Ultrasound-guided manipulation of Colle's fracture in adults is not beneficial over landmark based fracture reduction. The outcome of a systematic review and meta-analysis.

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Abstract

Background This review aims to determine the relative Risk of distal Radius (Colle’s) fracture (DRF) malalignment between ultrasound-guided and conventional/landmark guided/blind manipulation. Methods Major electronic bibliographic databases on ultrasound-guided manipulation of DRF were searched. Studies with randomized, quasi-randomized, and cross-sectional study designs meeting the inclusion criteria were included for this review. Ultrasound and landmark guided DRF manipulations were named cases and controls respectively. The Newcastle-Ottawa Scale (NOS) was used to assess the quality of included studies. Results Thirteen and nine studies were analysed in the qualitative and quantitative analysis. 951 DRF patients (475 cases and 476 controls) from 9 studies with mean ages of 51.52 ± 11.86 (22-92) and 55.82 ± 11.28 (18-98) years for cases and controls respectively were pooled for this review. The pooled estimate of Relative Risk from the studies included in MA was 0.90 (0.74-1.09). There was a 10% reduction in risk of malreduction of DRF with USG-guided manipulation than the blind manipulation however, sensitivity analysis revealed a relative risk of 1.00 (0.96-1.05). Discussion The ultrasound guided manipulation does not offer benefits in preventing malreduction over the landmark based manipulation of DRF. Unbiased high quality studies can further verify the findings of this review.

Introduction

Distal radius fractures (DRF) account for one-sixth of fractures in emergency rooms (ER) [1]. Manipulation and reduction (M&R) followed by splint application is the most acceptable treatment for extra-articular and minimally displaced intra-articular DRF. Nevertheless, the high Risk of failure of M&R or a need for operative intervention is the cause of concern in these injuries. Recently several studies have investigated the role of ultrasound (USG) in guiding M&R in DRF [1]. While X-rays estimate the accuracy of reduction at a point in time, fluoroscopy and USG offer a real-time assessment of fracture alignment in DRF. The claimed benefits of USG for DRF M&R include increased accuracy of reduction and reduced ER waiting time. Higher treatment costs are associated with USG and fluoroscopy to guide M&R [2]. The utility of both the Portable USG machines as the point of care and standard units is described for DRF M&R [3–4]. Malik et al. reviewed the accuracy of USG-directed M&R in DRF [1]. However, their review was limited to a narrative synthesis of the included studies [1]. It reviewed two studies with mixed populations of children and adults [5–6]. One study in their review reported ultrasound observations instead of DRF participants [7]. The conclusions in their review were drawn from studies with a risk of reporting bias (selective outcome reporting and incomplete outcome data) favouring USG-guided M&R. Since their review, we identified one randomized controlled trial, two cross-sectional studies, and a retrospective cohort study that studied the effects of USG-guided M&R in DRF [8–11]. Therefore, it was decided to review USG-guided M&R in DRF. The primary objective of this review is to find out the Relative risk of mal-reduction between ultrasound-guided and blind M&R in DRF.

Material And Methods

The procedures followed in this review were per the ethical standards of the responsible committee on human experimentation (institutional and national). We conducted this review following guidelines in the preferred reporting items for the systematic review and meta-analysis (MA) (PRISMA).

Eligibility Criteria (Inclusion Criteria And Exclusion Criteria):

We included studies published in English that compared USG guided and blind/conventional/landmark-based M&R for DRF in adults. Non-comparative cross-sectional studies analysing pre and post M&R X-ray parameters in USG-guided M&R were included in this review. Case series and case reports were excluded from this review. The studies which reported the sensitivity and specificity of USG for the detection of DRF were excluded; however, mixed studies describing the accuracy of reduction with the former were included. The definitions of various datasets in this review are described below:

1. USG-guided M&R was defined as the use of a portable/point of care (POCUS) or standard ultrasound machine to visualize fracture ends during the manipulation of DRF.
2. Blind/conventional/landmark-based manipulation was defined as a method of manipulation where tactile/palpatory feedback of distal Radius was used for aligning the DRF.
3. Cases: DRF where USG-guided M&R was done were defined as cases for this review.
4. Controls: DRF, where blind/conventional/landmark-based M&R was done, were defined as controls for this review.
5. Success and failures in cases and controls were defined based on the X-ray criteria or the investigator's report from the studies included in this review.

6. However, we defined an endpoint of one attempt to M&R for DRF for subgroup analysis. Patients requiring second manipulation or operative fixation were considered failures in the subgroup analysis. Patients needing operative intervention after the first attempt of M&R were also considered failures. Within the one attempt of the M&R procedure, the ultrasound view could be repeated as often as necessary until an acceptable alignment was obtained. Proper alignment is viewed by ultrasound as aligning the proximal and distal bone cortex into as straight a line as possible on the number of views that the study investigators deemed necessary.

7. For this review, a trained doctor for USG was defined as one who adequately completed the minimum training sessions defined by the study investigators before participating.

8. Cases study was a single-arm study where USG-guided M&R of DRF was executed in real-time, and later accuracy of fracture alignment was confirmed with X-rays.

9. The control study was a single-arm study where blind M&R of DRF was executed, and the accuracy of fracture alignment was later confirmed with USG and X-ray.

**Information sources**

Major electronic databases up to August of 2022 were searched to identify studies in the English language on USG for M&R of DRF. We searched Cochrane Central Register of Controlled Trials (CENTRAL) (2022, Issue 8), CINAHL (March 2008 to August 2022), Directory of Open access journals (DOAJ) (August 2022), EMBASE (1974 to August 2022), MEDLINE (February 1948 to August 2022), ProQuest (1990 to August 2022), PubMed (January 1952 to August 2022) and Scopus (1930 to August 2022) for studies on USG for M&R of DRF.

**Search Strategy**

Annexure 1 describes this review's search strategy for the electronic databases.

**Searching for other resources**

We hand-searched the references from the included studies on USG for DRF. We excluded reports from trial registries, conference proceedings, books, and dissertations.

**Selection of studies and data collection process**

Review authors SN and JA independently screened all titles and abstracts for potentially eligible studies. We obtained full-text reports where appropriate. The same two review authors independently performed the study selection. We resolved disagreements about the inclusion or exclusion of individual studies and data extraction by discussion between the two authors or with a third author (PR) for the final study selection to ensure a consensus. We did not contact the authors of included studies. The data collected included study design, population, interventions, outcome measures, and results. We did not mask the source and authorship of the trial reports.

**Data items (outcome measures):** The following characteristics from the included reports were recorded: 1. Success in cases and controls 2. Failures in cases and controls 3. Attempts to closed reduction 4. Patients needing operative intervention 5. Demographic outcomes (Age, gender, duration of fracture, classification, etc.)

**Assessment of Risk of bias in included studies**

Pairs of the same review authors performed independent 'Risk of bias assessment of the included trials. We used the New castle Ottawa scale for observational studies for Risk of bias assessment in this review [12]. The New castle Ottawa scale is designed to assess four, one, and three numbered items under the selection, comparability, and outcome domains. The maximum number of stars awarded for a study under each domain can be four, one, and three.

**Statistical analysis:**

**Effect measures**

MA of the included studies was done using Review Manager 5.4. The random effects model pooled success and failure across included studies as risk ratio. The estimation of heterogeneity and inconsistency across included studies was done using the Chi-square test and I2 test. The pooled estimate of the relative Risk of failure of M&R was graphically represented with a forest plot. A Higgins I2 statistic
was used to quantify heterogeneity, and if it was greater than 40%, then it was explored with subgroup analysis. A sensitivity analysis was done to find out the pooled estimate after eliminating studies favouring the USG guided M&R. Review author (P) performed the statistical assessments.

Results

Outcomes of search

We searched 3932 records up to August of 2022 for studies on USG-mediated M&R of DRF from electronic databases Cochrane Central Register of Controlled Trials (CENTRAL) (8), CINAHL (24), DOAJ (142), Embase (183), Medline (21), Proquest (96), Pubmed (190), and Scopus (3268). We isolated 19 studies meeting the inclusion criteria from electronic databases (2–11, 13–21). We could not extract any study from a hand search of references among the isolated reports. We analysed 13 studies for qualitative analysis [2–4, 7–11, 13–17]. Six studies were excluded from qualitative analysis [5–6, 18, 19–21]. Two studies each were excluded from narrative synthesis because they studied DRF in a mixed population (children and adults) [5–6] and did not report the accuracy of fracture alignment after M&R [19–20]. One study, each a case report of USG study in DRF [21] and sensitivity and specificity of USG in DRF (18) were also excluded from qualitative analysis. We analysed Nine studies for MA [2–4, 8–10, 13, 15–16]. Four studies were not included in the MA [7, 11, 14, 17].

Characteristics of included studies

We classified the studies included for qualitative analysis into two groups based on the number of arms in the study.

Group I included Seven studies with two arms each [2–3, 7–9, 14, 16]. Among these studies, there were two each randomized controlled trials [8, 14], ambispective studies [2, 16] and case control studies [3, 7]. The ambispective studies had prospective USG mediated M&R and retrospective blind M&R arm (2,16). There was one retrospective cohort study [9].

Group II: included Six observational studies with one arm [4, 10–11, 13, 15, 17]. Four studies had cross-sectional design [4, 10, 11, 13]. One study each had multicentre prospective cohort and double-blind diagnostic accuracy designs [15, 17]. Among the reports in group II, there were three each single-arm control only [4, 15, 17] and case only [10–11, 13] studies.

We included nine studies for MA [2–4, 8–10, 13, 15–16]. A sensitivity analysis was done excluding 3 studies [2–3, 16].

Characteristics of excluded studies is described above.

Outcomes Of Risk Of Bias Assessment:

Selection

All except two studies [8, 13] had selection bias for the numbered item of representativeness of the exposed cases and case definition of distal radius fracture. The studies used explicit radiological criteria to define a DRF [8, 13]. The participants were not independently validated and there was subjectivity in recruitment.

Comparability

This domain had numbered items of comparability based on study design or analysis. The design of the studies included in this review is described under the characteristics of included studies. Five studies from group I reported on the domain of comparability between the participants recruited in either of the groups [2–3, 8–9, 16]. The variables compared between the groups in these studies were age, gender, fractured side, type of fracture, mechanism of injury, the experience of caregivers for fracture manipulation and USG imaging, and radiological parameters before and after M&R. The comparative studies reported no difference between the groups on the described parameters.

Outcome

All studies were numbered a star on ascertainment of exposure included in this review.
The Domain of 'comparability' did not apply to single-arm group II studies. The numbered items of selection of controls, the definition of controls, and the same method of ascertainment of exposure for cases and controls under the domains of selection and outcome did not apply to single-arm group II studies. The numbered item of non-response rate under the outcome domain did not apply to all the studies included in this review.

**Demographic outcomes**

The pre-set criteria for an acceptable fracture alignment on radiography were reported by five and three studies from groups I and II [2–3, 7, 10, 13–16]. The radial height and inclination did not vary as acceptable criteria for fracture alignment; however, studies were heterogeneous for the volar tilt ranging from 10 degrees of dorsiflexion to 20 degrees of volar-flexion. Six studies relied on the orthopaedic surgeon/ treating physician decision for an acceptable fracture alignment [4, 8–9, 13, 15–16]; however, the inter-rater agreement and reliability of reduction success and assessment methods were reported by three studies [7, 10, 13].

**Patient selection**

All studies had significant heterogeneity in participant selection for M&R in this review. All except 2 studies did not classify DRF [2, 4]. Three studies included intra-articular DRF with minimal displacement for participant recruitment [2–3, 14]. Four studies stratified participants based on the availability of USG-trained personnel at presentation for sampling [4, 8–10]. In comparison, six studies sampled participants based on the convenient sampling method [3, 7, 13, 15–17]. Another three studies did not describe the sampling method for participant recruitment [2, 11, 14]. No study described the method of allocation concealment. However, two studies had DRF allocation by the hand surgeons and orthopaedic surgeons to the ultrasonography group [2, 7]. Seven studies [2, 8–10, 14–16] (4 emergency physicians, one each research assistant, an orthopedic surgeon, and hand surgeons) described the caregivers who recruited patients into the studies, while five did not [3, 7, 11, 13, 17].

Three studies described the age of the fracture at the time of presentation, while the others did not [4, 7, 16]. The choice of anaesthesia ranged from hematoma block to procedural sedation. Three studies [7, 10, 11] used hematoma block exclusively, while the rest were heterogeneous in selection of anaesthesia for M&R.

**USG machine and personnel**: Five studies utilized point of care ultrasound portable machines [4, 7–8, 10, 17], while seven studies [2–3, 9, 11, 13, 15–16] employed standard units for imaging the fracture site. The frequency of the USG probe ranged from 5 to 15 MHz for the studies in this review. Seven [3–4, 8, 13, 15–16] and two [2, 7] studies imaged, two (dorsal and radial) and three (dorsal radial and volar) distal radius surfaces to guide the fracture manipulation. Caregivers across included studies received USG training ranging from video demonstrations to certification. We could not draw logical conclusions on the influence of physician experience for achieving better radiological indices between the groups due to extensive heterogeneity in the included studies for the description of caregivers. Group I: Emergency physicians executed M&R in both groups in four studies [3, 8–9, 16], while two studies had mixed caregivers (emergency clinicians and residents [2, 14] or orthopedic surgeons and hand surgeons) execute M&R (2). Group II: Orthopaedic residents under supervision executed M&R in three studies [4, 7, 15], while emergency physicians and residents executed M&R in four [10–11, 13, 17]. There were 4 [4, 8–9, 14], 2 [15–16], and 2 [13, 17] studies where orthopedic surgeons and senior emergency physicians radiologists assessed primary outcomes. Five studies did not report outcome assessors in this review [2–3, 10–11, 14].

**Quantitative Analysis (Ma):**

We pooled 951 DRF (475 cases and 476 controls) from nine studies (group I five and group II four studies) [2–4, 8–10, 13, 15–16]. Three and two case and control single arm studies contributed 220 and 95 DRF. The mean age of cases and controls was 51.52 ± 11.86 (22–92) and 55.82 ± 11.28 (18–98) years. There were 159 each left and right cases. Ninety three left and 94 right DRF were pooled from controls. There were 202 male and 273 female cases. There were 147 and 294 male and female controls pooled in the review.

The pooled estimate of relative Risk from the studies included in MA was 0.90 (0.74–1.09) (Fig. 2). There was a 10% reduction in risk of malreduction of DRF M&R with USG-guided manipulation than the blind manipulation however, the estimate of effect did cross the null value. A sensitivity analysis was done after excluding 3 studies favouring USG guided M&R (2–3,16) demonstrated a Relative Risk of 1.00 (CI 0.96–1.05) (Fig. 3). The Relative Risk of malreduction was higher in group II 2% [RR = 1.02 [0.97, 1.08]] in contrast to group I, where it was 38% [RR = 0.62 [0.49, 0.80]] on subgroup analysis (Fig. 4).

**Discussion**
Since the emergency room is a busy area of any hospital, all efforts should be directed at improving its efficacy and outcomes. USG-guided DRF M&R might be efficacious in preventing malreduction because it provides real-time feedback on fracture alignment. We estimated a benefit of a 10% decrease in the risk of malreduction using USG-directed manipulation. However, we observed that our pooled estimate of effect ranged from 0.74 to 1.09. This uncertainty favouring USG-guided M&R by 26% and landmark-guided reduction by 9% is because of heterogeneity and bias introduced due to the inappropriate design of the included studies. We assessed Fig. 2 (forest plot). We found a group of studies [2–3, 16] with wide confidence intervals favouring the USG-guided M&R, while another group of six studies [4, 8–10, 13, 15] had narrow confidence intervals crossing the null effect. Sensitivity analysis after excluding the studies with wide confidence intervals [2–3, 16] revealed a Relative risk of 1 (0.96–1.05). The three studies with wider confidence intervals skewed our results, showing a demonstrable 10% risk reduction with USG-guided M&R. When we analysed the reasons for deviation of these studies, we found that two studies had an ambispective design with prospective USG-guided arm and conventional retrospective arm. While one study [2] reported no difference between the groups on radiographic indices, the other two [3, 16] described improvement in one (volar tilt). The findings of this review are more in line with one randomized controlled trial, which did not demonstrate a difference between both treatments [8].

The included studies were heterogeneous on the anesthæsia delivered for M&R, the type of ultrasound machines used, and the experience of the caregivers for fracture manipulation and radiographic outcome assessments. These factors were compared by very few studies included in this review. It needs to be more accurate to comment on the efficacy of ultrasound in improving the accuracy of reduction without studying the effects of the factors above.

There is a source of publication bias due to the non-inclusion of reports from trial registries and studies published in languages other than English. Malik et al. reported the non-availability of published results as the cause behind the non-inclusion of reports from trial registries. Individual studies had selective outcome reporting of the described primary endpoints. However, there was minimal scope for changing the primary research question in most of the studies. We did not investigate grey literature in this review.

We conclude that given the quality of studies available, the USG-guided manipulation of DRF offers no benefits over the conventional landmark-guided reductions. There are more costs to the treatment and reduction times in a busy emergency room [2]. Two studies imparted a substantive effect on this review due to the study design and the sample size [8, 13]. Both the studies did not find the difference between USG-guided and landmark-based M&R, therefore, we advocate future studies of larger sample size and methodological vigor to settle the controversy between the methods of M&R in DRF.

**Declarations**

**Conflict of interest.** No conflict of interest of any of the authors to declare for this manuscript

**References**


**Figures**
Figure 1
PRISMA 2009 Flow Diagram
Figure 2

Pooled estimate of effect Relative Risk between ultrasound versus blind/conventional/landmark guided distal radius fracture manipulation and reduction.

![Graph](image)

**Figure 3**

Sensitivity analysis after exclusion of studies that favored USG guided manipulation and reduction.

![Graph](image)
Group I (Comparative two arm studies)

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>USG Events</th>
<th>Total</th>
<th>Blind Events</th>
<th>Total</th>
<th>Weight</th>
<th>Risk Ratio M-H, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammann Stefan</td>
<td>25</td>
<td>71</td>
<td>67</td>
<td>142</td>
<td>34.0%</td>
<td>0.75 [0.52, 1.07]</td>
</tr>
<tr>
<td>Ang</td>
<td>4</td>
<td>62</td>
<td>26</td>
<td>102</td>
<td>15.0%</td>
<td>0.25 [0.09, 0.69]</td>
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<tr>
<td>Anita Sabzghabaei</td>
<td>6</td>
<td>66</td>
<td>16</td>
<td>65</td>
<td>12.2%</td>
<td>0.38 [0.16, 0.90]</td>
</tr>
<tr>
<td>Jhon P smiles</td>
<td>26</td>
<td>50</td>
<td>24</td>
<td>50</td>
<td>18.3%</td>
<td>1.04 [0.70, 1.55]</td>
</tr>
<tr>
<td>Kodama</td>
<td>2</td>
<td>43</td>
<td>7</td>
<td>22</td>
<td>7.1%</td>
<td>0.15 [0.03, 0.65]</td>
</tr>
<tr>
<td>Manoj</td>
<td>9</td>
<td>39</td>
<td>18</td>
<td>40</td>
<td>13.8%</td>
<td>0.51 [0.26, 1.00]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>330</strong></td>
<td></td>
<td><strong>421</strong></td>
<td></td>
<td><strong>100.0%</strong></td>
<td><strong>0.61 [0.48, 0.77]</strong></td>
</tr>
</tbody>
</table>

Total events: 71 158
Heterogeneity: Chi² = 16.11, df = 5 (P = 0.007); I² = 69%
Test for overall effect: Z = 4.22 (P < 0.0001)

Group II (non-comparative one arm studies)

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>USG Events</th>
<th>Total</th>
<th>Blind Events</th>
<th>Total</th>
<th>Weight</th>
<th>Risk Ratio M-H, Fixed, 95% CI</th>
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<tr>
<td>Bozkurt</td>
<td>39</td>
<td>40</td>
<td>19</td>
<td>20</td>
<td>11.5%</td>
<td>1.03 [0.92, 1.15]</td>
</tr>
<tr>
<td>Darryl Wood</td>
<td>28</td>
<td>35</td>
<td>24</td>
<td>35</td>
<td>10.9%</td>
<td>1.17 [0.88, 1.54]</td>
</tr>
<tr>
<td>Esmaeian</td>
<td>145</td>
<td>154</td>
<td>146</td>
<td>154</td>
<td>66.3%</td>
<td>0.99 [0.94, 1.05]</td>
</tr>
<tr>
<td>Rezashah</td>
<td>26</td>
<td>30</td>
<td>25</td>
<td>30</td>
<td>11.3%</td>
<td>1.04 [0.84, 1.29]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>259</strong></td>
<td></td>
<td><strong>239</strong></td>
<td></td>
<td><strong>100.0%</strong></td>
<td><strong>1.02 [0.97, 1.08]</strong></td>
</tr>
</tbody>
</table>

Total events: 238 214
Heterogeneity: Chi² = 1.93, df = 3 (P = 0.59); I² = 0%
Test for overall effect: Z = 0.74 (P = 0.46)

Figure 4

Comparative forest plots of studies between the group I and II.

Supplementary Files

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- annexure1.docx