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A novel technique for full anatomic restoration of volar tilt in distal radius fracture

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Objective: The aim of this study was to present a technique that allows the surgeon to easily and reliably achieve volar tilt in dorsally displaced distal radius fractures treated with variable-angle volar locking plates. The study introduced this technique using 2.4 mm variable angle locking screws as reduction tools, and investigated the radiological outcomes of this technique.

Methods: A total of 42 patients (30 female and 12 male; mean age: 58 years, range, 25 to 84 years) with unstable distal radius fractures were treated with this technique. All were patients with insufficient volar tilt in spite of primary fracture reduction through classic reduction techniques such as traction, manipulation, and direct fragment manipulation. Postoperatively, the patients were instructed to perform wrist active and passive motion exercises at home for minimum 30 minutes a day, and were allowed to perform activities of daily living after removal of splint. The patients were evaluated radiographically at minimum twelve months after surgery.

Results: Mean follow-up period was 15.1 months (range: 12 to 24 months). Volar tilt of the distal radius before surgery was −11.9±10.4 (minus value means dorsal angulation), and after screw leverage was 11.5±4.3° (uninjured side: 11.7±2.3°). Mean radiological outcomes at final visit were as follows: volar tilt; 10.8±4.5°, radial inclination; 24±3.2°, radial height; 12.2±1.7 mm, and ulnar variance; 0.2±1.7 mm.

Conclusion: We describe a simple, reliable technique to fine-tune volar tilt in dorsally displaced distal radius fractures fixed with variable-angle volar locking plates. This technique is especially useful when volar tilt remains insufficient in spite of primary fracture reduction through classic techniques.

Keywords: Distal radius fracture; reduction technique; screw leverage; variable angle locking plate; volar locking plate.

Open reduction and internal fixation with a volar locking plate have become increasingly common in the treatment of distal radius fractures.[1-4] Most modular fixed-angle volar locking plates have a predetermined volar tilt and radial inclination designed into the plate. Thus, the direction of the distal locking screw is guided by plate design. However, while the predetermined volar tilt and fixed direction of distal locking screws can restore volar tilt, difficulty arises when a surgeon wishes to manage the restoration of volar tilt.

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Variable-angle locking screw volar plates have recently become available, providing angular variability and allowing the surgeon to control the direction of the screw.[5] Using this angular variability and locking mechanism, proper restoration of volar tilt of the distal radius may be easily achieved.

The purpose of this study was to introduce this technique using 2.4 mm variable angle locking screws as reduction tools, and to investigate its radiological outcomes.

Patients and methods

Between April 2010 and April 2011, the technique was performed on 42 patients with acute unstable distal radius fractures. Surgery was indicated when the initial closed reduction was unsuccessful, or the fracture had re-displaced in the splint. Criteria for surgical fixation was one or more of the following: dorsal tilt angle greater than 10°, radial height less than 10 mm, radial inclination angle less than 15°, ulnar variance of greater than 2 mm with that of the contralateral side, and an articular gap or step-off of at least of 1 mm. Exclusion criteria were multiple trauma, associated neurovascular injuries, partial articular or marginal rim fractures, volarly displaced fractures (Smith fractures), pre-existing arthritis of the wrist and hand, and prior traumatic injury.

All patients were evaluated radiologically at minimum 12 months postoperatively. Radiographic evaluation consisted of the standard posteroanterior (PA), lateral, and anatomic tilt lateral views. Radial height, radial inclination, volar tilt, and ulnar variance were measured. In order to minimize inter-observer and intra-observer differences, three orthopedic surgeons measured the radiographic parameters twice and the average of the results was taken. All measurements were performed using PACS system computer-aided measurement software.

Surgical Technique: The patient is positioned supine on the operating table with a hand table extension, and the surgical approach made through the bed of the flexor carpi radialis (FCR) tendon. The deeper part of the FCR sheath is opened to enter the plane defined by the flexor pollicis longus (FPL) and flexor digitorum sublimis (FDS) tendons on the ulnar side, and the radial artery on the radial side. The FPL and FDS tendons are retracted toward the ulna, and the pronator quadratus (PQ) observed. The PQ is incised at the tendinous insertion on the radial side of the PQ, with plans for repair after plate fixation.

The fracture site is exposed and primary fracture reduction achieved with the classic techniques of traction, manipulation, and direct fragment manipulation. Fracture reduction is then temporarily stabilized through the radial styloid with oblique 1.2 to 1.4 mm Kirschner wires. The appropriate volar locking plate is selected and positioned in the center of the distal radius at the desired proximal-distal and medial-lateral orientations. The 2.4 mm, variable-angle LCP two-column volar plate (DePuy Synthes, Paoli, PA, USA) is placed on the volar cortex and fixed with a cortical screw at the elongated hole. Additional fixation of the proximal locking screw is optional (Fig. 1a). The forearm is rotated to the neutral position. A small folded sheet is placed under the distal ulnar to determine the anatomic tilt (20°) lateral view.

After provisional Kirschner wire removal, reduction is maintained manually (Fig. 1b). Under fluoroscopy with an anatomic tilt (20°) lateral view, the drill is passed down the plate hole of most ulnar side through the funnel-shaped drill guide to ensure placement in the optimal subchondral location to leverage the lunate facet fracture fragment (Fig. 1c). The locking screw is inserted to a depth of approximately 60% of the screw thread (Fig. 1d).

Additional improvement in reduction is achieved by using the screw as a lever to reduce volar tilt. Because most variable-angle locking plate systems have limitation in angular variability of the locking mechanism, the leverage should be performed within the available angle. The leverage angle should not exceed 15° angulation around the central axis of the locking hole in this plate system. Leverage force is applied by hand in a distal to proximal direction on the driver and screw junction. The fragment should be supported by application of a dorsal force while the screws are used as a lever (Fig. 1e). Improvement in volar tilt is verified by fluoroscopy, and the screw is further inserted while the driver is used to maintain reduction force on the screw until final locking with the plate (Fig. 1f). Leverage within the available angle does not break the locking mechanism between plate and screws (Fig. 2).

Volar tilt of the scaphoid facet fragment is reduced using the same technique through the second radial hole of the plate. Screw levering of the distal fragment not only restores volar tilt, it may also facilitate correction of articular step-off, especially for simple intra-articular fractures (AO/OTA classification C1 and C2). This technique requires a distal fragment large enough to permit screw leverage, so its application may be limited in complex intra-articular fracture (AO/OTA classification C3). Finally, additional distal locking screws are fixed without the leverage technique in order to provide additional stability, and the remaining shaft screws are

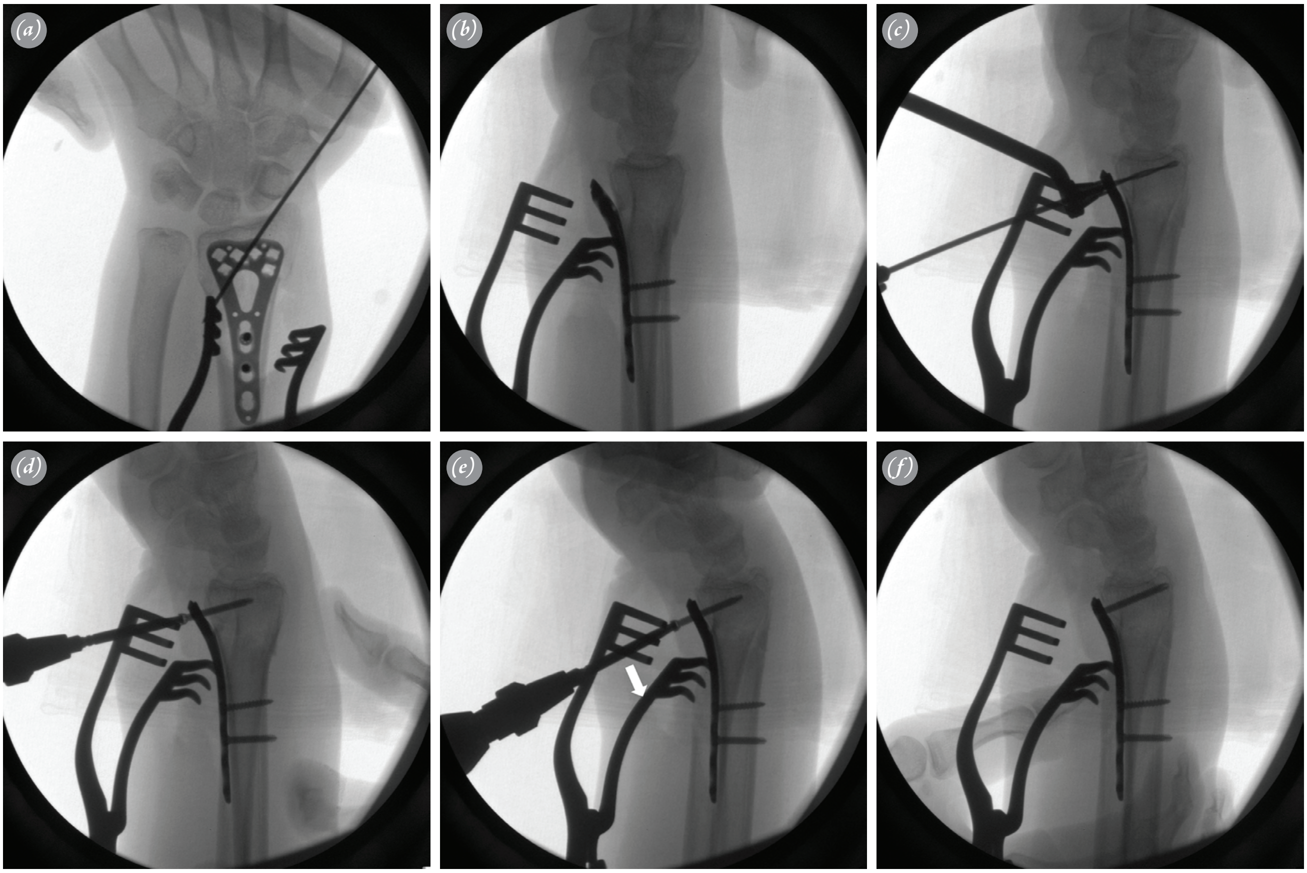

Fig. 1. **(a)** The fracture fragment is reduced by the classic reduction techniques of traction, manipulation, and direct fragment manipulation. A 2.4-mm, variable-angle LCP two-column volar plate (DepuySynthes, Paoli, PA, USA) is placed through one proximal cortical screw. Additional fixation of proximal locking screw is optional. **(b)** The forearm is rotated to the neutral position. A small folded sheet is placed under the distal ulna to determine the anatomic tilt (20-degree) lateral view. This view helps in the optimal subchondral placement of distal locking screws. After provisional Kirschner wire removal, the reduction is maintained manually. **(c)** Under fluoroscopy with anatomic tilt lateral view, the drill is passed down at the plate hole of most ulnar side through the funnel guide to ensure placement in the optimal subchondral location in order to leverage the lunate facet fracture fragment. **(d)** After drilling and determination of screw length, the locking screw is inserted to a depth of approximately 60% of the screw thread. **(e)** Additional improvement in reduction is achieved by using the screw as a lever to reduce volar tilt. Leverage force is applied by hand in a distal to proximal direction (white arrow) on the driver and screw junction. **(f)** Improvement of volar tilt is verified by fluoroscopy, and the screw is locked to the plate. If the fracture pattern is extra-articular, additional improvement of volar tilt can be achieved using the same technique through the other distal locking holes. If the fracture pattern is intra-articular, volar tilt of the scaphoid facet fragment is reduced using the same technique through the second radial hole of the plate.

fixed. The final reduction status and plate placement are verified with fluoroscopy. After surgery, the wrist is immobilized in a below-the-elbow splint. Active digital range of motion is started immediately. Sutures and splint are removed two weeks postoperatively. At that time, active and passive wrist motion is started with home program.

Results

Thirty female patients and 12 male patients (mean age, 58 years; range, 25 to 84 years) were included. Follow-up was a minimum of 12 months (mean: 15.1 months). There were 12 type A3 and 30 type C (C1: 8, C2: 17, C3: 5) fractures by AO/OTA classification. All fractures united at a mean of 3.8 months (range: 3 to 6 months).

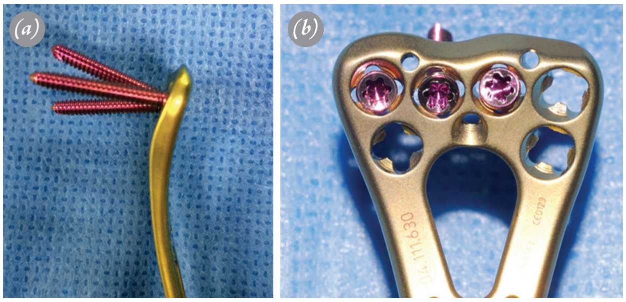

Fig. 2. Photograph showing the locking between screws and plate at three different angles; 15° upward, 0° and 15° downward. **(a)** Photograph showing good fit of the three differently-angled screw heads with the threads of plate holes. The leverage within available angle does not break the locking mechanism between plate and screws **(b)**. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

Table 1. Radiographic outcomes.

	Contralateral uninjured wrist	Before surgery	After surgery	Final follow-up	p*
Volar tilt (°)	9.7±4.7	-11.9±10.4**	11.5±4.3	10.8±4.5	0.36
Radial inclination (°)	23.1±4.3	15.5±8.4	24.6±3.0	24±3.2	0.63
Radial height (mm)	12.7±2.7	7.4±4.4	12.7±1.2	12.2±1.7	0.59
Ulnar variance (mm)	0.5±1.2	0.9±1.8	0.05±1.5	0.2±1.7	0.16

*p-value compares initial post-reduction radiologic parameters (after surgery) to final follow-up radiologic parameters using the Mann-Whitney U test.
**Minus value of volar tilt means dorsal angulation of distal fragment.

Mean volar tilt of the distal radius before surgery was −11.9±10.4 (minus value means dorsal angulation), and after screw leverage 11.5±4.3°. At final follow-up it was 10.8±4.5°. Using the Mann-Whitney U test, initial post-reduction radiologic parameters and final follow-up radiologic parameters were compared, and no significant differences were observed (Table 1).

Discussion

Most surgeons agree that anatomical reconstruction of the distal radius is required for an optimal functional outcome in distal radius fractures. Fracture reduction with a volar approach is generally undertaken using the classic reduction techniques of traction and manipulation in combination with direct fragment manipulation.[6] However, despite application of these techniques, a restored volar tilt may be insufficient compared to the contralateral normal wrist. In this situation, the locking screw leverage technique allows the surgeon to easily and reliably fine-tune volar tilt of the distal radius. Correct patient selection is an important factor in the success of this technique (Table 2). It should be applied to patients with dorsal displaced, and extra-articular or simple intra-articular distal radius fractures. Moreover, the bone stock and size of distal fragment should be adequate to permit screw leverage. Lastly, the leverage angle of the distal fragment should not exceed to 15°-20° around the central axis of the locking hole to avoid locking mechanism failure between the locking screws and plate.

Our technique has several advantages. It enables further fine-tuning of the correction of volar tilt after primary reduction through manual traction and direct fragment manipulation, and allows for fine-tuning of volar tilt in each fracture fragment, such as the radial and intermediate columns. This technique is not only for the restoration of volar tilt, it may also facilitates the correction of articular step-off especially for simple intra articular fracture (C1-C2). Moreover, additional tools for correcting dorsal tilt are not necessary with our technique. Some surgical techniques attempt to restore volar tilt by using tools such as a drill bit or wire.[6,7] It is best to avoid using additional reduction tools because they may break when used as a lever to correct dorsal tilt.

Table 2. Patient selection criteria for use of locking screw leverage technique.

Dorsal displaced distal radius fracture
Extra-articular or simple intra-articular fracture
The good bone stock and large size of distal fragment to permit screw leverage
Leverage angle of distal fragment <15°-20° around the central axis of the locking hole

Our technique has also some limitations. First, if there is inadequate distal bone stock, the screws may penetrate the articular surface of the distal radius while being used as levers. Thus, other reduction and fixation methods should also be considered in patients with significant osteoporotic bone. However, in our experience, this technique can be used in osteoporotic distal radius fractures, provided that the distal locking screws are fixed with subchondral bone just beneath the articular surface of the distal radius. To ensure success with this technique, it is critical to place the distal locking screws within the subchondral bone just beneath the articular surface. Secondly, because this technique requires a distal fragment large enough to permit screw leverage, this technique should not be applied in severe comminuted intra-articular fractures. Thirdly, if the leverage angle exceeds the available angular variability between screw and locking hole, the surgeon may encounter problems related to the locking mechanism, such as thread stripping, fusion of locking sides, reduction of fracture stability, challenges in implant removal, and tendon irritations due to prominent screw heads. Most variable-angle locking screws provide angular variability with a range of motion up to 30° or 40° between the plate and locking screw. The leverage should be performed within the available angle provided by various plate systems.

We described a simple, reliable technique to fine-tune volar tilt in dorsally displaced distal radius fractures fixed with variable-angle volar locking plates. This technique is especially useful when volar tilt remains insufficient in spite of primary fracture reduction through classic techniques. Thus, a combination of classic and locking screw leverage techniques will be able to restore the anatomy of the distal radius following fracture.

Conflics of Interest: No conflicts declared.

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