Distal Radioulnar Joint Problems and Treatment Options

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educational objectives

As a result of reading this article, physicians should be able to:

1. Describe the physical examination and diagnostic steps in characterizing conditions of the distal radioulnar joint.
2. List the conditions of the distal radioulnar joint.
3. Discuss the management options based on the current literature.

Forearm rotation and stability depend on the normal anatomic relationships about the radioulnar joints (distal and proximal), the interosseous membrane, and the shape of the forearm bones. Injuries to any of these structures result in pain, decreased strength, limited range of motion, and loss of forearm function. This article discusses the problems and their management options concerning the distal radioulnar joint based on the current literature.

ANATOMY

The radius and ulna constitute a bicondylar joint, articulating at distal and proximal radioulnar joints. Between these two joints, the interosseous membrane functions as a suspension bridge. The stability of proximal and distal radioulnar joints is provided by the thick and complex ligamentous structures, known as the annular ligament and the triangular fibrocartilage complex, respectively.

The distal radioulnar joint consists of two articular surfaces that are dissimilar in their radius and curvature, the sigmoid notch and the ulnar seat. The contact surfaces of this articulation changes in forearm rotation, ranging from 80° at neutral position to 10° in extremes of rotation.[1] The joint is mainly supported by the triangular fibrocartilage complex, which consists of the triangular fibrocartilage (articular disk), the dorsal and palmar radioulnar ligaments, the meniscus homologue, and the sheath of the extensor carpi ulnaris.[2] Among these structures, the dorsal and palmar radioulnar ligaments are the primary stabilizers of the joint. Each of these ligaments also consists of deep and superficial portions. The deep portions originate from the radius and conjoin to insert into the fovea. The superficial portions also originate from radius, but separately insert into the base of the styloid. In supination, deep portions of the palmar radioulnar ligament and superficial portion of the distal radioulnar ligament become taut. In pronation, deep portions of the distal radial ulnar ligaments and superficial portion of the palmar radioulnar ligaments are under tension.[3-6]

The central portion (80%) of the articular disk is avascular. The distal radioulnar and palmar radioulnar ligament as well as the peripheral 20% of the articular disk have a rich blood supply provided by the branches of the anterior interosseous artery, the ulnar artery, and the medullary interosseous arteries that penetrate through the ulnar head in the fovea area.[7] As a result, the peripheral tears of the triangular fibrocartilage have a good potential to heal due to their vascularity, whereas the avascular central portion (80%) has a minimal healing potential.

DIAGNOSIS

Physical Examination

Some of the distal radioulnar joint pa-

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thologies are grossly visible. A classic example is "the piano key" sign. With the palm placed flat on the examination table, the patient is asked to press to the table using his shoulder depressors while the forearm is in full pronation. Compared to the contralateral side, elevation of the head of the ulna relative to the radius is considered positive and suggests a destabilizing pathology of the triangular fibrocartilage complex.

Following identification of certain anatomic landmarks such as the ulnar head and styloid, triquetrum, pisiform, lunotriquetral joint, FCU tendon, ECU tendon, and the attachment of triangular fibrocartilage complex, the examiner should look for point of tenderness by gentle palpation of these structures and compare with the opposite extremity.

Two specific examination maneuvers are worth mentioning. First, the patient is asked to place his/her elbow on the table with the forearm perpendicular to the table. The examiner applies a shear force between the radius and the ulna with the forearm in full supination and full pronation. The amount of displacement between the radius and the ulna in full pronation and supination shows the integrity of the dorsal and the volar radioulnar ligaments, respectively. The comparison to the contralateral extremity however, is crucial. During this test, the shear/compressive force applied to the radius and the ulna may generate pain, which suggests distal radioulnar joint incongruity/arthritis.

This examination should be combined with a second maneuver, in which the effect of gravity on the ulnar side of the hand is eliminated. The patient is asked to stand with both elbows flexed at 90°. The examiner applies downward pressure to both mid-forearms while the patient is asked alternately to supinate/pronate the forearm and to resist the downward pressure. This maneuver loads the distal radioulnar joint through its range of motion, and allows translational motion between the radius and the ulna, while eliminating the gravity on the ulnar side of the hand. With incongruity/arthritis of distal radioulnar joint, the patient either feels pain at neutral forearm when the radius rolls over the top of the ulna or avoids resisting against the examiner's downward pressure. In this test, the applied force is loaded against the radioulnar joint by "grinding" the seat against the notch.

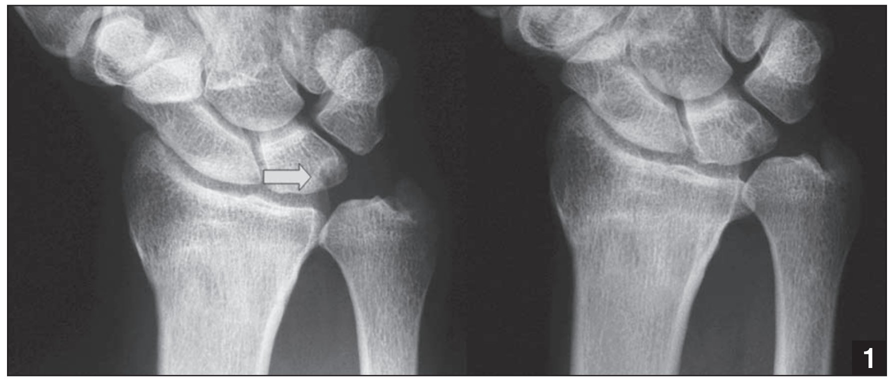

Figure 1: Radiograph shows a PA wrist view taken at the shoulder 90° abducted and the elbow 90° flexed (left). Radiograph shows the same wrist in pronated-grip view with more prominent ulna-plus deformity. The arrow shows the typical lesion on the proximal ulnar border the lunate indicating an ulna-carpal abutment (right). Figure courtesy of the Christine M. Kleinert Institute for Hand and Microsurgery.

Standard Radiography

The evaluation of the relation between the articular surfaces of the distal radius and the ulna, or as is so called ulnar variance, is an integral part of the radiographic examination.[8] This relation may be neutral (both articular surfaces the same length), positive (ulnar surface longer), or negative (ulna surface shorter). However, the position of the wrist is important in determining the ulnar variance.[9,10] The ulnar variance may change 1-2 mm during strong grip in pronation compared to a neutral PA view.[11,12] Therefore, 0° rotation PA and firm grip pronation radiographs should be taken to evaluate the position of the ulna relative to the radius (Figure 1). Zero degree rotation films are taken with the shoulder 90° abducted and the elbow 90° flexed on a flat surface. Positive ulnar variance is associated with the ulnocarpal impaction, the lunotriquetral ligament injuries and the triangular fibrocartilage complex tears. Negative variance on the other hand was implicated in the carpal ligamentous laxity and Keinbock's disease.

The second important parameter to evaluate on a PA view is the distal radioulnar joint angle and its congruency. Normally sigmoid notch and the ulnar seat rarely are parallel to each other,[13] and usually they slant toward the ulnar styloid with a 20° angle.[1] However, this relation sometimes may be parallel to the longitudinal axis of the forearm (neutral distal radioulnar joint), or may be angled towards the radial styloid (reverse distal radioulnar joint).[14] The articular configuration of the distal radioulnar joint is especially important in ulnar shortening osteotomies, since ulnar shortening in reverse distal radioulnar joint orientation may cause further impingement between the radial sigmoid notch and the ulnar articular seat.[14] Signs of arthritis at the radioulnar articulation should specifically be checked during the routine radiographic examination.

The lateral view is taken with the patient's shoulder adducted to the side, the elbow flexed 90° and the forearm in neutral. In a successful lateral view, the pisiform should be aligned with the distal third of the scaphoid. Oblique radiographs in semipronated and semisupinated positions may be used to view the pisotriquetral joint and hook of the hamate.

Arthrography

Triple-injection arthrography of the wrist is especially useful in diagnosing suspected triangular fibrocartilage com-

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Table 1

Palmer's Classification of Triangular Fibrocartilage Complex Lesions

Class/Subclass	Description
I	**Traumatic Injury**
IA	Central perforations
IB	Ulnar avulsion with or without distal ulnar fracture
IC	Distal avulsion (carpal attachment)
ID	Radial avulsion with or without sigmoid notch fracture
II	**Degenerative Injury**
IIA	Triangular fibrocartilage complex wear
IIB	Triangular fibrocartilage complex wear, lunate, or ulnar chondromalacia
IIC	Triangular fibrocartilage complex perforation, lunate, or chondromalacia
IID	Triangular fibrocartilage complex perforation, lunate, or chondromalacia, lunatotriquetral ligament perforation
IIE	Triangular fibrocartilage complex perforation, lunate, or chondromalacia, lunatotriquetral ligament perforation, ulnocarpal osteoarthritis

plex tears. First the radiocarpal joint is injected with contrast material. Three hours later, a second injection is placed into the distal radioulnar joint and the midcarpal row. A connection between these three compartments is considered positive for ligamentous tears. Several studies have shown superior results with triple injection compared to single injection arthrography.[15-17] A clinical correlation should be sought since asymptomatic wrists also may have connections between the proximal and the distal row. In a study investigating the usefulness of unilateral arthrographies, Herbert et al[18] concluded that in patients examined bilaterally with arthrography and physical examination, 74 % were found to have communications in the contralateral symptomatic wrists. Cantor et al[19] showed in 56 wrists that 88% of patients with ligament tears in symptomatic wrist had bilateral triangular fibrocartilage complex perforations.

The natural course of "degenerative" changes in the ulnar side of the wrist, leaks between the compartments often make the findings difficult to interpret. It is critical for the clinician to understand the age-dependent alterations at the triangular fibrocartilage, the distal ulnocarpal, radiocarpal, and the radioulnar joints.[20,21] The combination of arthrography with contrast medium injection enhances the ability to diagnose different pathologies.[22]

Computed Tomography

In addition to the diagnosis of fractures involving the distal radioulnar joint, computed tomography also is useful in assessing the subluxation and the articular surface congruency. Among various techniques, the epicenter method was found to be a reliable indicator and is sensitive to diagnose even the subtle subluxations in the joint.[23,24] It sometimes may be necessary to take stress views of the joint to reveal subtle signs of subluxation.

Magnetic Resonance Imaging

Occult fractures, chondromalacia, osteochondral defects, and triangular fibrocartilage tears are commonly diagnosed using magnetic resonance imaging (MRI). Studies comparing the value of MRI in the diagnosis of triangular fibrocartilage tears in comparison to arthroscopy revealed 90% accuracy rate with MRI.[25,26]

Scintigraphy

Three-phase bone scintigraphy is useful in patients with negative plain radiographs.[27] Most of the pathologies detected by scintigraphy however, would display increased activity in all three phases, including fractures, infection, bone bruise, and inflammation. Therefore, bone scans are sensitive, but not specific and plain radiographic correlation is always needed.

Classification and Management of Distal Radioulnar Joint Problems

Distal radioulnar joint problems can be separated into three groups: abutment, instability, and incongruity/arthritis.

Abutment

Ulnocarpal abutment is a chronic, degenerative process caused by increased load bearing across the ulnar side of the wrist.[28] Load transfer across the wrist joint in neutral variance and in neutral position is born by the radius (82%) and the ulna (18%).[29] The magnitude of this load transfer is affected by ulnar variance and the palmar tilt of the distal radius. A 2.5-mm increase in ulnar variance increases the ulnocarpal load to 42%. Any factors increasing the length of the ulna relative to the radius results in impaction or abutment of the carpal bones against the ulna and articular disk homolog.

Repetitive impaction of the ulnar head against the triangular fibrocartilage com-

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Table 2

Treatment Options for Ulnocarpal Abutment

Abutment	Treatment Options
Ulna-lunate	
Positive ulnar variance secondary to distal radius malunion	Corrective osteotomy to establish radial height and inclination and/or Ulnar shortening osteotomy
Ulna positive (neutral) without distal radioulnar joint incongruity	Ulnar shortening osteotomy Wafer procedure (open versus arthroscopic)
Ulna positive (neutral) with distal radioulnar joint incongruity	Ablative Procedures* Distal radioulnar joint implant arthroplasties*
Ulna-triquetral	
Ulnar styloid nonunion	Excision of styloid fragment Reattachment of triangular fibrocartilage, open versus arthroscopic
Long ulnar styloid	Ulnar shortening osteotomy

**See Table 4.*

plex and the ulnar carpus leads to triangular fibrocartilage complex perforation; chondromalacia of the ulnar head, and the lunate; and tearing of the lunatotriquetral ligament.[28] Several studies have identified an association between the perforation of the triangular fibrocartilage complex, ulnar positive variance, and tears of the lunatotriquetral ligament. Palmer and Werner[2] have found that 73% of specimens that have triangular fibrocartilage complex perforations also have ulnar positive or neutral variance and the majority of these also had lunatotriquetral ligaments tears. These data support the hypothesis that increased ulnar variance lead to degeneration and perforation of the triangular fibrocartilage complex and other structures of the wrist. The various patterns of perforations of the triangular fibrocartilage complex classified by Palmer are widely accepted (Table 1).[21]

Radiographically, two types of ulnocarpal abutment are identified, ulna-lunate abutment between the ulnar articular seat and the lunate and ulna-triquetral abutment between the ulnar styloid and the triquetrum. Ulna-lunate abutment is commonly associated with positive or neutral variance, but it also may occur in negative ulnar variance.[30] The condition is commonly associated with congenital positive ulnar variance, malunion of the distal radius, radial head resection, or premature physeal closure of the distal radius. Ulna-triquetral abutment however, is independent from ulnar variance and may occur due to ulnar styloid nonunion or a long ulnar styloid. The mechanism involves the impaction of the ulnar styloid against the proximal pole of the triquetrum. An excessively long ulnar styloid process has an overall length $>$6 mm. Impaction over a long period of time can lead to triquetral chondromalacia and eventually lunotriquetral instability.[31,32]

Regardless of the type of ulnocarpal abutment, initial clinical manifestations include acute or chronic ulnar sided wrist pain, exacerbated by activity, swelling and limitation of wrist and forearm motion. Treatment options however change considerably depending on the type of abutment (Table 2).

Initial treatment begins with activity modifications, splinting, and anti-inflammatory medications. Failure to respond to nonoperative treatment is an indication for surgery.[33] The goal of surgical treatment is to decrease the loading across the ulnar side of the wrist. If the etiology of the abutment is a distal radius malunion, this should be corrected either by re-establishing the radial height and inclination or by shortening the ulna to restore a congruent distal radioulnar joint. In the absence of a malunion, a positive ulnar variance with a congruent distal radioulnar joint can be treated in two different ways (Table 2).

Ulnar shortening involves the osteotomy and resection of the ulna at its distal third. The technique originally was described by Milch[34] in 1941 and has been modified since then.[35-38] Advantages of the technique include effective decompression on the ulnar side of the wrist, tightening of the extrinsic ulnocarpal ligaments possibly leading to a more stable lunotriquetral articulation, predictable rate of union and overall success rate.[39] The average union time in different studies ranged from 7 to 21 weeks with uniformly successful functional results. More than 95% of the patients in published series have good or excellent results.[35-37,40-43] Nonunion is seen in up to 4 %. Possible complications include a low rate of nonunion, failure to achieve pain free range of motion, need for the removal of the hardware, and a change in distal radioulnar joint configuration leading to distal radioulnar joint incongruity.

The Wafer procedure involves the excision of the distal 2-4 mm of the ulnar head and can be performed open or arthroscopically.[28,44,45] The technique is recommended only for the ulnolunate type of abutment,

Table 3

Treatment Options for Distal Radioulnar Joint Instability

Type of Instability	Treatment Options
Acute	
Simple	Closed reduction Cast immobilization
Complex	Closed versus open reduction with K-wire fixation Cast immobilization
Chronic	Soft-tissue reconstructions Intraarticular: Scheker,[77] Adams[78] Extraarticular[73-76]

Table 4

Treatment Options for Distal Radioulnar Joint Incongruity/Arthritis

Type of Arthritis	Treatment Options
Early Osteoarthritis	Ulnar shortening osteotomy[83] in selected cases
Established Osteoarthritis	Ablative procedures: Sauve-Kapandji,[89] hemi-resection interposition arthroplasty,[97] matched distal ulna resection,[98] Darrach[80]
	Implant Arthroplasties Hemi-arthroplasty (Swanson,[104] Herbert & van Schoonhoven,[106] and Berger[107]) Total arthroplasty (Scheker[108])

and resection includes only the distal portion of the ulna without jeopardizing the integrity of ulnocarpal ligaments and the horizontal portion of the triangular fibrocartilage complex. Possible advantages include the preservation of the triangular fibrocartilage complex, avoidance of nonunion, and hardware removal. The number of published series to date is limited and technique has yet to be applied on a larger number of patients.[46-50] Based on the limited number of patients, the technique effectively relieves pain and provides early return to work. Possible complications include inadequate resection of the ulna, and ECU tendonitis. The technique is contraindicated in patients with instability, or degenerative changes in distal radioulnar joint or in those who would require >4 mm of ulnar shortening.

The only comparative study between the ulnar shortening osteotomy and the Wafer procedure was reported by Constantine et al,[49] and based on a retrospective analysis of 22 patients (11 in each group) with ulnar-sided wrist pain and ulnocarpal abutment unresponsive to conservative treatment. The authors concluded that the Wafer procedure provided favorable pain relief without the potential for nonunion and hardware removal. However, the limited numbers of patients along with the selection bias for each treatment group are potential shortcomings of this study and therefore preclude to compare the potential risks and benefits of each technique. The treatment of ulnocarpal abutment in the presence distal radioulnar joint incongruency will be discussed in detail later in this review.

Instability

Instability is defined as an abnormal path of articular contact occurring during or at the end of the range of motion. This is due to either alteration in joint surface orientation or by deficiencies in the main restricting ligaments, or by both.[33]

Dislocations are classified as acute versus chronic (Table 3). Acute dislocations occur in various clinical conditions. It may be an isolated injury,[51-54] or may be the result of fractures of the radial head, the distal radius, and both bones of the forearm.[55-59] In isolated injuries, ulna dorsal dislocations occur as a result of hyperpronation injury, whereas ulna volar dislocations occur due to hypersupination.

In the acute setting, if there is a fracture, the deformity usually is apparent and warrants a complete radiologic examination of the forearm.[60,61] However, if distal radioulnar joint subluxation or dislocation is an isolated injury, only swelling may become apparent.[33] Wrist motions often are painful. The rotation of the forearm is always restricted. Pronation is blocked in volar dislocation of the distal radioulnar joint, and supination is blocked in a dorsal dislocation.[33] Absolute lateral view of the wrist with the forearm in neutral rotation is essential to detect subluxation or dislocation in either direction.[62]

The types of dislocation of the distal radioulnar joint include simple and complex (Table 3). Simple dislocations are reduced either spontaneously, or by closed means and minimal effort. Complex dislocations, however, include irreducible or easily subluxatable or dislocatible cases. This usually is due to interposition of the ruptured triangular fibrocartilage ligaments, the extensor digiti minimi tendon, the extensor carpi ulnaris tendon, and the extensors of the ring and little fingers.[57,63-65] Most of the complex distal radioulnar joint dislocations are high-energy injuries and frequently associated with ulnar styloid fracture.[66] The diagnosis in this case is dependent on clinical examination and plain radiographic findings.[67-69] An ulnar styloid fracture involving >50% of the styloid length or an ulnar styloid displacement of >2 mm were found to increase the risk of distal radioulnar joint instability.[70]

Treatment of simple subluxation/dislocation in the acute setting consists of immobilization in a reduced position for six weeks in an above-elbow cast. The position of the forearm should be neutral for bi-directional instability, supination for ulna dorsal dislocations, and pronation for ulna volar dislocations.[33] If closed reduction is needed, it should be performed under regional anesthesia to provide adequate muscle relaxation. After the reduction, if the distal radioulnar joint is still unstable, additional percutaneous K-wire fixation should be used. For neglected subluxations of the distal radioulnar joint, attempts at closed reduction should be based on the direction of the dislocation. Successful reduction of the distal radioulnar joint has been reported up to two months for dorsal dislocations, but only three weeks for volar dislocations.[53] Open reduction is indicated when closed reduction is not possible or not satisfactory. Associated fractures should be evaluated on the basis of their individual fracture pattern. However, if the ulnar styloid process is fractured, it should be stabilized by means of K-wire, tension band, or intraosseous wiring.[71] If the ulnar styloid is intact, but there is a tear of the triangular fibrocartilage complex, it should be reattached to the ulna. Postoperative immobilization position and duration are same as simple dislocations.

Chronic instability of the distal radioulnar joint can also occur as an isolated injury or may be associated with the distal radius malunion. In the absence of malunion, chronic instability can be treated with soft-tissue reconstruction provided that the following criteria are met: 1) congruent distal radioulnar joint, 2) stable radiocarpal ligaments, and 3) stable ulnocarpal ligaments (Table 3). Patients must be assessed individually for the integrity of these structures. If there is no satisfactory stability between the radius and the carpus or between the ulna and the carpus, attempts should be made to stabilize those structures initially. If the distal radioulnar joint is not congruent, soft-tissue reconstruction procedures usually are not successful.

Initially, chronic instability of the distal radioulnar joint is dynamic in nature, but later it becomes static as it progresses towards osteoarthritis of the joint. The stability of the joint is the function of both the intact restricting ligaments and the congruity of the radioulnar joint. Bowers[72] has classified the instability of the distal radioulnar joint under 4 main subheadings. In group 1, pathology is primarily in the ligamentous defects. In group 2, deficiencies in the intra-articular joint congruity results in loss of ligamentous tension. Group 3 involves the combination of ligamentous and articular surface pathology. In group 4, ligamentous deficiency is associated with extra-articular problems, such as distal radius metaphyseal malunion. If the distal radioulnar joint instability is due to malunion of the distal radius, this should be corrected initially. For all other cases, the management usually is based on the direction and the degree of instability, as well as the congruency of the distal radioulnar joint.

Two different reconstruction techniques have been described, extra-articular and intra-articular reconstructive techniques. Extra-articular reconstructions provide stability between the radius and the ulna without opening the distal radioulnar and the ulnocarpal joints. These techniques are easier to perform, but they do not re-establish the ligamentous anatomy of the distal radioulnar joint. Extra-articular reconstruction can be accomplished either by a direct radioulnar tether that is extrinsic to the joint,[73] or an indirect radioulnar link through an ulnocarpal sling or a tenodesis.[74-76] A radioulnar tether at the level of ulnar head does not provide a balanced forearm rotation and may restrict pronation/supination. An ulnocarpal sling or tenodesis is inherently slack and does not provide sufficient stability to the distal radioulnar joint. Intra-articular reconstructions on the other hand are technically more demanding, but are designed to restore the normal triangular fibrocartilage ligaments in their anatomic locations.[72,77-79] In his initial article, Scheker[77] reported complete pain relief in 12 out 14 patients with 2 patients reporting minor discomfort during heavy lifting. Satisfactory pronation/supination (80°/82°) also was established after surgery. Adams and Berger[78] in their report of distal radioulnar joint ligaments reconstruction also followed-up 14 patients at 2.2 years. Nine out of 14 patients had complete pain relief with an average pronation/supination angle of 72° and 70°, respectively.[78] Apart from these two studies, no long-term results of the ligamentous reconstruction of the distal radioulnar joint are available currently.

Figure 2: Early stage osteoarthritis developing on the lower 1/3 of the joint. This patient had a well-localized tenderness on the dorsum of the wrist and a positive radio-ulnar shear test on examination. Figure courtesy of the Christine M. Kleinert Institute for Hand and Microsurgery.

Incongruity/Arthritis

Incongruity of the distal radioulnar joint frequently occurs following distal radius fractures, chronic instability, infection, rheumatoid arthritis and is commonly associated with an arthritic joint. In the early stage of osteoarthritis where only the lower 1/3 portion of the distal radioulnar joint surface is involved, an ulnar shortening osteotomy can be performed in order to change the articular contact surfaces between the sigmoid notch and the ulnar articular seat (Figure 2). Using this

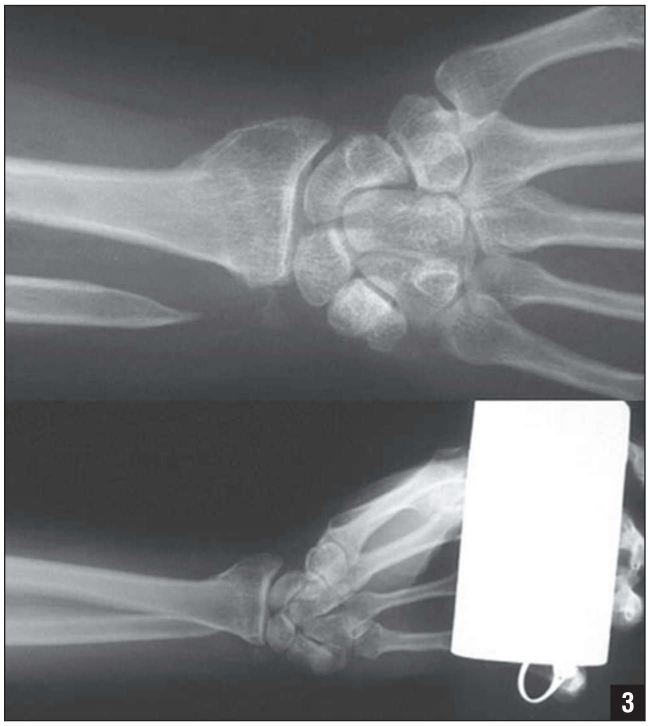

Figure 3: Demonstration of impingement between the radius and the ulna after distal ulna resection. The x-ray cassette is placed between the patient's elbow and the side of the body when the forearm is in neutral rotation with the elbow 90° flexed. On top, no contact between the radius and the ulna is seen under no-loading. On the bottom, impingement is apparent as soon as the patient lifts 2 lbs of weight. Figure courtesy of the Christine M. Kleinert Institute for Hand and Microsurgery.

technique, Scheker and Severo[80] reported complete pain relief in 16 out 32 patients at an average follow-up of 38 months. Persistence of severe pain requiring an ablative procedure was reported in 7 cases.

For the management of established arthritis, the oldest procedure is total resection of the distal end of the ulna, the Darrach procedure.[81,82] By excising the distal end of the ulna, the pain is effectively eliminated. Although earlier reports on the technique showed success with good or excellent results in >80% of the patients studied,[83,84] recent reports on larger groups of patients showed a much higher failure rate, with serious disability, especially in younger patients.[85,86] The procedure itself is a destabilizing procedure and when the distal ulna is resected, the triangular fibrocartilage complex, the radioulnar ligaments, and the ECU are removed from the ulna, leaving a potentially unstable forearm eventually leading to pain and snapping at the remaining ulnar stump (Figure 3).[85,86] Other possible complications include ulnar translocation of the carpus and attritional rupture of the extensor tendons.[83,87]

Other commonly used ablative procedures is the Sauve-Kapandji procedure, which involves fusion of the head of the ulna to the distal radius and the creation of a pseudarthrosis of the ulna.[88] This carries the advantage of supporting the ulnar carpus, preserving the triangular fibrocartilage complex, and the ECU tendon. Studies reported by Sanders et al[89] and Mikkelsen et al[90] showed pain-free range of motion in more than two thirds of the patients studied. Results were found to be more successful in young patients with post-traumatic radioulnar derangement. Later, Vincent et al[91] and Rothwell et al[92] applied the technique in patients with rheumatoid arthritis and reported equally satisfactory results. Overall, the technique is indicated in young patients with high-demand wrists and in patients with incompetent radiocarpal ligaments as in rheumatoid arthritis.[93] Reported complications include ulnar stump instability, radioulnar nonunion, and heterotopic ossification.[90,91,94,95]

Two of the ablative procedures used to preserve the ulnocarpal ligament complex are the hemiresection-interposition arthroplasty technique, introduced by Bowers[96] and the matched distal ulnar resection described by Watson et al.[97]

The hemiresection-interposition arthroplasty technique includes the resection of the distal radioulnar joint at the sigmoid notch. A portion of the ulna is retained to maintain the integrity of the triangular fibrocartilage complex and a portion of autologous tissue is interposed between the radius and the ulna to prevent impingement. The outcomes of the published series show good results in a well-selected group of patients.[96,98-101] The success of the procedure is dependent on the integrity of the triangular fibrocartilage complex.[100] The technique does not address the ulnocarpal abutment and, therefore should be combined with ulnar shortening osteotomy in cases of ulnocarpal abutment.[96,99] Reported complications include stylocarpal abutment, postoperative ECU tendonitis, reflex sympathetic dystrophy and neuroma of the ulnar dorsal sensory branch.[96,98]

In matched distal ulnar resection, the distal ulna is resected 270° circumferentially without any interposition between the radius and the ulna.[97] The procedure eliminates the distal radioulnar joint, but preserves the triangular fibrocartilage complex and the ulnocarpal sling mechanism. The experience with this technique is limited by the senior author's long-term follow-up of 32 patients, in which 24 patients showed good or excellent results.[102] The technique is relatively simple to perform and maintains the ulnar length. Therefore, patients with ulnocarpal abutment may not benefit from the procedure.

The common denominator of all the above-mentioned techniques is the resultant instability of the ulnar shaft and its impingement against the radius. Although the results of these procedures are found to be satisfactory in low-demand wrists, failures are common in active individuals. One final alternative for the management of distal radioulnar joint arthritis is prosthetic replacement with hemi-arthroplasty or total arthroplasty of the distal radioulnar joint.

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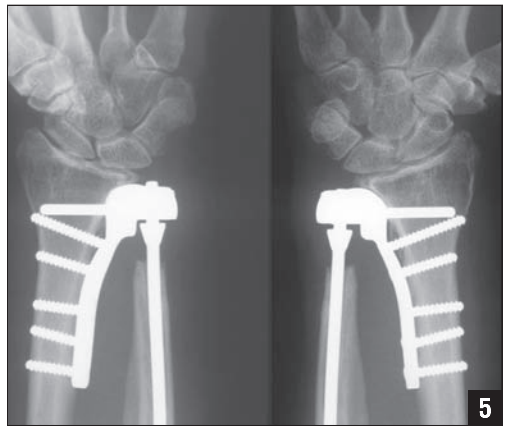

Figure 4: Radiograph at 24 months after reconstruction of the distal radioulnar joint with hemiarthroplasty[106] in painful arthritis of the distal radioulnar joint following an extrarticular distal radius malunion. Figure courtesy of the Christine M. Kleinert Institute for Hand and Microsurgery. **Figure 5:** The result of a total distal radioulnar joint arthroplasty using semiconstrained modular, ultra-high molecular weight polyethylene prosthesis in pronation (left) and supination (right). Prior to the prosthetic replacement, the patient had undergone excision of the distal ulna and presented with a painful wrist and forearm motion 2 years postoperatively. Follow-up 3 years after prosthetic replacement revealed full prono-supination of the forearm, as well as pain-free range of motion of the wrist and elbow. The patient returned to his previous job 4 months postoperatively. Figure courtesy of the Christine M. Kleinert Institute for Hand and Microsurgery.

Three implant designs are available for hemi-arthroplasty. Swanson's prosthesis consists of a silicone ulnar head implant and a round intramedullary stem.[103] Long-term results show effective pain relief, but 40% tilting of the prosthesis due to resorption and 15% of implant fractures.[104] In a technique described by van Schoonhoven et al,[105] a spacer is used to maintain the ulnar length relative to the radius. The ceramic head has no means of attachment of triangular fibrocartilage complex; therefore the stability of the distal radioulnar joint is dependent on the integrity of the triangular fibrocartilage complex. At 27-month follow-up, the authors reported reduced pain and improved grip strength and range of motion. Out of 23 patients, 2 had recurrent instability requiring surgery. All patients developed 1- to 2-mm bone resorption beneath the collar of the prosthesis with stem loosening occurring in only one patient. A hemiarthroplasty technique developed by Berger consists of a spherical head composed of a cobalt-chrome alloy (Figure 4).[106] Contrary to previous prostheses, this model allows stabilization of the triangular fibrocartilage complex and ECU sheath by means of sutures. It requires a congruent sigmoid notch to be present and may not be suitable for cases where excessive resection of the ulna has been performed. No complications have been reported. Radiographically, a universal mild resorption of the ulna occurs immediately proximal to the collar of the device. The only total arthroplasty option, as described by Scheker,[107] is a semiconstrained, modular prosthesis, made of stainless steel and ultra-high molecular weight polyethylene (Figure 5). The components replace both the distal ulna (stem and ulnar head) and the sigmoid notch (radial plate). Mid-term results of this prosthesis showed that all patients had improved grip strength and lifting (average 14 lb) without pain, and 18 of 23 patients were able to return to their previous work.

A recent trend in arthritic distal radioulnar joint reconstruction in active individuals is the replacement of the articular surfaces using hemi- or total arthroplasty options. With a better understanding of the distal radioulnar joint anatomy and biomechanics, advances in implant design technologies, and with more long-term follow-up studies on higher number of individuals, prosthetic replacement of the distal radioulnar joint is likely to become the standard of care for the management of arthritic distal radioulnar joints.

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