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HANDSURGERY

The effects of the Frag-Loc® compression screw on distal radius fracture with a displaced dorsoulnar fragment

Jung Il Lee[1] · Jung Hyun Cho[2] · Seoung Joon Lee[2]

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Abstract
Purpose The purpose of this study is to evaluate the radiographic and clinical outcomes of the Frag-Loc® compression screw with palmar plate fixation on distal radius fractures that include a displaced dorsoulnar fragment.
Patients and methods This retrospective comparative study enrolled 48 patients who had an unstable distal radius fracture and a dorsoulnar fragment that was more than 2 mm displaced and that had involvement of more than one-quarter of the articular surface. Twenty-six of the 48 patients were treated with a palmar locking plate without a Frag-Loc® compression screw (group 1) and the other 22 patients were treated with palmar locking plate with a Frag-Loc® compression screw to fix the dorsoulnar fragment (group 2). First, we reviewed all pre-surgical computerized tomographic (CT) scans. Second, we used the gap distance between the dorsoulnar and palmar fragment as seen on post-surgical axial and sagittal CT scans to determine outcome. The gap distance was measured at the point of maximum distance perpendicular to the plane of the main fracture line. Clinical outcomes were evaluated based on the patient-rated wrist evaluation (PRWE) score; the disabilities of the arm, shoulder and hand score; wrist active range of motion; and grip strength.
Results There were no statistically significant differences in clinical outcome between the two groups. However, there were statistically significant differences in post-surgical gap distance. The mean post-surgical gap distances for group 1 were 1.3 mm (range 0.2–3.8 mm) on axial CT scans and 1.4 mm (range 0.5–2.4 mm) on sagittal CT scans, while the mean post-surgical gap distances for group 2 were 0.7 mm (range 0.7–1.6 mm) and 0.7 mm (range 0.3–1.1 mm).
Conclusion This study shows that the Frag-Loc® compression screw can reduce the gap distance between the dorsoulnar fragment and the distal radius, according to evaluation of post-surgical axial and sagittal CT scans. This result suggests that the Frag-Loc® compression screw is an effective and simple treatment option to immobilize a dorsoulnar fragment associated with distal radius fracture.

Keywords Distal radius fracture · Volar locking plate · Palmar locking plate · Dorsoulnar fragment · Frag-Loc screw

Introduction

Distal radius fractures are one of the most common injuries seen by orthopedists, and are treated with various methods, depending on severity. Recently, an operative treatment using a palmar locking plate has emerged as a popular treatment for unstable distal radius fracture [1]. However, palmar locking plate fixation has several limitations. First, intra-articular fracture fragments can be difficult to identify and manipulate. Second, dorsoulnar fragment of the distal radius is difficult to treat using the palmar locking plate without additional dorsal procedures [2–5]. Because the dorsal ulnar fragment is part of both the radiolunate and the

✉ Seoung Joon Lee
lsjmd@kuh.ac.kr

[1] Department of Orthopedic Surgery, Hanyang University Guri Hospital, Guri, Korea

[2] Department of Orthopedic Surgery, Konkuk University Medical Center, 4-12, Hwayang-dong, Gwangjin-gu, Seoul 143-729, Korea

radioulnar articular surface, it plays a critical role in maintaining appropriate sagittal radiocarpal alignment and preventing dorsal collapse [5–7].

Dorsal plate fixation using a dorsal approach offers the advantages of direct visualization and reduction of the dorsoulnar fragment. However, hardware-related extensor tendon irritation, weak fixation power of the dorsal screw, and technical difficulties are major limitations of dorsal plate fixation [8–10]. Recently, the Frag-Loc® compression screw (Acumed, Hillsboro, OR, USA) has become available. This screw system was designed to immobilize the dorsal bone fragment of distal radius fracture using a palmar locking plate. Herein, we evaluate the radiographic and clinical outcomes of surgery using Frag-Loc® compression screw with palmar locking plate fixation for distal radius fractures that include a displaced dorsoulnar fragment.

Patients and methods

We conducted a retrospective comparative study of a case series to evaluate the radiographic and clinical outcomes of surgery using the Frag-Loc® compression screw to treat distal radius fractures that included a displaced dorsoulnar fragment. This study was approved by our institutional review board. The inclusion criteria for the study were unstable distal radius fracture with displaced dorsoulnar fragment $\geq$2 mm and involvement of more than one-quarter of the articular surface, according to pre-surgical computerized tomographic (CT) scans (Fig. 1). We excluded patients with AO/OTA type C3 distal radius fractures, because the dorsoulnar fragments in these cases are severely comminuted and are impossible to immobilize with a Frag-Loc® compression screw. Forty-eight patients were enrolled in this study between March 2012 and March 2014. All patients were treated with palmar locking plate fixation by one fellowship-trained orthopedic hand surgeon. Among these patients, 26 were treated with a palmar locking plate without Frag-Loc® compression screw (group 1) and 22 patients were treated with a palmar locking plate with Frag-Loc® compression screw to immobilize dorsoulnar fragment (group 2).

Surgical technique

Each patient was placed in a supine position on an operating table equipped with a hand extension. The surgical approach was through the bed of the flexor carpi radialis (FCR) tendon. After exposing the fracture site, provisional fracture reduction was achieved and the fracture was temporarily stabilized with one or two 1.2- to 1.4-mm Kirschner wire or reduction clamps. An Acu-Loc® plate (Acumed, Hillsboro, OR, USA) was placed on the palmar cortex and was fixed to the radial shaft with a cortical screw at the elongated hole. Next, a distal locking screw for the scaphoid facet fragment was inserted. In group 1, the distal locking screw was fixed to the dorsoulnar fragment under compression force of the surgeon's finger. In group 2, the sleeve for the Frag-Loc® compression screw was inserted into the most ulnar side hole of the plate. The guide wire was then inserted through the sleeve to the dorsal skin. A small dorsal skin incision was made over the guide wire and we used small retractors to maintain clearance of soft tissue and tendons. The Frag-Loc® compression screw was finally inserted over the guide wire using fluoroscopic guidance (Fig. 2).

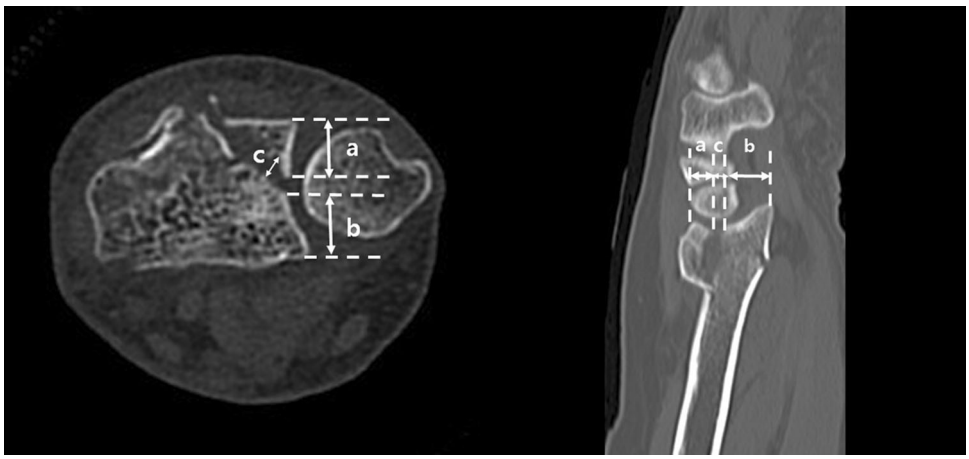

Fig. 1 Pre-surgical CT scan shows articular involvement of the dorsoulnar fragment. Distal radius fractures with a dorsoulnar fragment that involved more than one-quarter of the articular surface were included in this study. The measurement method to determine articular involvement was the length of the dorsoulnar fragment divided by the length of the dorsoulnar fragment plus the length of the palmar fragment [$a/(a + b)$]. The gap distance between the dorsoulnar and palmar fragments was measured, as described by Cole et al. at the point of maximum distance perpendicular to the plane of the main fracture line (c)

Outcomes evaluation

At the final follow-up, all patients' pre- and post-surgery CT scans of axial and sagittal views were evaluated, along with their clinical data, to assess outcome. The gap distance between the dorsoulnar and palmar fragments was measured, as described by Cole et al. at the point of maximum gap distance perpendicular to the plane of the main fracture line (Fig. 1) [11]. Two different orthopedic residents and one orthopedic hand surgeon measured the radiographic gap of the dorsoulnar fragment twice, and the results were averaged to minimize inter-observer and intra-observer differences. All measurements were performed using the computer-aided measurement software included in the PACS system. Objective clinical outcomes were evaluated based on wrist active motion and grip strength. Range of motion of the wrist was evaluated based on flexion, extension, supination, and pronation as determined with a standard goniometer. Grip strength was measured with the standard Jamar hydraulic hand dynamometer (Sammons Preston, Bolingbrook, IL, USA) with the elbow flexed at 90° and the forearm in neutral rotation. Grip strength was recorded as a percentage of the value of the uninjured hand. Overall clinical outcome was measured according to the score on the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire (range 0–100, with 0 as the best

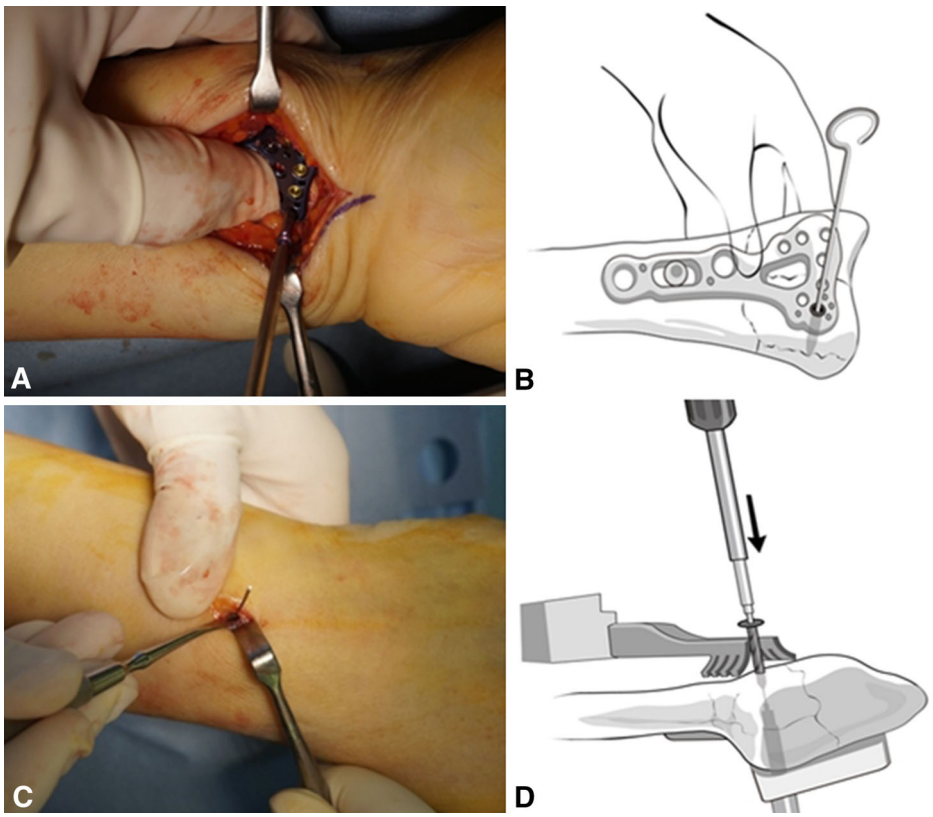

Fig. 2 The Frag-Loc® compression sleeve was inserted into the most ulnar side hole of the plate (**A**). The guide wire was then inserted through the sleeve to the dorsal skin (**B**). Small dorsal skin incisions were made over the guide wire and we use small retractors to maintain clearance of soft tissue and tendons (**C**). The Frag-Loc® compression screw was inserted over the guide wire using fluoroscopic guidance (**D**)

Table 1 Patient demographics

	Group 1	Group 2
Number	26	22
Gender (M/F)	8/18	6/16
Age (years)	60.4 (range 48–84)	64 (range 48–72)
AO/OTA type (C1/C2)	10/16	6/16
Follow-up period (months)	12 (range 8–16)	10 (range 8–12)

Group 1 was treated with a palmar locking plate

Group 2 was treated with a palmar locking plate and a Frag-Loc® compression screw

Table 2 Gap distance between dorsoulnar and palmar fragments

	Group 1	Group 2	*p* value
Pre-surgical CT(mm)			
Axial scan	2.7 ± 0.6	2.1 ± 0.7	0.472
Sagittal scan	2.3 ± 0.9	2.3 ± 0.8	0.08
Post-surgical CT(mm)			
Axial scan	1.3 ± 0.8	0.7 ± 0.4	0.012*
Sagittal scan	1.4 ± 0.7	0.7 ± 0.4	0.004*

Group 1 was treated with a palmar locking plate

Group 2 was treated with a palmar locking plate and a Frag-Loc® compression screw

* Statistically significantly difference between the two groups

result) and patient-rated wrist evaluation (PRWE) score at the final follow-up. Mann–Whitney U test was performed to compare the two groups' clinical and radiographic outcomes. The level of significance was $p \leq 0.05$.

Results

Eight male and 18 female patients were included in group 1 (mean age 60.4 years), among whom there were 10 type C1 and 16 type C2 fractures according to AO/OTA classification. Six male and 16 female patients were included in group 2 (mean age 64 years), among whom there were six type C1 and 16 type C2 fractures. The mean follow-up period was 12 months for group 1 and 10 months for group 2 (Table 1).

Radiographic outcomes

There were no statistically significant differences between the two groups regarding pre-surgical gap distance between dorsoulnar and palmar fragments. However, there were statistically significant differences between the two groups for post-surgical gap distance (Table 2). The mean post-surgical gap distance in group 1 was 1.3 mm (range 0.2–3.8 mm) based on the axial scan and 1.4 mm (range 0.5–2.4 mm) based on the sagittal scan (Fig. 3). The mean post-surgical gap distance in group 2 was 0.7 mm (range 0.7–1.6 mm) based on the axial scan and 0.7 mm (range 0.3–1.1 mm) based on the sagittal scan (Fig. 4). There were three patients who had complicated radiographs: two Frag-Loc® compression screw penetration of the dorsal cortex and, one articular incongruence at the sigmoid notch due to excessive compression (Fig. 5).

Clinical outcomes

There were no statistically significant differences between the two groups with regard to PRWE score, DASH score, wrist active range of motion, or grip strength at final follow-up (Table 3). The three radiographically complicated patients had no clinical symptoms.

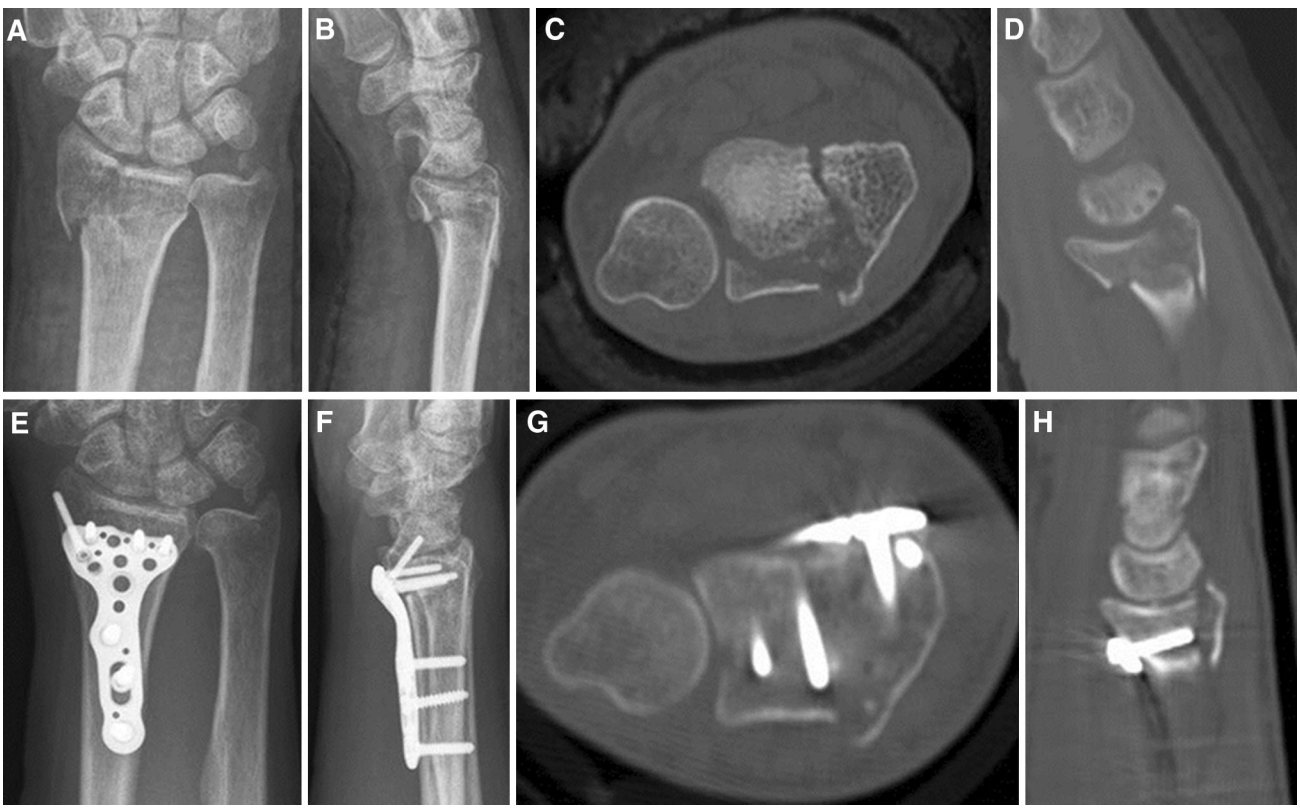

Fig. 3 Pre-surgical plain radiographs (**A**, **B**) and CT scans (**C**, **D**) show the displaced dorsoulnar fragment in the distal radius fracture. The patient was treated with palmar locking plate fixation. Post-surgical plain radiographs (**E**, **F**) show minimal displacement of the fracture fragment, but post-surgical CT scans (**G**, **H**) show that the dorsoulnar fragment was still displaced more than 2.0-mm

Fig. 4 Plain radiographs (**A**, **B**) and CT scans (**C**, **D**) show the displaced dorsoulnar fragment in the distal radius fracture. The patient was treated with palmar locking plate and Frag-Loc® compression screw fixation. Post-surgical plain radiographs (**E**, **F**) and CT scans (**G**, **H**) show good reduction in the gap distance of the dorsoulnar fragment

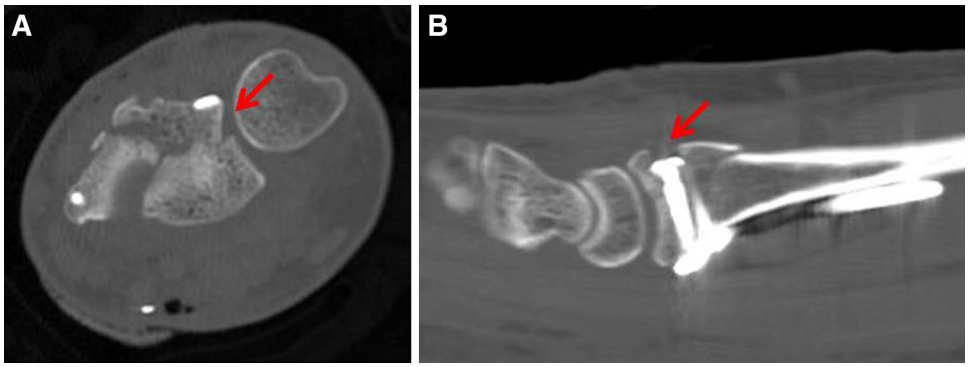

Fig. 5 Post-surgical CT scans show articular incongruence of the sigmoid notch (**A**) and penetration of the dorsal cortex by the Frag-Loc® compression screw (**B**) due to excessive compression

Discussion

Use of the palmar locking plate after open reduction is the most common surgical treatment for unstable distal radius fracture [1, 12, 13]. Although palmar locking plate fixation is a good treatment option for most distal radius fractures, the palmar locking plate has some complications and limitations. The overall complication rate ranges from 8 to 39 % and can include complex regional pain syndrome type I and damage to both the flexor and extensor tendons [12–14]. The palmar locking plate has limitations when used to treat several clinical conditions including AO/OTA C3 type fracture and small volar rim fracture with comminution. Moreover, the dorsoulnar fragment of the distal radius is difficult to treat with a palmar locking plate without including additional dorsal procedures [2–5].

Table 3 Clinical outcomes at the final follow-up

	Group 1	Group 2	*p* value
DASH score	11.1 ± 4.4	13 ± 5.0	0.135
PRWE score	10.2 ± 4.6	12.4 ± 3.7	0.730
Range of motion			
Extension	65 ± 7.0	60 ± 9.2	0.114
Flexion	51.5 ± 8.1	53.1 ± 7.0	0.328
Supination	86 ± 5.1	85 ± 5.3	0.347
Pronation	85 ± 5.2	86.8 ± 4.5	0.215
Grip strength	89.4 %	87.3 %	0.234

There was no significant difference between groups for any outcome measure

Group 1 was treated with a palmar locking plate

Group 2 was treated with a palmar locking plate and a Frag-Loc® compression screw

Because the dorsoulnar fragment makes up a portion of both the radiolunate and radioulnar surfaces, it plays a critical role in maintaining adequate sagittal radiocarpal alignment and preventing dorsal collapse [5]. The proper depth for insertion of the distal locking screws into the dorsoulnar fragment is important to achieve sufficient fixation power and interfragmentary compression. Nevertheless, most surgeons hesitate to apply the screws to the proper depth because of concern that it could lead to secondary problems with the extensor tendon problems if it should be penetrated by the screw tips [12].

Dorsal plate fixation using the dorsal approach provides the surgeon with the advantages of direct visualization and reduced dorsoulnar fragment. However, hardware-related extensor tendon irritation, weak fixation power of the dorsal screw, and technical difficulties are major limitations of this method [6–8]. The Frag-Loc® compression screw was designed to easily immobilize the dorsoulnar fragment, because it is difficult to immobilize the fragment with only the locking screws of the palmar locking plate. The Frag-Loc® compression screw is a two-part cannulated compression screw that consists of a sleeve and a screw. The locking sleeve is inserted into the dorsoulnar fragment through the most ulnar side hole of the plate, and the guide wire was passed through the locking sleeve. The Frag-Loc® compression screw was inserted through the guide wire after making a small dorsal incision. This method provides appropriate fixation power on the dorsoulnar fragment when inserting a screw from the dorsal to the volar side, and it offers maximum length from the volar side when fixing the cortex to the plate.

The dorsoulnar fragment is an intra-articular fragment that involves the radius sigmoid notch and the lunate fossa [5]. It has been reported that, when a dorsoulnar bone fragment is as thin as 2–3 mm, it cannot be easily fixed; however, even if such displacement remains, it does not affect stability or clinical outcome [15]. We also agree that immobilization of a thin and small dorsoulnar bone fragment is unnecessary. However, displacement of larger dorsoulnar fragments can lead to instability of the radiolunate and radioulnar joints [5]. Ikeda et al. reported that, if large dorsoulnar bone fragments are not properly repaired, late collapse might occur, so fixation of large dorsoulnar bone fragments is necessary [3]. We determined that large fragments involved more than one-quarter of the articular surface should be reduced and immobilized to prevent late collapse.

Another issue with displaced dorsoulnar fragment is post-traumatic arthritis. Since Knirk and Jupiter reported in 1986 that accurate recovery of the articular surface is the most important factor for successful long-term outcomes, it has become one of the most important concerns when treating distal radius fractures [16]. Intra-articular fragments can be divided into different specific fragment types. Most surgeons agree that a greater than 2 mm displacement of the central part of the lunate facet fragment is associated with a poor outcome and post-traumatic arthritis. Although the association between the dorsal part of the lunate facet fragment (dorsoulnar fragment) and arthritis is debatable, we suggest that any greater than 2 mm displacement of the dorsoulnar fragment should be reduced in order to prevent arthritic change. However, the follow-up period in this study is too short to verify this claim, and a larger scale and longer-term study is required to verify the association between a displaced dorsoulnar fragment and risk for post-traumatic arthritis.

There are several technical tips for successful use of the Frag-Loc® compression screw. First, pay attention when inserting Frag-Loc® compression screw with a guide wire that is also being used for another cannulated screw in the region to avoid entrapment of any surrounding soft tissue or extensor tendons [17]. When dorsal skin incision was made for insertion of the Frag-Loc® compression screw, we used small retractors to maintain clearance of soft tissue and tendons. Second, excessive compression should be avoided especially when dealing with osteoporotic bone. Although the dorsoulnar fragment is large enough to immobilize a Frag-Loc® compression screw, excessive compression can cause the screw to penetrate the dorsal cortex in osteoporotic bone. Moreover, excessive compression can also cause the articular incongruence of the sigmoid notch. It is necessary to pay close attention to verify the position of the Frag-Loc® compression screw and to operate under the guidance of a fluoroscopy.

Our study has several limitations to consider. First, this was a retrospective comparative case study. Thus, there was no randomization of patients who received the Frag-Loc® compression screw and those who did not. Second,

this study had a small sample size. A larger scale, prospective study is necessary to support our clinical results and obtain more outcome data.

Conclusion

This study showed that the Frag-Loc® compression screw can reduce the gap distance between the dorsoulnar fragment and the distal radius according to post-surgical axial and sagittal CT scans. This suggests that the Frag-Loc® compression screw is an effective and simple treatment option to fix dorsoulnar fragments associated with distal radius fractures.

Compliance with ethical standards

Conflict of interest None.

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