Chronic Instability of the Distal Radioulnar Joint: Diagnosis and Management

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Abstract

Chronic Instability of the distal radioulnar joint is not uncommon but often misdiagnosed and mistreated. This review focusses on chronic wrist instability and provides an insight into this uncommon disorder

Keywords:

Introduction

The distal radioulnar joint (DRUJ) is important for rotation of the forearm and stability of the ulnar wrist. Any DRUJ injury can cause limitation of the range of motion (ROM), decreased strength, pain, and instability. This article deals with DRUJ instability and reviews treatment methods and outcomes. Disturbances in DRUJ stability result from bone damage, triangular fibrocartilage complex (TFCC) and ligament injuries, and/or other soft tissue deficiencies. Instability due to injury may be acute or chronic in nature. Most acute cases are best treated conservatively. Chronic problems resulting in disability may require surgical treatment.

<H1>Anatomy and Biomechanics
Any ability to diagnose and treat injuries of the DRUJ requires a complete understanding of the complex anatomy. The first recent descriptions of the anatomy of the DRUJ came from case studies of dislocations of the DRUJ [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15]. Although a detailed description of the anatomy and biomechanics of the DRUJ is beyond the

scope of this article, a brief account ensues. The DRUJ is a trochoid, diarthrodial articulation that provides the distal link between the radius and ulna and a pivot for pronation-supination (Fig. 1). Its skeletal architecture allows both rotation and translation during normal forearm motion, which imposes strong reliance on the soft tissues for joint stability and a predisposition to instability after injury (Fig. 2). The DRUJ and proximal radioulnar joint are interdependent in producing forearm motion. Disruptions of either joint, deformity of the radius or ulna, or injury to the interosseous membrane (IOM) alters the function of both joints. Although either dorsal or volar instability may predominate, bidirectional instability is common, especially in chronic cases.

The DRUJ is a complex system which plays an important role in distributing applied load through the osteoligamentous system. The TFCC functions to transmit 20% of axially applied load from the ulnar carpus to the distal ulna and acts as the major stabilizer of the DRUJ and ulnar carpus [16]. The force transmitted across the

TFCC changes predictably with sequential axial loading to the hand and forearm. It is higher with positive ulnar variance than negative ulnar variance. To account for this people with positive ulnar variance have a thicker TFCC [17]. The force transmitted is also higher in pronation than supination and with forced grip [18]. This is because ulnar variance changes with rotation and increases an average of 1.95 mm with forced grip [19]. This dynamic loading probably plays a role in injuries sustained in patients who perform repetitive work which places their wrists in these positions.

Clinical Presentation - History

Although the radius together with the carpus comprise the mobile unit of the DRUJ, by convention DRUJ dislocation or instability is described by the position of the ulnar head relative to the distal radius. Traumatic TFCC injuries usually result from combined rotational and axial forces to the forearm. The majority of isolated, irreducible, or "locked," DRUJ dislocations is dorsal and caused by hyperpronation and wrist extension, usually in a fall on the outstretched hand. Conversely, volar dislocations are more subtle and occur in the supinated forearm or from a direct blow to the ulnar aspect of the forearm. Although most acute complete dislocations are dorsal, chronic volar instability is not uncommon but often missed because the clinical diagnosis is more difficult.

Etiology

The most common cause for DRUJ instability is a distal radius fracture. Dorsal angulation of the radius induces instability

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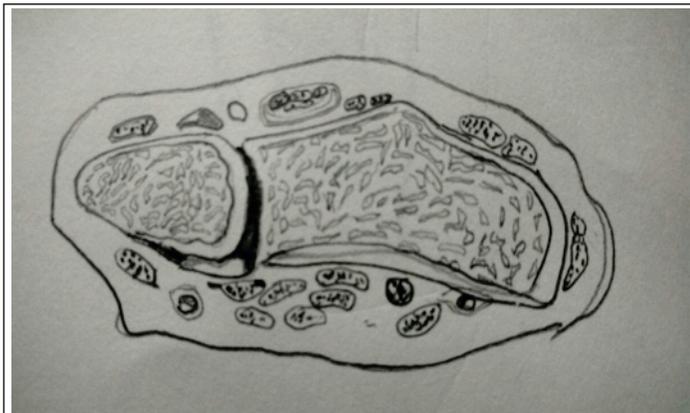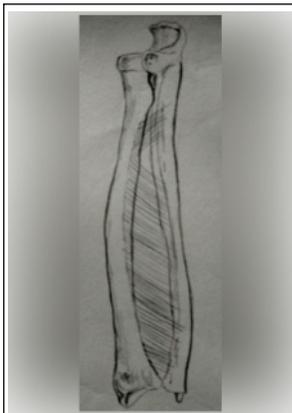Email: abhiwahe@gmail.com

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Figure 1: Schematic cross-section through the distal radioulnar joint showing the relation of the ulna head to the sigmoid notch of the radius. Note the shallow sigmoid notch in comparison to the ulnar head which has a larger radius of curvature.

Figure 2: The distal radioulnar joint is a hemi joint, the other half is the proximal radioulnar joint. The radius and ulnar are connected by the annular ligament, the triangular fibrocartilage complex, and the interosseous membrane.

Classification of Chronic DRUJ Instability
A. Ligament injury, including ulnar styloid fracture
· TFCC tear (radioulnar ligaments) from ulna
o No fractures
o Fleck fracture from fovea of ulnar head
o Basilar ulnar styloid fracture (displaced or mobile nonunion)
· TFCC tear (radioulnar ligaments) from radius
o No fractures
o Avulsion fracture of rim(s) of sigmoid notch
B. Intra-articular skeletal deformities of DRUJ

· Sigmoid notch deficiency
o Volar rim
o Dorsal rim
o Both volar and dorsal rims
· Ulnar head deficiency
o Malunion
o Previous partial or complete resection
C. Extra-articular skeletal deformities.
· Angular and/or rotatory deformities of forearm
o Radius
o Ulna
o Both radius and ulna
· Angular and/or rotatory deformities of wrist
o Radius
o Ulna
o Both radius and ulna

of the distal ulna. Angulation >20-30° creates marked incongruity of the DRUJ, distorts the TFCC, and alters joint kinematics [20, 21]. The radioulnar ligaments can tolerate no more than 5-7 mm of radial shortening before one or both ligaments tear [20]. The TFCC typically tears at its ulnar attachments [22]. As the severity of injury increases, the secondary stabilizers of the DRUJ and other structures on the ulnar side of the wrist sustain injury, including the IOM, extensor carpi ulnaris (ECU) sheath, ulnocarpal ligaments, and lunotriquetral interosseous ligament.
The majority of ulnar styloid fractures are not associated with DRUJ instability. The styloid shaft provides attachments for portions of the ulnocarpal ligaments, ECU tendon sheath and superficial limbs of the radioulnar ligaments while the styloid tip is devoid of soft-tissue attachments. Thus, a fracture through the base of the styloid is more predictive of a TFCC tear than more common fracture through the tip [23]. Despite the ulnar styloid shaft providing attachments for several stabilizing ligaments of the DRUJ, the radioulnar ligaments also have substantial attachments to the foveal region at the base of the ulnar styloid where it intersects with the ulna head. A basilar fracture of the ulnar styloid may thus occur without complete disruption of these ligaments. Conversely, a complete avulsion of the radioulnar ligaments and gross instability can occur without any type of styloid fracture. Occasionally, a small fleck of bone is avulsed from the fovea indicating disruption of the deep limbs of the

radioulnar ligaments. These variations of injury must be recognized to avoid pitfalls in treating instability. For example, fixation of an ulnar styloid fracture will not be sufficient if the integrity of the radioulnar ligaments is not restored.
Persistent symptoms following wrist injuries, especially after a distal radius fracture, are frequently caused by residual dysfunction of the DRUJ and often misdiagnosed. Pain, reduced motion, weakness, and mechanical symptoms may result. Chronic instability rarely improves spontaneously, but symptoms may lessen and become tolerable in mild cases. It is unknown if instability predisposes to wrist arthritis. A classification of chronic DRUJ instability based on anatomic sites of injury and deformity is useful for guiding treatment.

Figure 3: Pre-operative X-ray of a 54 years farmer, with a malunited fracture of the distal radius of 2 years duration and an unstable distal radioulnar joint (DRUJ). History and clinical exam revealed that his disability was from the DRUJ instability.

Figure 4: Post-operative X-ray at 2 months after a Sauvé-Kapandji procedure was performed. Note that the proximal ulnar stump has been stabilized with a tenodesis procedure (drill hole is seen in the proximal ulna.

Figure 5: Post-operative result at 4 months. Wrist flexion and extension did not improve much from the pre-operative range of motion; but, the pronosupination and grip strength were restored and the patient could resume his work.

Length deficiencies
o Radial head absent (essex-lopresti injury)
o Distal radius growth arrest
o Distal ulnar growth arrest.
· Defect in radius or ulnar shaft.

Diagnosis

DRUJ instability may coexist with other causes of ulnar-sided wrist pain including ECU tendonitis, ulnar impaction syndrome, and DRUJ arthritis. These conditions, among others, must be considered before instability is attributed as the main cause of symptoms. In isolated post-traumatic DRUJ instability, the most common history is a traumatic event involving a fall on the outstretched hand or a forced rotation of the wrist such as recoil from a power drill, which is followed by ulnar-sided wrist swelling and pain aggravated by forearm and wrist motion. Pain-at-rest and dorsal-ulna swelling typically improve, but pain with use continues and may become associated with symptoms of mechanical instability including weakness and a joint clunk. The distal ulna may remain tender to palpation and appears prominent. In mild instability, pain and weakness often occur only with activities that require power rotation of the forearm, especially while gripping, such as using a screwdriver. Pain or a mechanical block from dislocation may cause loss of motion.

Severe DRUJ instability in children is usually associated with a previous distal radius or forearm fracture and often presents late, sometimes years after the fracture. Children are more likely to complain of pain and popping in the wrist (or forearm) that is interfering with recreational activities, but they rarely have pain at rest. Loss of forearm motion is uncommon but the instability is obvious. Although a skeletal angular deformity is often identified radiographically, it is typically mild suggesting that a rotatory malunion exists and secondary ligament attenuation has developed over time leading to instability.

DRUJ instability in adults following a distal radius, distal ulna, or midshaft forearm malunion usually presents with loss of forearm motion, prominence of the ulnar head, and ulnar-sided wrist pain. Complaints are caused by the combined effects of the malunion on the radiocarpal, ulnocarpal, and DRUJs, with the relative effects of each dependent on the severity and type of deformity. Shortening from a distal radius malunion causes modest loss of both pronation and supination but infrequently produces dorsal or palmar DRUJ dislocation. Conversely, angular deformities of the distal radius or forearm are more likely to cause gross instability and unidirectional loss of motion of the DRUJ. Length discrepancies due to skeletal deficiencies in the proximal forearm, such as an essex-lopresti injury, are associated with IOM injuries and produce symptoms not exclusive to the DRUJ. Developmental skeletal deformities, such as Madelung's, behave similar to their posttraumatic counterparts however the symptoms typically progress slower.

Instability of the distal ulna following its partial or complete resection may produce symptoms early or late. Weakness and pain are associated with excessive dorsopalmar translation and radioulnar convergence. Diminished grip is particularly common in younger patients. Convergence can progress to impingement of the ulnar stump against the radius, producing crepitus and pain with forearm rotation.

Physical Examination

A chronically dislocating DRUJ commonly causes reproducible clunks that are visible and palpable as the ulnar head dislocates and reduces in the sigmoid notch during active or passive forearm rotation. Passive manipulation of the joint is occasionally necessary to complete the dislocation and compression across the joint may accentuate the clunk. A subluxating DRUJ is more subtle and difficult to detect. In volar subluxation, a slight prominence of the ulnar head is seen on volar aspect of the wrist and a depression on the dorsal side ("dimple sign"). Tenderness is present diffusely about the distal ulna but particularly over the fovea of the ulnar head, which is located in the depression between the flexor carpi ulnaris tendon and ulnar styloid. Passive manipulation of the radius relative to the ulna produces increased anteroposterior translation of the DRUJ, the so-called "piano key sign". This maneuver is performed with the forearm in neutral, supination, and pronation. More laxity normally occurs in the neutral position than either pronation or supination in which the support ligaments of the DRUJ should tighten unless completely disrupted. It is
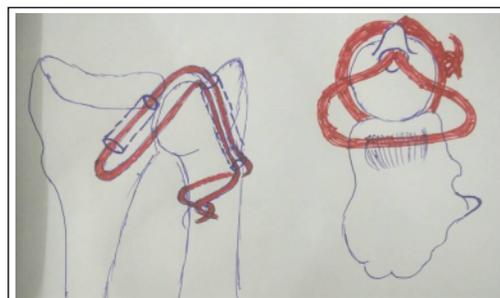
Figure 6: Schematic diagram showing the Adams-Berger reconstruction using a free tendon graft.

Figure 7: Pre-operative arthrogram of a 45-year-old patient presenting with post-traumatic chronic distal radio-ulnar joint (DRUJ) instability with pain. There were no arthritic changes in the DRUJ. Arthrogram shows dye in the DRUJ and also under the triangular fibrocartilage complex. This patient underwent an Adams-Berger procedure.

Figure 9: Post-operative pictures at 9 months showing full range of motion and good grip strength.

essential to compare the affected wrist with the contralateral extremity because the normal ROM and laxity of the DRUJ vary considerably among individuals. Resisted forearm rotation, especially at the extremes of pronation and supination, is often painful. A modification of the press test [24] originally described to diagnose TFCC tears, is useful for evaluating suspected bidirectional or dorsal DRUJ instability. In this modified test, the patient raises from a chair using their hands for assistance by pushing against a tabletop located to his or her front. Instability is shown by greater "depression" of the ulnar head on the affected side and is often associated with pain. Tenderness over the ulnar styloid is indicative of an unstable nonunion. In a dorsally angulated malunion of the distal radius, the ulnar head will be prominent volarly, especially with supination. Decreased motion and crepitus during pronation-supination, which may be accentuated by manually compressing the joint, are signs of DRUJ arthritis. ECU sheath incompetence and lunotriquetral ligament tears can be associated with DRUJ instability. ECU subluxation is most apparent in supination and ulnar deviation.

The lunotriquetral joint is assessed with the shear or ballotment test, which can demonstrate both instability and pain. Signs of other carpal instabilities, pisotriquetral joint degeneration and inflammatory arthritis should also be considered during the physical examination.

Imaging
Plain radiographs of the wrist are reviewed to determine the presence of bony deformities resulting from acute or old fractures, erosions, or depositions from arthropathies and joint degeneration from posttraumatic arthritis. Two orthogonal views of the forearm should be obtained when forearm deformity is suspected. Positioning is a key to obtaining good plain wrist films. A zero-rotation PA view is achieved by placing the humerus at 90° of abduction and the elbow at 90° of flexion on a flat surface. Signs of DRUJ instability in this view include: an ulnar styloid base fracture, a fleck fracture from the fovea, widening of the DRUJ, and >5 mm of ulnar minus variance compared to the opposite wrist. This view should also be inspected for evidence of carpal instability and ulnar impaction syndrome.

A true lateral radiograph is obtained with the arm at the patient's side and the elbow flexed 90°. An accurate view is marked by the pisiform palmar surface visualized midway between the palmar surfaces of the distal pole of the scaphoid and the capitate or the midpoint of the hook of the hamate.

Other evidence of correct alignment include superimpositions of the lesser four metacarpals, the proximal pole of the scaphoid on the lunate and the radial styloid in the center of the lunate. However, the lateral view is imprecise for diagnosing DRUJ subluxation.

Computed tomography (CT) has become the standard method for imaging DRUJ instability. To be a valuable study, both wrists must be evaluated on the same images and in identical forearm positions to make accurate comparisons between the normal and affected sides. It is important to align the forearms in the axis of the gantry and to image in neutral, supination, and pronation. To identify subtle DRUJ instability, several measurement methods have been used. Because CT accurately delineates the cross-sectional anatomy of the DRUJ, it is also useful for assessing sigmoid notch competency, ulnar head deformity, and DRUJ arthritis, which are important in selecting proper surgical treatment. Magnetic resonance imaging (MRI) has been used to diagnose TFCC tears but its sensitivity, specificity, and accuracy vary among reports. Gadolinium or saline injection improves the detection of TFCC communicating defects. To be valuable in the management of DRUJ instability, MRI is used to detect peripheral lesions of the TFCC. Dynamic wrist imaging with MRI or CT with forearm stress have been used to identify dorsal and palmar instability as well as lesions of the ulnocarpal ligament complex and may become important tools for correlating and diagnosing subtle instability. Other imaging modalities such as arthrography and scintigraphy have limited roles in assessing DRUJ instability but are useful when the diagnosis of instability is in question or other concurrent problems are suspected, such as ulnar impaction syndrome interosseous carpal ligament tears or a non-destabilizing TFCC tear.

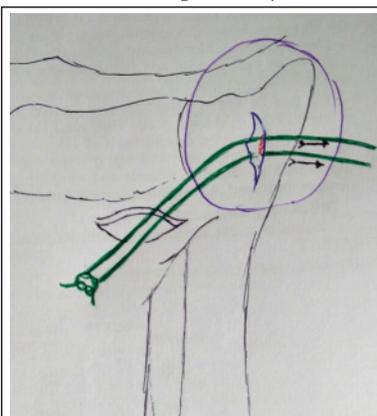**Figure 10**: Standard setup for performing wrist arthroscopy.

Figure 11: Schematic diagram showing the inside-out technique for arthroscopic triangular fibrocartilage complex repa.
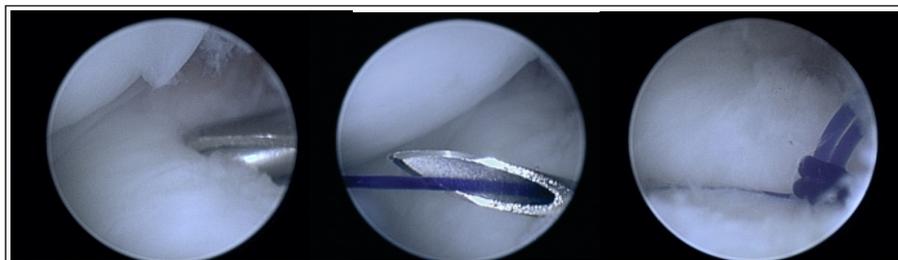
Figure 9: Post-operative pictures at 9 months showing full range of motion and good grip strength.

Arthroscopy is currently the "Gold Standard" for identifying TFCC tears. Scar and vascular invasion along the TFCC periphery and tears of the lunotriquetral interosseous ligament or ECU sheath are evidence of injury. A positive trampoline sign is indicative of a lax or hypermobile TFCC but does not establish the diagnosis of DRUJ instability. In the assessment of DRUJ instability, arthroscopy is most useful to evaluate symptoms that are inconsistent with instability or if other injuries are suspected of contributing to the complaints, especially if these can be treated by debridement alone. Direct DRUJ arthroscopy can provide additional information.

Treatment
Non-operative
Conservative management of severe, chronic DRUJ instability usually fails to relieve symptoms unless the individual is willing to use a splint that restricts forearm rotation on a regular basis. A 4 weeks trial of wrist and forearm splinting and anti-inflammatory medications is indicated for mild instability. A similar period in a long arm cast or Munster cast or splint may be tried in a low demand patient presenting with moderate instability and a recent exacerbation from increased activities. If other causes of ulnar sided wrist pain such as ECU tendonitis or ulnar impaction syndrome coexist with mild-to-moderate instability, non-operative treatment of those conditions, including steroid injection and splinting, may provide sufficient relief of symptoms. Caution is advised in patients with symptoms of instability who have a flat sigmoid notch and bilateral DRUJ hypermobility. These patients respond less predictably to reconstructive surgery. A strengthening program for the forearm and wrist should be attempted along with a soft brace or supportive taping during activities

causing increased symptoms. Recurrent dislocations may cause further attenuation of the soft-tissue restraints and predispose to degeneration of the dorsal and volar rim of the sigmoid notch. In adolescents, however, it may be appropriate to accept intermittent dislocations and await skeletal maturity to avoid potential injury to growing physic from reconstructive surgery. Regular follow-up examinations should be planned as rarely does instability improve with skeletal growth.

Surgical Management
Principles of surgical repair
Restoration of stability and a full, painless arc of motion are the goals of surgical treatment for the post-traumatic unstable DRUJ. The anatomic derangements responsible for instability must be identified for reliable treatment; causes can include bony deformity, ligament injury, or a combination. Soft-tissue repair or reconstruction in the presence of marked bony deformity will fail. The condition of the articular surfaces is a key factor in selecting among the treatment options. Unrecognized joint incongruity or arthritis will degrade the surgical outcome. However, it should not be assumed that the articular surfaces have deteriorated or the soft-tissues are irreparable in long-standing instability; a good outcome may be achieved by restoring ligament constraints.

Soft-tissue repair for chronic instability
In established DRUJ instability without a malunion of the distal radius or ulna, the first surgical option is delayed repair of the TFCC. The primary goal is to restore the mechanical integrity of the radioulnar ligaments which are typically torn from the fovea [25]. Although fixation of a basilar fracture of the ulnar styloid in an acute injury may help restore stability, styloid

Conclusions
Restoration of stability and a full, painless arc of rotation are the goals of treatment for the post-traumatic unstable DRUJ. Both surgeon and patient however must recognize the limitations of a ligament reconstruction, especially following complex injuries of the wrist. Alternative causes of ulnar-sided wrist pain must be carefully considered before instability is attributed as the primary cause of symptoms. In addition, adequate restoration of the skeletal architecture and soft tissues must be restored to achieve a satisfactory long-term outcome. Careful examination of the articular surfaces at the time of surgery may reveal underlying arthritis or un-reconstructable deficiencies indicating alternative procedures should be performed

fixation alone in chronic instability may be ineffective if there is associated soft tissue injury (TFCC). If the TFCC is irreparable because of soft tissue damage, a soft tissue reconstructive procedure is indicated. Numerous techniques have been described, which can be classified into three categories: (1) A direct radioulnar tether that is extrinsic to the joint; (2) an indirect radioulnar link through an ulnocarpal sling or a tenodesis or; (3) reconstruction of the distal radioulnar ligaments. Although the techniques in the first two categories may improve symptoms, they do not restore normal anatomy or mechanics of the DRUJ. A radioulnar tether at the level of the ulnar neck does not guide forearm rotation along its normal axis and it may reduce forearm rotation. Procedures that create an ulnocarpal sling or a tenodesis are inherently slack, especially in ulnar deviation, and do not correct radioulnar divergence or prevent radioulnar convergence. The Hui-Linscheid and Boyes-Bunnell techniques include provisions for both DRUJ and ulnocarpal joint instability [26, 27]. Although these techniques offer theoretical advantages, they failed to provide immediate DRUJ stability in cadaveric tests [27]. Despite their biomechanical deficiencies, non-anatomic reconstructions may be the only option in some cases. Specific indications for these

procedures include an adjunct to a partial or complete distal ulna resection, an unstable previously resected distal ulna, soft tissue support in association with prosthetic replacement, and a surgeon's preference over radioulnar ligament reconstruction for chronic instability.

Our series with mid-term outcomes for reconstruction of chronic DRUJ instability Twenty-two patients (7 female, 15 male); with an average age of 35.55 ± 12.41 years (range 17-55 years) with DRUJ instability were included in this study. The patients were qualified for surgery based on a clinical examination supported by imaging techniques. Eighteen of the 22 patients had a history of previous trauma and there was one patient with a Madelung deformity and three with an ulna positive variance. Different operative procedures were used due to the variety of clinical presentations: 10 patients underwent a Sauvé-Kapandji

procedure (Fig. 3-5); four patients were treated with Adams-Berger anatomic ligament reconstruction (Fig. 6-9); 3 patients underwent an arthroscopic TFCC repair (Fig. 10-12); 2 patients underwent a breen-jupiter procedure, and one patient each underwent an arthroscopic Feldon procedure, ulnar shortening osteotomy, and ORIF for nonunion of type II ulnar styloid fracture. The average follow-up was 6.77 ± 3.73 months (range 1-14 months).

Results
Pain reduced significantly (P < 0.05) in all patients. The ROM postoperatively did not differ significantly (P > 0.05). DRUJ stability was restored in all cases.

Complications
The most common surgical complications following repair or reconstruction for DRUJ instability are persistent joint pain, recurrent instability, stiffness, and weakness. In the

evaluation of a patient with persistent or recurrent problems, all potential causes for ulnar-sided wrist pain should be considered since other conditions can produce symptoms similar to those caused by instability. Residual instability can be caused by malunion of the distal radius. Burning dysesthetic pain can be caused by dorsal ulnar nerve injury. The history and physical examination should include all aspects of the original evaluation and inspect for changes since the initial treatment. Pain and weakness are most commonly caused by residual or recurrent radioulnar instability, radioulnar impingement, or DRUJ arthritis. A history of repeat trauma suggests possible disruption of the repair. Crepitance during forearm rotation indicates DRUJ arthritis. Repeat imaging studies may be needed to evaluate for persistent instability or evidence of arthritis. Selective local anesthetic injections may help isolate the sites most likely responsible for symptoms.

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