One Size Does Not Fit All: Distal Radioulnar Joint Dysfunction after Volar Locking Plate Fixation

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Abstract

Background Fractures of the distal radius are among the most common injuries treated by orthopedic surgeons worldwide. Failure to restore distal radius alignment can lead to fracture malunion and poor clinical outcomes, including distal radioulnar joint (DRUJ) instability and limitation of motion.

Case Description We present a unique case of DRUJ dysfunction following volar plate fixation of bilateral distal radius fractures and analyze the biomechanical causes of this complication. As a result of a relatively excessive tilt of the precontoured locking plate (in comparison to the patient's particular anatomy), the fracture on one side was "over-reduced," disrupting the biomechanics of the DRUJ, causing a supination block.

Clinical Relevance Volar locking plates are not a panacea to all distal radius fractures. Plate selection and fixation technique must include consideration of patient anatomy. Robust plates offer the advantage of providing rigid fixation but can be difficult to contour when reconstructing normal anatomy. Restoration of patient-specific anatomy is crucial to the management of distal radius fractures.

Keywords

- ▶ distal radius fracture
- ▶ volar locking plate
- ▶ wrist surgery
- ▶ DRUJ

Fractures of the distal radius are among the most common injuries treated by orthopedic surgeons worldwide.¹ Failure to restore distal radius alignment can lead to fracture malunion and subsequent poor clinical outcomes.^{2,3} Unstable, displaced periarticular fractures are frequently managed by open reduction/internal fixation (ORIF) utilizing locking plates designed to restore articular congruency and alignment, providing absolute stability according to the AO principles. The complications associated with operative fixation of these fractures have been well described.⁴ Here we present a unique case of DRUJ instability following volar locking plate fixation and analyze the cause of this complication.

Case Report

A 21-year-old woman presented with closed bilateral distal radius and ulna fractures following a motorbike accident (→Fig. 1). According to the Muller AO system both fractures were classified as 23-C3. The fracture patterns were almost

identical; the left distal radius sustained a comminuted transverse distal metaphyseal fracture with ulnar column intra-articular extension, 100% dorsal displacement, dorsal angulation of 10°, and an associated ulna styloid avulsion. The right distal radius fracture demonstrated the same pattern, with slightly more marked ulnar column intra-articular extension and dorsal angulation of 30°.

The patient underwent bilateral distal radius ORIF (right side first) by identical volar approaches. The fractures were reduced and fixed with AO Synthes 2.4-mm variable-angle LCP two-column volar distal radius plates (left: 02.111.631; right: 02.111.630; Synthes, West Chester, PA, USA) according to AO specifications. Intraoperatively, both fractures were considered anatomically reduced with full and unrestricted range of motion (ROM) and no fluoroscopic evidence of an Essex-Lopresti injury; no DRUJ instability, and no radial head instability or longitudinal instability of the intraosseous membrane. Both wrists were immobilized in plaster casts for a period of 2 weeks prior to clinical review.

Fig. 1 Anteroposterior (left) and lateral (right) radiographs demonstrating AO 23-C3 bilateral distal radius and ulna fractures. (a) Left. (b) Right.

At 2-week follow-up, clinical examination demonstrated both hands to be neurologically intact with satisfactory wound healing. The left wrist was well aligned and demonstrated a ROM of 60° flexion, 50° extension, and near full supination and pronation. The right wrist, however, demonstrated a clinically unstable DRUJ with reducible ulnar prominence, a supination block at neutral, 40° flexion, 30° extension, and 75° pronation. Review of the postoperative radiographs demonstrated the left distal radius and ulna reduced to anatomical position, with alignment of cortices and a volar tilt of 10° despite a 3-mm gap between the plate and the volar cortex (►Fig. 2a). The right distal radius was reduced flush onto the plate with a 16° volar tilt (►Fig. 2b). The DRUJ appeared unstable with dorsal ulnar subluxation. Computed tomographic (CT) imaging demonstrated restoration of articular congruence and ulnar styloid reduction (►Fig. 3a), with a volar tilt confirmed at 16° (►Fig. 3b).

Fig. 2 Postoperative radiographs (AP and Lat). (a) Left distal radius with a volar tilt of 10° and 3-mm gap between the locking plate and the volar cortex. (b) Right distal radius reduced flush onto the volar locking plate with 16° volar tilt and an unstable DRUJ with dorsal ulnar subluxation.

A diagnosis of a DRUJ disruption was presumed and referral made to a specialist tertiary hand surgery unit, where revision surgery of the right wrist was undertaken. Intraoperatively, as the volar tilt of the distal radius was reduced to anatomical, the DRUJ reduced and (surprisingly) remained stable. There was no disruption of the DRUJ, no soft tissue interposition from the radioulnar ligaments, and no other identifiable cause for DRUJ instability other than the excessive volar tilt. When the sole variable of the volar tilt was corrected, the DRUJ instability resolved. Fixation was then achieved with a 2.0-mm Stryker VariAx volar locking distal radius plate (Anatomical Volar DR Plate; right: 54–25386; Stryker, Mahwah, NJ, USA) contoured to fit the volar cortex (10° volar tilt) (►Fig. 4a). Screening under image intensification demonstrated a stable reduction with no ulnar subluxation or dislocation and smooth passive supination to 70°.

Fig. 3 Post-operative CT scans of the right wrist demonstrating near-anatomical articular surface reduction despite static widening of the DRUJ in the coronal plane (a). Dorsal distraction with volar tilt of 16° is seen in the sagittal plane (b). Axial view (c).

Fig. 4 Postrevision surgery. (a) Intraoperative (lateral) radiograph during revision surgery demonstrating an anatomical reduction with volar tilt of 10° and stable reduction of the DRUJ. (b,c) Postoperative clinical examination demonstrating restoration of pronosupination.

At 2-week follow-up after the revision surgery, clinical examination demonstrated maintenance of supination to 65° on the right side; with the rehabilitation having focused on the right side, the left forearm rotation had deteriorated, with only 45° of supination measured (→ **Fig. 4b**). Pronation was unrestricted (→ **Fig. 4c**). The patient went on to regain full and unrestricted ROM with complete fracture union.

Discussion

The distal radius and ulna form a three-column biomechanical construction consisting of the radial column (lateral radius, scaphoid fossa, and styloid process), the intermediate column (medial radius, lunate fossa, and sigmoid notch) and the ulnar column (distal ulna, triangular fibrocartilage complex [TFCC], and DRUJ). The normal volar tilt of the distal radius is 11° (2–20° range), with up to 2.5° variation between left and right sides.⁵ The anatomical relationships of the wrist

joint and DRUJ are very precise; even minor deformities can lead to significant biomechanical perturbations.^{6,7} The aim of surgery is to restore the wrist joint biomechanics and provide the patient with a pain-free and mobile wrist without functional limitation. The development of locking plate technology has seen a rapid adoption of precontoured volar locking plates for the management of periarticular fractures.⁴ Multiple volar locking plate options now exist; choosing which plate to use for a particular fracture depends on several factors including the fracture pattern and the surgeon's experience. Fixed-angle locking plates can act as an "internal-external fixateur" and do not require direct bone-plate contact for stable reduction; consequently, fracture reduction prior to plate fixation is commonly undertaken, in contrast to previous plate reduction techniques. Two-column side specific implants must be carefully selected by the surgeon to ensure that the correct side implant is chosen to prevent malreduction. To our knowledge, there have been no previous

reports of DRUJ instability due to the design of volar locking plates.⁸ Poor clinical outcomes are seen in distal radius fractures that heal with $>20^\circ$ dorsal tilt, 5 mm of ulnar variance, or loss of more than 10° radial inclination.² Previous studies have examined the effect of distal radius fracture malunion on wrist joint biomechanics, usually examining dorsally angulated distal radius malunion but not volar angulation. Interestingly, neither radial deformity or dorsal displacement is shown to result in DRUJ instability.⁹ Twenty degrees of volar or dorsal angulation have been shown to lead to shifts in joint load distribution.¹⁰

In the case described here, the ulnar subluxation and supination block were initially thought to be the result of a DRUJ disruption. However, following correction of the volar tilt with revision surgery, no DRUJ stabilization was required and no other cause of DRUJ instability could be identified. We hypothesized that the right distal radius was paradoxically “overreduced” into a Smith configuration of 16° to follow the tilt of the precontoured plate, and that this tilt was relatively excessive (for this specific patient’s anatomy), thereby disrupting the exquisitely sensitive biomechanics of the DRUJ. Revision surgery decreased the volar tilt to 10° , thereby reducing the DRUJ and restoring full supination. On the contralateral side the fracture was reduced anatomically, with the plate consequently sitting proud off the radius, resulting in normal biomechanical function. This hypothesis seems to have been proven, as the patient went on to regain near full ROM bilaterally with stable DRUJs requiring no further intervention. If the initial instability and supination block were actually caused by a DRUJ disruption, then merely correcting the volar tilt would not have stabilized the DRUJ.

Precontoured plates can facilitate expedient surgery, but they may fail to account for patient-specific anatomy at the extremes of the normal range. Because of the bilateral injuries in this case, a “normal side” was not available for assessment of the patient’s anatomy. Although this is rarely done, radiographic assessment of the unaffected side can provide an important reference point but may not be possible in the setting of simultaneous or previous fractures. Precontoured volar locking plates are not a panacea to all distal radius

fractures. Plate selection and fixation technique must include consideration of patient anatomy. Robust plates are advantageous in providing rigid fixation but can be difficult to contour when reconstructing normal anatomy and biomechanics. Restoration of patient-specific anatomy is crucial to the management of intra-articular fractures.

Conflict of Interest

None

References

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