Ultrasound directed reduction of distal radius fractures in adults: a systematic review

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TABLES: 3
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ABSTRACT

OBJECTIVE:
To conduct a systematic review of the clinical literature to determine whether ultrasound can be used to improve the reduction of distal radius fractures in adults in the emergency department.

METHODOLOGY:
A study protocol was registered on PROSPERO. EMBASE, PubMed/MEDLINE, the Cochrane Central Register of Controlled Trials and ClinicalTrials.gov of U.S. National Library of Medicine were searched for studies evaluating ultrasound assisted distal radial fracture reductions in comparison to standard care. The primary outcome of interest was manipulation success rates, defined as the proportion of fracture manipulations resulting in acceptable anatomical alignment, with secondary outcome being subsequent surgical intervention rates in ultrasound and standard care group of patients.

RESULTS:
248 were screened at title and abstract and 10 studies were included for a narrative synthesis. The quality of this evidence is limited but suggests ultrasound is accurate in determining distal radius fracture reduction and may improve the quality of reduction compared to standard care. However, there is insufficient evidence to determine whether this affects the rate of subsequent surgical intervention or functional outcome.

CONCLUSION:
There is a lack of evidence that using ultrasound in the closed reduction of distal radius fractures benefits patients. Properly conducted randomized controlled trials with patient orientated outcomes are crucial to investigate this technology.

KEYWORDS: Ultrasound, Distal Radius Fracture
INTRODUCTION

Distal Radial Fracture (DRF) s are one of the most prevalent fractures treated in emergency medicine department (ED) s around the world.[1–3]. In the UK, they account for around one-sixth of all the fractures seen in the ED,[4] with approximately 71,000 patients affected each year,[5]. They are more common in the elderly,[6] frequently occurring due to falls onto an outstretched hand, and their incidence is increasing,[7].

These injuries are often associated with wrist deformity, due to fracture displacement which requires manipulation to bring the bones into anatomical alignment (fracture reduction). In the UK, initial closed Manipulation Under Anaesthesia (MUA) is commonly undertaken in the ED,[8] by emergency physicians and this is typically carried out ‘blind’ without the use of real-time imaging. After manipulation, the wrist is placed in a plaster cast before getting x-rays ‘in cast’ to check the fracture position.

Despite ED fracture manipulation, up to as many as 41% of patients in UK subsequently require surgery by orthopaedic team to further reduce and or fixate the fracture.[9]. It has been suggested that real time imaging such as fluoroscopy or point of care ultrasound might enable more anatomical reductions and reduce this need for surgery.[10,11]. National Institute for Health and Care Excellence (NICE) and research prioritization initiatives have highlighted the need for research into the use of imaging in the reduction of DRFs in ED.[12].

Ultrasound is a harmless and potentially convenient alternative to fluoroscopy in the ED. It can be repeated, is not subject to Ionising Radiation (Medical Exposure) Regulations (IRMAR),[13], is routinely available and familiar to emergency physicians for whom point of care US is a core competency in many countries.[14]. Several small studies have described the use of ultrasound in the reduction of distal radius fractures.[10,11,15–17] in adults. Its use for identifying pediatric fractures has been well acknowledged,[18–21] and has also been used for reduction of forearm fractures in ED.[22]. However, the evidence for its use is not well established and it is not in widespread use. Furthermore, ultrasound could introduce delay to treatment, risk repeated further reduction attempts and associated complications.

There is a need for systematic review and evaluation of the available evidence to direct current best practice and future research.[23]. The purpose of this review therefore is to identify and evaluate studies to determine whether the use of ultrasound in directing a reduction of distal radius fractures in adults is beneficial in improving fracture reductions and reducing the need for subsequent surgical treatment, compared to standard manipulation without real time imaging.

METHODS

Protocol and registration
The protocol was registered in PROSPERO with the registration number CRD42019123186 before commencing the study. This systematic review was conducted with reference to the Cochrane Handbook for Systematic Reviews of Interventions,[24] and reported according to PRISMA guidelines.[25].

Information sources
The electronic databases EMBASE, PubMed/MEDLINE, CENTRAL and ClinicalTrials.gov were searched from inception until June 2019.

Search
The following search string was formed with the help of Information Specialists in The National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) South West Peninsula(PenARC) Evidence Synthesis Team Search and Review Clinic in University of Exeter, Exeter, UK and translated into each database:
(ultrasound OR ultra sound OR ultra-sound OR sonograph OR sonography) AND (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).

After database searches, supplementary searches were conducted via Google, Google Scholar, National Institute of Health Trial registry website, International Standard Randomized Controlled Trial Number Register websites and by examining the reference lists of included studies. A post hoc MeSH term only search was also conducted, which did not provide any additional studies.

**Study selection**

One reviewer (HM) screened studies identified by the searches against the selection criteria below using a predesigned proforma. Studies were screened against the inclusion/exclusion criteria at title and abstract. HM identified the full texts of articles and abstract that met inclusion criteria at this stage and screened them in full. Second reviewer (AA) reviewed the studies list after de-duplication and the studies included for this review. Included studies were available at full text except one, only available as an abstract,[26]. Any disputes between the two authors were resolved through discussion.

**Eligibility criteria**

**Study type:**

Randomised Control Trials (RCT), Non-randomized Controlled Studies (NRS) and observational studies in hospital setting were included in this review. Systematic reviews, case reports and case series were not included.

**Population:**

All studies including adult population, aged > 18 years were included. Studies including only patients aged < 18 years were excluded.

**Intervention:**

Studies utilising US to direct or determine adequacy of reduction of DRF, compared with standard care were reported. Studies that used US for diagnosis of DRF alone were excluded.

**Outcome:**

Primary outcome measures: Manipulation success rates determined by improvement in defined radiological parameters. Secondary outcome measures: Subsequent surgical intervention rates in US and standard care group of patients.

**Data collection process**

HM extracted relevant data from included studies into an Excel spread sheet (2010). Data extraction was reviewed by AA.

**Data items**

The data extracted included: authors, year of publication, language of publication, source, country of trial, methodological quality criteria, enrolment period, sample size, patient characteristics, intervention, and outcomes (manipulation success rate and surgical intervention percentages between US and standard treatment groups).

**Quality assessment of individual studies**

Quality assessment was undertaken for each study by HM using Effective Public Health Practise Project’s(EPHPP) Qualitative Assessment Tool for Quantitative Studies,[27] and checked by AA. This took place after studies were finalised for the narrative synthesis and helped to assess the quality of available evidence.

**Outcome measures**

Primary outcome measure was the difference in the percentages of successful manipulation rates between US and standard groups.

**Synthesis of results**

A narrative summary was conducted regarding use of US in management of distal radial fractures, given the clinical and methodological heterogeneity of the available studies.
RESULTS

Study selection
A total of 323 studies were identified via database search and 2 from Google search (Fig. 1). After de-duplication, 258 records were screened at title and abstract stage with particular attention given to the methodology section. At full text stage, 25 studies were screened and 10 included for the narrative synthesis.

Nine studies,[10,11,15–17,28–31] were identified as observational studies and one study was identified as randomised controlled trial,[26]. This RCT was published as an abstract,[26], and the author, upon contact, confirmed that there was no full text published. However, we chose to include this abstract due to its informative content.

There were six other trials,[32–38] identified on Clinicaltrials.gov, Netherlands Trial Register(NTR) and WHO International Clinical Trials Registry(CTRP) during the screening stage but none were published or had any results posted. One trial was incomplete due to recruitment issues,[36], two trials from Canada,[32,34], one study from Iran,[38] did not publish any results and the concerned personnel did not respond to the emails. One RCT was identified on Netherlands Trial Register,[37] but there was no response from the team and the trial registry had no update regarding the study. The only active RCT was a feasibility trial from UK which started recruiting in October 2019,[35].

As shown in Table 1, 10 studies were included for the Narrative synthesis.

Fig. 1 Flow diagram showing study selection
Study characteristics

Four of the included studies were Cohort studies,[11,15,16,29], among which two were multicentre,[15,29], one study was a Before-and-After study,[39], two studies were cross-sectional,[28,31], two were case-control,[17,30] and one was a RCT,[26]. All manuscripts were published in English from year 2002 till 2018 and originated in Taiwan,[16], Singapore,[10], USA,[15,30], Canada,[26,29], Japan,[11], Iran,[17,28] and Turkey,[40]. All studies included adult population except for two studies,[15,16] which also included children but did not give a separate data for them, with the age range of 3-95 years. The total number of patients in the included studies was 956, of which 638 received US assisted reduction of a DRF. Primary outcome of manipulation success rate was clearly described in 6 studies,[11,15,17,26,28,31] and secondary outcome involving surgical intervention after initial fracture manipulation was given in only four,[10,15,17,26]. Study characteristics are summarized in Table 1.

Table 1. Study characteristics of individual studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study type</th>
<th>Publication year</th>
<th>Language</th>
<th>Source</th>
<th>Country</th>
<th>Sample size</th>
<th>Interventional arm</th>
<th>Control arm</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chern Y-C et al</td>
<td>Prospective Cohort study</td>
<td>2002</td>
<td>English</td>
<td>Online Journal</td>
<td>Taiwan</td>
<td>27</td>
<td>NA</td>
<td>Adults and children aged 8 - 80 years</td>
<td></td>
</tr>
<tr>
<td>Chung JH et al</td>
<td>Case-control Study</td>
<td>2009</td>
<td>English</td>
<td>Online Journal</td>
<td>Singapore</td>
<td>62</td>
<td>104</td>
<td>Adults &gt; 21 years</td>
<td></td>
</tr>
<tr>
<td>ChenW-B et al</td>
<td>Multicentre Cohort Study</td>
<td>2009</td>
<td>English</td>
<td>Online Journal</td>
<td>USA</td>
<td>46</td>
<td>100</td>
<td>Adults and children aged 3-87 years</td>
<td></td>
</tr>
<tr>
<td>Brahim J, Turner J</td>
<td>Randomized Controlled Trial</td>
<td>2011</td>
<td>English</td>
<td>Online Journal</td>
<td>Canada</td>
<td>27</td>
<td>47</td>
<td>Adults &gt; 18 years</td>
<td></td>
</tr>
<tr>
<td>Kodama N et al</td>
<td>Cohort Study</td>
<td>2013</td>
<td>English</td>
<td>Online Journal</td>
<td>Japan</td>
<td>43</td>
<td>100</td>
<td>Adults 23-73 years</td>
<td></td>
</tr>
<tr>
<td>Eshkazi N et al</td>
<td>Prospective Cross-sectional</td>
<td>2013</td>
<td>English</td>
<td>Online Journal</td>
<td>Iran</td>
<td>154</td>
<td>154</td>
<td>Adults 22-73 years</td>
<td></td>
</tr>
<tr>
<td>Sabizghabaei A et al</td>
<td>Cross-sectional study</td>
<td>2016</td>
<td>English</td>
<td>Online Journal</td>
<td>Iran</td>
<td>85</td>
<td>120</td>
<td>Adults &gt; 18 years</td>
<td></td>
</tr>
<tr>
<td>Seokmanky B et al</td>
<td>Multicenter prospective cohort</td>
<td>2016</td>
<td>English</td>
<td>Online Journal</td>
<td>Canada</td>
<td>131</td>
<td>131</td>
<td>Adults aged 18-85 years</td>
<td></td>
</tr>
<tr>
<td>Liao BC et al</td>
<td>Case-Control study</td>
<td>2017</td>
<td>English</td>
<td>Online Journal</td>
<td>USA</td>
<td>23</td>
<td>43</td>
<td>Adults &gt; 18 years</td>
<td></td>
</tr>
<tr>
<td>Bozkurt O et al</td>
<td>Prospective cross-sectional</td>
<td>2018</td>
<td>English</td>
<td>Online Journal</td>
<td>Turkey</td>
<td>60</td>
<td>60</td>
<td>Adults &gt; 18-85 years</td>
<td></td>
</tr>
</tbody>
</table>

Quality assessment of studies

Quality assessment was undertaken by using Effective Public Health Practise Project’s (EPHPP) Qualitative Assessment Tool for Quantitative Studies,[27] as shown in Table 2. This tool used eight components to assess the quality of a study: Selection bias, Study design, Confounders, Blinding, Data collection methods, Withdrawals and drop-outs, Intervention integrity and Analysis appropriate to question. All components except for the last two: Intervention integrity and Analysis appropriate to question, needed rating. Each component could be rated as Strong, Moderate or Weak based on a questionnaire tool done for each individual study. The questionnaire tool was filled with the help of EPHPP dictionary. After all components were rated in the questionnaire tool, final rating of the individual paper was determined by the following pre-set criteria: Strong if no weak component, moderated if one weak component or Weak if two or more weak components. The majority of the studies,[11,16,17,26,28-31] had a weak global rating mainly due to not reporting controlling for confounders, data collection methods and follow up data for participants. The only RCT,[26], although having a strong study design, which also addressed for the confounders, had a weak global rating, due to limited information due to being in abstract form, regarding data collection and follow-up of patients.

Table 2. Quality assessment of individual studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Selection bias</th>
<th>Study design</th>
<th>Confounders</th>
<th>Blinding</th>
<th>Data collection methods</th>
<th>Withdrawals and dropouts</th>
<th>Global rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chern Y-C et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
</tr>
<tr>
<td>Chung JH et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Strong</td>
<td>Weak</td>
<td>Strong</td>
<td>Strong</td>
<td>Moderate</td>
</tr>
<tr>
<td>ChenW-B et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Brahim J, Turner J</td>
<td>Moderate</td>
<td>Strong</td>
<td>Strong</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
</tr>
<tr>
<td>Kodama N et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Eshkazi N et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Sabizghabaei A et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Weak</td>
</tr>
<tr>
<td>Seokmanky B et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
</tr>
<tr>
<td>Liao BC et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Weak</td>
</tr>
<tr>
<td>Bozkurt O et al</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Weak</td>
<td>Weak</td>
</tr>
</tbody>
</table>

Results of individual studies and synthesis of results
Results of individual studies are summarized in Table 3. Below is the synthesis of findings from included studies.

**Manipulation success rate:**
Manipulation success rate was significantly (p<0.05) increased in one study,[17] compared to the standard group. Three studies showed statistically non-significant (p>0.05) increased manipulation success rate in US group but no number was available for the control arm. Esmailian et al,[41] showed a 97.5% success rate in US group but no number was available despite a direct correspondence request to the authors. Chinnock et al had 6.5% patients undergo surgical fixation in the US group but no numbers were present for the control group.

**Surgical fixation rate:**
Two studies,[10,17] showed a significant (p<0.05) reduction in surgical rate seen in the US group. The only RCT in this review,[26] however, showed no difference in the rate of surgery between the two groups. Interestingly, this study also showed that a significantly greater number of attendings (consultants) performed reductions in the standard group, 65%(p=0.02) and details of randomisation and any concealment measures were not available despite a direct correspondence request to the authors. Chinnock et al had 6.5% patients undergo surgical fixation in the US group but no numbers were present for the control group.

**Accuracy of detecting a successful fracture reduction:**
Four studies,[15,28,30,31] determined US to have a higher sensitivity, three,[28,30,31] having a higher sensitivity and specificity, and three,[15,28,31] having a higher positive predictive value in detecting successful fracture reduction. Socransky et al,[29] reported a greater certainty regarding adequacy of reduction using US.

**Improvement in radiological parameters:**
All studies used radial shortening distance, radial inclination angle and volar tilting angle as the radiological parameters to determine adequacy of reduction. Two studies,[10,17] showed US to significantly (p<0.05) improve the volar tilt. Chern et al reported a significant (p<0.05) improvement in all radiological parameters, whereas Kodama et al,[11] showed no difference between two groups.

**Table 3. Results of individual studies.**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Rate of fracture reduction success</th>
<th>Accuracy of detecting successful fracture reduction</th>
<th>Surgical fixation</th>
<th>Improvement in radiological parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>CG</td>
<td>P-value</td>
<td>SN</td>
<td>SP</td>
</tr>
<tr>
<td>1. Chern T, et al</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2. Aung S, et al</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3. Chinnock B, et al</td>
<td>83%</td>
<td>80%</td>
<td>&lt;0.001</td>
<td>94%</td>
</tr>
<tr>
<td>4. Brahju J, Turner J</td>
<td>92.8%</td>
<td>90%</td>
<td>P=1.0</td>
<td>N/A</td>
</tr>
<tr>
<td>5. Kodama N, et al</td>
<td>95%</td>
<td>95%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>6. Esmailian M, et al</td>
<td>94.3%</td>
<td>94.3%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>7. Socransky S, et al</td>
<td>91.3%</td>
<td>91.3%</td>
<td>P=0.02</td>
<td>N/A</td>
</tr>
<tr>
<td>8. Lau BC, et al</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>99.5%</td>
</tr>
<tr>
<td>9. Bozkurt O, et al</td>
<td>97.5%</td>
<td>97.5%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>


**DISCUSSION**

We conducted a systematic review to identify, assess and summarize the literature reporting the use of ultrasound to assist in the closed reduction of distal radius fractures in adults. This review identified 10 studies from seven countries, with methodological heterogeneity and a total sample size of 956 patients. There is a suggestion that US may be a useful adjunct for the closed manipulation of DRFs. Its use is associated with a higher fracture reduction success rate,[11, 15,17,26,31] higher sensitivity in detecting an adequate reduction,[15,28,30,31] and hints at a possible reduction in subsequent surgical fixation rate,[17,39] when compared to control groups. However, the overall quality of the
studies and their evidence is weak. The sole RCT addressing the issue is of limited size, only
reported in abstract and so significant methodological limitations cannot be excluded.

However, ultrasound does provide real time imaging and aids anatomic alignment during fracture
reduction. It is plausible that this would enable better reduction as compared to a blind technique or
clinical assessment. At least in the UK, where alternative real time imaging in ED is rarely available,
US would seem a practical and pragmatic imaging option. US is cost effective in comparison to
alternative imaging modalities used in a range of Emergency Department presentations.[42].

Accuracy of US in detecting fractures is well evidenced,[43,44] and our review also supports its high
sensitivity and specificity for detecting an adequate fracture reduction. It provides a greater certainty
of reduction,[29] allows repeated attempts of manipulation before plaster cast immobilization and
confirmatory x-rays. It has given comparable results to other real time imaging techniques like
Fluoroscopy,[11].

DRFs undergo surgical fixation if the initial fracture manipulation or position at follow up is felt
unsatisfactory usually by an orthopaedic surgeon. Four studies reported this outcome and two
showed a significant reduction in the surgical fixation rates in US assisted reductions,[17,39]. The only
RCT in this review however reported no difference in rate of surgery in the US group compared to the
control arm. This discrepancy could be due to the methodology of these studies. However, it has
important implications for a resource limited setting like ED. None of the key studies reported on
functional outcomes. This and other patient oriented outcomes,[45] should be a key component of
future studies.

This is the only systematic review to date to have explored literature regarding US assisted reduction
of DRF in adults. We have used a broad search strategy, to include all published and non-published
literature. We included studies involving US in any aspect of closed DRF reduction, did not limit our
search to language and a thorough quality appraisal was undertaken. All the studies appraised in this
review presented some flaws and limitations which should be addressed in future studies. The
majority of studies were of weak quality, mainly due to weakness of study design, follow up data and
data collection methods and the presence of confounders. There was no power calculation in the
majority of studies, healthy controls used in some studies and no comparison or control group in
one,[16]. The review as a whole faced clinical and methodological heterogeneity. There was a small
number of studies and one was an abstract. All efforts were made to inquire more about data and
unpublished material, but no author corresponded to the emails except one,[26]. Another limitation of
this review is only one reviewer for the primary screening of studies. All steps were taken to build a
credible search strategy, but this could also be a limiting factor. Grey literature was assessed for the
completion of this review, but we cannot rule out the possibility that other unpublished evidence was
missed.

CONCLUSION

Ultrasound to assist in the reduction of distal radius fractures is a plausible and potentially helpful
cost-effective method to guide reductions in the ED. It is accurate in detecting fracture reductions and
if it’s use, as this review suggests, improves the quality of these reductions, it could conceivably
influence the subsequent need for surgery. However, only observational studies and 1 RCT of limited
quality has been conducted to date and none have included patient orientated outcomes. There is
therefore currently insufficient evidence to justify the routine use of US to assist in the reduction of
these common fractures. Adequately powered, high quality randomised controlled trials with
appropriate and meaningful patient orientated outcomes are crucial to determine if there are any
benefits of ultrasound use to assist in the reduction of distal radius fractures in the ED.

COMPETING INTEREST

None declared

FUNDING
This study did not receive any internal or external funding.
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42 Bierig SM, Jones A. Accuracy and Cost Comparison of Ultrasound Versus Alternative Imaging
44. doi:10.1177/875647930936240


APPENDIX:

Database(s): Embase 1974 to 2019 October 29

Search Strategy:

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