was carried out 1 March 2016.

### *Search*

The search string was generated with the aid of a scientific librarian:

*(colles, fracture OR colles fracture OR colles fractures OR colles OR distal radius fracture OR distal radius fractures OR distal radial fracture OR distal radial fractures) AND (traction jig OR finger stretch OR finger stretch traction OR finger trap OR finger trap traction OR manual reposition OR manual repositioning OR reposition OR repositioning OR manual reduction OR reduction OR closed reduction OR closed manual reduction)*

### *Study selection*

Management of the search results was carried out in Covidence.[12] Duplicate studies were identified automatically and manually in Covidence. Titles and abstracts of all retrieved studies were individually reviewed for relevant articles by two authors for inclusion. Eligible abstracts were collectively reviewed, and candidate studies were read in full text. Holkenborg et al[7] was only available as an abstract and was included because the corresponding author provided raw radiographic outcomes as well as additional details through correspondence.

### *Data collection process*

Disagreements between reviewers were resolved through discussion between the two first authors. If a decision was not reached, a third reviewer was advised. One review author entered the extracted data into Excel, and data registration was examined by a second author.

### *Data items*

The fracture should be classified by either the AO or Frykman classification[13] or provide a specified, reproducible method of measuring the displacement radiographically. Data extraction of included studies was performed using a data-extraction sheet based on type of study, country, baseline characteristics, intervention, comparator, radiographic outcomes as well as pain and success rate. Holkenborg et al[7] were contacted with additional questions, primarily concerning bias. In addition, Mr. Holkenborg kindly provided the radiographic outcomes and other details, though not a full paper. In Earnshaw et al,[14] radiographic outcomes were only reported graphically and were measured digitally to approximate numerical values. For the sake of comparison, the radial lengths in Kongsholm et al[8] and Holkenborg et al[7] were converted to radial shortening using the original reference.[15] Any disagreement regarding inclusion of an article was resolved by discussion or input from a third co-author (BV).

### *Risk of bias in individual studies*

To assess study quality, the Cochrane Collaboration's tool for assessing risk of bias in randomized trials was used.[16] We assessed the following: (1) random sequence generation (selection bias), (2) allocation concealment (selection bias), (3) blinding of participants and personnel (performance bias), (4) blinding of outcome assessment (detection bias), (5) incomplete outcome data, (6) selective reporting (reporting bias), (7) other sources of bias: major differences in baseline characteristics (age or gender). Each of the above domains were judged as being at low risk of bias, high risk of bias or unclear risk of bias (indicating either a lack of information or uncertainty over the potential for bias). None of the studies contained information about a pre-published protocol, and, apart from Holkenborg et al,[7] it was not possible to locate pre-published protocols through search engines.

### *Risk of bias across studies*

An assessment of publication bias was attempted through a search on ClinicalTrials.gov. No further studies were identified. Publication bias has been found likely to exist in another study.[17]

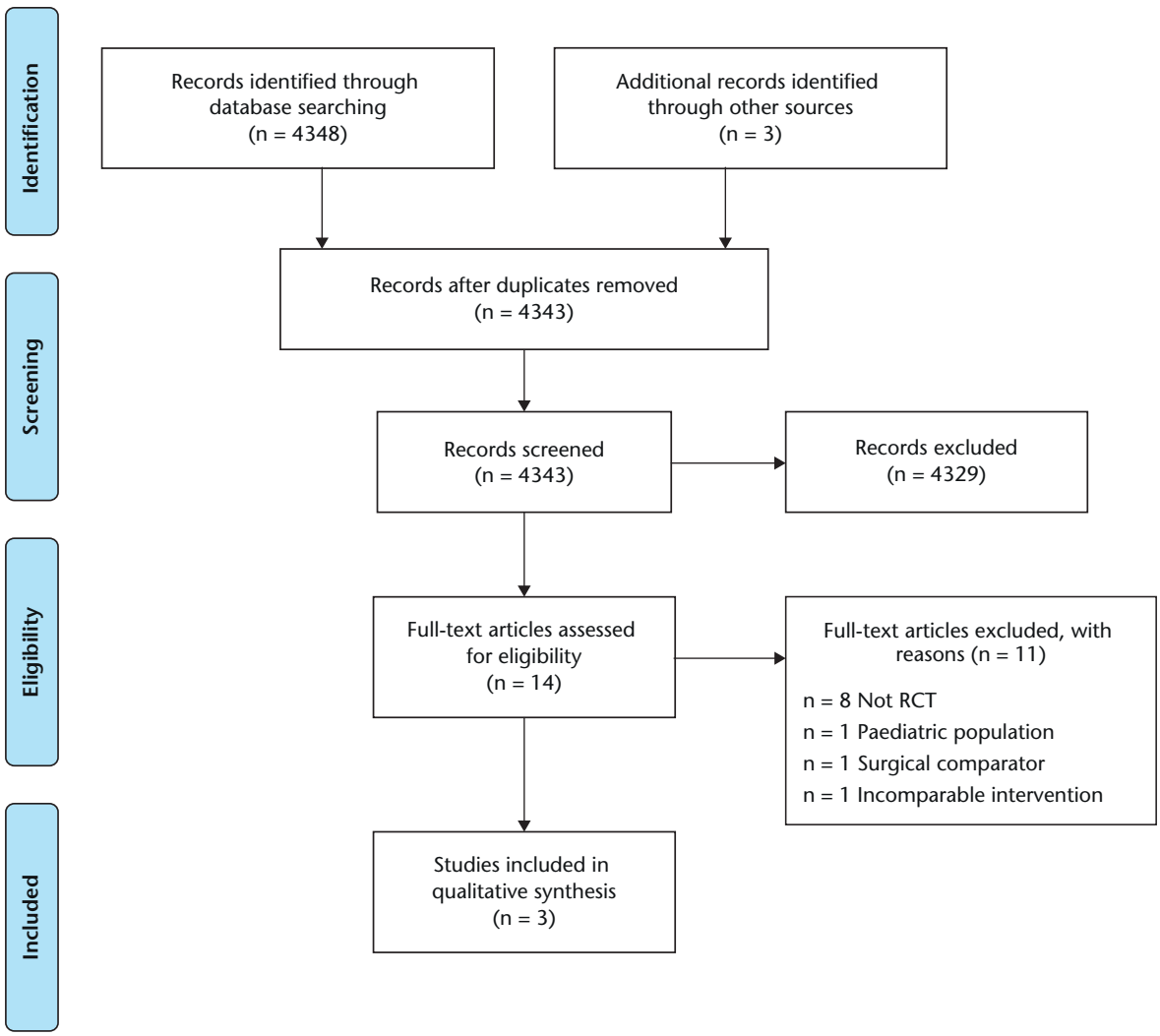



**Fig. 1** Flowchart of included studies.

### *Additional analyses and synthesis of results*

Dorsal tilt and shortening were evaluated across studies and were meta-analysed using forest plots (statistical software: Rewman 5.3). Intervention effect was expressed as standard mean difference. Pooled data were assessed for heterogeneity using chi$^2$ test and $I^2$ test. Heterogeneity was defined as absent between 0–25%, low between 26–50%, moderate between 51–75% and high between 76–100%. Fixed effect meta-analysis was performed when $p > 0.1$ and $I^2 < 50\%$, otherwise random effects meta-analysis was performed.

## Results

### *Study selection*

Searching the databases provided 4348 hits, and 14 articles were assessed in full after screening titles and abstracts (Fig. 1). Eight of these were not RCTs, one had a paediatric population, one used a surgical comparator and one tested a different method of closed reduction.[18] Three studies were included in the qualitative and quantitative synthesis (Table 1).

### *Study characteristics*

All three trials were based in Europe. A total of 483 patients were included (Table 1). Of these, 240 were treated using FTT and 243 using MT. Median ages were comparable between studies although range was not specified in Holkenborg et al[7] and inclusion period was not mentioned in Kongsholm et al.[8] Female gender was highly predominant across studies, although this was lower in Earnshaw et al[14] than the other studies (Table 1).

### *Risk of bias within studies*

Concerning the risk of bias in the studies, there was generally a lack of information within the articles (Table 2).

**Table 1.** Study characteristics

| | Country | *n* (FTT) | Median age (range) | Sex (female %) | Inclusion period |
|---|---|---|---|---|---|
| Earnshaw et al[14] | UK | 223 (112) | 65 (15–92) | 77 | Aug 1997–Oct 1998 |
| Holkenborg et al[7] | Netherlands | 144 (66) | 66 (N/A) | 92 | Jun 2008–Jul 2011 |
| Kongsholm et al[8] | Sweden | 116 (62) | 62 (19–86) | 91 | N/A |

*Note*. FTT, finger-trap traction.

**Table 2.** Quality assessment using the Cochrane Collaboration's tool for assessing risk of bias[16]

| | Sequence generation | Allocation concealment | Blinding of participants, personnel etc. | Incomplete data outcome | Selective outcome reporting | Other sources of bias |
|---|---|---|---|---|---|---|
| Earnshaw et al[14] | Unclear | Yes | Yes | Unclear | Unclear | Unclear |
| Holkenborg et al[7] | Unclear | Yes | Yes | Unclear | Yes | Unclear |
| Kongsholm et al[8] | Unclear | Unclear | Unclear | Yes | Unclear | Unclear |

**Table 3.** Study results

| | | Presentation | | Post-reduction | | Pain | Success rate (%) |
|---|---|---|---|---|---|---|---|
| | | Dorsal tilt (dgr) | Shortening (mm) | Dorsal tilt (dgr) | Shortening (mm) | | |
| Earnshaw et al[14] | Finger-trap traction | 23.6 +/- 12.0 | 5.5 +/- 3.9 | –2.5 +/- 2.0 | 1.9 +/- 1.0 | – | 87.0 |
| | Manual traction | 24.4 +/- 10.8 | 7.0 +/- 5.5 | –3.6 +/- 2.2 | 2.0 +/- 1.0 | – | 87.0 |
| Holkenborg et al[7] | Finger-trap traction | 27.4 +/- 12.0 | 3.8 +/- 3.9 | 5.3 +/- 9.3 | 0.2 +/- 2.8 | 44 | 71.2 |
| | Manual traction | 28.7 +/- 11.6 | 5.3 +/- 3.6 | 2.7 +/- 9.6 | 0.8 +/- 2.9 | 53 | 80.5 |
| Kongsholm et al[8] | Finger-trap traction | 21.8 +/- 12.8 | 6.6 +/- 4.4 | –0.2 +/- 4.3 | 1.3 +/- 2.5 | Less | – |
| | Manual traction | 19.4 +/- 12.3 | 6.5 +/- 4.0 | –1.9 +/- 3.8 | 2.0 +/- 2.4 | More | – |

*Note*. Values are mean +/- SD.

None of the studies addressed the randomization or allocation concealment in sufficient detail, and only Earnshaw et al[14] reported blinding of the radiographic assessors. Holkenborg et al[7] provided some additional information through email correspondence. Only Kongsholm et al[8] addressed completeness of data within the article. Only Holkenborg et al[7] had a protocol pre-published to assess selective outcome reporting and were available for additional inquiries regarding bias.[19]

### *Result of individual studies*

None of the radiological outcomes differ significantly between groups, apart from the dorsal tilt in Kongsholm et al[8] in favour of FTT (Table 3). In Kongsholm et al[8] there was significantly less pain associated with FTT. In Holkenborg et al[7] presented numbers are mm on a visual analogue scale and were not significant (Table 3).

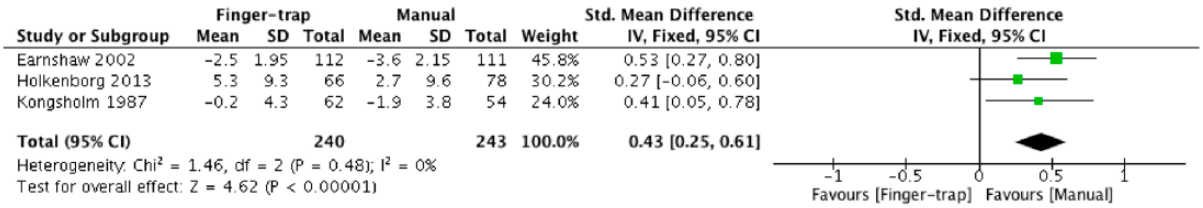
### *Synthesis of results*

Meta-analysis of dorsal tilt showed a mean difference of 0.43 (0.25, 0.61) in favour of MT ($p < 0.00001$) (Fig. 2). Meta-analysis of radial shortening showed a mean difference of –0.19 (–0.37, –0.01) in favour of FTT ($p = 0.04$) (Fig. 3).

## Discussion

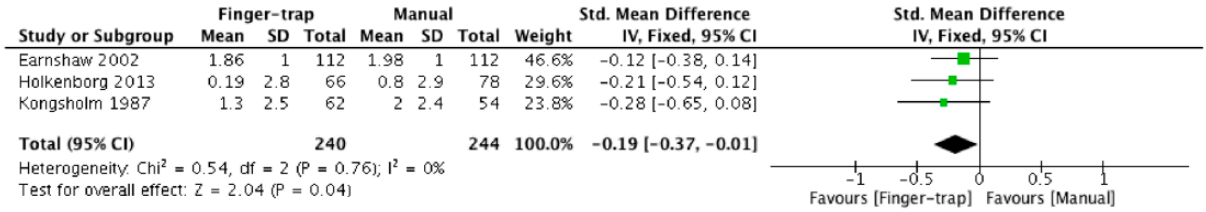
From the evidence presented here, there may be a slight but significant advantage in FTT in terms of restoring radial length but MT seems to provide a significantly better dorsal tilt post-reduction. In the pooled data, the differences are quite small: an improvement of 0.43 degrees in dorsal tilt and 0.19 mm improvement in radial length. However, in individual studies, the difference in radial length is as large as 0.65 mm, which is substantial. As several studies have identified radial shortening as the biggest factor of a poor outcome,[21,22] this indicates that improved reduction by finger-trap traction could potentially reduce the need for surgical intervention. These differences between the two methods seem logical considering the traits of the two methods. In FTT, there is a substantial amount of longitudinal traction for what may be a longer period than in MT.[8] On the other hand, it can be harder to apply dorsal pressure to the fragments during finger-trap reduction, as noted by Earnshaw et al.[14]

Even if radiographic outcomes are similar, there are other differences to consider, including pain and potential damage done by the reduction manoeuvre itself. Two of our included studies have measured pain as an outcome. In Kongsholm et al,[8] FTT reduction was significantly less




*Note*. FTT, finger-trap traction; MT, manual traction; SD, standard deviation; df, degree of freedom; Fixed, fixed effects model.

**Fig. 2** Forest plot of dorsal tilt in patients with a distal radius fracture after reduction with either FTT or MT.




*Note*. FTT, finger-trap traction; MT, manual traction; SD, standard deviation; df, degree of freedom; Fixed, fixed effects model.

**Fig. 3** Forest plot of fracture shortening in patients with a distal radius fracture after reduction with either FTT or MT.

painful than MT, even though this group was without anaesthesia. In a follow-up paper by the same research group, FTT was associated with significantly less neurological impairment, primarily less thumb numbness after 5 weeks.[20] Holkenborg et al[7] showed a significantly better Quick-DASH score in the FTT group as well as a reduced rate of carpal tunnel syndrome and Complex Regional Pain Syndrome. These findings may be indicative of less trauma being inflicted during the actual reduction manoeuvre by FTT and warrants further investigation. However, both Holkenborg et al[7] and Earnshaw et al[14] found reduction by FTT to be more difficult to perform than manual reduction. It is noted in Earnshaw et al[14] that manual reduction is the most commonly used method in the UK, whereas the finger-trap reduction method is often used in the US, and the difficulty in performing FTT may simply be a result of regional experience and preference as both studies are European.

Table 4 underlines the heterogeneity in the studies in both method and result. Though cast type seems to be relatively similar, method of anaesthesia is not comparable between studies at all and the follow-up time and amount of complications differ significantly as well. Kongsholm et al[8,20] reported on neurological complications defined as paraesthesia, weakness or numbness, which could vary a lot between patients. Furthermore, some of these neurological symptoms were transient and subsided in some patients and occurred in others between 5 weeks and 12 months. Finally, the two included groups also differ in method of anaesthesia. Holkenborg et al[7] used a more validated and reproducible method (Quick-DASH). Though Earnshaw et al[14] do not report specifically on complications, they do report 25% of patients requiring surgery. In Holkenborg et al,[7] 10 patients in each group required surgery, corresponding to 15% FTT and 13% MT. The statistically significant complication rate differences in Kongsholm et al[8,20] do not seem to be reproducible in the other studies, but this is probably due to their definition of neurological impairment being looser. The experience of the operator performing the reduction is impossible to evaluate in Kongsholm et al[8] as they do not specify who performed the reduction. In Earnshaw et al[14] and Holkenborg et al[7] FTT was combined with additional manipulation of the fragments after finger-trap suspension, making FTT a combination treatment in these groups.

One further study[18] tested a different method where the patient provided traction for the manoeuvre without anaesthesia. There were no significant differences between patient traction and MT in radiographic outcome, and patient traction was associated with significantly more pain.

No RCTs evaluating fluoroscopy were found, but Kodama et al[23] compared ultrasound-assisted closed reduction with a retrospective cohort of blind and fluoroscopy-assisted closed reduction control groups. Here, fluoroscopy-assisted reduction had a higher success rate than blinded closed reduction (94% versus 68%), but both reduction methods provided similar radiographic results.

There are some limitations to consider. Kongsholm et al[8] did not appear to be blinded in their radiographic

**Table 4.** Additional results

| | Follow-up | Surgery | Complications | Operator | FTT combined with manipulation | Anaesthesia | Cast |
|---|---|---|---|---|---|---|---|
| Earnshaw et al[14] | 5 weeks | 25%* | Not reported | Orthopaedic surgeon | Yes | Regional (Bier block) | Below the elbow |
| Holkenborg et al[7] | 6 months | FTT: 15% MT: 13%** | FTT: 5% MT: 14%*** | Emergency physicians or residents** | Yes | Haematoma block | Below the elbow |
| Kongsholm et al[8] | 1 year[20]^ | Not reported | 5 weeks: FTT: 3% MT: 20% $p < 0.01$ 1 year: FTT: 6% MT: 15% $p < 0.05$[20] | Not reported | No | MT: haematoma block FTT: No anaesthesia | Short arm cast |

*Notes*: *No significant difference in survivorship analysis; **Reported in correspondence with the primary author; ***Complex regional pain syndrome or carpal tunnel syndrome in 14% of MT versus 5% of FTT, but not overall significant; ^Reported in a follow-up article reporting on neurological complications; FTT, finger-trap traction; MT, manual traction.

assessments, which may pose a risk of bias. Concerning bias at review level, all identified research was retrieved. However, it has earlier been concluded that there likely exists a publication bias in the literature on distal radial fractures.[17] Our study is limited by the assumptions we make in gathering the quantitative outcome. Although the measurement of graphical data from Earnshaw et al[14] was performed as accurately as possible (measured by pixel), it is still an approximation of the actual results. In the data from Kongsholm et al[8] and Holkenborg et al[7] radial length was converted to radial shortening using the original reference article, but the validity of this conversion is untested.

In conclusion, the studies lack sufficient quality to reliably determine a difference between the two methods. Reduction by FTT seems to have a small significant advantage in restoring radial length, whereas reduction by MT seems to have a significant advantage in realigning dorsal tilt. The advantages are not necessarily clinically significant, and the studies were very heterogenic. Further research is warranted to investigate the best possible method of reduction in terms of radiographic outcome and patient comfort.

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