Original article

Should distal radioulnar joint be fixed following volar plate fixation of distal radius fracture with unstable distal radioulnar joint?

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ABSTRACT

Background: Distal radioulnar joint (DRUJ) instability often accompanies distal radial fractures. The goal of this study was to investigate whether DRUJ should be fixed to prevent recurrent DRUJ instability in distal radius fracture patients with unstable DRUJ following open reduction and volar plate fixation of the radius.

Methods: A retrospective chart review was performed on forty-nine consecutive patients presenting distal radius fracture who were diagnosed with distal radioulnar instability after radius fixation with volar plate. Group one consisted of 24 patients whose DRUJs were fixed in neutral for 6 weeks with 1–2 Kirschner wires (8 cases combined with casting), whereas group two consisted of 25 patients without DRUJ fixation. All patients had radiographic evaluation of their wrist and DRUJ for stabilities and underwent functional evaluation using modified Garland and Werley demerit scoring system (GW score).

Results: All patients were followed-up for an average of 15 months (12–24 months) after surgery. No significant difference was noted between the two groups with respect to gender, age, fracture types and damage types (no noteworthy medical comorbidities in either group). At the latest follow-up, patients in both groups had comparable grip strength, wrist motion, and visual analogue scale (VAS) and GW scores. Only one patient (2.4%) demonstrated DRUJ chronic instability, but did not require any additional surgery.

Conclusion: The results suggest that in patients with distal radius fractures, fixation of unstable DRUJs in neutral for 6 weeks does not have an advantage over non-fixation.

Level of evidence: III.

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1. Introduction

Distal fracture of the radius is one of the most common types of bone fractures [1–4]. DRUJ belongs to the family of pulley joints, and it is composed of the sigmoid notch of the distal radius and the ulnar head distal. Because of the curvature, differences of the sigmoid notch of the distal radius and the ulnar head articulates, the joint surfaces are not matched. Therefore, while spinning, rolling or sliding, joint movement happens between the sigmoid notch of the distal radius and the ulnar head articulates, and relative to the neutral position, the ulnar head slides to the dorsal side about 2.8 mm in supination position and slides to palmar side about 5.4 mm in pronation position [5]. In such situation, soft tissue plays an important role in stability. The soft tissue includes interosseous membrane of forearm (IOM), radial radioulnar joint capsule, triangle fibrocartilage complex (TFCC), pronator quadratus (PQ) and musculus extensor carpi ulnaris (ECU). The triangle fibrocartilage (TFC) is the articular discus formed between the mouth-shape nest and the sigmoid notch of the distal radius, extending to the base of ulna styloid. The center of TFC is composed of cartilage, known as joint dish and play a role in bearing. Layer cartilage is composed of palmar and dorsal radioulnar ligament at the edge and bears tension load. Tendinous sheath of extensor carpi ulnaris, radioulnar ligament and triangle fibrocartilage are collectively referred as TFCC and attached on the radioulnar styloid to maintain the continuity of distal radioulnar joint. TFCC plays a vital role in the stability of DRUJ.

Distal radius fracture and surrounding soft tissue damages often lead to distal radioulnar joint instability. The incidence of DRUJ instability was reported to be 10–19% after distal radius fracture...
2. Materials and methods

2.1. Patient enrolment

We performed a retrospective chart review to identify all patients who were treated for distal radius fracture from January 2007 to June 2010. Institutional review board approval was obtained before the start of the study. Inclusion criteria were as follows:

- displaced distal radius fracture with closed reduction failure or unstable fractures, which would be fixed with open reduction and internal fixation;
- unstable DRUJ diagnosed during surgery;
- no prior wrist surgery;
- age from 18 to 90 years old.

Patients were excluded if:

- they were given conservative closed reduction or external fixation bracket treatment for distal radius displacement fracture;
- fracture time was more than a month;
- an accompanying distal ulna fracture or the base of ulnar styloid fracture were reduced and internally fixed;
- patients with multiple injuries whose trauma severity score was more than 16 points;
- had a follow-up period of less than 12 months.

From the records between January 2007 and June 2010, we identified three hundred and thirty-two patients who were treated for distal radius fracture in our institute. Based on the inclusion and exclusion criteria, forty-nine patients were enrolled for our study. The forty-nine study subjects were comprised of thirty-five women and fourteen men with mean age of 59 years (in range of 32–82 years). Forty-eight patients had closed fractures, and one patient presented with a Gustillo type I open fracture [16]. In thirty-five patients, the mechanism of injury involved a fall on outstretched hand accompanied with hand pronation. Traffic accidents were responsible for the injury in five patients, and in nine patients, tumble during sports led to injury. This study was approved by the Medical Ethics Committee of local hospital.

2.2. Surgical procedures

According to Ring et al. [17], we measured and defined 5 mm or greater ulnar-positive variance as DRUJ instability. The DRUJ stability was further confirmed by the surgeon using the piano key test with volar and dorsal stress applied onto the DRUJ when the forearm was in supination, pronation, or neutral rotation. The examination was performed in the operation room immediately after the distal radius fixation and at all subsequent follow-up visits. Although no objective measurements were made, the contralateral limb was subject to the same range of motion and the piano key test was performed to assess any obvious baseline deficit.

All surgical procedures were performed using a Henry approach, distal radius fractures were reduced and fixed with a 3.5- or 2.4-mm volar locking compression plate and anatomical reduction was confirmed with plain radiography.

The forty-nine patients were categorized into two groups based on the surgeon’s preference for postoperative treatment. Group one consisted of twenty-four patients whose DRUJ were fixed in neutral for six weeks with 1–2 Kirschner wires (among them, eight patients combined with along arm cast), and group two consisted of twenty-five patients that were treated without fixation.

2.3. Follow-up evaluation

During the early follow-up period, on average, all patients had follow-up at two, six, and twelve weeks after surgery. Subsequent follow-ups were more variable but were based on a six-month, one-year, and two-year schedule. Patients were followed-up for a mean of sixteen months (in range of 12–24 months).

All patients were required to take wrist X-ray in lateral position after surgery and at their last follow-up visit to compare the ulnar deviation angle, volar tilting angle, radius height and ulnar variation to evaluate fracture healing and DRUJ alignment.

We compared wrist function and the degree of DRUJ instability between the two groups. One author, who was blinded for the radiographic results, examined all patients. Wrist function was evaluated by grip strength, range of wrist motion, range of forearm extension, flexion, supination and pronation, and Sarmien to improved Garland-Werley scoring system (GW score) [18].

Grip strength was measured using a Jamar dynamometer (Sammons Preston, Bolingbrook, Illinois) with the elbow flexed to 90° and the forearm in neutral rotation. Range of wrist and forearm motion was measured using a goniometer. According to the subjective and objective standards, GW score was divided into different functional levels: score 0–2 is excellent, 3–8 is good, 9–20 is mild and 21 is bad. Specific evaluation indices include evaluation of deformity, subjective and objective evaluation, and evaluation of complications. Evaluation of deformity: one point for ulnar styloid prominence, two points for residual back side tilt or disappearance of hand-ulnar deviation, and three points for reverse radial partial deformity. Subjective evaluation: zero point for optimal condition such as no pain, no sports limitation and no disability; two points for good condition such as occasional pain, mild exercise limitation and no disability; four points for fine condition such as occasional pain, partial sports limitation, wrist weakness, no disability and mild interference on daily life; six points for poor condition such as pain, sports limitation, disability and obvious interference of daily life. Objective evaluation: five points for stretch less than 45°, three points for ulnar deviation less than 15°, two points for supination or pronation less than 50°, one point for palmar flexionless than 30°, radial deviation less than 15°, cycloversion induces, distal radioulnar joint pain, or grip strength less than 60% of that of the health side. Complications:

- osteoarthritis: one point for mild osteoarthritis, three points for mild osteoarthritis with pain, two points for moderate osteoarthritis and four points for severe osteoarthritis, three points for severe osteoarthritis and five points for severe osteoarthritis with pain;
- nerve complications: one point for mild median nerve pressure, two points for moderate pressure and three points for severe pressure;
- finger movement disorders: one point for inability of fingers to touch palm, and two points for finger stiffness.
Pain in the affected wrist was assessed with the visual analogue scale (VAS) of pain [19], in which pain was expressed as an absolute value (zero for no pain and ten for the worst pain).

Chronic instability of DRUJ was assessed by physical examination [20]. The radius was grasped by one hand of the examiner while the forearm in a neutral position, and the distal end of the ulna, which was fixed by the contralateral hand of the examiner, was translated in dorsal and palmar directions with respect to the radius. DRUJ instability was determined to be present when noticeable displacement was observed at both sides of DRUJ relative to the contralateral uninjured side and pain or apprehension of the distal radioulnar joint was evident. The intraoperative distal radioulnar joint test was done by the same person. Most patients with loose distal radioulnar joint do not need comparison with contralateral side, only a few patients whose situations were hard to determine needs comparison with the opposite side. The stability of distal radioulnar joint stability was determined through piano key test, according to our experience, it was defined as unstable if the ulnar head can be shifted to exceed half of its own thickness.

2.4. Statistical analysis

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) 16.0 (SPSS Inc., Chicago, IL, USA). The Mann-Whitney U test was used to evaluate the significance of differences in continuous variables. Fisher’s exact test was used to evaluate the significance of differences in categorical variables. P-values < 0.05 were considered significant throughout the study.

3. Results

Table 1 summarizes the demographic characteristics of the two groups of cases. No significant difference in terms of age and gender was found between the two groups. There was no difference in either the Müller-AO types of the bone fracture or the energy levels of the fracture (P > 0.05).

3.1. Radiological findings

A representative image was shown in Fig. 1. Compared with the fixation group, there was no significant difference in either ulnar deviation angle, volar tilting angle, radius height or ulna variation on the images taken either immediately after the surgery or at the last follow-up (P > 0.05 for all comparisons) (Table 2).

Table 1

<table>
<thead>
<tr>
<th>Characteristics of the study population.</th>
<th>Fixation group (n = 24)</th>
<th>Non-fixation group (n = 25)</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Sex (case)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6</td>
<td>8</td>
<td>0.588</td>
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<tr>
<td>Female</td>
<td>18</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Age (x ± s, year)</td>
<td>59.4 ± 10.9</td>
<td>59.4 ± 11.2</td>
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<tr>
<td>Müller-AO Types (case)</td>
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<td></td>
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<td>4</td>
<td>0.314</td>
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<tr>
<td>Type B</td>
<td>3</td>
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<td></td>
</tr>
<tr>
<td>Type C</td>
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<td>14</td>
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</tr>
<tr>
<td>Energy (case)</td>
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<tr>
<td>Low</td>
<td>7</td>
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</table>

The values are given as the means ± SD. Comparisons were made between the fixation and non-fixation groups.

Table 2

| Comparison of radiographic evaluation in the fixation group and non-fixation group. |
|----------------------------------------|------------------------|-----------------------------|---------|
| Measurements                           | Fixation group (n = 24) | Non-fixation group (n = 25) |         |
|                                        | Postoperation          | End follow-up               |         |
|                                        | 18.8 ± 3.6             | 18.8 ± 3.6                  |         |
|                                        | 5.7 ± 3.7              | 5.1 ± 3.4                   |         |
|                                        | 11.5 ± 2.1             | 10.9 ± 1.7                  |         |
|                                        | 0.95 ± 0.18            | 0.95 ± 0.18                 |         |
|                                        | 19.1 ± 3.2             | 19.2 ± 3.3                  |         |
|                                        | 6.6 ± 3.8              | 6.6 ± 3.8                   |         |
|                                        | 11.0 ± 2.0             | 10.6 ± 1.7                  |         |
|                                        | 0.94 ± 0.14            | 0.94 ± 0.14                 |         |

The values are given as the means ± SD.

a Compared with fixation group postoperatively: P = 0.74.

b Compared with fixation group postoperatively: P = 0.39.

c Compared with fixation group postoperatively: P = 0.40.

d Compared with fixation group postoperatively: P = 0.83.

e Compared with fixation group at final follow-up: P = 0.65.

f Compared with fixation group at final follow-up: P = 0.14.

g Compared with fixation group at final follow-up: P = 0.50.

h Compared with fixation group at final follow-up: P = 0.83.

Fig. 1. Representative X-ray image after DRUJ fixation. Wrist X-rays were taken immediately following the surgery: a: anterior–posterior view of the wrist; b: lateral view of the wrist. Written informed consent was obtained from the patient to show the information here.

3.2. Range of wrist motion

Range of wrist motion is one of the measurements for evaluating wrist function. Compared with the fixation group, there was no
significant difference in either stretch-bend or supination-pronation of the wrist joint (P > 0.05 for all comparisons) in non-fixation group (Table 3).

3.3. Functional outcomes

We also made other measurements of wrist joint function, such as grip strength, VAS and GW scores. Compared with the fixation group, there was no significant difference in either grip strength, VAS scores or GW scores (Table 4).

3.4. Complications

Only one patient (2.4%) in the non-fixation group demonstrated DRUJ chronic instability at 24 months of follow-up. But the patient did not complain of wrist pain or functional disability, and no additional treatment was warranted.

4. Discussion

In the current study, we found that in patients with distal radius fractures, fixation of unstable DRUJs in neutral for 6 weeks does not have an advantage over non-fixation. To our knowledge, this is the first study to directly address the question whether distal radioulnar joint should be fixed following volar plate fixation of distal radius fracture with unstable distal radioulnar joint.

The exact mechanism that causes DRUJ instability is still not clear. Gofton et al. [21] reported that removal of the interosseous membrane, ulnar side wrist extensor muscles and pronator quadratus would not cause DRUJ instability. The distal interosseous membrane (DIOM) is a secondary stabilizer of DRUJ and has a considerably variable morphology. And it was shown that innate DRUJ stability was influenced by the anatomic variation of the DIOM [22]. With biomechanical study, most researchers think that, when dorsal radioulnar ligament strains, ulna is shifted to dorsal side; and when palmar radioulnar ligament strains, ulna is shifted to palmar side during supination. Ward et al. [23] first described that DRUJ capsule maintained joint stability with restrictive effect. Research by Watanabe et al. [24] suggested that dorsal joint capsule injury will lead to DRUJ instability in pronation position, while palmar joint capsule injury will lead to distal radioulnar joint instability in supination position. It has been always controversial whether ulnar styloid fracture combined with distal radius fracture will lead to radial radioulnar joint instability [25–28]. DRUJ ligaments are attached to the base of ulnar styloid, and the theory of DRUJ instability after ulnar styloid fracture was mainly from anatomical aspects [29]. Therefore, some researchers believed that the base of ulnar styloid fracture with displacement more than 2 mm will lead to DRUJ instability [12]. But a number of additional studies have suggested that [25,30,31], for the open reduction and internal fixation treatment of distal radial fractures, no treatment of ulnar styloid fracture will not affect wrist joint function and DRUJ stability. Kazemian et al. [13] assessed DRUJ instability using computed tomography immediately after surgery and at three months postoperation. Their study demonstrated that untreated stable or minimally displaced ulnar styloid fracture accompanied by distal radius fracture, had no adverse effect on the stability of the DRUJ after open reduction and internal fixation treatment of the radius. In our study, the ulnar styloid fractures, which did not affect the base, were not conventionally fixed.

Although the ratio of distal radial fractures with TFCC damage is high, with excellent reduction and fixation TFCC can recover after the distal radial fractures. In addition, the periphery of TFCC is usually around the easily damaged site of distal radial fracture. However, due to the good blood supply, this area has great healing potential [29], and the opportunity of cure without surgical treatment can be very high. In this study, after good reduction and fixation for distal radial fractures, without surgical treatment chronic DRUJ instability only occurred in one case. In comparison, the results showed that in distal radial fractures combined with unstable radioulnar joint, there are no significant difference in wrist joint grip strength, motion range and function score between fixation and non-fixation groups. We think that for distal radial fracture with unstable radioulnar joint, if distal radial fractures can get satisfactory anatomical reduction, one-stage fixation of DRUJ is not recommended. In addition, avoiding pin fixation in appropriate settings can prevent complications associated with pin fixation, such as pin track infection, pin migration, hardware failure, and potential additional exposure necessary for the procedure.

Our study is only a small scale, retrospective study. A large scale, randomized, prospective study is needed in the future to further confirm the finding in this study.

Our study demonstrated that following open reduction and internal fixation of distal radius with volar plates in patients with distal radius fractures, fixation of unstable DRUJs in neutral for six weeks does not have an advantage over non-fixation for a short period.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Acknowledgments

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