Coronal Shift of Distal Radius Fractures: Influence of the Distal Interosseous Membrane on Distal Radioulnar Joint Instability

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Distal radius fractures are frequently associated with distal radioulnar joint (DRUJ) injury and a substantial proportion of patients develop symptomatic instability after fracture union. Distal radioulnar joint instability can lead to ulnar-sided wrist pain, painful or limited forearm rotation, grip strength weakness, and/or degenerative arthritis.

Distal radioulnar joint stability depends on the triangular fibrocartilage complex (TFCC), bony articulation between the ulnar head and sigmoid notch of the radius with its fibrocartilaginous rim, dorsal and palmar radioulnar ligaments, distal interosseous membrane (DIOM), and the musculotendinous units of the extensor carpi ulnaris and pronator quadratus. Cadaveric studies have demonstrated that the primary stabilizer of the DRUJ is the TFCC (specifically the radioulnar ligaments) and that the DIOM is an important secondary stabilizer of the DRUJ.[1,2] In the setting of a distal radius fracture, the usually intact DIOM has a central role in DRUJ stability because the TFCC is frequently injured. The DIOM is an isometric stabilizer of the forearm and its stabilizing effect has been attributed to its resting tension.[1] A recent anatomic study defined the DIOM as originating palmar and proximal on the ulna and inserting distal and dorsal on the radius, thus providing a structural basis for its function in resisting dorsal translation of the radius in supination.[3] In addition, approximately 40% of patients have a distinct ligamentous thickening of the DIOM known as the distal oblique bundle (DOB).[1,4] Cadaveric studies revealed that the DIOM and especially the DOB have variable width and thickness. Kitamura et al[5] demonstrated that specimens with a distinct DOB and increased DIOM thickness had increased DRUJ stability.

Radial translation or coronal shift of the distal radius describes radial displacement of the articular fragment of a distal radius fracture in the coronal plane.[6,7] Coronal shift results in narrowing of the radioulnar distance proximal to the fracture site, which decreases DIOM tension and increases laxity. In a cadaveric study, Dy et al[6] demonstrated increased DRUJ instability in association with distal radius fractures with coronal shift deformity (as small as 2 mm) in specimens with a discreet DOB. Anatomic reduction of this deformity re-tensions the DIOM, thus increasing contact pressures and seating the ulnar head within the sigmoid notch (Fig. 1).[3,6,8,9] Fujitani et al[10] clinically verified these biomechanical investigations. In a prospective cohort of 163 patients with distal radius fractures treated with volar locking plates, the authors found that coronal shift (described as *radial translation* and *DRUJ gap*) was the most important predictor of DRUJ instability.

CLINICAL PICTURE

Distal radius fracture reduction has classically been assessed by radial inclination, ulnar variance, volar tilt, and articular congruity. The biomechanical and clinical literature cited above suggests that coronal plane reduction should be included among these criteria because of its importance for DRUJ stability. Although coronal shift can occur in isolation in an extra-articular fracture pattern as a result of the deforming force of the brachioradialis, it frequently occurs in combination with typical deformities of dorsal tilt, dorsal comminution, and radial shortening.

Previous literature focused on avulsion of the distal radioulnar ligaments from the fovea or ligamentous

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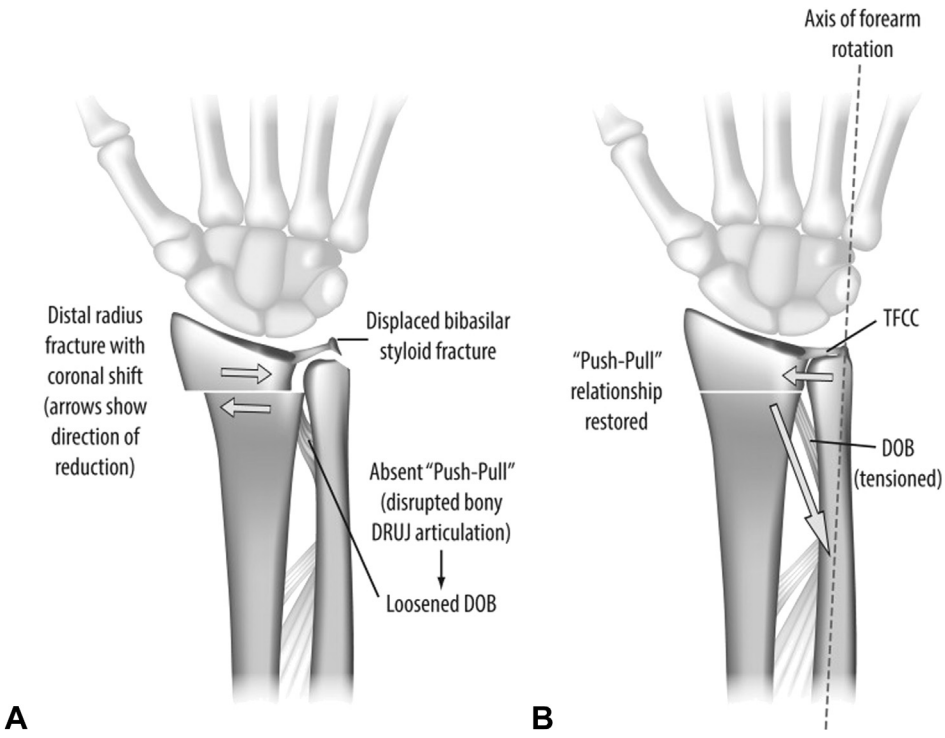

FIGURE 1: A Distal radius fracture with associated basilar ulnar styloid fracture and coronal shift of the proximal fracture fragment results in increased DOB laxity and decreased resting tension. As a result, DRUJ stability is compromised. **B** Tension, and consequently DRUJ stability, is restored upon coronal shift reduction. [Reprinted with permission from Dy CJ, Jang E, Taylor SA, Meyers KN, Wolfe SW. The impact of coronal alignment on distal radioulnar joint stability following distal radius fracture. *J Hand Surg Am.* 2014;39(7):1264–1272.[6]]

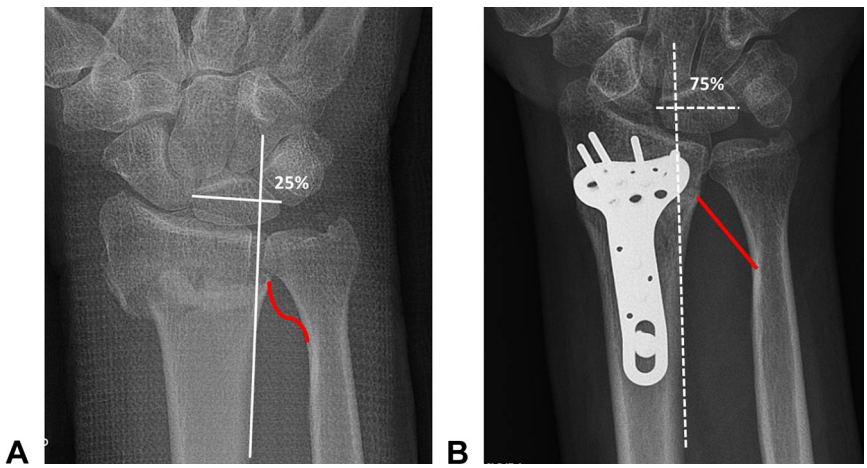

FIGURE 2: A Posteroanterior radiograph of extra-articular distal radius fracture with associated coronal shift. Red line simulates DOB laxity. **B** Intra-operative radiograph after coronal shift reduction and fixation demonstrates restored DOB tension (red line) and restored alignment of the lunate.

detachment via a basilar ulnar styloid fracture as causative mechanisms for DRUJ instability in the setting of distal radius fracture. In these clinical scenarios, open or arthroscopic TFCC repair or internal fixation of the DRUJ had been advised. However, several recent studies demonstrated no correlation between ununited or unrepaired basilar ulnar styloid fractures and DRUJ instability.[11,12] Interestingly, we and others observed residual DRUJ instability despite ulnar styloid repair when anatomic spacing between

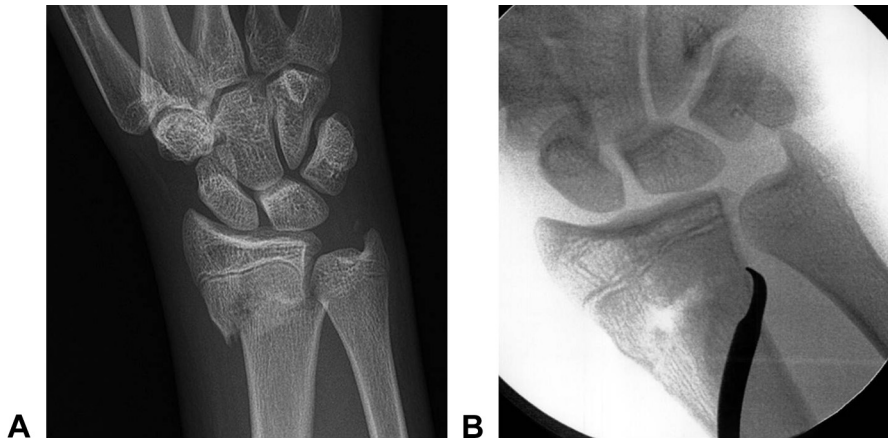

FIGURE 3: **A** Preoperative and **B** intraoperative posteroanterior radiographs demonstrating coronal shift reduction technique involving placement of a Hohmann retractor in the interosseous space.

the radius and ulna was not restored.[7] These reports highlight the importance of coronal plane reduction in restoring DRUJ stability. This understanding was also outlined by Orbay[9] in his classification of DRUJ injuries in the setting of distal radius fracture. He noted that when the DIOM is not torn, anatomic reduction of the radius appropriately tensions the DIOM and stabilizes the DRUJ without the need for TFCC reattachment.

Coronal shift is best measured on standard posteroanterior radiographs (Fig. 2). By extending a reference line along the ulnar aspect of the radial diaphysis distally across the carpus, Ross et al[7] demonstrated that the percentage of lunate width remaining ulnar to the reference line is an accurate index of radial translation (Fig. 2). In that series of 100 normal wrist radiographs, the mean percentage of lunate width ulnar to the reference line was 55% (range, 26% to 75%). Other radiographic findings that should raise suspicion for coronal shift include loss of the metaphyseal flare on the ulnar aspect of the distal radius just proximal to the sigmoid notch or an overlap of the radial styloid on the radial metaphyseal flare.

TREATMENT

Biomechanical and clinical evidence suggests that coronal shift deformity as small as 2 mm should be reduced to restore DIOM tension and minimize the chance of DRUJ instability.[6] In the operating room, coronal shift reduction can be easily performed from a dorsal or volar approach. Multiple techniques have been described in the literature that do not require additional incisions or fixation. Rapley et al[13] described several techniques for reduction including use of a Gelpi retractor to spread apart the radius and ulna until tension is restored or, alternatively, use of an external fixator. The authors also described a technique in which an Army–Navy retractor can be inserted in the interosseous space and then rotated 90° until the radius and DRUJ are reduced.[13] Moritomo and Omori[3] described a method that uses a volar locking plate as a reduction tool. We prefer a technique that involves application of a radial reduction moment on a Hohmann retractor placed on the ulnar metaphyseal flare with counter-pressure on the radial styloid (Fig. 3). The compendium of recent clinical and mechanical data suggests that coronal shift should be added to the classic measures of distal radius fracture reduction because of its fundamental role in DRUJ stability.

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