Instability of the distal radioulnar joint may occur following trauma or may result from inflammatory arthritis. Chronic instability of this joint creates pain, limitation of motion, and weakness. Lidstrom reported persistent pathologic mobility of this joint in 15% of the patients he reviewed with fractures of the radius, and other authors have reported similar results. Most papers refer to dorsal subluxation of the distal ulna as a condition in which the ulna articulates more dorsally in respect to the sigmoid notch of the radius than in normal patients. The difficulty with the radiologic diagnosis of dorsal subluxation distal ulna has been noted in the literature. The diagnosis is most often established by the patient’s history and physical examination. Palmar subluxation of the distal ulna occurs most frequently following displaced or malaligned fractures of the radius, and can often be diagnosed using a true lateral radiograph of the distal radius and ulna.

Multiple operations have been used or suggested as options for treating symptoms in instability. Ligamentous reconstruction or osteotomy have been proposed as solutions to the problem. Other authors have recommended resection arthroplasties, and hemiresection arthroplasties. There is no consensus in the literature as to the best treatment for pathologic instability of the distal ulna.

**ANATOMY**

Palmer and Werner and Gibson believe that the triangular fibrocartilage complex (TFCC) functions as the major stabilizer of the distal radioulnar joint. The extensor retinaculum and surrounding structures are also major restraints to both dorsal and palmar subluxation. The fibrocartilage complex arises from the ulnar aspect of the radius and inserts at the base of the ulnar styloid. The dorsal and palmar radioulnar ligaments make up the outer borders. The ulnar collateral ligament lies just deep to the extensor tendon sheath. Milch and Spinner and Kaplan believe that an intact ulnar collateral ligament and an intact ulnar styloid are critical to the stability of the distal ulna. The relative contributions to stability that these structures provide continues to be defined.

Hagart has proposed that we think of the radius and ulna as a forearm joint that has a proximal and a distal compartment. The concave distal articular surface of the radius must be able to freely rotate around the convex stable
distal ulna. Any displaced fracture of the forearm will naturally affect the tenuous relationship between the distal ulna and radius because of the relative joint incongruity secondary to displacement of the fracture.

CLINICAL PRESENTATION

Dorsal Subluxation of the Distal Ulna

Most patients with subluxation of the distal ulna have a definite history of trauma. Often there is no fracture but simply a history of a sprain of the distal radioulnar joint. In a review of 24 patients with dorsal subluxation of the distal ulna, 12 of the patients had either radius or ulnar fractures, while the remaining 12 patients had a history of trauma but no radiologic evidence of fracture. The chief complaint in these patients is pain accompanied by decreased rotation and weakness of grip. The distal radioulnar joint is tender to palpation, and there is a visible dorsal prominence of the ulnar head that is more pronounced in full pronation (Fig. 1A and B). Palpation of the ulnar head as the forearm is rotated will cause discomfort, and often there is an audible snap. As the instability worsens, the patient may have a positive "piano key" sign. The sign is best elicited when the wrist is palmarflexed against a fixed object with the forearm in pronation.

Anteroposterior and neutral lateral plane radiographs should be obtained in all patients (Fig. 2). Bowers recommends that the radius be in a neutral rotation for both the posterior, anterior, and lateral radiographs. The humerus is abducted 90 degrees, the elbow is flexed 90 degrees, and the cassette is placed flat on a sufficiently large foam block to maintain the arm in position. Ulnar variance can be measured on the posteroanterior film and the degree of dorsal subluxation can be evaluated on the lateral film. To measure the degree of dorsal subluxation, a CT scan in supination, neutral rotation, and pronation may be obtained. CT scans have helped us diagnose both subluxation and dislocation of the distal ulna.

Palmar Subluxation of the Distal Ulna

As opposed to dorsal subluxation of the distal ulna, chronic palmar subluxation of the distal ulna is most often due to a malunion of a forearm fracture. Palmar instability of the distal ulna occurs when the patient supinates. The malaligned radius fracture actually spins off the fixed distal ulna as the forearm rotates. The lateral radiograph of the forearm in supination will show the distal ulna to be in a palmar position relative to the distal radius (Fig. 3A and B). On physical examination, there is often a "clunk" in the distal radioulnar joint as the patient supinates. Once the subluxation occurs, a very prominent ulnar mass is evident at the distal palmar side of the forearm. Corrective osteotomy of the radius can be attempted as a treatment for this condition as long as the distal radioulnar joint surface has not become arthritic. If posttraumatic arthritis is present, then an interposition arthroplasty is indicated. At the present time, there is no agreement regarding the treatment for either chronic posttraumatic dorsal or palmar instability of the distal ulna. Hemiresection interposition arthroplasty may be used as a salvage procedure to relieve pain and restore function in both dorsal and palmar subluxation of the distal ulna.

OPERATIVE TECHNIQUE

The operative technique of distal radioulnar joint hemiresection arthroplasty has been de-
on the of dorsal neutral. CT
~luxation.

Ulna

The mal-
off the.

The operation proposed
can be used for both dorsal and palmar subluxation conditions when the surgeon feels that
neither soft tissue reconstruction nor corrective osteotomy is indicated. The procedure would
also indicate after failure of either soft tissue reconstruction or corrective osteotomy. A dorsal
incision is used to expose the distal radioulnar joint. The extensor retinaeulum is opened lon-
gitudinally over the fourth compartment for a
distance of 1 to 1.5 inches. Transverse incisions
are then made in the retinaeulum proximally
and distally and the retinaeulum is mobilized
as an ulnar-based flap. The fifth and sixth com-
partment tendons are retracted, and the dorsal
radioulnar joint capsule is raised from its attach-
ments to the distal radius (Fig. 4). Again, trans-
verse incisions are made proximally and distally
and the capsular flap is left attached to the distal
ulna. The surgeon is left with two separate,
ulnar-based flaps. Using osteotomes or a power
saw, the medial portion of the distal ulna is
reseeted, leaving intact the ulnar border and
ulnar styloid. Once the bone resection is com-
plete, the patient's forearm is put through a
passive range of motion. If there is any bone
block to motion, more bone can be resected.
The ulnar-based radioulnar capsule flap is used
as interposition material by placing it within
the joint and securing it with sutures palmarly
to the pronator quadratus fascia or the periost-
em of the distal radius (Fig. 5). This dorsal
capsule serves as both interposition material to
prevent bone-to-bone contact and also provides
a cheek-rein to motion of the distal ulna. If
additional stability is necessary, a portion of the
extensor carpi ulnaris can be detached prox-
ially and woven through the distal ulna. The
ulnar-based flap of extensor retinaeulum is then
placed below the ECU and extensor digiti min-

ced by Bowers. The operation proposed
can be used for both dorsal and palmar subluxation conditions when the surgeon feels that
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a cheek-rein to motion of the distal ulna. If
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extensor carpi ulnaris can be detached prox-
ially and woven through the distal ulna. The
ulnar-based flap of extensor retinaeulum is then
placed below the ECU and extensor digiti min-
for another 3 to 4 weeks. Upon removal of the cast, active range of motion and strengthening exercises are started (Fig. 7).

**DISCUSSION**

One difficulty encountered in comparing the results of various operations is defining the pathologic condition. Dorsal subluxation of the distal ulna is most often due to a soft tissue deficit resulting in subluxation of the distal ulna when the patient pronates. The diagnosis is made by history and physical examination; radiographs occasionally are helpful. Multiple soft tissue reconstructive procedures have been recommended for this condition.

Most of these reports deal with a small number of patients and residual limitation of motion is frequently encountered.

Hui and Linscheid\(^7\) collected eight cases of posttraumatic dorsal subluxation of the distal ulna, which they treated with ulna triquetral augmentation tenodesis. The diagnosis was based on clinical examination in these cases. They reported five excellent and three satisfactory results regarding pain relief, but noted postoperative limitation of motion in all cases; in three cases, residual joint laxity was evident.

Distal ulna resection has also been recommended for symptomatic dorsal instability of the distal radioulnar joint. Diminished grip strength and postoperative instability have been reported after this procedure. A recent report suggests that distal ulna resections in younger patients may result in a high complication rate.\(^7\)

Palmar subluxation of the distal ulna is less common than dorsal subluxation. Although there is much material in the literature describing the treatment of dorsal subluxation of the distal radioulnar joint, there is very little information regarding the treatment of palmar subluxation/dislocation of the distal ulna. This condition can often be diagnosed by taking a lateral radiograph of the distal forearm in supination. If one is not sure of the diagnosis on plain lateral radiographs, a CT scan of the distal radioulnar joint may help confirm the diagnosis.

Soft tissue reconstruction of the distal radioulnar joint for palmar subluxation will not be successful if a bony malunion is present. Corrective osteotomy may be indicated if the distal
Hemiresection Interposition Arthroplasty

joint surfaces are still intact and not arthritic. However, most often these patients present in a chronic phase, and it is our feeling that if any arthritis is present, hemiresection interposition arthroplasty is indicated.

Hemiresection arthroplasty is a salvage procedure that can be performed in both dorsal and palmar subluxation of the distal radioulnar joint. It is indicated when the surgeon feels that soft tissue reconstructive procedures or corrective osteotomies will not work. The procedure has yielded approximately 80% good to excellent and 20% fair results in both dorsal and palmar subluxation of the distal ulna.

REFERENCES


Figure 6. The extensor retinaculum is transposed below the extensor carpi ulnaris and extensor digiti minimi.

Figure 7. A postoperative radiograph showing the completed hemiresection arthroplasty.
30. Regan JM, Bickel WH: Fascial sling operation for instability of the lower radio-ulnar joint. Staff Meetings of the Mayo Clinic 2 June 1945, p 200

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ORIGINAL COMMUNICATIONS

Distal radioulnar joint arthroplasty: The hemiresection-interposition technique

The hemiresection-interposition technique for distal radioulnar joint arthroplasty was developed from anatomic studies that indicated the importance of preserving the functional elements of the ulnocarpal ligament complex. The technique has been previously described. My experience with 38 patients who were followed for an average of 2 1/2 years shows that the procedure is most valuable for patients with rheumatoid arthritis (85% had stable, painless pronation averaging 84° and supination of 77°, while 15% had mild pain and pronation of 70° and supination of 75°). It is also valuable for patients with degenerative or trauma-induced arthritis (100% had painless rotation-pronation averaging 80° and supination of 80°). A modified procedure is useful for patients with ulnocarpal impingement syndrome where the Milch shortening osteotomy may not succeed because of radioulnar incongruity. (J HAND SURG 10A:169-78, 1985.)

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This article describes a reconstructive approach to disorders of the distal radioulnar joint and triangular fibrocartilage complex (TFCC). The procedure, which was developed from anatomic studies of this joint, came about because past treatment modalities seemed too radical or empiric and failed to recognize the importance of preserving the integrity of the ulnocarpal ligament complex. My anatomic investigations (Fig. 1), along with those of others, have emphasized the importance of the TFCC in stabilizing the ulnar side of the wrist. TFCC serves several functions: (1) It provides a stable radioulnar connection that allows rotation via its triangular fibrocartilage component; (2) it provides a stable ulnocarpal connection with its ulnocarpal ligament components; (3) the triangular fibrocartilage component transmits forces that are delivered to the ulna from the hand-wrist unit; (4) the combined triangular fibrocartilage-ulnocarpal ligament functions as a sling that suspends the ulnar carpus from the radius; and (5) it extends the gliding surface for the proximal carpal row across the entire face of the distal end of the forearm bones. This anatomic concept has led treatment of the distal radioulnar joint and TFCC dysfunction away from ablative alternatives and toward preservation and reconstruction. The TFCC is destroyed by excision and is functionally disabled by the Darrach procedure. In an excellent study of the latter procedure, Dingman noted in 1952 that all of the patients with good or excellent results had very little bone removed or that the process of regeneration had been very active with little final discrepancy between the lengths of the radius and the ulna. He also noted that because the strength and stability of such wrists were unimpaired, one could reason that physiological regeneration was an asset rather than a detriment to the end result. The anatomic opinion that preservation of these structures is desirable and the clinical observation that regeneration is an asset led to the development of
Fig. 1. The "heart" of the TFCC. A shows the two major components, the TFCC and the ulnocarpal ligaments, while B shows the structures as seen in the human wrist. (Reproduced with permission of Betty Montgomery from Bowers WH: The distal radioulnar joint. In Greene DP, editor: Operative hand surgery. New York, 1982, Churchill-Livingstone Inc).

the hemiresection-interposition technique (HIT) for distal radioulnar joint arthroplasty.

Technique

Only the ulnar articular cylinder and its subchondral bone (Figs. 2 and 3) are removed, which leaves the shaft and styloid (with its triangular fibrocartilage connections) in osseous continuity. The important radioulnar and ulnocarpal connections remain undisturbed (Fig. 1). Therefore, ulnar column instability is avoided.

Several aspects of the technique have been refined since my initial description of the procedure. The retinacular flaps were developed to conserve tissue for dorsal stabilization of the extensor carpi ulnaris (ECU) and augmentation of the deficient triangular fibrocartilage. If not needed for these purposes, the first (proximal) flap is excised, and the second (distal) flap is used to cover the arthroplasty site. ECU stabilization is done only if the ECU is displaced palmarly or if it is unstable in its compartment. In these instances, the ECU is freed to its insertion on the base of the fifth metacarpal. The first (proximal) retinacular flap is then used to create a sling. The technique is similar to that recommended by Spinner and Kaplan, but varies in that after it is passed around the ECU, the flap is sewn to the fourth compartment wall distal to its point of takeoff. This ensures creation of a sling rather than a noose (Fig. 4). Interposition of material in the cavity that is left after excision is necessary because of the tendency of the radial and ulnar shafts to approximate one another after resection of the head. This tendency is most obvious with power grip (Fig. 5) when the ulnar head no longer counters the muscle action of the pronator quadratus and other forearm muscles. In most cases, the need for interposition will be satisfied by using the ulnar-based capsular flap, as demonstrated in the standard procedure (Fig. 3, B). In some instances, interposition bulk needs to be increased. If significant positive ulnar variance is present or if the styloid is unusually long, then the styloid may impinge on the triquetrum after head resection, thereby creating postoperative pain (cases 4, 23, 30, and 31). The best approach to this problem is prevention. If positive variance is greater than 2 mm, the HIT should be used with ulnar shortening. If variance is less than 2 mm or if the styloid length is the problem, shortening the ulna is unnecessary if inter-
Fig. 2. These skeletal specimens show the amount of bone that will be resected.

Fig. 3. The resection has been done (B), and the two options for interposition are shown. Either the dorsal capsule or an “anchovy” made of tendon/muscle is used.

position bulk is increased. This is accomplished by placing a carefully made ball of tendon and muscle about the size of the resected dome into the vacant joint cavity (Fig. 3, B) and stabilizing it through palmar and dorsal capsules with a few sturdy sutures. The material may be obtained from the palmaris longus (preferred), ECU, or flexor carpi ulnaris (FCU). This added bulk seems to counter shaft approximation sufficient to eliminate impingement. Augmentation of the triangular fibrocartilage may be needed in cases where its major stabilizing portions are impaired. After the ulnar head is removed, the triangular fibrocartilage can be clearly seen on both its surfaces. Lesions of the triangular fibrocartilage will be readily apparent. If centrally located, these perforations or tears are now functionally inconsequential since resection of the ulnar head has accomplished full decompression. Repair is unnecessary, and the lesion can be cleaned up with minor debridement. If the peripheral margins are disrupted or attenuated (as is frequently the case in the more severe cases of rheumatoid arthritis), they may be effectively repaired or augmented with the use of either the second
Bowers

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Fig. 5. A, The patient’s hand is relaxed and then forcefully gripped. B, An approximation of the radius and ulna after ulnar head resection is shown. In this case, there was no variance, and no stylocarpal impingement is expected (case 34).

retinacular flap or distally based strips of ECU or FCU. This technique is discussed in my original article. It should be emphasized that there is no standard way of reconstructing this structure. The surgeon must understand the functional goals of reconstruction and be willing to vary the technique according to the lesion presenting in each individual case.

Technical errors have occurred in three areas. The first is inadequate bone removal. Large osteophytes must be removed. All of the ulnar head should be removed. The remaining shaft should be rounded in cross section and resemble a tapering 1 cm diameter dowel. Before closure, rotation should be tested and shown to have no impingement. The radial and ulnar shafts should be compressed and rotated and the wrist ulnarily deviated to test for possible stylocarpal impingement. If present, the ulna should be shortened or the “anchovy” added to increase interposition bulk. Second, the shaft may fracture if resection has been too generous. This is not disastrous. The fragments can be sutured with a heavy suture, and postoperative splinting is continued for a full 3 weeks to allow adequate healing. Finally, I have observed that before the “sling” technique of dorsal ECU stabilization is used, some early postoperative discomfort could be attributed to decreased or painful ECU glide, which is thought to be caused by the “noose” effect of the classic Spinner technique.

Postoperative care

When triangular fibrocartilage reconstruction has not been performed, the forearm is immobilized in a short-arm bulky dressing with dorsopalmar plaster reinforcement. Finger motion is encouraged, but forearm rotation is neither encouraged nor discouraged. At 2 weeks, the operative dressing is changed to whatever splint is required for other procedures that have been performed, and unrestricted forearm rotation is allowed. If triangular fibrocartilage augmentation has been performed, a long-arm splint in neutral rotation is used for 3 weeks. Unrestricted rotation is then permitted.

Application

The HIT for distal radioulnar joint arthroplasty should be considered in the following situations.

Trauma. Unreconstructible fractures of the ulnar head or those displaced fractures entirely within the ulnar head provide a condition where articular incongruity of the distal radioulnar joint is likely. HIT may allow an early return to a functional state.

Ulnocarpal impingement syndrome with potentially inadequate surfaces of the distal radioulnar joint. Such cases are found in malunions of Colles fractures and early radial epiphyseal closures. In the former, irregularities of the distal radioulnar joint secondary to fractures will be a problem, while in the latter, the joint may be inadequate in size and conformation.
Fig. 6. A, “Settled” Colles fracture that shows intact triangular fibrocartilage and ulnolunate-triquetral impingement on the arthrogram. B, The head is resected along with a 3 mm segment of adjacent shaft to shorten the ulna. The ulnar shaft/styloid axis is stable in this 6-month film.

to allow a successful Milch osteotomy. In this case, it would be reasonable to perform the HIT for arthroplasty along with ulnar shortening (Fig. 6).

Rheumatoid arthritis. The early stages of this disease provide a major indication for the procedure. The HIT, together with ulnocarpal synovectomy, has proved a valuable preventive and reconstructive option. Its major usefulness is during the earliest stages of synovitis that are unresponsive to medical management. When it is used with triangular fibrocartilage augmentation and anchovy interposition, it provides stable rotation for later cases that is unobtainable with other procedures (Fig. 7).

Arthritis after trauma and osteoarthritis of the distal radioulnar joint. If the triangular fibrocartilage is adequate or reconstructible, the HIT is the procedure of choice (Figs. 8 and 9).

Chronic painful triangular fibrocartilage tears. Although limited debridement of these tears, perhaps coupled with the Milch shortening osteotomy, is the procedure of choice, HIT may be considered when articulation of the distal radioulnar joint is also inadequate.

Ulnar head chondromalacia. Little is known about this condition. It is often diagnosed only after the head has been removed during a Darrach procedure for a painful clicking wrist. The HIT provides a conservative approach and is preferred over the Darrach procedure.

Contraindications

The basis for this procedure is a functionally adequate or reconstructible TFCC. Otherwise, there are no advantages over the Darrach procedure or its modifications. An arthrogram will help assess the triangular fibrocartilage and joint surfaces before surgery. In fact, the only instance where the TFCC is unreconstructible is with severe arthritis. Here, a modified Darrach procedure coupled with radiolunate arthrodesis is a good choice. Alternatives might include the Lauenstein or Baldwin procedures.

Results

Thirty-eight patients were operated on and followed for sufficient duration to allow me to come to some conclusions about this procedure (Table 1). Most patients had rheumatoid arthritis (27 patients, or 71% of the total). Five patients had ulnocarpal abutment syn-
Fig. 7. A, In this patient with rheumatoid arthritis, pain in the distal radioulnar joint and a ruptured extensor digiti minimi were treated with HIT (case 121). A painful silicone rubber trapezial implant was also removed. B, A follow-up x-ray film was taken 4 years later. She was without symptoms.

Fig. 8. A, Painful arthrosis of the distal radioulnar joint with osteophyte on the ulnar head. B, Two years later, the wrist is asymptomatic with rotation of 80° of pronation and 80° of supination (case 36).
Fig. 9. A, This patient required arthrodesis of the wrist for painful radiocarpal arthrosis. Rotation was also painful. At operation, the distal radioulnar joint showed degenerative changes, and HIT was performed. B, Eight months after surgery, he was able to perform heavy manual labor with no pain and $90^\circ/90^\circ$ rotation (case 37).

drome of various etiologies (13% of the total), and six had distal radioulnar arthrosis (16%). Excluding the patient with an 11-year follow-up, the follow-up averaged 31 months. Patients with less than a 3-month follow-up were not included. Patients with a 3- to 6-month follow-up were included only if I felt that a conclusion could be reached.

Assessment was difficult. Surgery in patients with rheumatoid arthritis was intended to prevent progressive destabilization of the wrist and reduce the risk of tendon rupture. Surgery in the ulnocarpal abutment group was intended to decompress ulnocarpal impingement. Finally, surgery in the arthrosis group was intended to eliminate rotational pain. The goal common to all three groups was to provide relief of pain and to accomplish this with a procedure that allowed a stable functional arc of rotation that was without complications. Thus, pain, arc of rotation, and stability were selected as tests of this procedure.

Pain was determined by asking the patient to rotate his/her forearm in both the relaxed and grip modes and to report pain as absent, mild, or worse. I then examined the patient and recorded my assessment of pain to palpation and passive rotation. Next, I measured rotation and questioned the patient about his/her perception of stability.

Grip strength was considered a parameter, but was disregarded as a meaningful way to evaluate this procedure. Excluding my bias that formal grip testing in patients with rheumatoid arthritis is misleading, the multiplicity of other procedures performed could have contributed to changes in this test. In fact, most patients who were relieved of pain reported increased functional grip even if it was not reflected in the measurement.

Rheumatoid arthritis. In the rheumatoid arthritis group (cases 1 through 27), 86% were women. The ages averaged 53.5 years, with the youngest 36 years old and the oldest 72 years old. Most had classic seropositive rheumatoid arthritis, and all were being treated by a rheumatologist. As with all of the distal radioulnar joint procedures in this group, the ECU was stabilized dorsally, and therefore, it was not listed as a separate procedure. The HIT was employed as a preventive as well as therapeutic measure in patients with mild rheumatoid arthritis who had painful function of the distal radioulnar joint and synovitis, but only minimal destructive changes in the osseous skeleton (67.8% of the arthritic patients in this study). These patients are listed in Table I as having the HIT alone or with synovectomy. Synovectomy of the distal radioulnar joint was used with synovectomy of the ulnocarpal joint in a dual ex-
Table I. Data on 38 patients on whom HIT was performed

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Patient</th>
<th>Age(yr)/race/sex</th>
<th>Problem(s)</th>
<th>Procedure(s)</th>
<th>Length</th>
<th>Rotation</th>
<th>Pain</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M. O.</td>
<td>67/W/female</td>
<td>RA</td>
<td>1,2,3</td>
<td>16 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>R. G.</td>
<td>65/W/male</td>
<td>RA</td>
<td>1,2,3,4</td>
<td>36 mo</td>
<td>90/60</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>P. D.</td>
<td>60/B/female</td>
<td>Juvenile RA</td>
<td>1,2,3,4</td>
<td>3 mo</td>
<td>40/60</td>
<td>None</td>
<td>Total elbow done simultaneously</td>
</tr>
<tr>
<td>4</td>
<td>B. G.</td>
<td>35/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>12 mo</td>
<td>60/90</td>
<td>Mild pain</td>
<td>Stylocarpal impingement</td>
</tr>
<tr>
<td>5</td>
<td>M. S.</td>
<td>43/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>4 mo</td>
<td>70/70</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>H. M.</td>
<td>72/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>17 mo</td>
<td>60/50</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>M. I.</td>
<td>66/W/female</td>
<td>RA</td>
<td>1,2,3 (left)</td>
<td>8 mo</td>
<td>70/70</td>
<td>None</td>
<td>Radiolunate arthrodesis</td>
</tr>
<tr>
<td>8</td>
<td>M. I.</td>
<td>66/W/female</td>
<td>RA</td>
<td>1,2,3,7 (right)</td>
<td>3 mo</td>
<td>70/60</td>
<td>Mild pain</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>M. B.</td>
<td>52/W/female</td>
<td>RA</td>
<td>1,2,3</td>
<td>72 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>S. G.</td>
<td>54/W/female</td>
<td>RA</td>
<td>1,2,3</td>
<td>133 mo</td>
<td>80/80</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>B. L.</td>
<td>67/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>43 mo</td>
<td>60/40</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>P. M.</td>
<td>70/W/female</td>
<td>RA</td>
<td>1,2 (right)</td>
<td>46 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>P. M.</td>
<td>70/W/female</td>
<td>RA (ruptured extensors)</td>
<td>1,2,5 (left)</td>
<td>49 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>W. L.</td>
<td>59/B/male</td>
<td>RA</td>
<td>1,2</td>
<td>33 mo</td>
<td>60/60</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>S. D.</td>
<td>47/W/female</td>
<td>RA</td>
<td>1,2 (left)</td>
<td>35 mo</td>
<td>80/70</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>S. D.</td>
<td>46/W/female</td>
<td>RA</td>
<td>1 (right)</td>
<td>46 mo</td>
<td>90/40</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>T. B.</td>
<td>52/W/female</td>
<td>RA, gout</td>
<td>1</td>
<td>38 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>J. J.</td>
<td>55/W/female</td>
<td>RA</td>
<td>1</td>
<td>67 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>C. G.</td>
<td>40/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>68 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>H. L.</td>
<td>61/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>60 mo</td>
<td>80/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>H. L.</td>
<td>59/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>78 mo</td>
<td>80/80</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>S. R.</td>
<td>40/W/female</td>
<td>RA</td>
<td>1,2</td>
<td>63 mo</td>
<td>90/90</td>
<td>None</td>
<td>Patient had moderate pain for 6 mo</td>
</tr>
<tr>
<td>23</td>
<td>P. K.</td>
<td>43/F/female</td>
<td>RA</td>
<td>1</td>
<td>31 mo</td>
<td>90/90</td>
<td>Mild pain</td>
<td>Stylocarpal impingement</td>
</tr>
<tr>
<td>24</td>
<td>J. T.</td>
<td>72/W/female</td>
<td>RA</td>
<td>1,2,3,6</td>
<td>3 mo</td>
<td>60/60</td>
<td>Mild pain</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>W. C.</td>
<td>52/W/male</td>
<td>RA</td>
<td>1,2,3,6</td>
<td>6 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>B. C.</td>
<td>36/W/female</td>
<td>RA</td>
<td>1</td>
<td>8 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>B. McC.</td>
<td>44/W/female</td>
<td>RA</td>
<td>1</td>
<td>4 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

RA, rheumatoid arthritis; TFC, Triangular fibrocartilage.

Procedure: 1, hemiresection-interposition arthroplasty; 2, wrist synovectomy; 3, triangular fibrocartilage augmentation; 4, total wrist replacement; 5, repair extensors; 6, anchovy interposition; 7, wrist arthrodesis; 8, Milch ulnar shortening.

Posure over the ulnar aspect of the wrist. Wrist with more severe destruction (ulnocarpal descent and triangular fibrocartilage-ulnocarpal ligament disruption) were approached as a reconstructive operation. In these patients, retinacular flaps and distally based portions of ECU or FCU were used to recreate or augment the ulnocarpal ligaments and triangular fibrocartilage according to the requirements of each individual case. If the TFCC was not reconstructible, the HIT was abandoned and modified Darrach procedure was performed, often with a radiolunate fusion. These patients were not included in this study. Range of rotation in the 27 patients with arthritis averaged 80° of pronation and 75° of supination with 13 patients achieving and maintaining 90°/90° rotation. No patient complained of instability. There were no tendon ruptures after surgery. Four patients complained of mild pain at follow-up. Two of them had radiographic evidence of stylocarpal impingement. In retrospect, these two patients should have had an anchovy interposition as a modification to the basic operative procedure. In the remaining two, the cause of pain could not be determined. None of the four required treatment.

Unnocarpal impingement group. HIT should have been combined with ulnar shortening or anchovy interposition in the six patients (12.8% of the total) with an ulna that was too long and who also had painful ulnocarpal impingement and articulation of the distal radioulnar joint considered too incongruous for simple ulnar shortening. Where this combined procedure was
Table I. cont’d

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Patient</th>
<th>Age(yr)/race/sex</th>
<th>Problem(s)</th>
<th>Procedure(s)</th>
<th>Follow-up</th>
<th>Rotation (degrees)</th>
<th>Pain</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>L. H.</td>
<td>63/W/female</td>
<td>Settled Colles</td>
<td>1.8</td>
<td>3 mo</td>
<td>60/60</td>
<td>None</td>
<td>TFC intact at surgery; ulna fractured at surgery; healed uneventfully</td>
</tr>
<tr>
<td>29</td>
<td>G. R.</td>
<td>36/W/female</td>
<td>Early radial epiphyseal closure with ulnocarpal abutment syndrome</td>
<td>1.8</td>
<td>24 mo</td>
<td>90/90</td>
<td>None</td>
<td>TFC good on arthrogram and at surgery</td>
</tr>
<tr>
<td>30</td>
<td>J. F.</td>
<td>36/W/female</td>
<td>Severe ulnar plus secondary to Galeazzi fracture</td>
<td>1</td>
<td>6 mo</td>
<td>60/70</td>
<td>Mild pain</td>
<td>Stylocarpal impingement</td>
</tr>
<tr>
<td>31</td>
<td>J. C.</td>
<td>40/W/female</td>
<td>Settled Colles with ulnocarpal abutment syndrome</td>
<td>1 (8 at second procedure)</td>
<td>4 mo</td>
<td>90/90</td>
<td>Moderate pain*</td>
<td>Stylocarpal impingement later revised with Milch osteotomy; good result; no pain</td>
</tr>
<tr>
<td>32</td>
<td>T. D.</td>
<td>45/W/male</td>
<td>Settled Colles with ulnocarpal abutment and radioulnar arthrosis</td>
<td>1.8</td>
<td>12 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>D. W.</td>
<td>39/W/female</td>
<td>Radial shaft fracture, old Colles-radioulnar arthrosis</td>
<td>1, plate radius</td>
<td>24 mo</td>
<td>90/90</td>
<td>None</td>
<td>Ulnar head fracture; intra-articular</td>
</tr>
<tr>
<td>34</td>
<td>J. S.</td>
<td>38/W/male</td>
<td>Painful rotation after operation for radioulnar instability</td>
<td>1</td>
<td>6 mo</td>
<td>80/80</td>
<td>None</td>
<td>TFC good on arthrogram and at surgery</td>
</tr>
<tr>
<td>35</td>
<td>M. L.</td>
<td>25/W/female</td>
<td>Probable old perilunate dislocation, radioulnar pain</td>
<td>1 plus lunatetriquetral arthrodesis</td>
<td>12 mo</td>
<td>70/70</td>
<td>Mild pain*</td>
<td>TFC had central perforation; *pain resolved after pisiform excision</td>
</tr>
<tr>
<td>36</td>
<td>B. V.</td>
<td>42/W/male</td>
<td>Distal radioulnar arthrosis</td>
<td>1</td>
<td>26 mo</td>
<td>80/80</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>M. H.</td>
<td>28/W/male</td>
<td>Posttraumatic arthrosis</td>
<td>1.7</td>
<td>8 mo</td>
<td>90/90</td>
<td>None</td>
<td>Scaphoid nonunion</td>
</tr>
<tr>
<td>38</td>
<td>A. F.</td>
<td>28/W/female</td>
<td>Resolved infectious arthrosis</td>
<td>1.7</td>
<td>42 mo</td>
<td>90/90</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

done (four patients), all patients achieved painless stable rotation of 80° of pronation and 80° of supination. In the two patients on whom HIT was performed without ulnar shortening or anchovy interposition, stylocarpal impingement was present on the x-ray films, motion was 75° in pronation and 50° in supination, and both patients had mild pain on rotation. A second operation was done for one of these patients (case 31). After the ulna was shortened, pain resolved and a 90°/90° arc of motion was achieved.

Distal radioulnar joint arthritis. In five patients (16.2% of the total), the problem was an arthritic distal radioulnar joint. In these cases, HIT alone achieved relief of pain and excellent motion. Pronation averaged 83° and supination 83°, and no instability was reported. One patient with mild pain was later found to have pisotriquetral arthrosis that was relieved by injections into the joint. The patient underwent excision of the pisiform and her pain resolved.

Complications

In the entire study of 38 patients, six patients had pain after surgery. One patient’s pain was relieved by excising the pisiform. In the remaining five patients, pain could be attributed to stylocarpal impingement. One patient with moderate pain had excellent results after her ulna was shortened. Thus, the overall incidence of unresolved postoperative pain was 10.5%. In these four patients, pain was mild and none required treatment. I believe that this problem of stylocarpal impingement, which was present in all four patients, can now be anticipated and effectively prevented by
anchovy interposition or ulnar shortening during the original operation.

Discussion

Aristotle said, "Understanding the principle is more than one-half the problem solved." The anatomic fact that for ulnocarpal stability to exist, the ulnocarpal complex of the triangular fibrocartilage must function (or be reconstructible) has recently been understood. Dingman's observation that the best Darrach procedure has active osseous regeneration provided further support. It became obvious that the best way to provide stability is to never lose it. The continuity of the shaft/styloid/ulnocarpal ligament/carpal connection should not be interrupted. The benefits of the Darrach procedure in this context are provided by resection of the head alone. Technical variations in the procedure developed later. The advantages are: (1) the procedure is easily performed and anatomically sound; (2) recovery of motion is rapid and painless; and (3) exposure of the TFCC is excellent and allows many reconstructive options otherwise unavailable.

Follow-up in various applications has been adequate to demonstrate a late problem (stylocarpal impingement) and to resolve it (added interposition bulk). The procedure appears to be sufficiently useful to warrant its addition to the surgical management of the distal radioulnar joint and TFCC dysfunction.

REFERENCES