Chronic Instability of the Distal Radioulnar Joint

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The skeletal architecture of the distal radioulnar joint (DRUJ) provides minimal inherent stability; the sigmoid notch is shallow, and its radius of curvature is 50% greater than that of the ulnar head.1 Thus, the DRUJ relies heavily on soft-tissue (ie, ligament, muscle) support for stability. The structures that contribute to DRUJ stability are the pronator quadratus muscle, extensor carpi ulnaris (ECU), interosseous membrane, DRUJ capsule, and components of the triangular fibrocartilage complex (TFCC).2

Of these structures, the TFCC is arguably the most important for maintaining normal DRUJ kinematics.1,3 The palmar and dorsal radioulnar ligaments are the prime components of the TFCC that stabilize the DRUJ. These ligaments appear as thickenings at the combined junctions of the TFCC, DRUJ capsule, and ulnocarpal capsule. As each ligament extends from its respective distal margins of the sigmoid notch, it divides in the coronal plane into two limbs. The deep or proximal limb attaches at the fovea, and the superficial or distal limb attaches to the base and midportion of the ulnar styloid. The precise roles of the radioulnar ligaments have been debated, but it is known that the palmar and dorsal ligaments both act in concert with the rims of the sigmoid notch to constrain the joint and are necessary for normal stability in either a dorsal or palmar direction.2,4,5

Inadequate healing of the soft-tissue stabilizers after traumatic disruption of the DRUJ may cause persistent instability, resulting in pain, decreased grip strength, and mechanical symptoms. The first surgical option is delayed direct repair of the TFCC.6,7 When the TFCC is irreparable because of retraction or primary tissue damage, a reconstructive procedure is indicated. Numerous reconstructions have been described and can be classified into three categories: (1) a direct radioulnar tether that is extrinsic to the joint,8 (2) an indirect radioulnar link via an ulnocarpal sling or tenodesis,9,11 and (3) reconstruction of the radioulnar ligaments.12-14 Although the techniques in the first two categories may improve symptoms, they are not anatomic, and laboratory studies indicate that they do not restore normal joint stability or mechanics of the DRUJ.15 A radioulnar tether using flexor or extensor tendons (flexor carpi ulnaris or extensor carpi ulnaris) at the level of the ulnar neck does not guide the forearm along its normal axis of rotation. In addition, a tendon tethering technique risks reduction of forearm rotation. An ulnocarpal sling or a tenodesis uses the carpus to link the radius to the ulna. Although these techniques may restore ulnocarpal stability, the indirect radioulnar connection is inherently slack and thus suboptimal for restoring DRUJ stability.

Reconstruction of the distal radioulnar ligaments offers the best possibility of restoring normal DRUJ primary constraints and kinematics. Although controversy remains regarding the specific functional importance of the palmar and dorsal radioulnar ligaments during pronation and supination,1,16,17 it has been shown that gross instability of the DRUJ requires disruption of both ligaments.2 Reconstruction of only one ligament will effectively manage unidirectional dislocation but may not correct an associated lesser instabil-
ity in the opposite direction. Thus, reconstruction of both ligaments seems to be the optimal method for surgically managing posttraumatic chronic DRUJ instability.

Indications
The primary indication for DRUJ ligament reconstruction is DRUJ instability with an irreparable TFCC. DRUJ instability may coexist with other causes of ulnar-sided wrist pain, including ECU tendon subluxation, ulnar impaction syndrome, and DRUJ arthritis. These conditions, among others, must be ruled out before considering instability as the main cause of symptoms.

Symptomatic dysfunction of the DRUJ after wrist injury, especially after distal radius fracture and subsequent malunion, is relatively common. Residual dorsal angulation of the distal radius >20° to 30° is associated with increased loading of the distal ulna, radioulnar joint incongruity, TFCC distortion, and palmar DRUJ instability. For DRUJ instability caused by malunion of the distal radius, ligament reconstruction should be performed in conjunction with corrective osteotomy of the distal radius and/or ulna. For the patient in whom a previous distal radius fracture involved deformity of the sigmoid notch, a notch osteoplasty may be indicated as an adjunct to DRUJ reconstruction.

Contraindications
Ligament reconstruction is contraindicated in the presence of DRUJ arthritis. Although reconstruction could be performed in conjunction with hemiresection of the distal ulna, other procedures, such as tenodesis, would likely be as effective and be more efficiently accomplished in this situation. Additionally, deficiency of the sigmoid notch may result in recurrent instability. A computed tomography scan should be obtained to determine the adequacy of the dorsal and volar rims of the sigmoid notch, and to assess the degree of DRUJ arthritis.

Surgical Technique
In the patient with chronic instability, we prefer to reconstruct both the dorsal and volar radioulnar ligaments to restore joint stability and mechanics. A 5-cm incision is made dorsally between the fifth and sixth extensor compartments over the DRUJ. The fifth compartment is opened over the radioulnar joint, and the extensor digiti minimi tendon is retracted. An “L”-shaped DRUJ capsulotomy is made, with one limb along the dorsal rim of the sigmoid notch and the other just proximal to the dorsal radioulnar ligament (Figure 1). The ECU sheath is not opened or dissected from the ulnar groove during the procedure. Scar is debrided from the fovea, however, functioning remnants of the TFCC are retained.

The periosteum beneath the fourth dorsal extensor compartment is elevated from the dorsal margin of the sigmoid notch. A guidewire for a 3.5-mm cannulated drill bit is driven through the distal radius approximately 5 mm proximal to the lunate fossa and approximately 5 mm radial to the articular surface of the sigmoid notch. The site is chosen so that, if necessary, a tunnel through the distal radius can be enlarged to accommodate the tendon graft without disrupting the subchondral bone of the lunate fossa or sigmoid notch (Figure 2). Fluoroscopic views confirm proper guidewire position, and
the tunnel is made with a cannulated drill (Figures 3 and 4). A tunnel is created in the distal ulna between the fovea at the base of the ulna styloid and ulnar neck. A 3.5- to 4-mm drill hole is made in the ulnar neck at its subcutaneous border. For this technique, a guidewire is inserted in the hole and driven through the fovea. Alternatively, if the wrist is flexed, the guidewire may be driven through the fovea and out the ulnar neck. A 3.5-mm cannulated drill bit is used to create the tunnel. If necessary, the tunnel may be enlarged with larger drill bits or gouges to accommodate both limbs of the graft (Figure 5).

A palmaris longus or plantaris tendon graft is harvested. Alternatives include a toe extensor tendon or a strip of the flexor carpi radialis or flexor carpi ulnaris tendon. Because the flexor carpi ulnaris is already partially exposed during this procedure, it is a good alternative. The volar opening of the radius tunnel is exposed through a 3- to 4-cm longitudinal incision extending proximally from the proximal wrist crease between the ulnar neurovascular bundle and the finger flexor tendons. A suture retriever is passed through the radius tunnel from dorsal to volar, and one end of the graft is pulled back through the tunnel. A straight hemostat is passed over the ulnar head but proximal to the remaining TFCC and pushed through the volar DRUJ capsule. The other end of the graft is grasped with the hemostat and pulled back along this tract. Using the dorsal exposure, both graft limbs are passed through the ulnar tunnel to exit the ulnar neck. The limbs are passed in opposite directions around the ulnar neck, one passing deep to the ECU sheath (Figure 6). With the forearm in neutral rotation and the DRUJ manually compressed, the limbs are pulled taut, tied together, and secured with sutures. The tendon graft that is not long enough to pass around the ulnar neck can be secured in a variety of ways. One method is to make a second hole in the ulnar neck, pass each limb in different directions, and tie over the bone bridge. The dorsal DRUJ capsule and extensor retinaculum are closed in layers with 3-0 sutures, leaving the extensor digiti quinti subcutaneous.

In the patient with a history of fracture involving the sigmoid notch or in whom deformity of the DRUJ is noted on plain radiographs, a preoperative computed tomography scan is recommended to evaluate the dorsal and volar rims of the sigmoid notch as well as the shape of the ulnar head. A sigmoid notch osteoplasty can be done as an isolated procedure or as a complement to ligament reconstruction. Osteoplasty increases the prominence of the rim to create a better bony buttress. In the procedure described by Wallwork and Bain, parallel osteotomies are made, with one just proximal to the lunate fossa and the other at the proximal margin of the sigmoid notch (Figure 7). A third osteotomy is made in the coronal plane 5 mm from the articular surface of the notch and between the first two cuts. The osteotome is carefully advanced and at each increment is levered in an ulnar direction to produce a thin, curved osteocartilaginous flap. The wedge-shaped defect is filled with bone graft harvested from the distal radius and fixed with Kirschner wires. Because the osteotomies are proximal to the radioulnar ligament, ligament tension is increased, which also improves joint stability. The published cases of this technique are limited, but the concept appears sound. A good result was achieved when sigmoid notch osteoplasty was used as a sole procedure to treat palmar instability in a patient with a flat sigmoid notch.20
An alternative to sigmoid notch osteoplasty is angular osteotomy of the ulna. A closing-wedge osteotomy is made in the distal third of the ulna to tilt the ulna toward the sigmoid notch in the position of instability. The osteotomy is fixed with a compression plate. Preoperative planning, patient selection, and intraoperative assessment must be exact to achieve a good result with this demanding technique.21

Rehabilitation
Postoperatively, the patient is placed in a long arm splint with the forearm in neutral to slight supination or pronation, depending on which is the most stable position. At the first postoperative visit (approximately 10 days), the patient is converted to a long arm cast extending just above the elbow to control forearm rotation. At 3 weeks, the cast is changed to a short arm well-molded cast that partially limits forearm rotation; the patient remains in this cast for an additional 2 to 3 weeks.

**Pearls**

**Ligament Reconstruction**
- Harvest tendon graft early to determine the proper size for bone tunnels.
- Use a suture passer to aid graft passage.
- Use fluoroscopy to confirm guidewire placement.
- When performing a corrective osteotomy for distal radius malunion, make the bone tunnels first.

**Osteoplasty**
- When used with distal radioulnar ligament reconstruction, make the distal radius bone tunnel for the ligament reconstruction before creating the osteoplasty.
- For a volar rim osteoplasty, identify the osteotomy site by palpation and fluoroscopy rather than via DRUJ capsulotomy.
- When indicated, a ligament reconstruction will help stabilize the bone graft.

**Pitfalls**

**Ligament Reconstruction**
- The surgeon must not fail to recognize malunion of the radius or ulna.
- A flat or deficient sigmoid notch should be augmented by a sigmoid notch osteoplasty.
- Preexisting DRUJ arthritis will be a source of persistent pain.

**Osteoplasty**
- Avoid breaking through the cartilage when levering the rim into place.
- Make the osteochondral flap broad enough without violating the lunate fossa.
The patient is then converted to a removable commercial or custom wrist brace to be used for at least 2 more months as motion and strength are recovered. Therapy begins with active and gentle passive wrist flexion, extension, pronation, and supination. No limitations are placed on active motion, but only gentle passive motion should be used during the first month of therapy. Strengthening is started early, but high forces with the arm in full pronation and supination are avoided. At 4 months postoperatively, more aggressive exercises are added, with the goal of recovering 85% of “normal” forearm pronation rotation by 6 months. No use of the hand for sports or lifting >5 lb is allowed until at least 4 months postoperatively.

Summary

The ligament reconstruction technique described closely reconstructs the anatomic origin and insertion of the palmar and dorsal radioulnar ligaments. In a series of 14 patients, stability was completely restored in 12. Patients were able to return to their previous work, athletic activities, and avocations without limitations. Recovery of strength and motion was at least 85%. One patient with initial bidirectional instability and good early surgical correction developed recurrent varol instability. Another patient had persistent preoperative ulnocarpal instability and an insufficient volar rim of the sigmoid notch from a previous fracture, but the DRUJ was stabilized. Ligament reconstruction is effective for DRUJ instability but requires a competent reconstructive procedure for dorsal subluxation of the distal radioulnar joint. 

References

Citation numbers printed in bold type indicate references published within the past 5 years.