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Hemiresection Arthroplasty of the Distal Radioulnar Joint

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Painful disorders of the distal radioulnar joint (DRUJ) and the triangular fibrocartilage complex (TFCC) are becoming recognized and treated more frequently. A systemic approach to these often difficult to diagnose problems can lead to the appropriate treatment, and if necessary, the appropriate surgical intervention. This issue devotes its attention to wrist arthritis; therefore, the focus of this article is on arthritis of the DRUJ treated specifically by hemiresection arthroplasty of the DRUJ. Arthroplasty techniques, in general, of the DRUJ are grouped into several categories. There are excisional arthroplasties, complete and partial, which include the Darrach procedure, the Feldon wafer procedure, the matched (Watson) resection, and the hemiresection interposition (Bower) arthroplasty [1–5]. Also included are ulnar shortening and replacement arthroplasty. There are now sufficient studies on most of these techniques to give excellent comparison and functional outcomes [6–21]. This allows the surgeon to make the appropriate choice of procedure, based on a thorough knowledge of the patient and their functional demands.

Anatomy

The anatomy of the DRUJ and its supporting ligaments is complex. During the last few years important kinematic studies on the normal wrist have increased understanding considerably [22,23]. A thorough knowledge of the anatomy is necessary to manage the pathologic conditions that arise. Stability is achieved through articular contact and ligamentous stabilizers. The DRUJ articulation is a trochoid one, similar to that of the proximal radioulnar joint. The shallow sigmoid articular notch has dimensions 1.5 cm dorsal to volar and 1 cm proximal to distal. The notch has three distinct margins (dorsal, distal, and palmar). The dorsal margin is acutely angular in cross-section and the palmar less so. The carpal distal margin is the junction between the notch and the distally facing lunate facet. The two are separated by the attachment of the triangular fibrocartilage to the radius. The articulation of the ulnar head with the sigmoid notch is not congruous in as much as the radius (Fig. 1) [24]. The shallow arc of the sigmoid notch is greater than that of the ulnar convexity. Because of the different radii of curvature there is a sliding/rolling component with forearm pronation and supination. In the normal ligamentous support the two surfaces allow a dorsal volar translation. This translation has been measured as 2.8 mm dorsal and 5.4 mm palmar in 0° rotation position. During this midrange the sigmoid notch accepts 60°–80° of the 130° articular convexity. In the extremes of rotation, however, less than 10% of the surface may be in contact with the dorsal or palmar margin of the notch. Because of the less constrained articular surface, the ligamentous stabilizers play a much more important role in this joint. The TFCC (as described by Palmar) [25–28] contains the annular ligaments, the articular disc, a meniscus homolog, and the ulnar collateral ligaments. The ulnar collateral ligaments suspend the lunate and triquetral carpal bones to the ulna (ulnolunate and ulnotriquetral).

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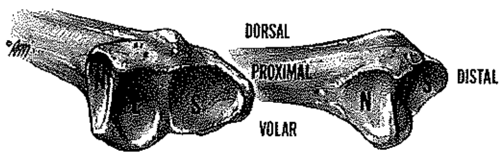

Fig. 1. The bony anatomy of the distal radius and the distal radioulnar joint. (*From* Green's operative hand surgery, volume 1, 4th edition. New York: Elsevier; 1998; with permission.)

The TFCC attaches the radius to the ulna and is part of an extensive fibrous system that arises from the carpal margin of the sigmoid notch, cups the lunate and triquetral bones, and reaches the volar base of the fifth metacarpal (Fig. 2) [29].

Stability of the radioulnar and carpal unit is influenced additionally by the configuration of the sigmoid notch, the slope of the ulnar dome, the interosseous membrane, the extensor retinaculum, the dynamic forces of the extensor carpi ulnaris (ECU), pronator quadratus, and the dorsal carpal ligamentous complex. The triangular fibrocartilage complex provides a continuous gliding surface across the entire distal two forearm bones for carpal flexion, extension, and translational movements. It also provides a flexible mechanism for stable rotational movements of the radius around the ulnar axis. It suspends the ulnar carpus from the dorsal ulnar base of the radius, and it cushions forces transmitted through the ulnar carpal axis. The peripheral margins of the triangular fibrocartilage consist of thick lamellar collagen adapted to bare tensile loading, often referred to as the dorsal and palmar radioulnar ligament. It also solidly connects the ulnar axis to the volar carpus. The portion of the TFCC called the triangular fibrocartilage is 1–2 mm thick at its base and is attached to the distal margin of the sigmoid notch. Viewed from within the radioulnar joint, the styloid attachment seems folded. The intra-articular fold and its vascular hilum have been termed the ligamentum subcruetum. The triangular fibrocartilage has a thin central portion occasionally referred to as the articular disc. It is chondroid-type fibrocartilage and the type of tissue that bears compressive loads. The distribution of forces is important in understanding abnormalities of the DRUJ. Compressive force across the carpal ulnar articulation is partially transmitted through the center of the TFCC to the ulnar

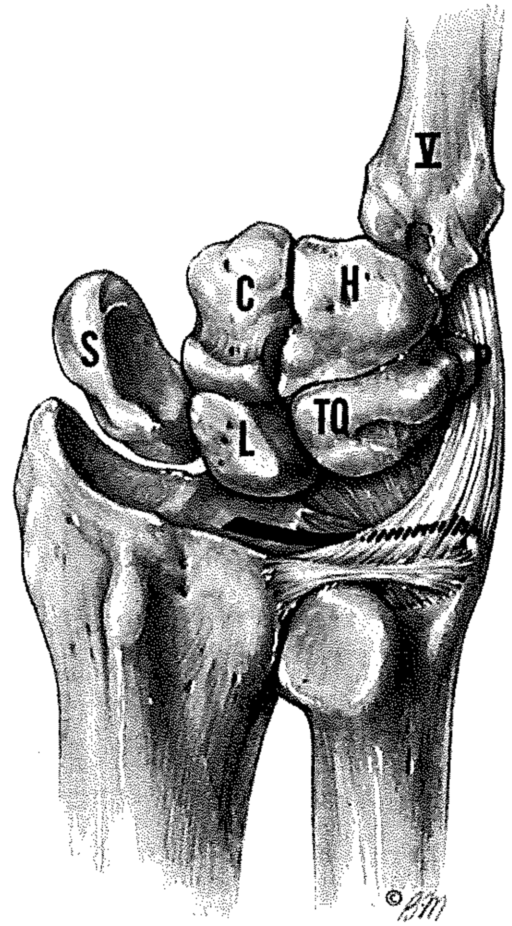

Fig. 2. The ulnar collateral ligaments, including the ulnolunate and ulnotriquetral ligaments. The meniscal Homologue, the radioulnar ligaments, and the TFCC are shown cupping the ulnocarpal bones in this anatomic picture. (*From* Green's operative hand surgery, volume 1, 4th edition. New York: Elsevier; 1998; with permission.)

dome. This force tends to have a separating effect on the radius and ulna. The TFCC converts some of this compressive force into a tensile force with its lamellar peripheral collagen arrangement [30,31]. The pronator quadratus muscle action and the interosseous membrane help with this functional demand. The rest of the load is taken by the ulnar dome. Palmar and Warner have shown experimentally that in a neutral variant 80% of the static axial load is borne by the radius, whereas 20% is borne by the ulna. If the ulnar length is increased 2.5 mm the load borne by the ulnar dome increases 40% [26].

Mechanics

The rotational movement of the radius–TFCC complex over the ulnar dome allows various loading scenarios. This variable loading may account for the location and nature of tears seen in the TFCC by Chidgey [32] and others [26,33]. The marginal ligaments of the TFCC are important, not only in load transference from the carpus to the ulna but also in the stability of the radioulnar joint. In extremes of rotation the compressive forces between the radius and ulna are resisted by the reciprocal tensile forces developed within the TFCC marginal ligaments. Numerous studies now support how this complex functions [32–35]. The two structures (TFCC and ulnocarpal ligaments) are morphologically distinct and have individual roles, even though the complex functions as a unit. The role of the ulnocarpal ligaments is to provide a stable connection between the ulna and the volar ulnar carpus. This ligament resists dorsal displacement of the distal ulna relative to the carpus. Destruction of this ligament, as is seen commonly by attenuation in rheumatoid arthritis, allows volar displacement of the carpus in relation to the distal ulna, a condition that is even more obvious in pronation. Disruption of any of these elements, the TFCC, the radioulnar ligaments, the ulnocarpal ligaments, the pronator quadratus, the ECU subsheath, and the interosseous membrane, may lead to arthrosis, limited motion, or instability.

Indications

There are several procedures that may be grouped under the heading arthroplasty of the DRUJ. A subgroup of these procedures is known as partial resection arthroplasties or hemi-arthroplasties. This article focuses on the partial resection arthroplasty known as the Bower hemiresection arthroplasty [2]. Partial resection arthroplasty may be viewed as an attempt to address selectively the pathology yet retain elements of the articulation important to its function. There is an element of retaining structure of the ulnar column and its ligamentous attachments to the radius and carpus in this procedure. The ulnar shaft styloid axis is kept intact. Hemiresection arthroplasty is indicated primarily in the treatment of post-traumatic, degenerative, and rheumatoid arthritis of the DRUJ. Although these types of arthritis are etiologically different, they present similar treatment problems conservative and surgical.

The differential diagnosis for pain at the DRUJ includes arthritic deformities, instability, ulnocarpal impaction, acute subluxation, chronic subluxation or dislocations, chronic instability of the DRUJ, and inflammatory conditions (ie, rheumatoid arthritis).

Examination

Arthritis of the DRUJ causes significant disability and severe pain. The physician must correlate the history, physical examination, and diagnostic data to be able to make a well defined clinical decision on how best to treat the patient and improve their quality of life. Arthritis of the DRUJ primarily presents with pain. There is crepitation with pronation and supination. The history would be a gradual onset with increasing frequency over many years.

Included in this decision are the demands of the patient, their work history, their age, and their hand dominance. The physical examination should include the age, dominance, characteristics of the symptoms, range of motion, pronation and supination, flexion and extension, and comparison to the contralateral side. Crepitation on the piano key maneuver and testing the patient's distal DRUJ with the elbow flexed at a 90° angle in 3° of motion, full pronation and supination, and neutral is necessary. Palpation along the areas of the triangular fibrocartilage, the foveal region, and the ulnar styloid are all performed. Other tests include the lunotriquetral sheer and shuck test and an impaction test in maximal wrist extension with force across the palm. All can reveal provocative findings of pain. Palpation of the ECU tendon sheath is done, as is resisted pronation to elicit any tendon subluxation. Diagnostic injection of an anesthetic or steroid also is used in assessing which area is contributing to the patient's source of pain and disability. Pre- and postinjection improvement of grip strength and pain in the possible area of the patient's pathology is favorable. Fluoroscopy can be used to guide the needle to the area of pain. This allows for more reproducible results and diagnosis. The patient frequently is asked to duplicate the motion that causes their symptoms.

Diagnostic studies

Standardized radiographs are extremely important in the DRUJ. Assessing ulnar positive and negative variance becomes important in stylocarpal impingement and in ulnocarpal impaction syndrome. A standard zero rotation PA and lateral radiograph in neutral are obtained. Motion series can be added, including ulnar deviation and radial deviation. A clenched fist can be added to supplement these initial radiographs. Findings include narrowing of the joint space in the DRUJ, sclerosis of the articular surfaces, and spur and cyst formation. MRI, including an arthrogram to supplement, is used specifically for ligamentous injury, such as the lunotriquetral, TFCC, and scapholunate ligaments. With increasing age, arthritis is found more commonly. This also correlates with increasing findings of ligament tears, and the true pathology sometimes can be somewhat questionable. Several studies have shown up to 50% of individuals over the age of 60 years may have TFCC tears that are asymptomatic [27,36]. Computed tomography with 3-D reconstruction has proven useful in evaluating subluxation of the distal radioulnar with axial cuts in pronation and supination. It also can evaluate thoroughly the surfaces of the DRUJ that may be arthritic. The ability to manipulate these images, computed tomography, and MR may become used more frequently in an educational role to the patient in an office setting and in simulating surgical procedures. Other diagnostic techniques include arthroscopy to supplement the findings of MRI and arthrography. Because arthritic conditions frequently are accompanied by associated ligamentous tears, arthroscopy can be used to assess the quality of cartilage before performing a hemiresection. The relevance of positive arthrograms has been questioned because of a high incidence of symmetric lesions. There is also a poor correlation with physical examination in some arthrographic findings. Injection of a contrast material in a triple versus single injection arthrography is debated. Because this is performed most commonly by radiologists without the presence of a surgeon, the benefit of having a direct view of the arthrogram is lost. Some surgeons perform their own arthrogram for this reason.

MRI increasingly uses enhancing materials to increase visualization of soft-tissue and bony pathology. Use of extremity coils and stronger magnets are creating much better and clearer images of the wrist ligaments with MRI.

Arthroscopy increasingly is being used in the wrist and other small joints in the hand over the last 5–10 years. The direct visualization of these injuries has no equivalent in determining pathology. It also can be diagnostic and therapeutic. In this present age of patient care, however, frequently it would be difficult without an MRI or other diagnostic tests to do a simple arthroscopy as a pure diagnostic tool. Arthritic disorders are still somewhat limited in their treatment with arthroscopy. Recent articles have revealed benefit by doing a Feldon wafer resection arthroscopically with TFCC debridement [21]. The DRUJ is a less predictably entered joint. It is extremely small and difficult to insert the arthroscope. As the tools and the applications increase, someday this may be more common.

Surgical approach

The keys to exposure are the ECU tendon and the extensor digiti minimi (EDM) tendons. As the ECU tendon enters the retinacular compartment, it lies directly on top of the ulnar styloid in any position of forearm rotation. The EDM changes from the muscle to tendon as it enters this retinacular compartment. This tendon lies along the radial attachment of the TFCC. For exposure of the major portion of the ulnar articular surface the

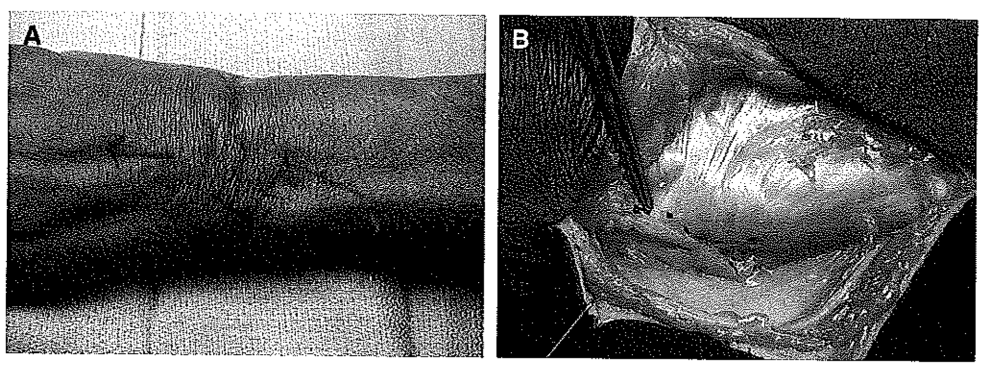

Fig. 3. (*A*) The dorsal approach. The arrow points to the patient's hand. (*B*) The ulnar nerve with the forceps and the dotted marks on the ulnar aspect. There is an additional ulnar nerve in the soft tissues in the bottom right corner.

procedure is begun with the wrist in full pronation. The incision begins laterally three fingerbreadths proximal to the styloid along the ulnar shaft and gently curves around the distal side of the head to end dorsally at the mid-carpus. Further extension can be performed distally, as this incision can be curved back ulnarly (Fig. 3A,B). The incision lies just dorsal to the dorsal branches of the ulnar sensory nerve, which must be found and protected with retraction or vessel loops during the procedure. Dorsal veins also are retracted, and the dissection is carried to the obliquely lying extensor retinacular fibers. Beneath the proximal border of the retinaculum the capsule of the ulnar head passes between the EDM and the ECU or fifth and sixth compartments.

The proximal and ulnar half of the extensor retinaculum is reflexed radially to uncover the ECU and EDM tendons. The base of this flap is the septum between the EDM and extensor digitorum comminus (EDC) compartment. Care is taken to maintain the EDC compartment intact.

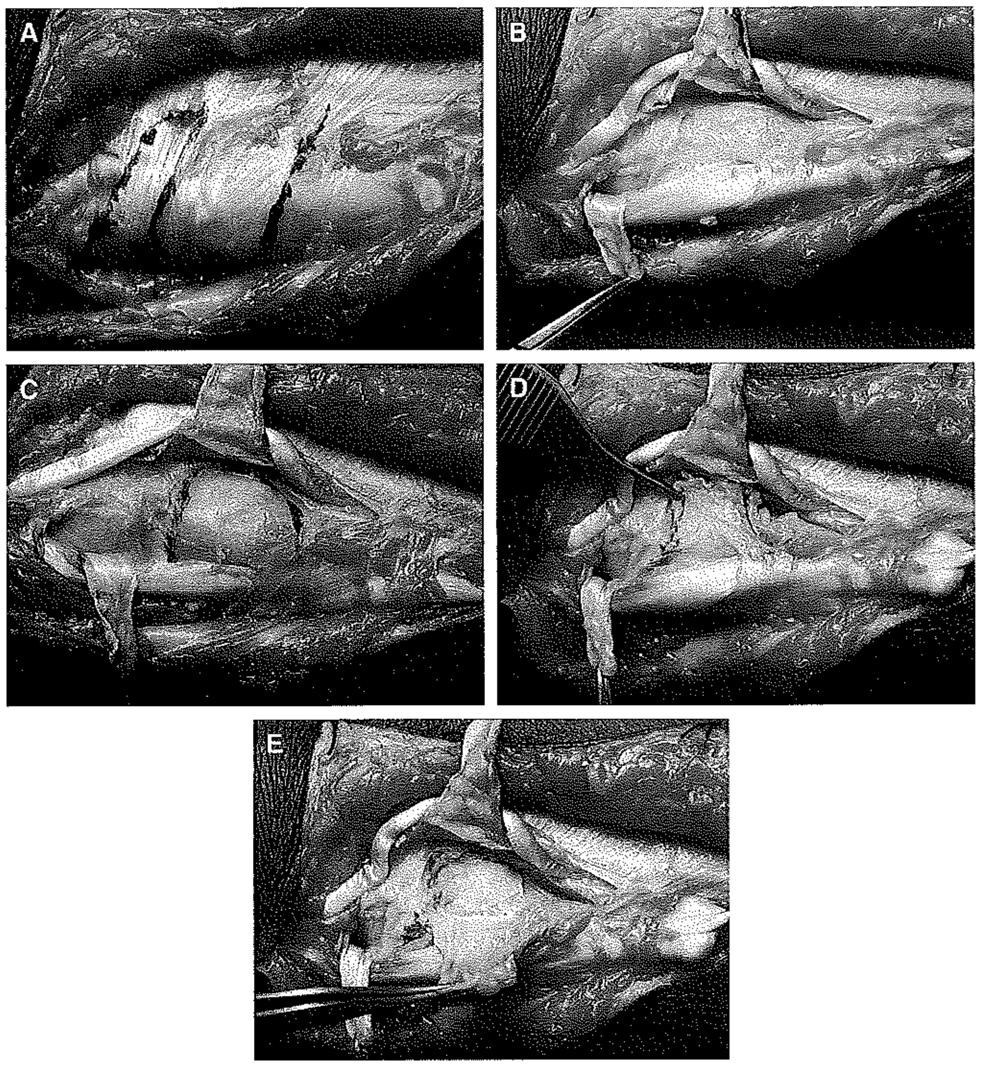

Fig. 4. (*A*) The proximal radial-based and the distal ulnar-based retinacular flaps that potentially are to be used to sling the ECU and to cover the capsule. (*B*) Those flaps opened, taking careful attention not to violate most of the ECU sheath. (*C*) The capsular incision marked. (*D*) That capsular incision made. (*E*) On opening that capsular incision, the ulnar head is exposed.

The EDM is retracted to reveal the dorsal margin of the sigmoid notch of the radius and the TFCC. The capsule then is sharply detached from the radius with a 1-mm cuff for later repair (Fig. 4A–E). As the capsule then is reflected toward the ulna, the ulnar head is exposed. A small lamina spreader or retractor can be placed to view the sigmoid notch. To better expose the underside of the TFCC, the forearm could be brought into neutral rotation and a small retractor placed, pulling the capsule distally. Further exposing the TFCC, as this is commonly debrided during the case of any central tearing, is done by releasing the EDM and ECU from the retinacular compartment. This can be done by reflecting the distal half of the extensor retinaculum opposite that of the first flap in an ulnar direction with an ulnar-based flap. The retinaculum is divided along the EDM septum, and the base of this flap is the attachment of the ECU compartment nearest the ulna. The ECU should be released fully only if its pathology is involved; otherwise, it should be kept unviolated in its sixth compartment and subperiosteally dissected from the ulnar shaft. This is critical because of its stabilizing function.

When the EDM and the ECU are reflected to either side one observes the transverse fibers of the dorsal radiotriquetral ligament. This ligament may be incised along its course parallel to the fibers to look at the lunate and triquetral surfaces within the radiocarpal joint. A triangular-based flap may be elevated. For exposure of the styloid the forearm is carried into full supination with the groove of the ECU used to mark its dorsal base. The reflected capsule may be used as an interpositional flap on performing a partial distal ulna resection. The ECU should be returned to its groove, and the first retinacular flap can be used as a stabilizing sling for the tendon if necessary (Fig. 5).

The intact DRUJ surfaces and the ulnocarpal joint structures cannot be explored fully by a single approach because of the close contact of the radius and the ulna. This approach allows visualization of 60% of the ulnar head, carpal base of the TFCC, lunotriquetral ligament, triquetrum, prestyloid recess, and most of the DRUJ synovial cavity. If carefully dissected and replaced, none of this exposure should alter the mechanics or stability. It is the resection of the distal ulna that uncouples the rotational unit of the DRUJ. This leads to the instability problems and impingement frequently seen as a complication of this procedure.

Fig. 5. The subperiosteally elevated portion of the ECU off of the distal ulna so as to prepare for the osteotomy. The freer is in the radiocarpal joint proximal to the TFCC.

Hemiresection

In performing a hemiresection arthroplasty there is no need to enter the radiocarpal joint or expose the carpal surface of the TFCC unless a pathologic tear is suspected. The retinacular flaps that were developed can be used for augmentation of the deficient TFCC if necessary (the distal flap) or in stabilization of the ECU tendon (the proximal flap). If at all possible, the ECU sheath should not be removed from its retinacular compartment if it is stable. Only in cases in which instability occurs should this be stabilized with a flap. Subperiosteally reflecting off of the ulna allows for visualization of the ulnar head and distal ulnar head.

The DRUJ capsule then is divided, exposing the articular surface, at which time a synovectomy may be performed. The ulnar articular surface and the subchondral bone then are removed with a combination of an oscillating saw, osteotome, or rongeurs. The most common pitfall in this area is to inadequately remove the distal ulnar articular surface. One needs to make sure that with pronation and supination they get the entire articular surface, the osteophytes around the sigmoid notch, and the ulnar head articular surfaces. The most difficult portion to remove is the volar portion of the head. The TFCC can be visualized on removing the head, and at this point most central TFCC tears can be debrided if necessary (Fig. 6A,B).

At this point one can assess the possibility of ulna stylocarpal impingement. Usually this is assessed preoperatively with appropriate radiographs also. On compressing the radial and ulnar

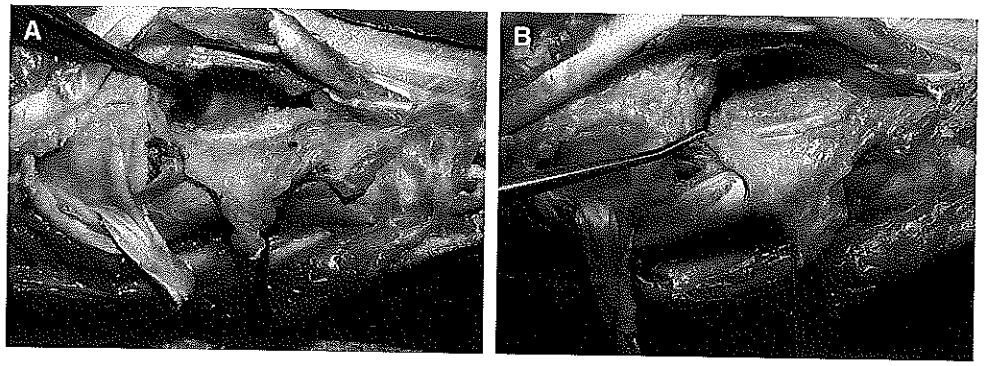

Fig. 6. (*A*) The early portion shows the most dorsal radial aspect of the distal ulna removed. (*B*) On rotating the ulna through a full pronation and supination, the full hemiresection is achieved. In the depths of the wound the freer points to distal radius aspect of the DRUJ.

shafts with the wrist ulnarly deviated, if there is any question about the ulnar styloid impinging on the carpal bones, the ulna then should be shortened. The shortening can be done through the metaphyseal base at the site of the ulnar head or more proximally with plate application. The usual fixation is with several 2.0 or 3.0 nonabsorbable sutures (Fig. 7) [37]. The next step is to place in the resected ulnar space material, usually tendon, as an interposed bulky material to maintain radial ulnar shaft separation. This also is meant to prohibit impingement in cases in which the ulna is a zero variant (palmaris longus or ECU/FCU tendon strip) (Fig. 8A–C).

The ECU compartment then is replaced into the area. Sometimes a portion of the distal retinacular flap is sewn down into the capsule to maintain the interpositional material. If the ECU compartment needs to be stabilized it is then performed (Fig. 9A–D). If no shortening is performed, a postoperative short arm bulky dressing with dorsal and palmar plaster splints is applied. Finger motion is encouraged within 3–5 days with early anti-edema and therapy. At 2 weeks the sutures are removed and the patient is placed into a short arm cast or wrist splint for 2–4 more weeks.

If an ulnar shortening is performed with the hemiresection, the initial immobilization is a long arm sugar tong or long arm splint controlling forearm rotation. This then is converted to a short arm cast with interosseous molding at 2–4 weeks. This allows slightly more rotation but it is important that the short arm cast have good interosseous molding. A wrist splint then is used from 6 weeks to full use over the next 4 weeks. The patient is assessed at every visit for osteosynthesis with radiographs and at that point may remove any protective splinting. This typically takes 10–12 weeks.

The surgical alternatives for conditions of post-traumatic, degenerative, and inflammatory arthritis of the DRUJ are excision of the distal end of the ulna, known as the Darrach procedure

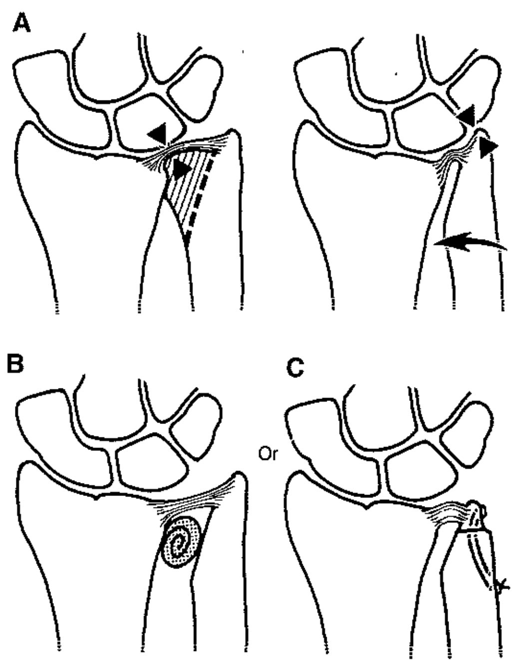

Fig. 7. (*A–C*) In cases of stylocarpal impingement the ulna is shortened, either (as this shows) through an interosseous wiring technique or as can be performed with two anchors through drill holes of a nonabsorbable suture. (*From* Green's operative hand surgery, volume 1, 4th edition. New York: Elsevier; 1998; with permission.)

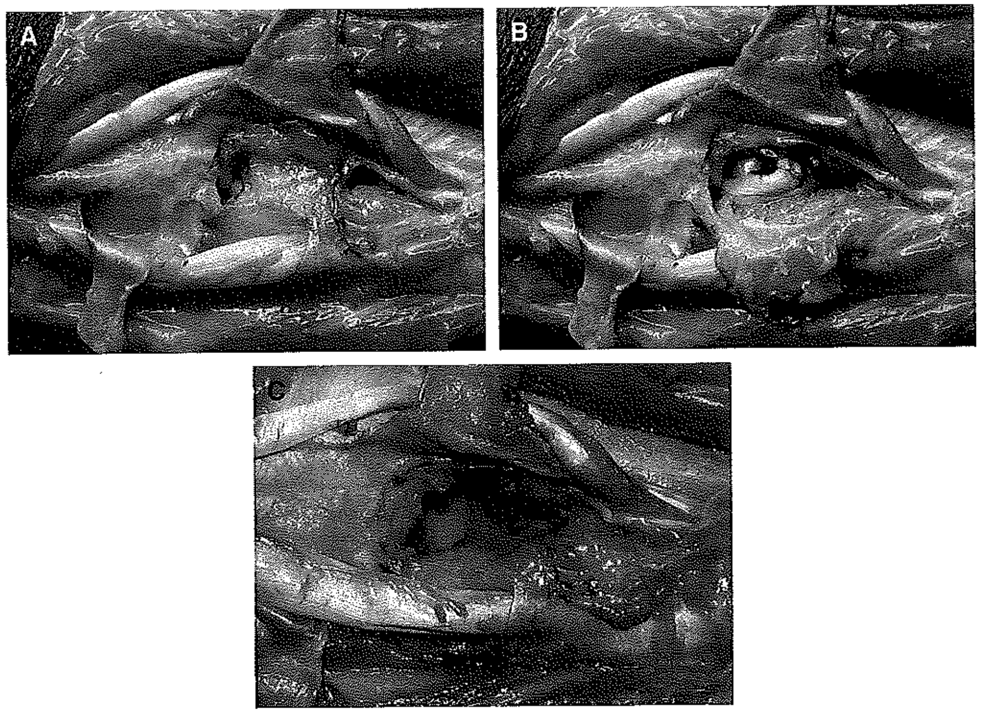

Fig. 8. (*A*) The previous DRUJ capsular flap (see Fig. 4*C*). This flap is shown sewn down to the volar capsule and tissue after the resection covering the hemiresection. (*B*) The palmaris longus tendon sewn typically to a previously placed stitch along the volar capsule to secure it, followed by closure of the capsule over top in (*C*).

with one of the many modifications of this technique to stabilize the ulnar stump, the hemiresection arthroplasty, the Sauve-Kapandji procedure, and other salvage-type procedures, including a one-bone forearm and a more proximal distal ulnar resection. Replacement arthroplasty increasingly is used also. This article primarily focuses on the hemiresection arthroplasty technique, its most appropriate indication, pitfalls, and salvage techniques used in the event of failure of treatment.

The problems associated with the Darrach operation were improved on by Bowers in 1985 [2] and Watson [3]. Both of these procedures proposed a similar philosophy and a technique in a partial resection of the distal ulna. The ulnar styloid axis and the soft-tissue attachment to the TFCC were left intact. These were operations designed to handle the shaft instability that was found after many Darrach procedures. More attention to detail was required with these procedures. Adequate resection is imperative to prevent postoperative impingement between the remaining ulnar shaft and the radius. This is the most common source of continued pain and failure of the procedure. Despite these techniques, radioulnar convergence still occurs. These initial studies were performed primarily in patients who had rheumatoid arthritis. Bowers reported on 38 cases, and 27 of 38 were rheumatoid [2]. Watson reported on 48 cases, 34 of which were rheumatoid [3]. Other studies [14–16,18,38–40] have added experience in combined series revealing primarily patients who have rheumatoid arthritis at 42%, patients who have instability at 29%, ulnocarpal impingement 21%, primary osteoarthritis 5%, and 3% other traumatic problems. In this multi-series review 76% of the patients were pain free and 24% had mild pain. Two percent of these patients were treated with repeat operation for stylocarpal impingement [6].

The purpose of this procedure is to obtain relief of pain by complete resection of only the articular prominence, leaving the ulnar column intact. This procedure was an outgrowth of what Dingman described as the best of the Darrach procedures, in which there was minimal resection followed by some regeneration of the ulnar shaft within the retained sleeve of the periosteum. An interposition of tendon, muscle, or capsule is

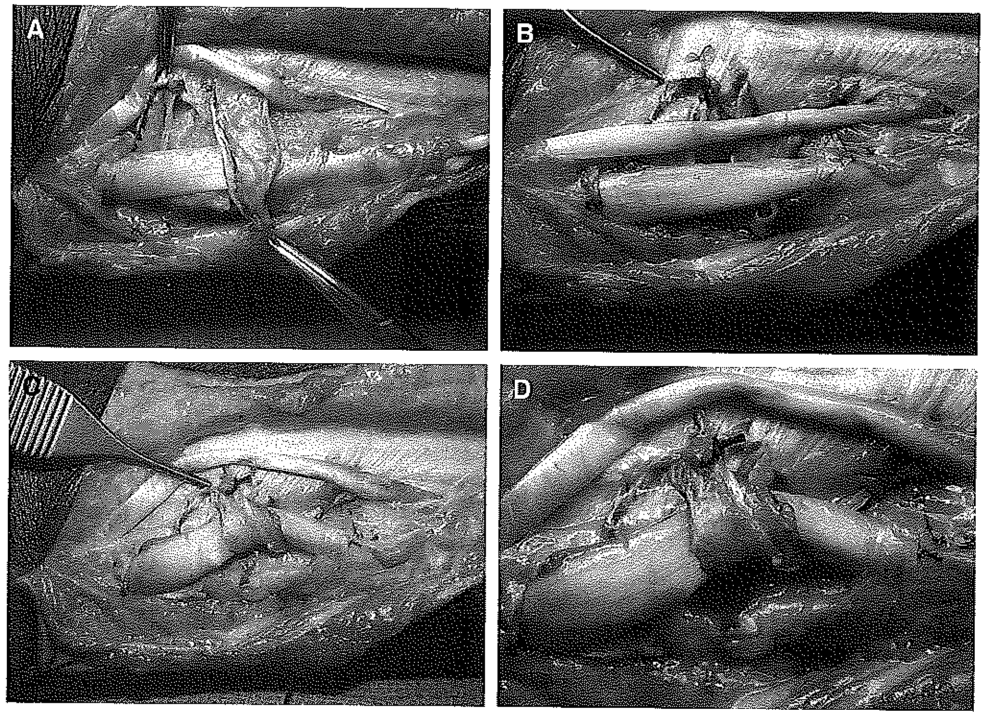

Fig. 9. (*A*) With no need to stabilize the ECU, the previous ulnar and the previous proximal and distal retinacular flaps can be sewn back, leaving the fifth compartment transposed. (*B*) Those retinaculum sewn in place. Note the proximal stability of the ECU tendon on the right side. (*C, D*) A sling and close-up using the proximal radial-based retinaculum. This sling is slightly tighter than standard, but in the case of a rheumatoid, this would be used for stabilization.

placed in the vacant DRUJ synovial cavity to limit contact of the radial and ulnar shafts in convergence. The procedure supposes an intact or reconstructible TFCC. It should not be used in situations in which ulnar variance is positive unless the ulna is shortened as part of the procedure. This avoids the common problem of stylocarpal impingement. Most cases in patients who have rheumatoid arthritis with TFCC have unreconstructable TFCCs. Here a modified Darrach procedure coupled with radiolunate arthrodesis is a good choice; another alternative is a Sauve-Kapandji procedure. An additional contraindication is preoperative evidence of ulnocarpal translation. The operation has one inherent problem. If the articular surfaces are removed sufficiently, they unload the ulnocarpal articulation, changing the normal force distribution in the wrist. The normal articular dome provides a stable seat for the radius to ride in its rotational arc, and its absence allows the two shafts to come together. If on a preoperative PA radiograph the amount of narrowing would allow the styloid to come within 2 mm of the ulnar deviated carpal bones, one may anticipate stylocarpal impingement. The treatment for this is a shortening of the ulna with a tension band, nonabsorbable sutures through drill holes, anchors, or other forms of fixation.

Summary

One of the critical requirements for this procedure to succeed is a functional TFCC structure. In rheumatoid arthritis or traumatic disruption of the DRUJ, the TFCC is unstable. If the TFCC can be reconstructed and DRUJ arthritis exists, this is the situation in which the hemiresection procedure excels. In the face of a normal DRUJ without arthritis, an ulnar shortening with a repair of the TFCC, if necessary, is the more appropriate procedure. The other caveat for this procedure to succeed is a careful preoperative plan to make sure stylocarpal impingement does not occur. The procedure does not restore stability in the unstable painful radioulnar joint; it simply substitutes a less painful instability. When correctly planned and performed the hemiresection interposition technique can be a good procedure in the arsenal of treatment for the DRUJ.

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