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Devising for a distal radius fracture fixation focus on the intra-articular volar dislocated fragment

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HIGHLIGHTS

- We reported our devision for distal radius fractures.
- Our procedure may be useful.
- It is difficult to fix volar displaced fragment.

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ABSTRACT

Introduction: Distal radius fracture (DRF) accompanied by intra-articular volar displaced fragment is difficult to reduce. This volar fragment remains when treated with a simple buttress effect alone, and V-shaped deformity may remain on the articular surface. We attempted to improve dorsal rotational deviation of volar fragment by osteosynthesis applying the condylar stabilizing technique. We report the surgical procedure and results.

Materials and methods: The subjects were 10 cases of DRF accompanied by intra-articular volar displaced fragments surgically treated (mean age: 69 years old). The fracture type based on the AO classification was B3 in 1 case, C1 in 4, C2 in 2, and C3 in 3 cases. All cases were treated with a volar locking plate. Reduction was applied utilizing the angle stability of the volar locking plate, similarly to the condylar stabilizing technique. On the final follow-up, we evaluated clinical and radiologic evaluation. To evaluate V-shaped valley deformity of the articular surface, the depth of the lunate fossa of the radius was measured using computed tomography (CT).

Results: The duration of postoperative follow-up was 11 (6–24) months. Mayo wrist score was 93 (Excellent in 10 cases). No general complication associated with a volar locking plate was noted in any case. Volar tilt on radiography were 11° (4–14). The depth of the lunate fossa on CT was 3.9 ± 0.7 mm in the patients.

Conclusion: This procedure may be useful for osteosynthesis of distal radius fracture accompanied by intra-articular volar displaced fragments.

1. Introduction

Distal radius fracture (DRF) accompanied by intra-articular volar displaced fragments is often difficult to reduce. It is classified as a type B3 volar Barton fracture and type C volar dislocation in the AO classification. Since volar subluxation occurs due to a shear force in this fracture, open reduction through the volar side using a buttress plate is applied in many cases [1–3]. However, the palmar carpal ligament pulls the volar displaced fragment and causes rotational deviation toward the dorsal side on applying reduction [4,5]. This dorsal rotational deviation of the volar bone fragment remains when treated with a simple buttress effect alone, and V-shaped valley deformity may remain on the articular surface (Fig. 1).

In cases with a residual intra-articular volar displaced bone fragment, limitation of range of motion of the wrist joint, carpal

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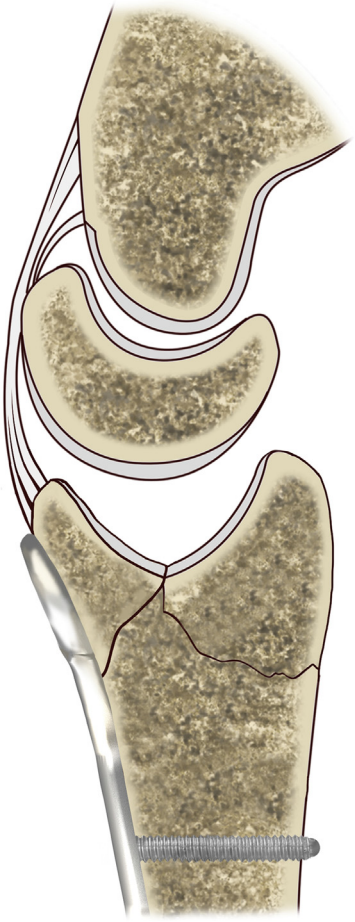

Fig. 1. V-shaped valley deformity of the articular surface made by the buttress plate. When buttress fixation was applied to a lesion with residual dorsal rotational deviation of the volar bone fragment, V-shaped valley deformity of the articular surface remained.

bone subluxation, and early arthropathic changes of the wrist joint are frequently observed [6–8]. It is known that articular cartilage is markedly damaged in DRF accompanied by intra-articular volar bone fragment [9], creating problems to be resolved with regard to reduction fixation of these bone fragments. We attempted to improve dorsal rotational deviation of postoperative residual intra-articular volar bone fragment by osteosynthesis applying the condylar stabilizing technique [10,11] in patients with DRF accompanied by a volar displaced fragment. Our surgical procedure and clinical outcomes will be presented here.

2. Materials and methods

This study was approved by the Ethics Committee for Medical Research of our university, and informed consent prior being included into the study was obtained from all patients.

The subjects were 10 cases of DRF accompanied by intra-articular volar displaced fragments surgically treated at our hospital between 2013 and 2014 (3 males with 4 fractures and 6 females with 6 fractures, mean age: 69 years old). The fracture type based on the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification [12] was B3 in 1 case, C1 in 4, C2 in 2, and C3 in 3 cases. All cases were treated with osteosynthesis using a volar locking plate, and the implant used was the Acu-Loc 2 plate for distal placement (Aculoc 2, Nihon Medical Next, Osaka, Japan).

Surgery was performed under brachial plexus block or general anesthesia. The radius was reached through the Henry approach, and the fractured region was exposed. Soft tissue was exposed up to the watershed line to place the plate for the distal side. The plate closely contacted the intra-articular volar bone fragment that had rotationally deviated toward the dorsal side and was temporarily fixed. A distal locking screw was inserted into the intra-articular volar bone fragment to anchor the plate (Fig. 2a), in which the proximal side of the plate was suspended from the radius, similarly to that in the condylar stabilizing technique [10,11]. A diaphyseal cortical bone screw was then inserted to reduce and fix the volar displaced fragment with the plate as a buttress plate (Fig. 2b). Postoperative external fixation was not necessary, and the patients were permitted to move their wrist joint and fingers early after surgery.

On the final follow-up, the range of motion of the wrist joint, grip strength (% of that on the healthy side), Visual Analog Scale (VAS), Quick Disabilities of the Arm, Shoulder and Hand (Q-DASH) score, and Mayo wrist score were evaluated for clinical evaluation. For imaging evaluation, the volar tilt (VT) and ulnar tilt (UT) were measured on postoperative plain radiography.

To evaluate V-shaped valley deformity of the articular surface, the depth of the lunate fossa of the radius was measured using computed tomography (CT): In the CT sagittal view, a line connecting the distal ends of the radius on the palmar and dorsal sides was drawn, and a line vertical to this was extended to the radial articular surface. The longest length of this line in the lunate fossa was measured as the depth of the lunate fossa (Fig. 3). This lunate fossa depth was measured after bone union. To compared it with the normal value, it was measured in healthy subjects ($n = 10$ males, mean age: 28.8 years old) with no bone damage of the wrist joint, and compared with the depth in the patients after surgery.

3. Results

The duration of postoperative follow-up was 11 (6–24) months. The range of motion of the wrist joint was: flexion, 73° (60–80); extension, 77° (60–90); pronation, 86° (70–90); and supination, 85° (60–90). The grip strength of the affected limb was 18 kg (7–35), and % of that on the healthy side was 73%. The VAS was 2, the Q-DASH score was 18.4 (2.27–45.45), and the Mayo wrist score was 92 (Excellent in 10 cases) (Table 1). VT and UT on plain radiography were 11° (4–14) and 21° (18–25), respectively. The depth of the lunate fossa on CT was 3.9 ± 0.7 mm in the patients and 3.6 ± 0.3 mm in the 10 healthy subjects ($p > 0.05$) (Fig. 4). No general complication [13,14] associated with a volar locking plate, such as damage of the tendon, was noted in any case.

4. Discussion

Normally, DRF containing a volar displaced fragment is classified as the unstable type. Retention of the position acquired by manual reduction is difficult, and surgical treatment is selected in many cases [1,16]. Regarding the surgical procedure, a favorable outcome of fixation with a buttress plate expecting a buttress effect from the volar side of the radius has occasionally been reported [2,17]. However, in DRF accompanied by a volar displaced fragment, the fragment is pulled by the palmar radiocarpal ligament [8,15,18], and dislocation of the bone fragment and V-shaped deformity of the articular surface remain when treated with a simple buttress effect alone (Fig. 1). This procedure increases the depth of the lunate fossa in the residual displaced radial articular surface and induces arthropathic changes, being a cause of poor outcomes [8,19].

There have been various reports on DRF with residual incongruity of the articular surface. Doi et al. and Fernandez et al.

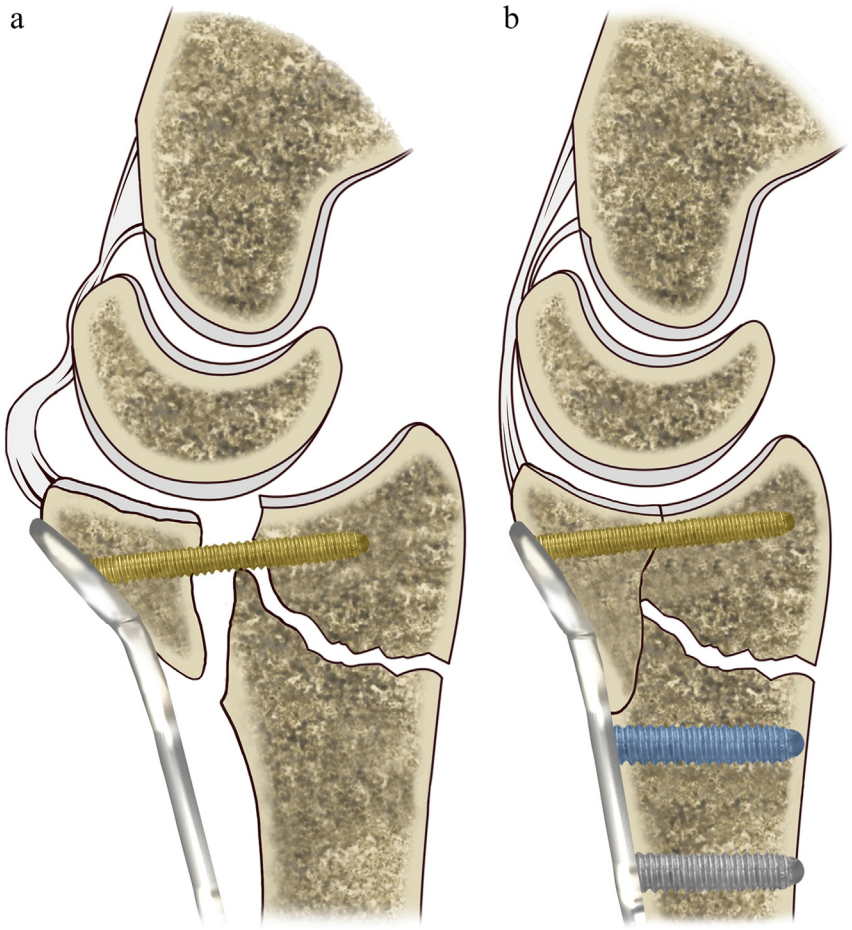

Fig. 2. Condylar stabilizing technique using a plate for distal placement. a: The plate closely contacted the volar intra-articular bone fragment that had rotationally deviated toward the dorsal side. A distal locking screw was inserted into this intra-articular volar bone fragment to anchor the plate, in which the proximal side of the plate was suspended from the radius, similarly to that in the condylar stabilizing technique. b: A diaphyseal cortical bone screw was inserted to reduce and fix the volar displaced fragment with the plate as a buttress plate.

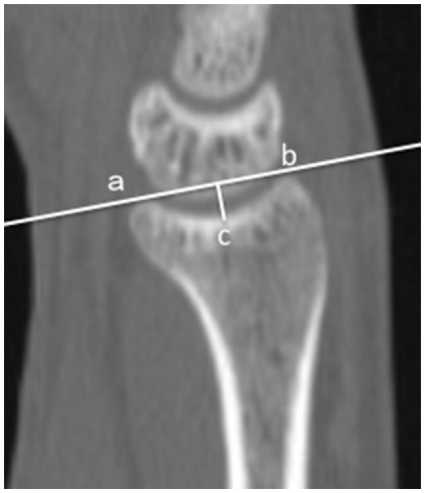

Fig. 3. Measurement of the depth of the lunate fossa of the radius. In the CT sagittal view, a line connecting the distal ends of the radius on the palmar (a) and dorsal (b) sides was drawn, and a line (c) vertical to this was extended to the radial articular surface. The longest length of this line in the lunate fossa was measured as the depth of the lunate fossa.

stated that dislocation of the articular surface should be limited to within 1 mm because arthropathic changes are observed after surgery in patients with residual incongruity of the articular surface [20,21], and Mehta et al. reported that a 1 mm or greater step off of the articular surface causes wrist joint pain [22]. In addition, studies on corrective osteotomy for malunion after distal radius fracture reported that cases accompanied by a volar displaced fragment accounted for a high rate, and Schweizer et al. called attention to osteosynthesis for volar displaced fragment [23]. In addition to these complications, malunion of volar displaced fragment may cause radiocarpal subluxation and functional disorder, such as median neuropathy [7]. Thus, it is necessary to pay sufficient attention to reduction of this bone fragment.

Regarding the characteristic of this procedure, a distal locking screw was inserted into the volar displaced fragment and then a diaphyseal cortical bone screw was inserted, i.e., reduction was applied utilizing the angle stability of the volar locking plate, similarly to the condylar stabilizing technique [10,11]. Anchoring the volar bone fragment through the distal locking screw enables reduction similarly to that of finger fracture using a hook plate [24,25]. Our procedure not only inhibits dislocation of the volar bone fragment toward the distal side through simple buttress plate fixation but also reduces dorsal rotational deviation of the fragment, which may achieve favorable reduction of the VT and lunate fossa of the radius.

The risk of flexor tendon damage by the volar locking plate as a

Table 1
Results of distal radius fractures with volar Barton fragment.

Case	Age	Sex	AO	F/U	ROM	E	P	S	Grip strength	VAS	Q-DASH	Mayo
			Classification	mo	F				%[a]			
1	71	M	C2	12	80	80	90	90	68.4	0	0	95
2	58	M	C3	6	70	70	90	90	71.4	5	27.27	90
3	58	M	C3	6	75	75	90	90	100	5	27.27	90
4	75	F	C3	15	70	60	90	60	54.5	0	2.27	95
5	75	M	C2	6	70	70	90	90	94.6	0	4.55	100
6	57	F	C1	24	70	85	80	90	83.3	1	2.27	83
7	82	F	B3	6	80	75	80	90	52.6	3	45.45	90
8	62	F	C1	13	70	70	90	70	68.4	2	13.64	90
9	87	F	C1	12	60	60	70	90	50.0	4	38.64	95
10	69	F	C1	12	80	70	90	90	87.0	0	4.55	92

M: male, F: female, AO: Arbeitsgemeinschaft für Osteosynthesefragen, F/U: follow-up, mo: month, ROM: range of motion, F: flexion, E: extension, P: pronation, S: supination, VAS: Visual Analog Scale, Q-DASH: Quick Disabilities of the Arm, Shoulder, and Hand score, Mayo: Mayo wrist score.
[a] Percentage grip strength on the affected side relative to that on the healthy side.

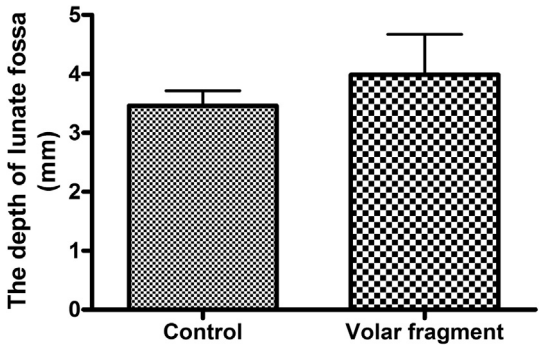

Fig. 4. Depth of the lunate fossa in the group treated for distal radius fracture accompanied by a volar Barton fragment and healthy group. The depth was 3.9 ± 0.7 mm in the patient group and 3.6 ± 0.3 mm in the healthy group (10 subjects), showing no significant difference ($p > 0.05$).

complication may increase compared to that of a plate placed proximal to the watershed line. Soong et al. stated that the incidence of flexor pollcis longus tendon damage differed depending on the positional relationship between the volar end of the radius and plate in the lateral view on plain radiography, and flexor tendon damage was due to the shape of the plate. However, they also stated that, regardless of these, attention should be paid to poor reduction and an unfavorable position of the plate [26]. Furthermore, although it is important to repair the pronator quadratus muscle during surgery, plate removal after bone union may be essential to reduce the risk.

There are several limitations of this study. Firstly, regarding the measurement of the lunate fossa of the radius on CT, CT images were acquired at a 1 mm slice thickness. Thus, it is unclear whether or not the deepest site of the lunate fossa could be selected. At present, this problem with evaluation using CT may be difficult to overcome. Secondly, the number of cases was only 10. Reportedly, volar dislocation-type fracture accounts for about 1–10% of distal radius fracture cases [1,8]. The 10 cases were out of 117 cases of distal radius fracture surgically treated at our hospital during the study period, and this frequency was similar. Furthermore, this sturdy does not be compared with the cases in which the normal fixation with a buttress plate. So, the future, we will consider the long-term results of this case and we want to compare each of the influence of arthropathic changes. Although there were several limitations, this procedure may be useful for osteosynthesis of distal radius fracture accompanied by intra-articular volar displaced fragments.

Conflicts of interest

None.

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Ethical approval

312, Ethical Approval of Juntendo University Shizuoka Hospital.

Author contribution

YS (first author) mainly make this manuscript and was an assistant of operative procedure. KN (corresponding author) mainly performed medical examinations and surgery for this patient. HO, MK, KA, KK and OO discussed and advised about the treatment for this patient. All authors read and approved the final manuscript.

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