Management of Post-Traumatic Malunion of Fractures of the Distal Radius

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KEYWORDS

• Distal radius fracture • Malunion • Osteotomy
• Computer-assisted surgery

Fractures of the distal radius are a common occurrence, composing 10% to 12% of all fractures.[1,2] In spite of being seen as routine, a large retrospective study found that only 2.9% of 2132 individuals who had Colles' fractures were free from permanent loss of function.[2] Malunion and post-traumatic arthritis are the most commonly seen sequelae. After reviewing several studies, Amadio and Botte[3] quoted a pooled average malunion rate of 23.5% for conservatively treated distal radius fractures. In those managed operatively the risk decreased to 10.1%.[3]

Distal radius malunion has been extensively reviewed in the literature, with several articles elucidating the natural history, evaluation, and treatment options.[3–12] In this article the authors strive to provide an overview of the literature surrounding distal radius malunions, while highlighting areas that have not been reviewed as extensively; including intra-articular malunion, computer-assisted techniques, bone graft alternatives, and volar fixed-angle plate osteosynthesis.

EXTRA-ARTICULAR MALUNION

Anatomy

The anatomy of the distal radius and its associated radiographic measurements are well-known (**Fig. 1**). The distal radius typically has a radial tilt of 11° to 12° volar, a radial inclination of 22° to 23°, and a radial length of 11 to 12 mm.[13–17] Often the ulnar variance is used in place of measuring radial length.[18] The normal ulnar variance varies among individuals, and is best determined by comparison with the contralateral limb.

Graham[19] has defined acceptable parameters of the distal radius as: ulnar variance of less than 5 mm compared with the contralateral wrist, radial inclination on the posteroanterior (PA) radiograph greater than 15°, and radial tilt measured on the lateral radiograph between 15° dorsal and 20° volar.

Kinematics

Eighty percent of the joint reactive force across the wrist is borne by the radiocarpal joint.[20] Radial shortening has been associated with alteration of force transfer across the wrist, pain, and decreased rotation. Loss of radial length is seen by some as the most important cause of symptoms in distal radius malunion.[1,6,21] Palmer and Werner[22] have shown an increase of 18% to 42% in the force borne by the distal ulna, with a relative shortening of 2.5 mm of the radius. As the radius shortens relative to the ulna, the triangular fibrocartilage complex (TFCC) becomes tighter and the distal radioulnar joint (DRUJ) is disrupted, leading to pain and loss of forearm rotation.[23–25] Shortening of 6 to 8 mm causes the ulna

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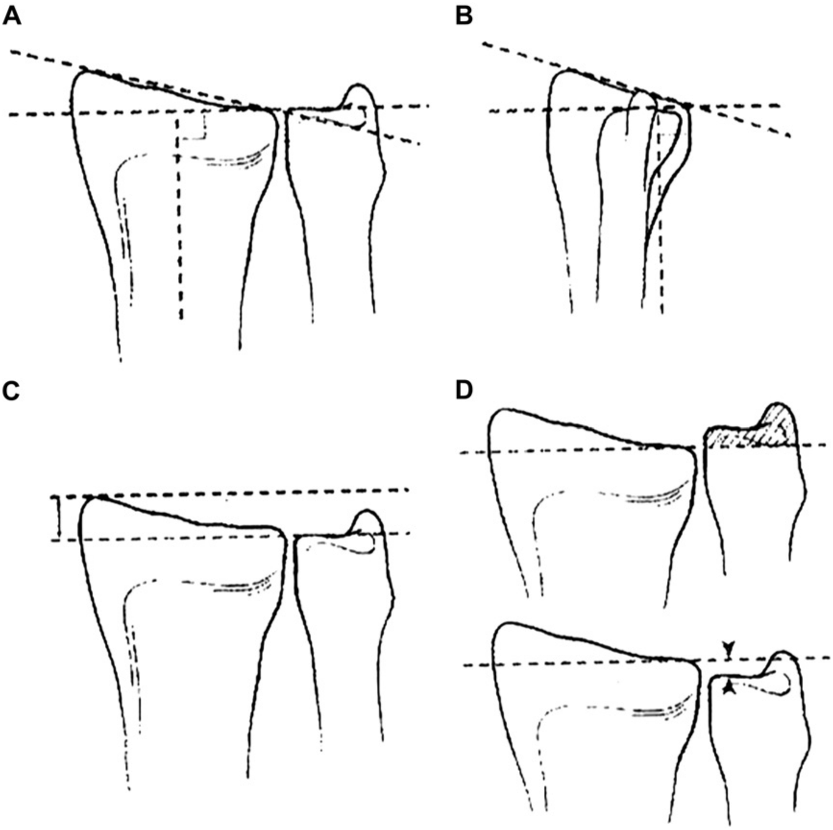

Fig. 1. Standard measurements of the distal radius. (*A*) Radial inclination. (*B*) Volar tilt. (*C*) Radial length. (*D*) Ulnar variance. (*From* Sharpe F, Stevanovic M. Extra-articular distal radial fracture malunion. Hand Clinics 2005;21:472; with permission.)

to impinge on the triquetrum or the extreme ulnar aspect of the lunate.[6,26–28] Bronstein and colleagues[29] found that 10 mm of shortening resulted in a mean 47% loss of pronation and 29% loss of supination. The DRUJ was effectively locked by ulnocarpal abutment at 15 mm of shortening. In a study of 61 Colles' fractures, Jenkins and Mintowt-Czyz[30] found that a mean shortening of 4.7 mm led to increased wrist pain. Four to 5 mm of shortening appears to be a threshold to the onset of wrist symptoms. There is general agreement that radial shortening of greater than 5 mm leads to unsatisfactory outcomes.[1,7–10,23,25,28–33]

Dorsal angulation is by far the most common deformity seen in distal radius malunion.[3] Despite its frequency, there is a vast disagreement in the acceptable parameters of dorsal angulation, ranging from 0° to 30°.[1,7,8,16,23,28,32,34,35] As dorsal angulation increases, the load distribution shifts from volar-radial to dorsal-ulnar.[10,20,22,36–38] In a cadaveric study, Short and colleagues[20] demonstrated that the load through the ulna increased from 21% at 10° of volar tilt to 67% at 45° of dorsal tilt. At 30° of dorsal angulation, 50% of the load was borne by the ulna. In a similar study, Miyake and colleagues[38] concluded that osteotomy to decrease abnormal wrist loading should be conducted when dorsal angulation exceeds 20°. Increased dorsal tilt also affects the DRUJ and the midcarpal joint. Abnormalities of statistical significance in rotation and instability of the DRUJ have been demonstrated at 20° to 30° of dorsal angulation.[39,40] Bronstein and colleagues[29] did not find a significant change in forearm rotation as dorsal tilt increased to 30°. They suggested that the decreased rotation observed clinically may relate to subacute capsular scarring. As dorsal tilt increases, there is a tendency for the midcarpal joint to compensate by flexing, leading to painful synovitis at the midcarpal level and a dorsal intercalary segment instability (DISI) type deformity.[7,16,41,42] This deformity is classed into a lax, reducible form that corrects with osteotomy, and a nonreducible form that remains unchanged with osteotomy.[3] Increased volar tilt (Smith's fracture) leads to decreased wrist extension and dorsal subluxation of the ulnar head, which restricts supination.[7,27]