The Effect of Displaced Dorsal Rim Fragment in a Distal Radius Fracture

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Abstract

Background In intra-articular fracture of distal radius, the intra-articular fragments can be divided into some specific fragments. In particular, the poor outcomes have been well documented for reduction loss of the volar lunate facet, but the effect of a displaced dorsal rim fracture has rarely been addressed.

Materials and Methods The records of 26 patients with dorsal rim fragment displaced by more than 2 mm after volar locking plate (VLP) fixation for a dorsally displaced distal radius fracture (DRF) treated from March 2006 to March 2009 were retrospectively reviewed. Clinical assessments including grip strengths, wrist range of motions, and Disabilities of Arm, Shoulder, and Hand (DASH) scores were performed at 12 months postoperatively. Widths of the distal ends of dorsal rims were determined by preoperative computed tomography (CT). Dorsal rim fragment displacements were measured in immediate postoperative plain lateral radiographs. Radial inclination, volar tilt, and ulnar variance were measured on immediate postoperative wrist radiographs. Arthritic changes of radiocarpal joints were graded using radiographs obtained at 12 months postoperatively.

Description of Technique DRFs were fixed using a VLP in the usual manner. Although DRF displacement was noticed after plate fixation, no further procedure was performed. The sizes of articular portions of dorsal rim fragments were measured arthroscopically in 5 of the 26 patients at the time of plate fixation.

Results At 12 months postoperatively, mean grip strength, wrist flexion arc, and mean wrist extension arc were 86 ± 13 , 87 ± 11 , and $91 \pm 10\%$, respectively, of contralateral sides. Mean forearm supination and pronation were 96 ± 8 and $99 \pm 5\%$, respectively, of contralateral sides. Mean DASH score was 11 ± 10 points. Preoperatively, mean width of the distal end of dorsal rim fragments and mean displacements of dorsal rim fragments were 2.0 ± 0.6 and 3.0 ± 0.9 mm, respectively. Mean width of the articular portions of dorsal rim fragment by arthroscopic examination was 1.0 ± 0.4 mm. Mean radial inclination was 21 ± 4.8 degrees, mean volar angulation was 4.8 ± 3.9 degrees, and mean ulnar variance was 0.6 ± 1.8 mm at immediate postoperatively. Two patients showed grade I arthritic changes at 12 months postoperatively.

Conclusions The articular portions of dorsal rim fragments measured arthroscopically were smaller than determined by CT. Furthermore, the study shows that displaced dorsal rim fragments in dorsally displaced DRFs treated by VLP do not adversely affect wrist clinical outcomes.

Keywords

- distal radius fracture
- dorsal rim fragment
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- volar locking plate

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The distal radius is the most common site of fracture in the upper extremity.¹ Dorsal comminutions are commonly observed in distal radius fractures (DRFs), because a fall with an outstretched hand is the usual injury mechanism and the dorsal cortex is weaker at the distal end of the radius than the volar cortex.^{2,3} This dorsal comminution makes the treatment difficult,⁴ and dorsal rim fractures sometime develop during dorsal comminution of DRF.⁵

The intra-articular fragment of distal radius can be classified as the volar lunate facet, radial column, and ulno-dorsal and dorsal rim fragments.⁶ Since Knirk and Jupiter⁷ concluded that accurate articular restoration is critical for achieving successful long-term outcomes for DRF, reduction of articular fragments has been considered one of the most important aspects of DRF management. However, unlike the volar lunate facet fragment, the importance of dorsal rim fragment restoration has not been well described.

Dorsally displaced DRFs have been successfully managed using a volar locking plate (VLP) as determined clinically and radiographically,^{8,9} and thus, the use of VLP is increasing.^{10,11} However, when DRFs are treated with a VLP, a separate dorsal approach is usually required to treat dorsal rim fragments. However, if displacement of the dorsal rim fragment does not affect the outcome, this step can be omitted. In this study, we recruited a series of patients with DRFs with a displaced dorsal rim after VLP fixation who were treated nonoperatively. Dorsal rim fractures were characterized by computed tomography (CT) and arthroscopy, and wrist functional outcomes were evaluated at 1 year postoperatively.

Patients and Methods

From March 2006 and March 2009, we retrospectively reviewed 26 patients who had a dorsal rim fragment that was displaced by more than 2 mm after VLP fixation. Although other intra-articular fractures occurred in conjunction with dorsal rim fractures, if other intra-articular fragments were accurately reduced as determined by immediate postoperative radiography, the case was included in our series. However, we excluded cases with a large ulnodorsal fragment that was displaced sufficiently to cause incongruity of the sigmoid notch as determined by preoperative CT. There were 24 females and 2 males of overall mean age 64 years (range, 36–78). The dominant wrist was involved in 15 patients.

At 12 months postoperatively, patients were accessed clinically by a physiotherapist, who was blinded to the radiographic results and independent of the treating surgeon. Clinical assessments included grip strength, wrist range of motions (ROMs), and Disabilities of Arm, Shoulder, and Hand (DASH)¹² score. Grip strength was measured using a Jamar dynamometer (Sammons Preston, Bolingbrook, IL) with the elbow flexed at 90 degrees and the forearm in neutral rotation. Values are expressed as percentages of contralateral (uninjured) wrists. Regarding grip strength calculations, we allowed for 10% greater strength of the dominant hand when the right hand was dominant, but did not compensate when the left hand was domi-

nant.^{13,14} Wrist ROMs (extension, flexion, supination, and pronation) were measured using a hand-held goniometer. The DASH questionnaire consists of 30 items that address abilities to perform specified activities (21 items) or symptoms (9 items). DASH scores range from 0 to 100, and higher scores indicate greater disability.¹²

For radiographic assessments, plain posteroanterior and lateral radiographs of injured wrists were obtained immediately after surgery and at 12 months postoperatively. CT was performed preoperatively. Plain radiographs and CT images were acquired by digital radiography and saved in a picture archiving and communications systems (PACS, PiViewSTAR; INFINTT, Seoul, South Korea). Radiographic measurements were made using a software tool in PACS. Widths of distal ends of dorsal rims (→Fig. 1) were measured in preoperative CT scans using a millimeter ruler. Dorsal rim fragment displacements were measured in immediate postoperative plain lateral radiographs using a millimeter ruler (→Fig. 2). Radial inclination, volar tilt, and ulnar variance were measured on immediate postoperative wrist radiographs as previously described.⁶ Arthritic changes of radiocarpal joints were graded using radiographs obtained at 12 months postoperatively, as previously described.⁷

Surgical Technique

A 6- to 7-cm volar skin incision was made, and forearm fascia was exposed by incising the flexor carpi radialis tendon sheath. Another longitudinal incision was made on the forearm fascia at the ulnar side of the radial septum

Fig. 1 Standard lateral view plain radiograph showing a displaced dorsal rim fragment postoperatively. We measured the gap between the dorsal rim fragment and distal radius at their distal ends (arrows indicate gap).

Fig. 2 Preoperative CT scan (sagittal view) showing a dorsal rim fragment. We measured width of the distal end of the dorsal rim fragment (asterisk).

to contain the radial artery. The flexor tendon and the muscle belly of the flexor pollicis longus were retracted ulnarly to expose the pronator quadrates muscle widely through the space between the flexor pollicis longus and the radial septum. The pronator quadratus muscle was then released using an L-shaped incision. Hematoma or callus at the fracture site was removed by curettage, and primary reduction was confirmed fluoroscopically. If the preliminary reduction was satisfactory, it was fixed temporarily with one or two 1.6-mm K-wires or bone-holding forceps. However, if the preliminary reduction using the above-described method was not satisfactory, the brachioradialis tendon was released, and a volar plate (3.5- or 2.4-mm volar locking compression plate—Synthes GmbH, Switzerland) was applied. Although displaced dorsal rim fractures were noticed after plate fixation, no further procedures were performed.

The sizes of articular portions of dorsal rim fractures were assessed arthroscopically in 5 of the 26 patients. Briefly explaining the arthroscopic measurement, we visualized articular portion of dorsal rim fracture using 3 to 4 portal (► **Fig. 3**), and inserted the hook with distal tip of 1 mm through 4 to 5 portal. Then, we measured maximal width of articular surface of dorsal rim fragment by comparing with the length of distal tip of the hook.

Postoperatively, a short-arm splint was applied for 4 weeks, and subsequently, wrist motion was allowed with intermittent short-arm brace protection for another 2 weeks.

Fig. 3 Arthroscopic examination in a 58-year-old man with a displaced dorsal rim fragment. The asterisk indicates the articular surface of dorsal rim fragment and the arrow indicates gap.

Results

At 12 months postoperatively, mean grip strength of injured wrists was $86 \pm 13\%$ of that of contralateral wrists. As compared with contralateral sides, mean wrist flexion arc was $87 \pm 11^\circ$, mean wrist extension arc was $91 \pm 10^\circ$, forearm supination was $96 \pm 8\%$, and forearm pronation was $99 \pm 5\%$. Mean DASH score was 11 ± 10 points.

The mean width of the distal end of dorsal rim fragment on the preoperative CT was 2.7 ± 1.1 mm. The mean displacement of the dorsal rim fragment on the immediate postoperative radiographs was 3.0 ± 0.9 mm. The mean width of the articular portion of the dorsal rim fragment on arthroscopic examination was 1.0 ± 0.6 mm. The mean radial inclination was 21 ± 4.8 degrees, mean volar angulation was 4.8 ± 3.9 degrees, and mean ulnar variance was 0.6 ± 1.8 mm on the immediate postoperative radiographs. Two patients exhibited grade I arthritic change at 12 months postoperatively.

Discussion

Several studies have shown that accurate reduction of articular congruities importantly determines the outcomes of DRFs.^{7,15} For intra-articular fractures, intra-articular fragments can be classified by fragment type.⁶ Poor outcomes due to reduction loss of the volar lunate facet have been well documented,^{16–18} but effects of displaced dorsal rim fractures have received little attention. In 2012, we compared DRFs with and without displaced dorsal rim fragment after VLP fixation and concluded that a displaced dorsal rim fragment has no adverse effect on the clinical and radiographic outcomes.²

This study has several limitations. First, the follow-up period was too short to identify the effect of displaced dorsal rim in the development of arthritis. Second, we recruited the patients with other intra-articular fragments if these were

accurately reduced at immediate postoperative radiographs. However, we did not confirm the reduction status of other intra-articular fragments using postoperative CT. Substantial evidence indicates that the radiographs are inferior to CT to evaluate the articular congruity.¹⁹ Third, we also did not evaluate displacement of dorsal rim fracture using postoperative CT; rather, we used plain radiographs.

A displaced dorsoulnar fragment is the most common type of intra-articular fracture found in DRF.⁵ Although some authors have expressed concern about dorsoulnar fragments because they represent intra-articular fractures,^{20,21} poor outcomes related to displaced dorsoulnar fragments have not been reported. In the present study, we excluded the case with a dorsoulnar fragment that caused incongruity at the sigmoid notch by preoperative CT.

Lee et al²¹ enrolled 48 patients with an unstable DRF involving more than one-quarter of the articular surface and a dorsoulnar fragment displaced by >2 mm. In the study, patients were divided into two groups according to the method used to treat displaced dorsoulnar fragments. In one group, a Frag-Loc compression screw (Acumed, Hillsboro, OR) was used to treat displaced dorsal rim fractures, whereas in the other group displaced dorsal rim fractures were not fixed. The authors concluded that dorsoulnar fragment fixation did not lead to better clinical outcomes in terms of wrist ROM, grip strength, or DASH score.

In the present study, mean width of the distal ends of dorsal rim fragments as measured by CT was 2.7 mm, but arthroscopic evaluation showed that the mean width of articular portions of dorsal rim fragments was 1 mm. This finding indicates that about two-thirds of articular surface of dorsal rim fragment observed by CT are not real articular surfaces, but probably extra-articular bony surfaces. Further anatomical study is required to determine the composition of the peripheral articular margin in distal radius; nevertheless, we believe that this is a reason why displaced dorsal rim fragments do not adversely affect clinical outcomes.

Although the presumed mechanical relationship between articular surface incongruity and subsequent osteoarthritis is still poorly understood, it is believed that osteoarthritis is caused by change in the radiocarpal stress.²² Several biomechanical studies^{23–25} have measured contact stress using pressure-sensitive film in cadaveric models with an articular step-off mimicking intra-articular malunion. Interestingly, a step-off of more than 1 mm in volar lunate facet was found to increase contract pressure in the radiocarpal joint.²⁴ However, contact pressure was not significantly different and contract area increased up to a step-off value of 2 mm when an articular step-off was made in dorsal distal radius.²³ These findings could explain why a volar lunate facet incongruity leads to poor outcomes, whereas a displaced dorsal rim fragment does not.

In conclusion, this study shows that the articular portions of dorsal rim fragments are actually smaller than indicated by CT and that displaced dorsal rim fragments in dorsally displaced DRF treated by VLP do not adversely affect wrist clinical outcomes.

Conflict of Interest

None.

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