MINI-SYMPOSIUM: SURGICAL RHEUMATOLOGY

(iv) The management of the rheumatoid wrist

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KEYWORDS
Rheumatoid Disease; Synovitis; Arthrodesis; Arthroplasty; Inflammatory wrist arthropathy; Surgical management; Classification systems

Summary
The wrist joint is often involved early in Rheumatoid arthritis (RA) and is regarded as one of the main targets of the disease. As the wrist plays a key role in the chain of the articulations in the upper extremity, treatment of this joint preserves the patient’s ability to work and to remain independent. When surgical therapy is considered, evaluation of the stage of the disease is as important as the type of rheumatoid involvement. This can be achieved by an extensive clinical and functional assessment of the whole extremity. Moreover, adequate understanding of the radiological findings helps to recognize the type of rheumatoid destruction, possible further development of the disease and its direct consequences on surgical decisions. Several classifications exist that describe the rheumatoid wrist involvement and present possible treatment algorithms.

The success of surgical management depends on a well-considered strategy in timing the different procedures. Prophylactic surgery may prevent further destruction and deformation. This includes synovectomy of the tendons in order to prevent attrition rupture, to avoid challenging tendon reconstruction. Together with synovectomy of the wrist, including the distal radio-ulnar joint, long-lasting pain relief can be observed. In later stages of the disease, it is the extent of destruction at the radiocarpal level which has great implications in reconstructive surgery. Possible options are partial joint fusion, combined with an ulnar head resection, total wrist fusion or wrist arthroplasty. In cases of severe destruction, however, definitive stabilization by total wrist fusion is indicated. A pain-free, stable wrist joint often outweighs the disadvantage of the lack of mobility.

Introduction
Rheumatoid arthritis (RA) is a life-long condition, and the disease activity might change over time. Therefore, an understanding of the pathomechanics and the possible course of the disease is important to provide an individualized management for every patient.

Usually, the wrist joint is involved early in the course of the disease and it is regarded as one of the main targets in RA. As the wrist plays a key role in the chain of articulations in the upper extremity, treatment of this joint preserves the patient’s ability to work and to remain independent.

When surgical therapy is considered, evaluation of the stage of the disease is equally as important as the type of rheumatoid involvement.
Natural course of the rheumatoid wrist

Wrist deformation

Three main factors play an important role in the pathologic process of wrist deformation: cartilage destruction, synovial proliferation and ligamentous laxity. The cartilaginous thinning is caused by cytochemical effects, with degradation and inhibition of new cartilage synthesis.\(^1\) The synovial expansion may cause bony erosion, particularly at the sites of vascular penetration of bone. These erosions cause sharp bony edges, which might lead to tendon rupture.\(^2\) In addition, synovial expansion causes stretching of the retaining extrinsic and intrinsic ligaments of the wrist, thus causing carpal supination and ulnar translation.\(^3\) Stretching of the scapholunate ligament results in scapholunate dissociation, whereas more global laxity and instability are responsible for ulnar translation.

Force application across the wrist is predominantly caused by muscles which act in palmar and ulnar directions. With ongoing destruction of the rheumatoid wrist, they lose their physiologic moment arms in relation to the centre of rotation and become a deforming force\(^3\) (Fig. 1). Paralleling the processes at the radiocarpal and midcarpal joints, the distal radioulnar joint undergoes pathologic changes, which were described by Backdahl\(^4\) and subsequently were called the \textit{caput ulnae syndrome} (Fig. 2).

The ulnar side of the wrist is often the first place of significant synovitis in the rheumatoid wrist. The long-term prognosis, however, is determined by progression of the disease at the radiocarpal level. Together with progressive ligamentous laxity, palmar subluxation of the carpus occurs. An associated supination of the carpus causes a luxation of the extensor carpi ulnaris (ECU), a major stabilizer of the ulnar side of the wrist and the distal ulna.
The wrist deformity pattern has an influence on the development of deformities of the distal aspects of the hand. Shapiro associated radial carpal supination together with palmar subluxation with ulnar phalangeal drift, ulnar carpal translocation with radial phalangeal deviation, and loss of carpal height with swan neck deformity of the fingers.

**Involvement of the soft tissues around the wrist**

Soft tissue involvement around the wrist is common. However, tenosynovitis and, as an end stage, impending tendon rupture, may be the most important indication for surgery. Since reconstruction of ruptured tendons is usually very challenging, it is of prime importance to prevent attrition rupture by early surgical intervention.

**Flexor tendons**

Tenosynovitis of the flexor tendons at wrist level may cause locking, limitation of motion, nerve compression and, in the worst case, rupture of tendons. Early clinical signs include localized pain, morning stiffness, triggering of single digits, and nocturnal paresthesia due to carpal tunnel syndrome (CTS). In rheumatoid patients, flexor tendon involvement seems to correlate with higher disease activity. Gray and Gottlieb observed a significantly higher prevalence of rheumatoid nodules, CTS, wrist extensor synovitis, and elbow epicondylitis in patients with active flexor tendon inflammation.

Rupture of the flexor tendons is significantly less frequent than of the extensor tendon in RA. The main mechanisms of tendon destruction are invasion of the tendon by the inflammatory synovial mass, attrition on prominent bony spurs, or a combination of both. Owing to its anatomic localization near the scaphoid, the flexor pollicis longus (FPL) tendon, followed by the profundus to the index finger, is the most common flexor tendon to rupture. It is not only contact with a bony spur but also the carpal instability in advanced wrist destruction that might cause tendon attrition. Although FPL and also index profundus ruptures often cause little disability in rheumatoid patients, surgery is warranted to prevent further tendon ruptures.

The incidence of compression neuropathy in patients who have RA is high. CTS in association with flexor tenosynovitis is observed in as many as 60% of the patients.

**Extensor tendons**

Extensor tenosynovitis often presents as a painless soft tissue mass at the dorsum of the wrist in the region of the retinaculum or, more frequently, distal to it. Pain related to pathology of extensor tendons, unlike the flexor tendons, is unusual; in these cases, underlying wrist pathologies must be excluded.

The extent of synovial mass in the extensor compartments does not correlate with the degree of tendon damage, and prediction of possible ruptures is difficult, even when magnetic resonance imaging (MRI) is used. Rupture of an extensor tendon might be the end of a process of synovial infiltration, attrition on bony prominences, and ischemia (Fig. 3). Dorsal dislocation of the ulna and persistent tenosynovitis of more than 6 months are additional risk factors. Owing to its anatomical course, the tendon of the extensor digiti minimi ruptures first. This rupture might be clinically silent, because the extensor digitorum communis extends all four fingers. Therefore, patients must be checked for independent little finger extension.

![Figure 3](image_url)

*Figure 3* Intraoperative finding of multiple extensor ruptures. The appearance of the tendon ends suggest an attrition mechanism.
Evaluation of the rheumatoid wrist

Clinical examination

Physical examination should always include the whole chain of articulations within the limb to be treated. Bad function of the elbow and the shoulder joint might endanger the result of interventions at the level of the hand. When assessing the function of the upper extremity, the following parameters should be checked:

- Localized swelling and tenderness; the extent and the exact anatomic localization should be noted.
- The degree and location of any deformity should be checked; the degree to which the deformity is actively or passively correctable should be distinguished.
- The range of motion, using a goniometer, should be recorded according to the neutral-zero method; at the level of the hand, all joints should be measured, regardless of the planned site of intervention.
- The examination of the wrist differentiates between the radiocarpal, midcarpal, and distal radioulnar joints.
- Often due to marked deformity or pain, or both, the classic instability signs in the wrist might be difficult to check; do not hurt the patient more than necessary during the examination.
- Check for tendon continuity; especially important tendons at wrist level are the radial-sided extensors. Independent function of the superficial and deep flexors must be controlled as well as independent function of the two extensors in the second and fifth digits.
- Compression neuropathy, especially carpal and cubital tunnel syndrome, should be looked for.
- If applicable, strength measurement should be performed; grip strength and key pinch are recorded, using a Jamar dynamometer or a vigorimeter.

Radiological examination

The type and extent of destruction in the wrist are best seen in conventional radiographs, which should always be taken in at least two different planes, preferably anteroposterior and true lateral views. Radiographs repeated at fixed intervals show the evolution of destruction over time and help to optimize the surgical treatment strategy.

When considering surgical therapy of the rheumatoid wrist, it is mandatory to know the type of rheumatoid destruction. Especially in early disease, recognizing the type of disease, will facilitate the choice of procedure for the individual patient.

In order to address the possible future evolution of the disease and its direct consequences on surgical decisions, Simmen and Huber, proposed a classification of rheumatoid wrist involvement based on a radiologic long-term analysis (Table 1 and Figs. 4–7). The Schulthess classification of rheumatoid wrist involvement is integrated into the universal wrist classification of Stanley, Lluch, Simmen and Herren (Table 3).

| Table 1 Simmen classification of the rheumatoid wrist involvement. |
|-------------------|---------------------------|
| Ranking | Operation |
| Type 1 | Spontaneous tendency for ankylosis |
| Type 2 | Osteoarthritic destruction pattern relatively stable over time |
| Type 3 | Disintegration with progressive destruction and loss of alignment |
| 3A | Ligamentous destabilization |
| 3B | Bony destabilization |

Computed tomography and magnetic resonance imaging

Computed tomography (CT) and MRI are rarely indicated in the evaluation of a rheumatoid wrist. There is limited additional information that these examinations could provide. For the following conditions, CT or MRI examination might be considered:

- Staging of synovitis (MRI)
- Identifying of tendon ruptures (MRI)
- Monitoring disease activity (MRI)
- Evaluation of the distal radioulnar joint (CT)

Sonography

High-resolution sonography is becoming a more and more popular diagnostic tool as experienced examiners achieve precise detection of erosions and synovitis with a high intra- and interobserver reliability.

Functional assessment of the rheumatoid wrist and hand

To evaluate the pre-therapeutic state of the hand, disease progression, and outcome of treatment, specific assessment tools of wrist and hand function are needed. In patients with RA, not only improvement of single function parameters but also general improvement of health status and quality of life should be measured in a standardized manner. Three different approaches to assess the extent to which the hand is affected might be differentiated:

1. Description of the anatomic deviation and disorders. This can be done by measuring with a goniometer, using photographic documentation or video-based image analysis.
2. Measurement of functional deterioration. Several tests have been described to evaluate hand function in complex deformity patterns.
3. Assessment of disability. Different tools, usually self-administered questionnaires, exist to measure disability related to the wrist (patient-rated wrist evaluation questionnaire), to the hand (Michigan hand outcomes...
Surgical management of the rheumatoid wrist

Timing of the surgery

The success of surgical reconstruction depends on a well-considered strategy in timing the different procedures. Souter defined general rules when choosing priorities in the surgical sequence of rheumatoid patients:

- lower limb before upper limb;
- from proximal to distal;
- painful joints first;
- prophylaxis versus reconstruction versus salvage;
- consider combinations: hand and foot, elbow and wrist, wrist and metacarpophalangeal joints; and
- start with a winner operation.

In addition, Souter also established a ranking system of operations: based on the parameters of elimination of pain, improvement of function, preventive value, cosmetic improvement, and hazard of complications, the possible operations are ranked according to their order. Table 2 lists the corresponding procedures at the level of the hand and wrist.

However, indications for surgical procedure might be influenced by multiple factors: concomitant musculoskeletal involvement, the general health condition, disease activity, patient’s needs and desires, compliance, social and medical environment. Therefore, a careful analysis of the needs during rehabilitation is important before a surgical procedure is proposed.

Classification and treatment algorithm of the rheumatoid wrist

A treatment algorithm will always generate controversy. A disease, such as RA, with so many different faces, may profit from classification. Besides typing and staging wrist involvement in RA, the distribution of certain categories should describe surgical consequences. The classifications that are presented in Tables 3 and 4 are based on the observations of experienced RA surgeons and summarize the ideas of Stanley, Lucht, and Simmen.
Prophylactic surgery

Two main goals can be achieved when undertaking prophylactic surgery. Firstly, it may stop or, at least, retard the disease process. Secondly, and even more importantly prophylactic surgery may prevent complications that could have otherwise occurred.

Synovectomy of the wrist joint

Wrist synovectomy may not be indicated in every situation. Rheumatoid wrists classified as type 1 (ankylosis) and type 2 (arthritic) may qualify for this procedure, whereas in type 3 wrists (destabilization) bony stabilization is needed in addition to the synovectomy.

The removal of synovitis decreases the pressure in the joint and may have some sort of prophylactic effect before the synovial mass has stretched the retaining structures. In addition, some denervation effect is supposed. The main effect of synovectomy is pain relief but often at the expense of some wrist motion, especially in flexion. To diminish this problem, arthroscopic synovectomy might be considered in selected cases of localized synovitis if no extensor tendon or distal ulna treatment is needed.

In general, the indications for carpal synovectomy include:

- persistent synovitis that does not respond to adequate medication for more than 6 months;
- persistent pain and local tenderness without major bone deformity; and
- treatment in combination with dorsal tenosynovectomy or treatment of the distal ulna, or both.

Synovectomy of the extensor and flexor tendons

Indications for extensor tendon synovectomy are similar to those for wrist synovectomy: persistent, even painless, swelling in the extensor compartment after adequate medical treatment is an indication for surgical intervention.

There are two main indications for isolated flexor tendon synovectomy. First is CTS, often combined with excision of bony spurs and synovectomy. Secondly, in a case of tendon rupture, excision of bony spurs is almost mandatory to prevent further tendon damage. A combination of dorsal wrist surgery and decompression of the carpal tunnel is possible, because there are no special rehabilitation requirements after flexor synovectomy.
The treatment of the distal radioulnar joint has, besides functional and therefore reconstructive aspects, a significant prophylactic importance. It is a frequent target of RA destruction. According to Resnick, synovial proliferation is observed in three areas of the distal radioulnar joint: distal to the ulnar head, in the prestyloid recess, and in the recess of the ECU tendon. This is important to recognize when a synovectomy of the radioulnar joint is performed. The damage of synovitis is related to the duration and degree of inflammation, as well as the mechanical stress imposed on the anatomical structure.

The synovitis invades the triangular fibrocartilage complex and the palmar and dorsal radioulnar ligaments, resulting in destabilization of the distal radioulnar joint. Synovial infiltration of the ECU tendon provokes a palmar subluxation of the tendon with further instability. Parallel processes at the dorsal lip of the sigmoid notch enhance this situation. The classic caput ulnae syndrome, as described by Backdahl, is an end stage of this destructive process and presents with a characteristic dorsal prominence of the distal ulna in combination with the local bulge of the synovia and even signs of tendon rupture. Forearm rotation is markedly reduced and painful. Instability of the distal radioulnar joint may produce a painful clicking in supination/pronation.

Deformity alone is not necessarily an indication for surgery. Often, a combination of pain and functional impairment, together with the need to prevent further damage, provide the indication for a surgical procedure. A more aggressive approach is required in cases of tendon rupture to prevent further damage.

The basic principle of the surgical correction of the distal radioulnar joint in RA includes:

- Joint and tendon synovectomy
- Partial or total resection of the ulnar head
Stabilization of the ulnar stump
Stabilization of the radiocarpal joint if needed

In early cases, and most often in younger patients, with limited destruction, there may be an indication for joint and tendon synovectomy only. In the majority of cases, the distal ulna has to be addressed by complete or partial resection or by fusion of the distal radioulnar joint. General results of the combined approach with synovectomy and ulnar head resection are consistent with good to excellent pain relief and a minimal incidence of recurrent synovitis and symptomatic distal ulnar stump instability. However, critical analysis, especially of higher-demand patients, shows a significant rate of failures and unsatisfactory results, such as instability of the distal ulnar stump and a significant increase in ulnar wrist translocation. To overcome these problems, different variations of ulnar head resection, such as the Bower’s hemiresection-interposition arthroplasty or the matched ulnar resection according to Watson et al., were also proposed for the rheumatoid wrist. These techniques have the advantage of leaving some of the stabilizing structures of the ulnar side of the wrist, although a correction of the carpal subluxation and a complete stabilization of the distal radioulnar joint are difficult to achieve.

Greater popularity, especially among European surgeons, has been noted for the Sauve–Kapandji procedure in which the distal ulnar stump is fused more proximally to the radius with an ulnar pseudarthrosis. This procedure preserves the stabilizing elements on the ulnar aspects of the wrist. Several series reported good results for rheumatoid conditions, although unstable distal ulnar stumps are also reported. Different procedures were proposed to prevent or to correct this ulnar stump instability. The most popular are stabilization slings from the ECU or the flexor carpi ulnaris or pronator quadratus interposition transfer. Because most distal ulnar stumps tend to be dorsally dislocated, it makes more sense to use a flexor carpi ulnaris tenodesis. In addition, once ulnar translation starts,

Figure 7 Type 3B (bony unstable) rheumatoid wrist with complete bony destruction, loss of bone stock, and dislocation of the carpus.
it is unlikely that this process can be stopped by a Sauve–Kapandji operation. These cases need stabilization on the level of the radiocarpal joint.

Another method of treating a destroyed distal radioulnar joint is ulnar head replacement. It was first described by Swanson, who used a silicone cap for better stabilization of the ulnar side of the wrist. Several studies proved unsatisfactory results in the long-term with these implants and, therefore, this technique is no longer recommended. Subsequently, different implants have been developed as a more constrained articulation with two components or as a simpler replacement of the distal ulna with a ceramic head. These implants were primarily developed as salvage for recurrent instability after failed surgery at the distal ulna. Their long-term results will determine if more generous indications can be justified.

It is important to keep in mind that it is not possible to stabilize the radiocarpal joint by reconstruction of the ulnar aspect of the wrist. Furthermore, the long-term prognosis of the wrist is dependent on radiocarpal integrity.

### Reconstructive surgery

#### Partial fusion

The expected natural course of disease at radiocarpal level has great implications for the decision regarding which surgical procedure should be performed. Type 1 and 2 wrists, according to the Simmen classification, have low probability of undergoing radiocarpal dislocation. Therefore surgical treatment, including the aforementioned wrist and tendon synovectomy and usually ulnar head resection, gives satisfactory long-term results.

In contrast, type 3 wrists, because of ligamentous or bony destruction, or both, require a procedure that provides realignment and stability. In the later stages of the disease, an original type 2 wrist, which is considered stable, might undergo significant carpal collapse and may begin to mimic type 3 (unstable) evolution. Partial fusion of the rheumatoid wrist in the early stages, is a prophylactic procedure. In an established deformation pattern, reconstruction may be necessary.

The concept of partial fusion in rheumatoid wrists was first described by Chamay et al. and later by Linscheid and Dobyns. It includes the realignment of the subluxed carpus by reduction of the proximal carpal row combined with long-term stability. In cases of excessive radiocarpal damage, the concept of limited wrist fusion might be expanded to a radioscapulohumate fusion.

A review of the literature shows good clinical results and high patient satisfaction for limited wrist fusion in rheumatoid patients. The range of motion varies postoperatively but, on average, is reported to be in the functional range, because of ligamentous or bony destruction, or both. This should be noted, however, that most series observed deterioration over time with ongoing destruction of the wrist.

Advanced disease stages and already destabilized wrists should therefore be treated by total wrist fusion.

Because radiolunate fusion provides stability on the ulnar side of the wrist, it is usually combined with an ulnar head resection. It is possible to perform radiolunate fusion together with a Sauve–Kapandji procedure (Fig. 8). Although there may be a theoretical advantage to that approach, no series has shown superior results so far. However, this combined procedure preserves the contour of the ulnar head and therefore might benefit in a cosmetic sense.

### Total wrist fusion

There is an ongoing debate on whether to fuse a destroyed rheumatoid wrist or perform a radiocarpal arthroplasty. Despite the good clinical results of complex wrist arthroplasty, the complication rate remains high. In addition,
wrist arthroplasty requires good bone stock and a reason-
able, or reconstructible, tendon balance, two conditions
that are rarely present in advanced rheumatoid destruction.

Silicon wrist spacers offer an alternative, although they are
only recommended by most investigators in low-demand
patients.39

Most wrists with advanced rheumatoid disease require
definitive stabilization by total wrist fusion. The advantage
of a pain-free, fusion of the wrist joint often out-weighs the
disadvantage of lack of mobility.38,41,42 Bilateral wrist fusion
is still a subject of controversy,38 and most patients would
personally prefer to have at least one mobile wrist.
However, personal experience and the publication of
Rayan43 show patients with a high degree of acceptance
even for bilateral fusion.

Two main concerns dominate the discussion that sur-
rounds wrist arthrodesis: the position of fusion and the
surgical technique to obtain secure and stable fixation. For
most activities of daily living a functional range of motion
requires 10° of flexion and 35° of extension.44 By analyzing
different tasks, activities concerning personal care and
hygiene were found to be performed in slightly flexed wrist
positions. However, besides overall function, wrist position
seems to affect grip strength. Flexed wrist posture is
associated with decrease of grip strength, whereas there is
no difference in strength between neutral (0°) and an
extended fusion position.45 In patients who have RA,
associated elbow and shoulder disease, as well as bilateral
hand involvement have to be taken into consideration when
choosing the ideal arthrodesis position. Lateral deviation
affects the position and the function of the fingers,
especially with coexisting ulnar drift at the metacarpophalangeal (MCP) joint level. Five to ten degrees of ulnar deviation are needed to counterbalance an ulnar drift of the fingers.3,23 Most investigators prefer a neutral flexion–extension position with mild ulnar deviation for wrist fusion in rheumatoid patients.43 In most cases, a neutral or slightly flexed position for the dominant hand, to facilitate personal care, and a slightly extended position for the nondominant hand combined with 5–10° of ulnar deviation are chosen.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Treatment options according to the type and the stage of the disease in the wrist.</th>
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<tbody>
<tr>
<td>Disease type</td>
<td>Stage of disease</td>
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<tr>
<td>A. Destructive</td>
<td>Synovectomy, soft tissue balancing ± ulnar head surgery</td>
</tr>
<tr>
<td>B. Reactive</td>
<td>Synovectomy, soft tissue balancing ± ulnar head surgery</td>
</tr>
<tr>
<td>C. Ligamentous</td>
<td>R(S)L fusion + ulnar head surgery</td>
</tr>
<tr>
<td>D. Mutilans</td>
<td>Synovectomy, soft tissue balancing ± ulnar head surgery</td>
</tr>
<tr>
<td>E. Juvenile</td>
<td>Synovectomy, soft tissue balancing ± ulnar head surgery</td>
</tr>
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R(S)L, radio(scapho)lunate fusion; TWR, total wrist replacement.

Figure 8 Combined radiolunate fusion and Sauve–Kapandji procedure.
Different fixation methods for wrist fusion have been described in the literature. Since the first description by Clayton in 1965, which was later popularized by Mannerfelt and Malmsten, different investigators have favoured the Rush or Steinmann pin technique in the original method or with slight modifications. There are some reports of radiocarpal fusion using bone grafts with or without absorbable internal fixation. Bone grafting alone had a longer time to fusion than a combination of bone grafting and internal fixation. As an alternative to the pin technique, plate fixation for wrist fusion is popular, especially in posttraumatic conditions (Fig. 9). A comparison between plate and pin fusion techniques in rheumatoid patients showed no significant difference in the clinical results or in the complication rate. However, pin fixation has some significant advantages over the plate fixation in RA. RA is more frequent in women, who, with small wrist sizes, cannot always accommodate the plate, which is often too bulky to be applied. In addition, the soft tissue and skin condition may not be ideal to cover a plate adequately and, most often, secondary removal of the implant is needed. In severe RA, bone quality might be so poor that no screw

**Figure 9** (A) Complete dislocation of a rheumatoid wrist type 3. (B) Final radiograph after completed Rush pin and staple augmentation total wrist fusion.

**Figure 10** Radiolunate fusion with a 2 mm condylar plate. Despite good initial reposition, there was redislocation of the carpus back to initial deformity. Subjectively, there was no pain, and no revision was needed.
fixation is possible. Rheumatoid patients also have a high fusion rate that tends to require less rigid fixation than osteoarthritic patients. Lastly, pin osteosynthesis is clearly less costly.

Tendon reconstruction

**Extensor tendon reconstruction:** As outlined above, rupture of extensor tendons is the final stage of a complex pathomechanical process. The best treatment of tendon rupture is prevention by early aggressive treatment of the distal radioulnar joint and the accompanying tenosynovitis. It is mandatory, when planning extensor tendon reconstruction, to assess wrist and MCP joint function. Any wrist correction or treatment of MCP joint dysfunction, or both, should be best performed together with tendon reconstruction. No tendon reconstruction can mobilize a subluxed MCP joint, and a secondary procedure that consists of MCP joint reconstruction and extensor tenolysis may not give satisfactory results. If there is any doubt about MCP joint function, traction on the distal ends of the tendons for reconstruction demonstrates the quality of MCP joint extension ability. If needed, subluxed extensor tendons should be recentered over the MCP joints at the same time that the extensor reconstruction is performed.

Direct end-to-end repair of ruptured tendon in rheumatoid patients is almost never feasible. The long-standing process of tendon attrition creates a wide zone of destruction within the tendon. Therefore, the most frequently used techniques for extensor tendon repair are tendon transfer and, in selected cases, tendon reconstruction with a free tendon graft. With two sites of suture lines, the free tendon graft has the disadvantage of greater possibility of adherence, although Bora et al. reported no differences between free tendon grafts and tendon transfers. As free tendon grafts, the palmaris longus tendon or, in cases of wrist fusion, a graft from the radial wrist extensors might be used. The use of toe extensor tendons in RA must be carefully undertaken to avoid secondary morbidity.

Tendon transfers might be performed as end-to-side transfers or an end-to-end reconstruction. Table 5 gives an overview of possible transfers for the different rupture scenarios.

The best tendon for transfer is the extensor indicis proprius (EIP) tendon, followed by the flexor superficialis of the ring or middle fingers. The use of wrist extensor tendons is not advised because the excursion of the wrist motors is significantly less than that of the finger extensor tendons, thus producing incomplete motion. The prognosis of tendon reconstruction is best in single or double tendon rupture, whereas the treatment of multiple ruptures is considered as a salvage procedure. The rupture of the extensor tendons to the thumb is often an isolated event, which is best treated with a transfer of the EIP to the extensor pollicis longus tendon.

**Flexor tendon reconstruction:** As outlined before, the flexor tendon that ruptures most commonly in RA is the FPL, followed by the profundus tendon of the index finger. Rupture of flexor tendons in the region of the finger pulleys is rare, and most flexor tendons rupture in the carpal canal. Principally, this is a good zone for safe flexor tendon reconstruction with minimal danger of postoperative adhesions. In cases of flexor tendon rupture, an excision of bony spurs is mandatory to prevent further ruptures. Before surgery and possible tendon reconstruction, the following points should be clarified:

- How much functional loss does the patient have with the ruptures?
- What is the general condition of the wrist and finger joints?
- Is the patient suitable for what might be a long rehabilitation process with an unpredictable result?

As an alternative to tendon reconstruction, interphalangeal joint fusion, especially in arthritic joints, may be indicated as there are far fewer rehabilitation difficulties. If there is an indication for flexor tendon reconstruction, the following principles are important:

- Isolated FPL ruptures are reconstructed with a transfer of a superficialis tendon, preferably from the ring finger, depending on the conditions of the other tendons.
- Ruptures of profundus tendons are best treated by an end-to-side tenodesis with an intact adjacent profundus tendon.
- In cases of rupture of the profundus and superficialis tendons in one finger, a tendon transfer from an intact superficialis is performed.
- Some investigators have recommended bridge grafts; others prefer tendon transfers.
- Isolated superficialis tendon ruptures, which are rare, need no reconstruction.

### Table 5

<table>
<thead>
<tr>
<th>Ruptured tendons</th>
<th>Transfer</th>
<th>Alternatives</th>
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<tbody>
<tr>
<td>EDM</td>
<td>EDM to EDC V</td>
<td>No treatment</td>
</tr>
<tr>
<td>EDM, EDC V</td>
<td>EDM V to EDC IV</td>
<td>EDC V to EDC IV</td>
</tr>
<tr>
<td>EDM, EDC V, EDC IV</td>
<td>EIP to EDC (+EDC V)</td>
<td>EIP to EDM</td>
</tr>
<tr>
<td>EDM, EDC V, EDC IV</td>
<td>EIP to EDC IV and V</td>
<td>Flexor digitorum</td>
</tr>
<tr>
<td>EDC III</td>
<td>EDC III to EDC II</td>
<td>Superficialis IV to EDC IV and V</td>
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<td>EIP to EDC III</td>
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EDC, extensor digitorum communis; EDM, extensor digiti minimi; EIP, extensor indicis proprius.
expected, and there is no space for experimental procedures. In the wrist, resection interposition arthroplasty might be considered a salvage procedure together with silicone wrist replacement.

**Conclusion**

Knowing the natural course of rheumatoid wrist involvement is mandatory if one is to provide RA patients with the best possible surgical treatment. Treatment of soft tissue involvement is as important as bony reconstruction. Early surgical intervention may prevent tendon rupture.

Although the indications for surgery arise more often from ulnar wrist involvement, the long-term prognosis depends on the course of the radiocarpal joint. For the treatment of the distal ulnar joint, ulnar head resection combined with dorsal tenosynovectomy may be advised for elderly and less-demanding patients. The Sauve–Kapandji procedure, perhaps combined with a flexor carpi ulnaris tenodesis or a pronator transposition, may be preferred in the younger, more demanding RA patient.

Depending on the type of rheumatoid wrist involvement, a destabilized wrist needs additional fixation of the radiocarpal joint in the early stages. In patients with unsalvageable, functionally unacceptable, recurrent instability of the distal ulna, an ulnar head prosthesis may be considered.

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**References**