The correct surgical treatment of the rheumatoid wrist has an important impact on the function of the affected hand. Surgical decisions should be based on individual deformity and potential progression of the disease. A classification of rheumatoid wrist involvement is presented that considers the natural progression of the disease and helps to optimize the treatment of these patients. If a destabilizing form of destruction is found, limited or complete wrist fusion is often the treatment of choice. Among partial fusions, the radiolunate arthrodesis gives consistent, good clinical results. It preserves some wrist motion with realignment of the carpus and stabilization to prevent further dislocation. In cases of severe destruction and deformity, complete wrist fusion, preferably performed by using large-pin technique, gives pain-free long-term stability of the wrist.

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The wrist is one of the main targets of rheumatoid arthritis.1-2 The classic pattern of deformity and destruction shows involvement of the radiocarpal and the radioulnar joint with destabilization of the carpus caused by attenuation of the extrinsic wrist ligaments, resulting in an ulnar translation of the wrist. With ongoing disease, a radial deviation and carpal supination is observed.3-5 Although considered a uniform systemic disease of immunogenetic background,6 the patients show various courses of this disease, especially at the wrist level. The recognition of the pattern of progression may have implications on the management and on the surgical treatment of these patients. Most currently used classifications of wrist deformity highlight the actual destruction of the carpal joints but do not include the different possible patterns of progression.7-9 For optimal surgical treatment of rheumatoid wrists, it is mandatory to recognize the type of destruction pattern at early stages of the disease. Based on radiologic long-term analysis, Simmen and Huber10 and Flury et al11 proposed a new classification of rheumatoid wrist involvement considering the type of destruction in relation to the possible future development of the disease with direct consequences for surgical decisions. Three patterns of destruction are distinguished, based on the morphology of destruction and the course over the duration of the disease. Serial radiographs allow the classification into either type I, II, or III wrists. Type I rheumatoid wrists show a spontaneous tendency for ankylosis (Fig 1), type II wrists show a destruction pattern that resembles the osteoarthritic wrist with changes remaining relatively...
stable over time (Fig 2), and type III wrists show a disintegration with progressive destruction and loss of alignment. Type III is further subdivided into type IIIa with more ligamentous destabilization (Fig 3), and type IIIb that shows bony destruction resulting in complete loss of the carpal architecture (Fig 4). The classification into the different types is based on serial radiographs with measurement of carpal height ratio and ulnar translation. A change in the carpal height ratio of more than 0.015 and/or an increase of ulnar translation of more than 1.5 mm per year classifies a wrist in the type III category.

Type I and II wrists have a low probability of undergoing radiocarpal dislocation. Therefore, surgical treatment including wrist and tendon synovec-tomy, and usually ulnar head resection, gives satisfactory long-term results. In contrast, type III wrists, because of ligamentous and/or bony destruction, require a procedure that provides both realignment and stability.

It is important to classify the wrist as early as possible in the course of the disease. It is easier to distinguish the different forms if the destruction is not too advanced. For example, in latter stages of the disease, an original type II wrist might undergo significant carpal collapse and begin to mimic a type III evolution of disease.

The concept of partial fusion in rheumatoid wrists was first described by Chamay and later by Linscheid and Dobyns. Chamay applied his observation of spontaneous radiolunate fusion with preserved functional range of motion (ROM) and long-term stability.
the treatment of rheumatoid deformities. The idea of limited fusion in the rheumatoid wrist 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 radioscapholunate fusion. Review of the literature shows good clinical results and high patient satisfaction for limited wrist fusions in rheumatoid patients. The ROM postoperatively varies but, on average, is reported to be in a functional range with 50° to 90° flexion/extension and 10° to 30° ulnar/radial deviation. It should be noted, however, that most series observed deterioration over time with ongoing destruction of the wrist (Fig 5). The long-term results are highly dependent on the type of destruction and the natural course of the disease. We recommend that an advanced disease stage, especially an advanced type III (destabilized) wrist, should rather be treated by total wrist fusion or wrist arthroplasty rather than by limited fusion alone.

Despite the good clinical results of total wrist arthroplasty, the complication rate remains high. In addition, wrist arthroplasty requires good bone stock and a reasonable or reconstructable tendon balance, 2 conditions that are rarely present in advanced rheumatoid destruction. Silicon wrist spacers offer an alternative, though they are only recommended in low-demand patients by most investigators. Therefore, most wrists with advanced disease require a definitive stabilization by total wrist fusion. A pain-free, stable wrist joint often outweighs the disadvantage of the lack of mobility. Although bi-

FIGURE 3. A type IIIa (ligamentous unstable) rheumatoid wrist showing complete dislocation of the carpus to the palmar-ulnar side with preserved bone stock.

FIGURE 4. The type IIIb (bony unstable) rheumatoid wrist with complete bony destruction, loss of bone stock, and dislocation of the carpus.
lateral wrist fusion is still a subject of controversy, personal experience and a publication by Rayan et al effectively show high patient acceptance even for bilateral fusion. However, subjectively, most patients would like to have at least 1 mobile wrist. Two main concerns dominate the discussion around wrist arthrodesis: the position of fusion and the surgical technique to obtain secure and stable fixation.

A functional ROM for the wrist has been found to consist of 10° of flexion and 35° of extension for most activities of daily living. 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 decreased grip strength, whereas there is no difference in strength between neutral (0°) and extended fusion position. In patients suffering from rheumatoid arthritis, associated elbow and shoulder disease as well as bilateral hand involvement has to be taken into consideration when choosing the ideal arthrodesis position. Lateral deviation of the carpus affects the position and function of the fingers, especially with coexisting ulnar drift at the metacarpophalangeal joint level. Five degrees to 10° of ulnar deviation is needed to counterbalance an ulnar drift of the fingers. Most investigators prefer a neutral flexion/extension position with mild ulnar deviation for wrist fusion in rheumatoid patients. In our personal experience, an individual decision has to be made for every patient. Preoperative evaluation can be performed with splints in different positions. In most cases, a neutral or slightly flexed position for the dominant hand, to facilitate personal care, and a slightly extended position for the non-dominant hand combined with 5° to 10° of ulnar deviation is chosen.

Different fixation methods for wrist fusion have been described in the literature. Since the first description by Clayton in 1965 and later popularized by Mannerfelt and Malmsten, different investigators have favored the Rush or Steinman pin technique either in the original method or with slight modifications. There are some reports of radiocarpal fusion by 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 still a subject of controversy, personal experience and a publication by Rayan et al effectively show high patient acceptance even for bilateral fusion.
fusion is popular, especially in posttraumatic conditions. A comparison between plate and pin fusion technique in rheumatoid patients showed no significant difference either in the clinical results or in the complication rate.

However, in our experience, pin fixation has some significant advantages over plate fixation in rheumatoid patients. Rheumatoid arthritis is more frequent in women who, with small wrist sizes, cannot always accommodate the plate, which are often too bulky to be applied. In addition, the soft tissue and skin condition might not be ideal to cover a plate adequately and most often a secondary removal of the implant is needed. In severe rheumatoid arthritis, bone quality might be so poor that no screw fixation is possible at all. 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.

**Technical Aspects**

**Radiolunate Fusion**

The rheumatoid wrist is approached via a dorsal straight incision centered over the axis of the 3rd metacarpal. The extensor retinaculum is longitudinally divided in the interval between the 5th and 6th extensor compartment. An extensor tendon synovectomy is performed. The terminal branch of the posterior interosseus nerve is identified on the radial floor of the 4th extensor compartment and resected. The wrist joint is opened with a longitudinal incision in the axis of the capitate and 2 triangular flaps are raised from the radius. This gives access to the radiocarpal and the midcarpal joint and synovectomy can be performed. The indication for radiolunate fusion with wrist dislocation and/or destruction of the radiolunate joint with preservation of the radioscaphoid fossa is con-
firmed. In cases of severe complete destruction of the radiocarpal joint and preservation of the midcarpal joint, radioscapohamate fusion might be considered. The remaining cartilage is removed from the radiolunate joint to the subchondral cancellous bone, maintaining the curvature of both articulating elements to allow good matching of the lunate with the radius. The lunate is inset so that the radius covers approximately two thirds of the lunate. The reduction is held with a preliminary K-wire. Fluoroscopic radiographic examination is mandatory to confirm the correct position of the lunate in all planes. In cases of severe bone deficiency, a bone graft, often harvested from the resected ulnar head, might be used. The internal fixation may be performed with 13 × 10-mm titanium power staples (Fig 6) or when good bone quality is present, with a 2.0-mm minicondylar plate, or by other methods (Fig 7). The arrangement of the staplers is critical; ideally, 2 to 3 staples should be placed in different converting angles to prevent redislocation (Fig 8).

The wrist capsule is closed and the extensor retinaculum is divided with the distal half being placed under the extensor tendons to reinforce the wrist capsule and to cover the implant. Plaster splint immobilization is recommended for 6 to 8 weeks. After radiologic evidence of healing, wrist mobilization can be started.

FIGURE 7. Techniques of fixation in radiolunate fusions.
**Authors' Own Experience**

Flury\(^7\) evaluated the different surgical procedures at the wrist in rheumatoid patients with relation to the natural course of the disease. A small but matched series of type IIIa wrists (with destabilized ligaments according to Simmen\(^1\)) were compared. One group (n = 10) had a dorsal wrist synovectomy combined with an ulnar head resection, and the other group (n = 7) had the addition of a radiolunate fusion. Both groups were matched for preoperative deformity, duration of disease, and preoperative mobility. Average follow-up was 6 years (2–15 years).

1. There was no significant difference for the carpal height ratio between the groups. It seems that the radiolunate fusion was unable to prevent carpal collapse effectively, an observation that already has been made in other studies.\(^3\),\(^6\)

2. The ulnar translocation could be reduced and maintained in the radiolunate fusion group, whereas in the group of synovectomy and ulnar head resection, significant progression of the ulnar translation was observed.

3. In the group with the radiolunate fusion, all patients had a significant reduction in pain long term. In the synovectomy/ulnar resection group, 50% of patients had ongoing wrist pain.

4. There was no significant difference in postoperative function.

5. The postoperative difference in the ROM between the synovectomy group and the radiolunate fusion group was not significant (32° v 42° ROM for flexion/extension).

**Total Wrist Fusion**

For total wrist fusion, the wrist is approached the same way as described for the radiolunate arthrodesis. Some rheumatoid wrists have severe deformation with ulnar and palmar dislocation (Fig 9). In such circumstances, because of the contracted soft tissues, some shortening of the radius is required to allow reduction of the wrist. After resection of the distal radius, the radiocarpal and the midcarpal joints are debrided down to cancellous bone. If reduction is possible without too much tension on the soft tissues, the pin insertion point in the third metacarpal is prepared. The proximal third of the third metacarpal, the interval between the second and third metacarpals, or the intramedullary shaft of the third metacarpal can be chosen (Fig 10). If the axis is more favorable, the second metacarpal can also be used. When using the proximal third insertion technique, an ulnar lateral bone window of approximately 6 × 4 mm is made. A special tapered rasp is then used to open the canal for the pin. The rasp should be directed to the middle of the capitate, perforating the proximal carpal row either in the scaphoid or lunate. A Rush pin 2.5 to 3.5 mm in diameter and about 15 to 25 cm in length is then bent to accommodate the desired fusion position,
and advanced from the metacarpal to the radius. Alternatively, the pin can be placed through a hole made in the head of the third metacarpal and driven proximally in an intramedullary fashion, though this method fixes the angle of fusion to neutral, or it can be driven into the junction of the bases of the second and third metacarpals, allowing some control over the angle of fusion but slightly less rigid fixation. Before final placement of the rod, cancellous bone graft from the ulnar head is placed. If additional rotational stability is required, 2 or 3 titanium staples may be placed to bridge the former radiocarpal joint (Fig 11). Postoperatively, a splint is applied for 1 to 2 weeks followed by a cast for 6 to 7 weeks until radiographic fusion has occurred.

**Authors' Own Experience**

Jaschke et al analyzed 93 wrist fusions in rheumatoid arthritis patients performed at our institution. The following observations were made:

1. Ninety-two of 93 (98%) wrists fused within 8 to 12 weeks in the desired position.
2. Two thirds of the wrists were placed in neutral or slightly dorsiflexed (up to 15°) position.
3. In 3 patients (8%), the pin had to be removed because of irritation at the base of the metacarpal. No other significant complications were observed.

**FIGURE 9.** Complete dislocation in a rheumatoid wrist with loss of carpal architecture.

**FIGURE 10.** Techniques of pin fixation in total wrist fusion.
4. Two cases of iatrogenic metacarpal fracture healed without consequences with a plaster immobilization.

5. A total of 82% of the patients rated their subjective surgical result as excellent or good.

Based on these results, which are similar to most other clinical series, we recommend performing wrist fusion using the pin technique. The results are highly reproducible and the nonunion and complication rate is low.

Complications

Radiolunate Fusion

The most common complication with radiolunate fusion is malposition of the hardware. Staples or screws can penetrate or bridge the midcarpal joint and cause damage to the cartilage, necessitating hardware removal. This complication must be considered a technical error because careful fluoroscopic intraoperative checks can avoid this problem.

The fusion rate in all series, as well as in the authors’ own personal experience, is high and consistently exceeds 90%. Despite this high success rate, cases with severely affected bone quality and strong deviating forces may fail to fuse. Good internal fixation, best performed with staples, or a miniplate and cast immobilization for 6 to 8 weeks is mandatory.

Wrist Fusion

Nonunion is rare in patients suffering from rheumatoid arthritis. The average fusion rate in the literature is more than 90%, a figure we confirm in our series. In the Rush pin technique, care should be taken at the insertion point of the pin at the metacarpal base. Predrilling of holes before opening the cortex might prevent iatrogenic fractures. In using the Steinman pin technique, either between the metacarpals or in an intramedullary fashion in the 3rd metacarpal, one must ensure good fixation of the pin into the distal radius and a good interference fit of the pin at the metacarpal bases or within the 3rd metacarpal. The most common problem, especially with using the pin technique, is obtaining the desired wrist position. Exact planning and careful prebending of the rod is helpful.

Conclusion

Wrist involvement in rheumatoid arthritis is very common. There is no uniform pattern of destruction and all patients need an individual treatment plan designed to match the stage and degree of disease. Simmen’s classification into 3 distinguished types of wrist involvement has a direct impact on the surgical treatment of these patients, especially in the early stages of the disease. The classification not only describes the actual stage of the disease but also anticipates the future development of destruction. Type III wrists, the destabilizing form, require a stabilizing procedure either as a partial or total fusion of the wrist.

Among the limited fusions available, the radiolunate fusion offers the prospect of good realignment with stabilization of the carpus. Subjectively, the results are satisfactory, though the radiolunate fusion has only a limited or no effect on future carpal collapse. On the other hand, limited wrist fusion has a
clear advantage in the long-term stability and pain relief compared with synovectomy and ulnar head resection alone. If there is advanced destruction of the radiocarpal joint and a preserved midcarpal joint, the concept of limited fusion might be expanded to a radioscapholunate fusion procedure.

In cases of complete destruction of the carpus, often combined with dislocation, a total wrist fusion is able to correct the position of the hand, often aiding in the balance of the metacarpophalangeal joints. In bilateral wrist destruction, a fusion on 1 side and a wrist arthroplasty on the contralateral side might provide better overall patient function than bilateral wrist fusions. In most patients, a wrist fusion should be performed on the dominant hand and an arthroplasty on the nondominant side.

REFERENCES


