Management of Acute Distal Radioulnar Joint Instability Following a Distal Radius Fracture: A Systematic Review and Meta-Analysis

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Purpose: We sought to review the clinical outcomes of conservative and operative treatment options for acute distal radioulnar joint (DRUJ) instability associated with distal radius fractures in adult patients.

Methods: A systematic search of PubMed, MEDLINE, and EMBASE for articles published between 1990 and 2020 involving DRUJ instability associated with distal radius fractures was performed. The primary outcomes analyzed included clinical grip strength; range of motion; the disability of the arm, shoulder and hand (DASH) score; and the modified Mayo wrist score (MMWS).

Results: Of the 531 articles identified in the literature search, 8 met our defined criteria and were included in the final analysis. The cumulative sample size was 258 patients at a mean follow-up of 11.1 months (range, 3–16.9 months). Treatment groups included cast immobilization in supination, K-wire stabilization, and triangular fibrocartilage complex (TFCC) repair. Statistical analysis revealed no difference across groups in active flexion-extension or DASH scores. A significant decrease in grip strength was found in patients who underwent TFCC repair compared with those who underwent both cast immobilization (P = .04) and K-wire stabilization (P = .02). Furthermore, we found a significant decrease in active pronation-supination between patients who underwent TFCC repair and those who underwent cast immobilization (P = .03). Patients who underwent TFCC repair were also found to exhibit decreased MMWS as compared with those who underwent K-wire stabilization (P = .05). Overall, persistent DRUJ instability was only found in 4 patients (1.5%), without a significant difference between treatment groups.

Conclusions: This study suggests functional advantages of certain treatment modalities over others, with the range of motion being highest in patients who underwent cast immobilization and grip strength being highest in patients who underwent K-wire stabilization. However, the mean DASH scores showed no difference across all groups, calling into question the clinical need to pursue operative treatment via K-wire stabilization or TFCC repair over conservative treatment via cast immobilization. This study will hopefully serve as a foundation for future prospective studies to help improve and standardize treatment algorithms in patients with DRUJ instability and distal radius fractures.

Type of study/level of evidence: Therapeutic II.

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Distal radius fractures (DRF) are the most common fractures of
the upper extremities, with an incidence of approximately 640,000
in the United States per year.1 Meanwhile, the incidence of
concomitant distal radioulnar joint (DRUJ) instability varies
widely.2–4 Although the optimal treatment method of associated
acute DRUJ instability in the setting of DRF is controversial, many
studies suggest that DRUJ instability is a poor prognostic factor,
often resulting in chronic pain, decreased range of motion, and
decreased grip strength if undiagnosed or untreated.3–6

The DRUJ is an anatomically complex structure with little
inherent bony stability. This is due to a mismatch of the radius of
curvature between the relatively larger sigmoid notch and ulnar
head as well as the shallow nature of the articulation. This bony
architecture enables a full 160° arc of pronosupination but comes at
the cost of instability to volar and dorsal translation.7 Previous
biomechanical studies have shown that the dorsal and volar radi-
oulnar ligaments (RUL) that comprise the triangular fibrocartilage
complex (TFCC) are the main restraint to DRUJ translation, along
with contributions from the interosseous membrane (IOM) and the
dorsal capsular ligaments (DCL).9,10 However, it is not surprising
that DRFs with associated TFCC injuries involving the RUL or ulnar
styloid fractures that disrupt the foveal attachment of the deep RUL
insertion have been associated with a higher incidence of DRUJ
instability.8,11–13 Therefore, it is not surprising that TFCC repair
on restoring DRUJ stability is controversial. Previous studies have shown that
associated ulnar styloid fracture non-union after DRF fixation does
not lead to long-term DRUJ instability.14–16 In addition, while
studies have shown good preliminary results with arthroscopic
TFCC repair, there remains no high quality evidence indicating that
repair is necessary, provided the DRF is anatomically reduced and
stabilized.17,22,25

These findings have led many authors to argue that, in the
context of persistent DRUJ instability following anatomic reduction
and fixation of the DRF, the added surgical time and potential risk of
morbidity of TFCC repair may not be justified.11,26 Particularly in
cases with intact support from other structures such as IOM and
DCL,10,12,27 therefore, other treatment options, such as cast
immobilization or K-wire stabilization of the DRUJ, should be
considered.11,28–31

Given the lack of consensus regarding a standardized treatment
algorithm and reference standard for the diagnosis of DRUJ insta-
bility, the purpose of this systematic review is to comprehensively
investigate and compare outcomes of conservative and surgical
treatment of acute DRUJ instability associated with a DRF fracture.
Results from this analysis will hopefully highlight functional dif-
fferences across treatment groups in order to better inform optimal
care for this challenging patient population. We hypothesized that
conservative treatment would be non-inferior to more invasive
options.

Materials and Methods

Protocol

The study protocol was registered with PROSPERO, an interna-
tional prospective register of systematic reviews (CRD42020197386). This systematic review was conducted ac-
cording to the Preferred Reporting Items for Systematic Reviews
and Meta-Analyses (PRISMA) guidelines32 and the figure depicts
the study identification process. To identify relevant publications,
we searched PubMed, MEDLINE, and EMBASE and included studies
published between January 1990 and May 2020. The key words
used in the search queries were “DRUJ,” “instability,” “repair,”
“fracture,” “TFCC,” “ulnar,” “styloid,” “radioulnar,” and “reduction.”
Studies in which a part of the study population met the inclusion
criteria were included if the results of the subgroup were
presented separately. References of included articles were
reviewed to incorporate additional relevant studies. Articles not
available in English and duplicates were removed. Review articles,
case reports, and technical notes as well as studies that had
repeated patients or included a subset of future articles were also
excluded.

Studies were initially screened by the primary author based on
title and abstract and then further eliminated with a full manu-
script review. A study was included if it met all of the following
criteria: (1) the study population included adult patients with DRF,
(2) acute DRUJ instability was measured intraoperatively or
immediately post-operatively, (3) the patient received treatment
for the DRUJ instability, and (4) the distal radius fracture underwent
anatomic reduction and internal fixation. Theoretically, larger
associated ulnar styloid and ulnar styloid base fractures are thought
to be inherently unstable secondary to their TFCC and ligamentous
attachments.33–35 As a result, patients with more extensive fracture
patterns such as ulnar fractures involving more than the tip of the
ulnar styloid or fractures with extensive comminution of the ulnar
head were excluded.

Quality assessment

The level of evidence for each study was recorded following The
Journal of Bone and Joint Surgery and the Oxford Centre for Evi-
dence Based Medicine criteria and was graded by the primary
author from levels 1 through 5.36

Data extraction

The primary outcomes analyzed were functional clinical mea-
sures. Clinical data extracted from the final studies were patient
demographics, treatment interventions, length of follow-up, and
clinical results, defined by grip strength, range of motion, DASH
score,36 MMWS,37 and incidence of chronic DRUJ instability.

Data analysis

Upon final screening, data from articles were pooled for analyses
distinct cohorts created based on treatment group. Final treatment
groups included cast immobilization, K-wire stabilization and TFCC
repair (arthroscopic and open). Of note, as the ulnar fovea is the
attachment site for the deep radioulnar ligaments within the TFCC,
we included fixation of ulnar styloid tip fractures into this treat-
manship group. Patients who underwent fixation of more extensive
ulnar fractures were omitted. In order to calculate averages for
further analysis, cases were assigned frequency weights. Analysis of
variance testing was conducted to analyze differences among
treatment groups and Tukey testing was used to identify specific
groups between which differences occurred. An alpha of 0.05 was
set for determining significance for all clinical outcome measures.

Results

Study selection

A total of 531 articles were originally identified from the liter-
ature search as depicted in Figure 1. After excluding studies that did
not meet the inclusion criteria, 8 studies were selected for inclusion
in the systematic review (Table 1).
Study demographics

Within the 8 included studies, a total of 258 wrists (258 patients) were analyzed with a weighted mean age of 53 years (range 18–89). The mean follow-up time was 11.1 months (range, 3–16.9 months). Of note, a significant number of patient fractures were classified as AO type C. Detailed demographics are displayed in Table 2.
physician-based scoring system, the MMWS is determined by the
DASH, which found no difference between the groups. As a
which favored K-wire stabilization over TFCC repair, as well as the
dalities for DRF associated with secondary DRUJ instability.

Clinical outcome measures

Final clinical outcomes evaluated are displayed in Table 3. Grip
strength was significantly decreased in TFCC repair compared with
both cast immobilization (18.7 kg vs 24.6 kg, \( P = .04 \)) and K-wire
stabilization (18.7 kg vs 25.3 kg, \( P = .02 \)). No significant difference
was found across treatment groups with regards to active range
of motion in flexion-extension. However, TFCC repair was associated
with a significant decrease in active pronation-supination when
compared with cast immobilization (152.2 vs 166.2, \( P = .03 \)). In
addition, TFCC repair was associated with decreased MMWS
compared with those treated with K-wire stabilization (84.5 vs
89.6, \( P = .05 \)). Despite having considerable power in the study, there
was no statistical difference detected between groups when
comparing DASH scores.

Across all patients included in the study, recurrent DRUJ insta-
bility post-operatively was rare (n = 4, 1.5%) and not associated
with any specific treatment method. However, the method and
frequency of screening were highly variable as no reference stan-
dard for diagnosing DRUJ instability in this setting currently exists.

Discussion

DRUJ stability is critical for proper force transmission between
the forearm and wrist. Undiagnosed DRUJ instability can result in
recurrent subluxation, dislocation, and/or pain.4,38 Persistent, chronic
instability at this joint is associated with many long-term
complications, with specific links to ulnar sided arthritis, wrist
pain, reduced grip strength, and motion limitation.27,19–41 However,
there is a paucity of data addressing the management of acute
DRUJ instability following DRF treatment. Focusing on literature
since 1990, we sought to systematically review all treatment mo-
dalities for DRF associated with secondary DRUJ instability.

Treatment groups identified included conservative manage-
ment such as cast immobilization and surgical interventions,
ranging from K-wire stabilization of the ulna to the radius to a more
invasive TFCC repair. Patient outcomes were gauged via the MMWS,
which favored K-wire stabilization over TFCC repair, as well as the
DASH, which found no difference between the groups. As a
physician-based scoring system, the MMWS is determined by the
physician’s assessment of pain, the active flexion/extension arc,
grip strength, and the ability to return to regular employment or
activities.39 Given the increased grip strength in K-wire patients
compared with TFCC patients, it is reasonable to see the trend in
MMWS score as well. Interestingly, the DASH is self-administered
by patients and, thus, captures the patient’s own perception of
their recovery. While our results seem to indicate differences in
functional outcomes, there seems to be minimal difference in pa-

tient satisfaction across all treatment groups. Thus, functional
differences, while important, must be weighed when considering
treatment options in the context of patient need and satisfaction.

Cast immobilization with the forearm in supination for 4 to 6
weeks is effective in providing the stability needed for the soft
tissue stabilizers of the DRUJ to heal. However, concerns for joint
stiffness and muscle atrophy from prolonged immobilization have
limited its widespread use. Previous studies have indeed shown
that cast immobilization for DRUJ instability does result in rela-
tively worse short-term functional outcomes; however, long-term
functional outcomes are comparable to patients who underwent
operative intervention.43 Our review builds upon this study and
suggests that, despite initial immobilization, patients treated with
cast immobilization have improved active range of motion at
longer-term follow-up. This improvement is statistically significant
when compared with surgical TFCC repair and may be attributable
to the lack of scar formation related to open or percutaneous
operative intervention.

K-wire stabilization of the DRUJ is an alternative strategy that
effectively maintains DRUJ congruity by using the intact ulna as a
strut to stabilize the soft tissue stabilizers of the DRUJ.25,31 How-
ever, placement of the K-wire across the DRUJ can restrict prono-
supination and lead to complications such as infection, hardware
failure, pin-site irritation, and pain.44,45 Moreover, K-wire stabili-
ization requires a secondary pin removal procedure after 4 to 6
weeks to prevent stiffness and possible contracture.21,45,46 In our
study, K-wire fixation did lead to better grip strength and MMWS
scores as compared with TFCC repair, but did not significantly
improve wrist motion or DASH scores relative to cast immobiliza-
tion. Therefore, the added time, cost, and potential morbidity
relative to cast immobilization must be considered.

TFCC repair is another treatment alternative to cast immobi-
лизация and K-wire stabilization for DRUJ instability. Theoretically,
the DRUJ is stabilized through direct re-attachment of the soft

Table 1
Details of Included Studies

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Level of Evidence</th>
<th>Total DRUJ Repairs</th>
<th>Mean Age (years)</th>
<th>Female/Male (number)</th>
<th>Dominant/Non-Dominant (number)</th>
<th>Mean Follow-up (months)</th>
<th>AO Type (type: number)</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaizeman/2011</td>
<td>IV</td>
<td>8</td>
<td>29.4</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>Long arm cast in supination (6 wks)</td>
</tr>
<tr>
<td>Lee/2016</td>
<td>III</td>
<td>130</td>
<td>58.3</td>
<td>82/48</td>
<td>-</td>
<td>16.9</td>
<td>-</td>
<td>Sugartong splint in mid-supination (4ks) OR 1.6 mm K-wire fixation OR arthroscopic TFCC repair</td>
</tr>
<tr>
<td>Kim/2012</td>
<td>IV</td>
<td>19</td>
<td>45</td>
<td>10/9</td>
<td>-</td>
<td>12</td>
<td>A: 10</td>
<td>1.6mm K-wire fixation (1-2 dorsal, 1 radial)</td>
</tr>
<tr>
<td>Bajwa/2015</td>
<td>IV</td>
<td>15</td>
<td>53</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>A: 10</td>
<td>1-2 K-wire fixation in neutral (6 wks)</td>
</tr>
<tr>
<td>Liu/2014</td>
<td>III</td>
<td>24</td>
<td>59.4</td>
<td>18/6</td>
<td>-</td>
<td>16</td>
<td>A: 8</td>
<td>Open TFCC repair</td>
</tr>
<tr>
<td>Johandi/2017</td>
<td>IV</td>
<td>12</td>
<td>50.5</td>
<td>3/9</td>
<td>4/8</td>
<td>12</td>
<td>A: 3</td>
<td>Open TFCC suture</td>
</tr>
<tr>
<td>Garcia-Ruano/2014</td>
<td>IV</td>
<td>21</td>
<td>42</td>
<td>4/17</td>
<td>12/9</td>
<td>4.7</td>
<td>-</td>
<td>Arthroscopic TFCC repair</td>
</tr>
<tr>
<td>Gong/2015</td>
<td>IV</td>
<td>29</td>
<td>53</td>
<td>21/8</td>
<td>-</td>
<td>12</td>
<td>A: 12</td>
<td>Open TFCC suture</td>
</tr>
</tbody>
</table>
tissue stabilizers or fixation of their bony insertion to restore native anatomy. However, in our study TFCC repair failed to show any superior clinical benefit with regard to range of motion, grip strength, or functional outcome measures when compared with K-wire and cast immobilization. This is supported by previous studies that have shown that TFCC repair is not necessary to achieve a good long-term clinical outcome as long as there is stable anatomic DRF fixation.\(^4\)\(^5\) This is also supported by studies that have shown residual DRUJ laxity after an untreated TFCC injury after DRF fixation is common (45%) and often painless (97% of patients).\(^4\)\(^8\)

In addition, while this study did not directly address the impact of ulnar styloid fracture on DRUJ instability, the literature surrounding ulnar styloid fracture management is conflicting. Although some evidence may suggest that ulnar styloid base fractures may contribute to joint instability, a recent systematic review by Almedghio et al.\(^6\)\(^6\) found no significant correlation between an ulnar styloid fracture and the functional and clinical outcomes of DRF treatment, irrespective of size or displacement of the ulnar styloid fragment. This is further supported by Yuan et al who conducted a meta-analysis on clinical outcomes in DRF patients with concomitant ulnar styloid fractures and demonstrated that there was no significant difference of outcomes between union and non-union of ulnar styloid fractures.\(^5\)\(^0\)

Despite performing a comprehensive systematic review, there are several limitations to our study. First, the studies included had a relatively short follow-up time, ranging from 3 to 16.9 months. Second, most of the studies had a small sample size, owing to the low incidence of the injury complex and the difficulty in diagnosis, limiting the power of this study. Because of the limited number of available studies, we were unable to separate specific immobilization angles within cast immobilization, as immobilization ranged from mid supination to full supination and physicians often employed patient-specific angles within this range. We were also unable to control for hand dominance or stratify treatment groups by injury severity, although we note that the majority of included studies involved AO Class C fractures, indicating that these treatment options were considered in relatively high impact injuries. Lastly, although the objective and subjective outcome measures compared in this review are important components in determining a “successful” treatment, other patient-specific factors that were not included or measured may contribute to overall patient satisfaction. Moving forward, further studies are required to help determine the optimal treatment of DRUJ instability in this complex and controversial setting.

Based on our systematic review, clinical outcomes between the treatment groups do not support the use of more invasive TFCC repair to manage DRUJ instability associated with DRF. Moreover, across the groups, the incidence of persistent, symptomatic DRUJ instability at long-term follow-up was incredibly low regardless of post-DRF fixation treatment choice (1.5%). There may be tradeoffs between different techniques, with K-wire stabilization resulting in better grip strength and cast immobilization a better range of motion, but there is no indication that the time, effort, and expense of TFCC repair is necessary. However, larger controlled trials should be conducted to elucidate these differences and their implications on both functional outcomes and patient satisfaction.

### Table 2
Reported Post-operative Outcomes by Treatment Group

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Grip Strength (kg)</th>
<th>Flexion (°)</th>
<th>Extension (°)</th>
<th>Pronation (°)</th>
<th>Supination (°)</th>
<th>DASH</th>
<th>MMWS</th>
<th>DRUJ Instability at Follow-up (no. of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast immobilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaizeman/2011</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Lee/2016</td>
<td>24</td>
<td>105</td>
<td>-</td>
<td>158</td>
<td>14</td>
<td>85</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lee/2016*</td>
<td>23</td>
<td>122</td>
<td>-</td>
<td>164</td>
<td>17</td>
<td>89</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lee/2016**</td>
<td>24</td>
<td>122</td>
<td>-</td>
<td>166</td>
<td>16</td>
<td>83</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Kim/2012</td>
<td>28</td>
<td>58</td>
<td>64</td>
<td>11</td>
<td>84</td>
<td>11</td>
<td>84</td>
<td>0</td>
</tr>
<tr>
<td>K-wire stabilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bajwa/2015</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.5</td>
<td>-</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lee/2016</td>
<td>26</td>
<td>109</td>
<td>-</td>
<td>159</td>
<td>16</td>
<td>87</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lee/2016*</td>
<td>27</td>
<td>120</td>
<td>-</td>
<td>163</td>
<td>15</td>
<td>91</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lee/2016**</td>
<td>25</td>
<td>119</td>
<td>-</td>
<td>163</td>
<td>17</td>
<td>90</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Liu 2014</td>
<td>23.8</td>
<td>103.5</td>
<td>-</td>
<td>152.3</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>TFCC repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee/2016</td>
<td>23</td>
<td>120</td>
<td>-</td>
<td>163</td>
<td>14</td>
<td>85</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Johandi/2017</td>
<td>21.4</td>
<td>48</td>
<td>55.8</td>
<td>68.3</td>
<td>79.2</td>
<td>8.5</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Garcia-Ruano/2014</td>
<td>16</td>
<td>58</td>
<td>64</td>
<td>72</td>
<td>78</td>
<td>12</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

No star = patients without ulnar styloid process fractures; * = patients with ulnar styloid process tip fracture; and ** = patients with ulnar styloid process fracture.

### Table 3
Comparison of Postoperative Outcomes by Treatment Group

<table>
<thead>
<tr>
<th>Postoperative outcome</th>
<th>Cast Immobilization (n = 94)</th>
<th>K-wire Stabilization (n = 69)</th>
<th>TFCC Repair (n = 52)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip strength (kg)</td>
<td>24.6 ± 1.0</td>
<td>25.3 ± 0.8</td>
<td>18.7 ± 2.2</td>
<td>.01</td>
</tr>
<tr>
<td>Flexion-Extension (°)</td>
<td>120.0 ± 3.2</td>
<td>112.2 ± 4.3</td>
<td>117.4 ± 5.3</td>
<td>.44</td>
</tr>
<tr>
<td>Pronation-Supination (°)</td>
<td>166.2 ± 2.7</td>
<td>158.6 ± 2.8</td>
<td>152.2 ± 4.0</td>
<td>.04</td>
</tr>
<tr>
<td>MMWS</td>
<td>84.9 ± 1.4</td>
<td>89.6 ± 1.2</td>
<td>84.5 ± 0.4</td>
<td>.04</td>
</tr>
<tr>
<td>DASH</td>
<td>15.0 ± 1.3</td>
<td>11.4 ± 3.8</td>
<td>11.5 ± 1.5</td>
<td>.55</td>
</tr>
</tbody>
</table>

\(^*\) Post hoc analysis shows significant difference between TFCC repair and other treatment options.

\(^1\) Significant difference between cast immobilization and TFCC repair.

\(^2\) Post hoc analysis shows significant difference between TFCC repair and K-wire stabilization.

\(^3\) Sample size differed in the analyses for MMWS comparing K-wire stabilization (n = 45) to TFCC repair (n = 32) and for DASH comparing K-wire stabilization (n = 60) to other treatment groups.
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