Limited arthrodesis for the rheumatoid wrist

Limited arthrodesis of the proximal carpal row to the radius, synovectomy of the extensor tendons and the wrist joint, and a Darrach procedure were carried out in 25 unstable and painful rheumatoid wrists that had ulnar shift and/or palmar subluxation of the carpus. The average follow-up period after the operation was 3 years. Satisfactory results were obtained with relief of pain, improved forearm rotation, and increased grip strength. The average degree of extension and flexion was reduced, respectively, 70% and 54% at follow-up compared with the preoperative range. Postoperative x-ray films showed deterioration in the lunocapitate joint in 12 wrists; however, the wrists remained stable and painless. (J HAND SURG 1992;17A:1103-9.)

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Synovectomy of the extensor tendons and the wrist joint with a Darrach procedure has been recommended for the treatment of rheumatoid patients when conservative management failed. The clinical results of this procedure were satisfactory. With time, however, palmar and ulnar subluxation of the carpus was observed.

Limited arthrodesis of the proximal carpal row to the radius for rheumatoid wrists has been reported by several authors. However, their follow-up period was short, and the indications for this procedure were not clearly presented. This article describes the clinical and x-ray indications for limited arthrodesis for the rheumatoid wrist with synovectomy of the extensor tendons and the wrist joint and with a Darrach procedure.

Materials and methods

The operation was performed on 25 wrists of 24 rheumatoid patients (21 women and 3 men) from June 1984 to June 1988. The average patient was 56 years of age (range, 35 to 73 years). The disease had been present an average of 9 years (range, 1 to 38 years). The average follow-up after the operation was 3 years (range, 2 to 6 years).

Preoperative x-ray changes were judged by Larsen's classification (Fig. 1). Five wrists were grade II, definite early abnormality; 10 were grade III, medium destructive abnormality; 10 were grade IV, severe destructive abnormality; and no wrists were considered to be grade I or V, normal or mutilating abnormality.
Surgery was performed in patients who had continuous pain and persistent synovitis for more than 6 months in spite of conservative treatment with medication, splints, and exercise. X-ray findings were also a factor in the decision to perform surgery: (1) x-ray changes between grade I and IV (2) the presence of a midcarpal joint space greater than 1 mm on the posteroanterior x-ray film, and (3) ulnar shift or palmar subluxation of the carpus on the radiocarpal joint measured by the techniques that follow.

The ulnar carpal shift ratio (e/MC) was measured from a posteroanterior x-ray film of the wrist in the neutral position. The normal value for e/MC is 0.085 ± 0.023 (mean ± SD), a ratio that is increased with the progression of ulnar carpal shift, as seen in Fig. 2.

The palmar carpal subluxation ratio (h/MC) was measured from a lateral x-ray film of the wrist in the neutral position. The normal h/MC ratio is 0.199 ± 0.024 (mean ± SD), a ratio that is increased with the progression of palmar carpal subluxation as seen in Fig. 2.

Normal values of e/MC and h/MC were obtained from a group of 25 normal wrists of 20 women and 5 men, whose ages were comparable to those of the patients whose wrists were operated on. Their average age was 57 years (range, 35 to 75). If the preoperative e/MC or h/MC was beyond the normal value of mean ± 2 SD (i.e., e/MC > 0.131 or h/MC > 0.247), we confirmed that it had ulnar shift or palmar subluxation of the carpus.

If all the clinical and x-ray conditions were present, limited arthrodesis between the radius and the proximal carpal row combined with a synovectomy of the extensor tendons and the wrist joint and with a Darrach procedure was the recommended treatment.

We performed 25 limited wrist arthrodeses, 16 radiolunate arthrodeses, and 9 radioscapholunate ar-
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Fig. 2. A, Measurement of ulnar carpal shift ratio (e/MC). As proposed by Youm et al., e is the distance from the rotation center of the wrist, which is located in the proximal vert of the capitate, to the radius. MC is the length of the long finger metacarpal. B, Measurement of palmar carpal subluxation ratio (h/MC). As proposed by Youm et al., h is the distance from the rotation center of the wrist located on the proximal border of the capitate in the midline to the dorsal cortex of the diaphysis of the radius.

arthrodeses. If the joint destruction was localized to the radiocarpate joint we fused the lunate to the radius, and if destruction extended to the radiocaphal joint the fusion was extended to include the scaphoid and the radius.

Additional operative procedures included reconstruction of ruptured extensor tendons in five wrists (two by extensor tendon transfer and three by free tendon graft). Flexible silicone hinge implant arthroplasty for three metacarpophalangeal joints was performed and arthrodeses for the metacarpophalangeal and interphalangeal joints of the thumb were performed.

Operative technique

Through a dorsal incision, a synovectomy of the extensor tendons and the wrist joint with a Darrach procedure was performed first.16-19 A distally based rectangular flap was made in the dorsal capsule to expose the radiocarpal and midcarpal joint. A synovectomy was performed, and the carpus, which was transposed either ulnaward or palmarward, was restored to its anatomic position and the lunate was placed in the lunate fossa. An arthrodesis of this joint was performed and fixed with Kirschner wires and staples. If bone grafting was needed, cancellous bone from the resected distal ulna was used. A short arm cast or an Orthoplast palmar splint (Johnson & Johnson, Raynham, Mass.) was applied for 3 to 4 weeks.

Results

Clinical assessment. Preoperative pain disappeared completely in 21 wrists (84%), and 4 wrists (16%) continued to have mild pain with wrist motion. In two cases postoperative pain was due to inappropriate positioning of the hardware; staples entered the midcarpal joint in one and the Kirschner wire caused painful lumps in subcutaneous tissue in the other. In the other two wrists, mild pain with motion was due to progression of the disease. Recurrence of swelling in the radial part of the radiocarpal joint was noted in one wrist.

The average extension decreased from 26 degrees to 18 degrees (70%), and flexion decreased from 38 degrees to 18 degrees (54%) postoperatively. The total arc of extension and flexion decreased from 20 degrees to 80 degrees preoperatively, to 0 to 60 degrees postoperatively (Fig. 3). Supination increased from 73 degrees to 85 degrees and pronation increased from 69 degrees to 76 degrees, presumably as a result of a Darrach procedure.

Preoperative grip strength was 80 ± 30 mm Hg (mean ± SD), which increased to 114 ± 46 mm Hg at follow-up (p < 0.05).

X-ray assessment. Twenty-one wrists showed a trabecular pattern with bone union (84%), three wrists (12%) had a fibrous union, and one wrist (4%) had a

Fig. 3. Distribution of total arc of extension and flexion of wrist before operation and at follow-up.
nonunion because of early displacement of the Kirschner wire.

The width of the lunocapitate joint was measured from serial postoperative posteroanterior x-ray films. If the joint space increased more than 2 mm, the wrist was placed in the widening group. If the joint space decreased to less than 1 mm, the wrist was assigned to the narrowing group. Others were placed in the “no change” group, and each group was evaluated according to the signs and symptoms seen on the clinical evaluation.

Widening was found in five wrists (20%); pain and recurrent swelling were not noted in this group (Figs. 4 and 5). The average extension decreased from 16 degrees to 14 degrees and flexion decreased from 28 degrees to 18 degrees.

Narrowing was found in seven wrists (28%), five of which had total wrist fusion at follow-up (Fig. 6). The fixed position of the wrists was neutral. One wrist had mild pain caused by postoperative flare-up disease.

Thirteen wrists (52%) were in the “no change” group (Fig. 7). Recurrence of swelling was noted in one wrist, and mild pain on motion was noted in three wrists. The average extension decreased from 30 degrees to 24 degrees, and flexion from 40 degrees to 24 degrees. The
Fig. 6. Radiolunate arthrodesis in 55-year-old woman. A, Preoperative x-ray film. B, Two and one half years later, total fusion occurred spontaneously in a functional position as a result of disuse. Limited fusion failed, but the patient was satisfied with the stable and painless wrist in spite of the loss of wrist motion.

Fig. 7. Radiolunate arthrodesis in 59-year-old woman. A, Preoperative x-ray film. B, Three years later, the lunocapitate joint was almost the same as preoperatively. This case was included in the "no change" group.

status of decreased range of motion in extension and flexion were similar to those in the widening group. Ulnar carpal shift and palmar carpal subluxation were measured within 1 year before surgery and on follow-up, which was an average of 3 years after surgery.

Preoperative e/MC was significantly higher than in the control group and decreased significantly on follow-up. It was found that the ulnar shift was reduced and fixed in a more satisfactory position (Table I).

Preoperative h/MC was significantly higher than in the control group and changed little on follow-up. However, further instability in the midcarpal joint did not occur in the lateral plane (Table I).

Discussion

Limited wrist arthrodeses have been performed in the wrist since O’Rahilly20 presented a comprehensive review of carpal and tarsal abnormalities. In 1971 Stack and Vaughan-Jackson32 described a wrist of a rheumatoid patient in whom ulnar drift of the fingers was prevented by spontaneous radiolunate fusion. In 1983 Chamay et al.16 observed spontaneous radiolunate fu-
Table 1. Comparison of ulnar carpal shift and palmar carpal subluxation ratios (mean ± SD)

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Control (n = 25)</th>
<th>Surgically treated wrists (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preoperative</td>
<td>Follow-up</td>
</tr>
<tr>
<td>Ulnar carpal shift</td>
<td>0.085 ± 0.023</td>
<td>0.158 ± 0.045*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.118 ± 0.046†</td>
</tr>
<tr>
<td>Palmar carpal subluxation</td>
<td>0.199 ± 0.024</td>
<td>0.254 ± 0.065*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.233 ± 0.057</td>
</tr>
</tbody>
</table>

*p < 0.01 compared to control.
†p < 0.01 compared to preoperative.

sion of a rheumatoid wrist, seen as beneficial to function, and, as a result, performed arthrodeses between the lunate and the radius in seven patients. In 1985 Linscheid and Dobyns\textsuperscript{11} reported satisfactory experience with radiolucent arthrodeses in 19 wrists, including trauma cases. Stanley and Boot\textsuperscript{12} observed that the procedure was helpful in the slowly progressive rheumatoid wrist with localized proximal carpal row disease. The results of this study show that although the postoperative changes in the lunocapitate joint occurred in half the wrists (48%), it did not cause any apparent functional trouble at follow-up evaluation.

Total wrist fusion occurred in five wrists (20%). However, these wrists were fixed in a functional position with an improvement in grip strength and forearm rotation. With the exception of one patient who had a progressive disease process, the patients were satisfied with the operation in spite of their loss of wrist motion. Widening of the lunocapitate joint occurred in 20% of the patients with resorption of the distal surface of the lunate and the proximal surface of the capitate. We attribute the widening to the mild synovitis caused by an increase in mechanical stress, but neither swelling nor instability was noticed in the “widened” joint.

Total wrist arthrodesis\textsuperscript{22-25} or implant arthroplasty\textsuperscript{26-33} had been recommended for treatment of the rheumatoid wrist. These procedures present problems, however, as total arthrodesis sacrifices the tenodesis effect of wrist motion, which decreases extrinsic muscle-tendon units from finger motion and power of pinch and grip. Wrist arthroplasty has the problem of loosening, breakage,\textsuperscript{29,33} and the more recently recognized silicone particle–induced synovitis.\textsuperscript{29,31}

To overcome these problems, limited arthrodesis is a safe procedure that produces a stable functional wrist. We recommend it for the moderately deteriorated rheumatoid wrist. If, however, control of the disease is judged to be too difficult to prevent carpal collapse or if the midcarpal joint has disappeared in the relatively early stage, total arthrodesis\textsuperscript{22-25} is recommended.

REFERENCES


Rheumatoid wrists treated with synovectomy of the extensor tendons and the wrist joint combined with a Darrach procedure

Forty-three rheumatoid wrists in 43 patients with bilateral wrist involvement were treated with synovectomy of the extensor tendons and wrist joint combined with a Darrach procedure in the period from 1966 to 1986. Clinical and radiologic assessment of the wrists was carried out after an average follow-up period of 11 years, with comparison of the treated and the opposite untreated wrists. The authors confirmed what others have concluded regarding the operation: pain was generally decreased, forearm rotation increased, and wrist extension and palmar flexion changed little. Radiologically, carpal collapse and palmar carpal subluxation progressed nearly parallel to the opposite wrists, but ulnar carpal shift was much greater in the surgically treated wrists. Therefore it is suggested that some measure to prevent ulnar carpal shift, such as Clayton’s tendon transfer or radiolunate arthrodesis, should be included in this operation. (J HAND SURG 1992;17A:1109-17.)

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The favorable effects of synovectomy of the extensor tendons and wrist joint combined with a Darrach procedure in the early stage of rheumatoid arthritis have been reported by a number of authors. However, the evaluations in the surgically treated wrists reported in previous articles have been made solely at a certain postoperative time, in spite of the assumption that changes may occur along the postoperative time span. Also, no comparison has been made with the untreated rheumatoid wrists. This study

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compares the clinical and radiologic course between the surgically treated and the opposite untreated wrists in the same patients and discusses the favorable and unfavorable effects of the operation and offers measures to prevent the latter.

Materials

During the period from 1966 to 1986 dorsal tenosynovectomy of the extensor tendons and the wrist joint combined with a Darrach procedure were performed in our Orthopaedic Department on 65 rheumatoid wrists of 54 patients with bilateral wrist involvement. For a comparative study between the treated and the untreated rheumatoid wrists, we selected 43 patients (35 women and 8 men) in whom the operation was performed in only one wrist. The indication for surgery was either persistent unilateral pain that lasted more than 6 months in spite of conservative treatment, significant disability, or tendon ruptures.

Ages of these 43 patients ranged from 23 to 71 years, with an average age of 44 years. Thirty-three wrists (77%) were operated on in patients between 30 years and 59 years of age. Duration of the disease before surgery ranged from 1 year to 20 years (an average of 7 years). Of 43 surgically treated wrists, 31 were on the dominant right side, and 12 were on the nondominant left side. Severity of the radiologic change in the affected wrists was evaluated with Larsen’s standard reference films. Of 43 wrists operated on, 11 (26%) were classified as grade I or II (i.e., with slight or definite early abnormality); 32 (74%) were grade III or IV (i.e., with medium or severe destructive abnormality). The postoperative follow-up period ranged from 4 to 22 years (average, 11 years).

As additional operative procedures in the 43 patients, reconstruction of ruptured extensor tendons was performed in 3 patients, synovectomy of the metacarpophalangeal or proximal interphalangeal joints in 3 patients, and synovectomy of the ipsilateral elbow joint with resection of the radial head in 2 patients.

Operative procedures

Operative procedures were performed according to the method of Tajima, which is as follows. A lazy S or straight oblique skin incision is made on the dorsum of the affected wrist, protecting veins and sensory branches of the ulnar and radial nerves. The extensor tendons are exposed proximal to the extensor retinaculum, which is split longitudinally at the ulnar border of the sixth dorsal compartment and raised as a radially based flap. A complete synovectomy of the extensor tendons is carried out, and the terminal branch of the posterior interosseous nerve is also resected.

A longitudinal capsular incision is made over the distal end of the ulna, which is exposed subperiosteally, and a transverse osteotomy is performed 1.5 cm proximal to the end, preserving any triangular fibrocartilage complex (TFCC) that is not destroyed. After a Darrach procedure, proliferated synovium in the radioulnar and the palmar aspect of the radiocarpal joint can be removed by manual distraction and radial deviation of the wrist joint. If the synovial proliferation is palpable beneath the dorsal capsule at the radiocarpal or intercarpal joints, a second capsular incision is made at the proliferated synovium is removed, with care taken not to injure the intercarpal and palmar ligaments.

To prevent dorsal subluxation of the distal ulna after a Darrach procedure, the pronator quadratus muscle is raised as a flap and sutured to the dorsal periosteum of the ulnar stump to create a dynamic palmar traction effect of the remaining ulna. Goldner and Hayes have suggested stabilization with a strip of extensor carpi ulnaris tendon passed through a drill hole in the ulna with the forearm in supination. Tsai and Stillwell have employed a distally based portion of flexor carpi ulnaris tendon to stabilize the ulna. We prefer to use the pronator quadratus as a stabilizer because of its simplicity.

The reflected extensor retinaculum is sutured back to the original position if the dorsal wrist capsule is preserved and provides wrist stability. If part of the dorsal capsule has to be removed with the proliferated synovium in the advanced stage, the extensor retinaculum is split transversely into two flaps and the wider distal flap is placed beneath the extensor tendons to reconstruct the dorsal capsule. The proximal flap is placed over the extensor tendons and looped around the extensor carpi ulnaris tendon to act as a sling to prevent anterior dislocation. Bleeding points are electrocauterated after the tourniquet is released, and a drain is inserted. A short arm cast or a palmar splint immobilizes the wrist for 3 to 4 weeks postoperatively, after which wrist exercises are begun.

Methods of assessment

The surgically treated wrists and the untreated wrists were assessed clinically and radiologically, and the results were compared. The data within 1 year before operation and the latest data after the operation were compared for the clinical assessment.

1. Pain and swelling. Spontaneous pain, motor pain, and tenderness were included in the category of pain, and each was classified as mild, moderate, or severe. Swelling was recorded as positive when elastic synovial proliferation with fluctuation was palpable on the wrist.

2. Range of motion (ROM)
   - Palmar flexion
   - Extension

3. Compensatory movements
   - Wrist movement
   - Scapulohumeral movement

4. Radiographic assessment
   - Changes in radiographs
   - Wrist alignment
   - Bone destruction
   - Collar of carpal bones

Average ages were calculated for each group.
Fig. 1. X-ray assessment of rheumatoid wrist. A, Measurement of carpal collapse ratio (c/MC) after Tremtham. The distance between the middle point of the base of the third metacarpal and the most ulnar border of the radius; MC, the length of the third metacarpal. B, Measurement of ulnar carpal shift ratio (e/MC). e, The perpendicular distance from the center of rotation proposed by Youm et al., which is located on the proximal one fourth of the capitale in the midline, to the extension of the midaxial line of the radius. C, Measurement of palmar carpal subluxation ratio (h/MC). h, The perpendicular distance from the rotation center of the carpus proposed by Youm et al., which is located on the middle point of the most proximal border of the capitale, to the extended line along the dorsal cortex of the radial diaphysis.

2. Range of motion. The degrees of wrist extension, palmar flexion, supination, and pronation were measured and recorded.

3. Complications. Incidence of infection, delayed wound healing, and repeated operation were recorded.

4. Radiologic assessment. The radiologic assessment was based on the serial x-ray films taken during the period from 2 years before the operation to 10 years after the operation.

Changes with passage of time were analyzed by three parameters: carpal collapse ratio (c/MC), ulnar carpal shift ratio (e/MC), and palmar carpal subluxation ratio (h/MC) (Figs. 1 and 2). The normal value of each parameter was obtained from 69 x-ray films of normal wrists in 60 female and 9 male subjects with an average age of 44 years (range, 15 to 75 years).

 Destruction of carpal bones was represented by the carpal collapse ratio (c/MC) (Fig. 1, A). This ratio increased as the carpal collapse progressed. Normal value of c/MC was 0.569 ± 0.039 (mean ± SD).

The ulnar carpal shift was measured by e/MC, with use of a posteroanterior x-ray film of the wrist in the neutral position (Fig. 1, B). This ratio increased as the ulnar carpal shift progressed. Normal value of e/MC was 0.092 ± 0.028 (mean ± SD).

The palmar carpal subluxation was measured with use of a lateral x-ray film of the wrist in neutral position (Fig. 1, C). This ratio increased as the palmar carpal subluxation progressed. Normal value of h/MC was 0.207 ± 0.030 (mean ± SD).

Throughout the postoperative period, spontaneous radiocarpal and/or midcarpal fusions were counted. Completion of fusion was judged by complete immobility at the fused part in the stress radiographs.

Results

Pain and swelling. In all the surgically treated wrists, moderate or severe pain with swelling was present preoperatively. At the time of follow-up, pain was
Fig. 2. X-ray films illustrating different patterns of rheumatoid wrist deterioration. A, Carpal collapse. B, Ulnar carpal shift. C, Palmar carpal subluxation.

Table I. Comparison of range of motion between the surgically treated and the opposite untreated wrists in the same patients (n = 43)

<table>
<thead>
<tr>
<th>Motion</th>
<th>Surgically treated* (degrees)</th>
<th>Untreated* (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preoperative</td>
<td>Follow-up</td>
</tr>
<tr>
<td>Extension</td>
<td>38 ± 19</td>
<td>41 ± 18</td>
</tr>
<tr>
<td>Flexion</td>
<td>27 ± 15</td>
<td>24 ± 15</td>
</tr>
<tr>
<td>Supination</td>
<td>75 ± 19</td>
<td>88 ± 9†</td>
</tr>
<tr>
<td>Pronation</td>
<td>69 ± 27</td>
<td>73 ± 13</td>
</tr>
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</table>

*Mean and standard deviation.  †p < 0.01.

Table II. Correlation between preoperative and postoperative ulnar carpal shift in the surgically treated and the opposite untreated wrists (n = 43)

<table>
<thead>
<tr>
<th>Preoperative</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulnar shift</td>
<td>No. of wrists</td>
</tr>
<tr>
<td>+</td>
<td>24</td>
</tr>
<tr>
<td>-</td>
<td>19</td>
</tr>
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Ulnar shift (+) = e/MC ≥ 0.12 (mean + SD in normal group).
Ulnar shift (-) = e/MC < 0.12.
Progression = preoperative e/MC + 0.028 (SD in normal group) ≥ follow-up e/MC.
No change = preoperative e/MC + 0.028 > follow-up e/MC.

In the untreated wrists, 11 (26%) had mild or moderate pain at the time of the operation in the opposite wrist, and in 8 (19%) the pain persisted until the time of follow-up. New pain appeared in 6 wrists; thus, 17 wrists (33%) had pain at long-term follow-up. Swelling was noted in 14 untreated wrists (33%) at the time of the operation; in 10 (23%) it persisted until follow-up. Later swelling appeared in 5 additional wrists; therefore, 15 wrists (35%) had swelling on follow-up.

Range of motion. In the surgically treated wrists, the degrees of extension and flexion of the wrist and pronation of the forearm changed little; however, the degree of supination increased significantly.

On the other hand, in the untreated wrists, the degree of extension and supination changed little; however, flexion and pronation decreased significantly (Table I).

Complications. No wound infection or delayed wound healing occurred. However, additional operative procedures were performed in four wrists (i.e., one total wrist fusion because of progressive instability due to recurrent synovitis and three procedures for reconstruction of ruptured extensor tendons).

Radiologic assessment. The carpal collapse rate decreased progressively in the treated as well as the untreated wrists. The rapidity of carpal collapse in the treated wrists:fig. Although the increase was significantly greater than in the untreated wrists (Fig. 3), the untreated wrists continued to increase at a faster rate than in the treated wrists. The following the...
Fig. 3. Comparison of carpal collapse ratio (c/MC) between the surgically treated and the untreated wrists. Shaded area shows the normal range (mean ± SD).

Fig. 4. Comparison of ulnar carpal shift ratio (e/MC) between the surgically treated and the untreated wrists. Shaded area shows the normal range (mean ± SD).

ized wrists was nearly parallel to that in the untreated wrists (Fig. 3).

Although ulnar carpal shift ratios in both the treated and untreated wrists gradually increased over time, it increased significantly more in the treated wrists than in the untreated wrists after more than 2 years following the operation ($p = 0.01$). This result proved that the operative procedure definitively accelerated the ulnar shift in comparison with the conservative treatment (Figs. 4 and 5). Regardless of whether ulnar shift existed preoperatively, it progressed postoperatively in more than half of the treated wrists (Table II).

Palmar carpal subluxation progressed to a certain degree in both the treated and the untreated wrists, but
no significant difference was found between the two groups (Fig. 6).

In the treated wrists, the spontaneous fusion rate in the radiocarpal joint increased from a preoperative 2% to a postoperative 35%, whereas in the untreated wrists it increased from 0 at the time of the operation to 9% at the time of follow-up. In the midcarpal joint, the increase was from 14% to 30%, the same in both the treated and the untreated wrists (Fig. 7). Once the fusion occurred in the radiocarpal joint, no more ulnar carpal shift took place, regardless of the condition of the midcarpal joint.

Both radiocarpal and midcarpal fusion occurred in one treated wrist and in two untreated wrists at the time of follow-up (Fig. 7). Three treated wrists and the same number of untreated wrists changed into the mutilated type.

Discussion

This follow-up study showed, from the clinical standpoint, that the operative procedure resulted in relief of pain, decrease in swelling, and long-lasting improvement in forearm rotation, even in advanced stages of rheumatoid arthritis. We believe that these results were
Fig. 6. Comparison of palmar carpal subluxation ratio (h/MC) between the surgically treated and the untreated wrists. Shaded area shows the normal range (mean ± SD).

Fig. 7. Comparison of incidence of spontaneous radiocarpal, midcarpal, or total fusion between the treated and the untreated wrists in the same patients (n = 43). MC, Midcarpal fusion; RC, radiocarpal fusion; total, fusion of both joints.

Thought about by two factors. One was the disappearance of active synovitis as a result of a thorough synovectomy, and the other was removal of an osteoarthritic and painful incongruity of the distal radioulnar joint after a Darrach procedure. The progressive joint destruction after synovectomy was probably associated with recurrence of synovitis or immunologic disorder in the periarticular bone, which induces osteoclast activation.20, 21

From the radiologic standpoint, the operative procedure showed only a disadvantage of accelerated ulnar carpal shift. We thought that the main factor in causing ulnar carpal shift was the deficiency of ulnar bony support after excision of the distal end of the ulna. This
caused ulnar shift more readily along the inclined slope of the articular surface of the radius.

Conversely, Black et al. and Newman pointed out that the ulnar shift of the proximal carpal row was related to the destructive disease process around the distal radius rather than to the Darrach procedure itself. Taleisnik emphasized that synovial destruction of the palmar ligaments at the insertion of the unocarpal complex caused ulnar carpal shift.

In relatively early cases, where some part of the TFCC was preserved, we sutured it with the dorsoulnar capsule to the ulnar border of the radius under sufficient tension to prevent ulnar carpal shift. However, this soft tissue reconstruction proved ineffective according to our follow-up study, which revealed the same degree of postoperative shift as that in the wrists without reconstruction of TFCC.

In the advanced stage of rheumatoid arthritis, when rheumatoid synovitis existed both within the wrist joint and around the extensor tendons, synovial proliferation frequently became continuous by breaking through the intervening capsule. Accordingly, some part of the degenerated capsule had to be removed with the proliferated synovium. In such cases, the dorsal capsule was reconstructed with use of the distal portion of the transversely split extensor retinaculum to prevent ulnar carpal shift. We applied a short-arm cast or a palmar splint for 3 to 4 weeks postoperatively. We thought this immobilization period was long enough to allow for capsular healing.

Acceleration of the ulnar carpal shift was prevented completely by spontaneous fusion between the radius and the proximal row postoperatively in 15 operated wrists (35%). Chamay et al. and Linscheid and Dobyns performed radioulnar arthrodesis to prevent ulnar carpal shift, and they reported that this was successful.

We confirmed that after synovectomy of the extensor tendons and the wrist joint combined with a Darrach procedure, pain was generally decreased, forearm rotation increased, and extension and flexion of the wrist changed little. Radiologically, carpal collapse and palmar carpal subluxation were nearly parallel in both groups, but ulnar carpal shift was much greater in the surgically treated wrists. Therefore, we thought that the wrist synovectomy in the early stage should be combined with any procedure that would more securely prevent ulnar carpal shift (e.g., Clayton and Felic’s tendon transfer). In synovectomy in the late stage, limited arthrodesis such as radioulnar arthrodesis would be necessary for further improvement in the result of operative treatment.

REFERENCES
Biomechanical characteristics of extensor tendon suture techniques

Despite their ease of exposure, extensor tendons can be difficult to handle and suture well. Compared with flexor repair, little is known about the various factors that affect the suturing of extensor tendons. The present study was designed to investigate several biomechanical parameters involved in extensor repair. All techniques studied shortened the tendon considerably and produced significant losses of flexion at the metacarpophalangeal and proximal interphalangeal joints. In addition, repairs achieved with all suture techniques were considerably weaker than those achieved when comparable techniques were used on flexor tendons. However, the Kleinert modification of the Bunnell technique provided the strongest sutures in extensor tendons, produced no gapping, caused the least worrisome loss of metacarpophalangeal and proximal interphalangeal flexion, and best approximated the results found in an idealized tendon-shortening model. (J HAND SURG 1992;17A:1117-23.)

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With the application of dynamic splinting to the postoperative treatment of extensor tendon repair, interest in the quality of results achieved after injury to these tendons has been renewed. Although dynamic splinting appears to improve results, all aspects of treatment, including intraoperative techniques, require similar scrutiny if the best result is to be achieved. The present study was designed to investigate several biomechanical parameters involved in extensor tendon repair, including (1) the strength and quality of several suture techniques when performed on extensors in zone VI (Fig. 1); (2) the degree of shortening pro-