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A new complication in volar locking plating of the distal radius: longitudinal fractures of the near cortex

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Objective: The purpose of this study was to document a new complication in volar locking plating of the distal radius.

Methods: Between January 2007 and January 2014, 223 patients were identified from the department's surgical database with retrospective chart and radiographic review. Sixty-eight patients were over 60 years of age. All fractures were operated with Acu-Loc® (Acumed, Hillsboro, OR, USA) wrist volar locking plating systems. Longitudinal fracture lines (LFL) beneath volar plate-extending proximal shafts were documented. Correlations between age groups and LFLs were investigated. Radiographs with LFLs were assessed at final follow-up for the following parameters: volar tilt, radial inclination and radial length.

Results: Twenty-eight of 68 patients over age of 60 years had LFLs. Correlation was significant for age groups ($p<0.05$). The effect of these fracture lines on radiographic parameters was not significant ($p>0.05$).

Conclusion: Surgeons should be aware of the complications that may occur with volar locking plates. Understanding of potential complications and their results are important. As a result of aging, thinning, and weakening, the near cortex may become more brittle. When the plate is reduced on the bone with a nonlocking screw, the conical head of diaphyseal locking screws can extend over plate thickness and penetrate the near cortex, acting as a screwing wedge. Additional divergent configuration may promote this effect and crack the cortex.

Keywords: Complication; distal radius; fracture; longitudinal fracture; volar locking plate.

Level of Evidence: Level IV, Therapeutic study.

Distal radius fractures (DRFs) are one of the most common injuries in the population, the incidence of which increases with ageing.[1] A study of 15293 adults demonstrated a 6-fold higher likelihood among women compared with men between the ages of 60 and 94 years.[2] Osteoporotic changes characterize the fracture in elderly patients. Primarily, weakening of the metaphyseal bone renders simple fractures unstable and makes distal bone fixation a challenge. Open reduction and internal fixation with a volar locking plate (VLP) has become a popular option for the treatment of unstable osteoporotic fractures because it provides stable fixation with superior stiffness and axial loading strength, while also allowing early mobilization.[3,4] Today various types of VLP designs have been developed and used. Although they have become an increasingly popular method for

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treating DRFs, some treatment complications, particularly in the elderly, have become evident with increased clinical usage.[5] Many complications related to surgical technique and implants that lead to poor functional outcomes have been reported in the literature.[6,7] Even when performing the technique in accordance with manufacturer guidelines, plate and screw designs may trigger complications due to patient properties.

The following study is a retrospective case series of a previously unreported complication observed with a VLP design in elderly patients with DRFs. An intraoperative longitudinal fracture in the near cortex occurred while applying locking shaft screws of a well-known implant design, Acu-Loc® and Acu-Loc® 2 (Acumed, Hillsboro, OR, USA), into first generation plate (FGP) and second generation plate (SGP) wrist plating systems. Probable causes and radiographic results are discussed. This information may aid surgeons when confronting such complication and manufacturers in improving their designs.

Patients and methods

Following manufacturer guidelines, after open reduction, plate placement and fixation with a 3.5-mm nonlocking proximal screw, distal 2.3-mm locking screws were applied with an SGP volar distal radius plating system.[8] During proximal 3.5-mm locking screw placement, a longitudinal fracture line (LFL) was observed beneath the volar plate, extending to the proximal shaft in a 73-year-old female with an unstable DRF (Figure 1a). It was thought that the LFL was the result of an unrealized longitudinal cortical fissure. The nonlocking screw was removed, and stability was tested under fluoroscopy. Considering that the locking mechanism would not provide the necessary stability for DRF repair, the LFL was fixed with 2 more coronal screws (Figures 1b, c). After re-examining preoperative X-rays and discussing probable causes with the other surgeons, it was decided to design this retrospective study (Figures 2a, b).

A retrospective review was performed of patients with DRF who were treated with an FGP or SGP in our institution between January 2007 and January 2014. All patients were operated by the same team of board-certified hand surgeons, all of whom had at least 5 years' experience in DRF treatment with fixed-angle screw VLP systems. The inclusion criteria were as follows: aged 18 years or above, operated with an FGP or a SGP volar fixation for a DRF, and have at least 4 postoperative posterior to anterior X-rays with a minimum 12 months of follow-up for radiological reduction and fracture control. Patients who received other volar plate brands, or who had LFLs in preoperative X-rays, or who had malunions were excluded. All fractures were classified according to the AO/ASIF classification system.

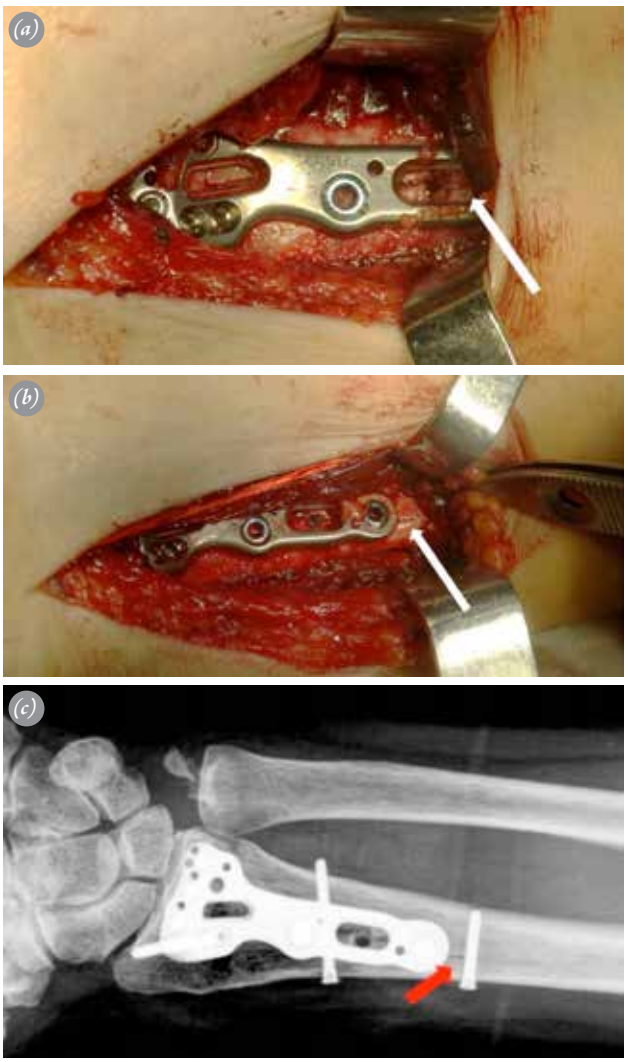

Fig. 1. **(a)** Longitudinal fracture line in screw hole (white arrow). **(b)** Longitudinal fracture line fixation with 2 more coronal screws (white arrows). **(c)** Longitudinal fracture line fixation with 2 more coronal screws (red arrows). [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

Surgery was performed under general or regional anesthesia with use of an arm tourniquet. A volar approach through the bed of the flexor carpi radialis was performed. The pronator quadratus was elevated to expose the volar distal radius. The fracture was reduced and held temporarily with K-wires, according to the surgeon's preference. The plate was placed on the volar cortex and first fixed at the gliding hole to allow appropriate positioning for image-controlled subchondral placement of the interlocking screws. After distal locking, proximal locking screws were placed with drilling guides. No

Fig. 2. **(a, b)** A fracture line cannot be detected in preoperative X-rays.

bone graft was used in any case. If possible, the pronator quadratus muscle was reinserted. A removable splint was applied for pain relief. Active digital range of motion therapy was started immediately. Fifteen days after surgery, sutures and the splint were removed, and physiotherapy with active and passive wrist mobilization was started unless there was an additional injury or concern.

For radiological evaluation, X-rays taken at the time of injury, postoperative X-rays, and those taken at follow-up examinations were assessed on a picture archiving and communication system. All radiographs were examined by 3 independent surgeons under modifying magnification and contrast. An LFL-extending plate proximal in any postoperative X-rays was reviewed among the surgeons and accepted as a complication when all were in agreement. Radiographs with LFL were assessed at final follow-up with postoperative films, and the following parameters were measured: volar tilt, radial inclination, and radial length.

Numerical data were analyzed as mean and standard deviation (SD). In addition to descriptive analysis for age distribution, t-tests were used for age means and LFL observation, as well as early postoperative and follow-up radiographic values for shortening, volar tilt, and radial inclination loss in longitudinal fracture group patients. Correlations of age group, implant type, and LFL observation were evaluated with chi-square test.

Results

Two hundred twenty-three patients (123 female, 100 male) were identified from the department's surgical database, with a mean age of 50.7 years (range: 19–89 years; SD 15.8); 124 of them were operated with FGP (between Jan 2007 and Oct 2012) and 99 with SGP (between Oct 2012 and Jan 2014) (Table 1). There were 88 type A, 15 type B, and 120 type C fractures. Mean follow-up was 37.9 months (range: 12–80 months).

An LFL-extending plate proximal in postoperative X-rays was observed in 36 patients (mean age: 66.3 years; SD 11). There were 187 patients without an LFL (mean age: 47.67 years; SD 14.8). There was a statistically significant difference between mean ages of the LFL group and the non-LFL group ($p < 0.05$).

Age group descriptives for LFL group patients exhibit a lower bound of 62.55 years, with a 95% confidence interval for mean. Thus, patients over 60 years of age were reevaluated. There were 68 patients (55 females, 13 males) over 60 years of age (mean: 69.6 years; SD 7.5; range: 60–89 years) in both implant groups. Twenty-eight had LFLs (Table 2). Correlation between categorical (age over 60 and LFLs) variables was significant ($p<0.05$).

Bone healing had occurred in all patients at time of final follow-up. The patient fixed with coronal screws was excluded when comparing the first postoperative X-rays of all patients with those taken at final evaluation. Mean radial height was 11.18 mm (SD 2.7) preoperatively and 10.95 mm (SD 2.5) postoperatively; volar tilt was 6.35° (SD 2.7) preoperatively and 6.23° (SD 2.7) postopera-

Table 1. Sex and age classification of patients in the 2 groups.

Sex and age (yrs) (mean, range)	Acu-Loc® (FGP)	Acu-Loc® 2 (SGP)	Total
Male (44.4, 20–86)	60 (44.5, 20–86)	40 (44.4, 22–76)	100
Female (55.7, 19–89)	64 (57.2, 33–83)	59 (54, 19–89)	123
Total (50.7, 19–89)	124	99	223

Table 2. Number of patients with or without LFLs in both plate groups.

		Acu-Loc®(FGP)		Acu-Loc® 2® (SGP)		
		LFL yes	LFL no	LFL yes	LFL no	Total
Over 60 years old	Male	0	6	2	5	13
	Female	10	20	16	9	55
Below 60 years old	Male	0	54	2	31	87
	Female	1	33	5	29	68
	Total	11	113	25	74	223

LFL: Longitudinal fracture lines.

tively; radial inclination was 21.46° (SD 3.8) preoperatively and 20.92° (SD 4) postoperatively. There was no significant change in radiographic parameters of patients with LFLs who received the previously described protocol ($p>0.05$).

Discussion

VLPs have been frequently used for the treatment of DRFs over the past decade. Biomechanically stable fixation, allowing rapid mobilization and return of early wrist function, is the main advantage.[3,4,9,10] However, recent studies report complication rates as high as 22–27%.[11–13] These complications may arise from the injury or method of treatment, or a combination of both. The most common ones are nerve- and tendon-related complications involving the distal part of the fixation.[6,7,14] Our study focused on complications stemming from a more proximal point in locking fixation of DRFs.

To our knowledge, this study investigating a previously unnoticed complication following VLPs for DRFs in a specific implant group (Acu-Loc® and Acu-Loc® 2) is unique in the literature. Two generations of plating systems have been used in fracture fixation since 2004. The first screw is a 3.5-mm nonlocking cortical screw through the slot hole in the plate. After drilling the cortices with the 2.8-mm drill, a 3.5-mm nonlocking screw is used to reduce the plate down to the bone. After inserting the threaded drill guide into the screw hole and drilling both cortices with the 2.8-mm drill and measuring with the depth gauge, both designs use the same locking 3.5-mm proximal shaft screws (manufacturer product ordering codes COL-3080 to COL-3180).[8,15] These screws have a conical-shaped head with pitches for locking the plate. In our opinion, this can be one of the reasons for LFLs on the volar cortex. When the plate is reduced on the bone, the conical head with a large diameter can extend over the plate thickness and insert into the near cortex, acting as a screwing wedge (Figures 3a, b). It may be prevented with drilling the near cortex with a larger drill or not reducing the plate as much to the underlying cortex with the nonlocking screw. Another solution can be improving or changing the screw design by manufacturers.

Age-related bone loss involves a gradual and progressive decline in composition, structure, and function, which predisposes cortical thinning and metaphyseal weakening. Osteoporotic changes characterize both the fracture and treatment patterns in elderly patients. Although VLPs provide stable fixation, due to thinning and weakening of the cortices, they create a more brittle surface for rigid plate and screw fixation. Cortices lacking elasticity can be too stiff for optimum screw pitch purchase. LFLs were observed in 28 of 68 patients over 60 years of age. There were only 8 patients below 60 years who had LFLs, 6 of whom were over 50 years. Another reason for this proportional increase may be the thinning and weakening of the near cortex due to aging. Investigators who recommend open reduction and inter-

Fig. 3. **(a, b)** A 3.5-mm locking shaft screw with a conical head extending over the plate thickness. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

nal fixation for unstable DRFs in older patients did not report such a problem in their series.[16–20] Implant type difference might have an impact on this, which could be due to not identifying the LFL because it is mostly covered by the plate or muscle mass proximal to the plate. Additionally, it is difficult to realize on postoperative X-rays if the line is not wide enough or not in a perpendicular plane.

After an LFL combining locking screw holes in the near cortex, the focus of our interest was whether a secondary loss of reduction would result from an instability pattern. However, radiographic parameters did not show a significant difference between radial height, radial inclination, and volar tilt. Stability might be sustained by the screw tip and far cortex constitution until fracture union. Although there is a current lack of literature supporting this hypothesis, this may be valuable for surgeons who are confronted with the same problem.

In identifying the characteristics for classification and treatment, many surgeons use computer tomography (CT) scans for DRFs. However, information obtained from the traction radiographs showed little significant difference with regard to fracture characterization and treatment recommendations.[21] The decrease in the cost of radiographs compared with CT scans is another benefit. We do not use CT imaging at our institution for DRFs routinely, which creates a limitation in diagnosing preoperative LFLs, as it is impossible definitively preoperatively diagnose LFLs without a CT scan.

We acknowledge the limitations in our study, particularly the retrospective collection of data. The procedures were performed by a large number of surgeons. Radiographic parameters did not differ in the follow-up, but due to the retrospective design, we could not evaluate the clinical parameters after occurrence of LFLs.

Conclusion

As with the adoption of any new technologies, surgeons should be aware of the complications that may occur with VLP of DRFs. Understanding of potential complications and their results are important. Early recognition allows for early intervention when complications arise and ultimately provides the surgeon and patient with the best chance for optimal outcomes.

Conflicts of Interest: No conflicts declared.

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