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ORIGINAL ARTICLE

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Radiological follow-up study of rheumatoid wrists after radio-lunate limited arthrodesis with ulnar head resection

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Abstract Radio-lunate limited arthrodesis (RLA) is an established surgical intervention for damaged rheumatoid arthritis (RA) wrists. The goal of RLA is to conserve the range of motion (ROM) and level of activities of daily life (ADL) by delaying more extensive fusion. In this study, we retrospectively reviewed the outcome of RLA with ulnar head resection (UHR) in terms of pain score, ROM, and radiographic parameters, including carpal height ratio, ulnar translation ratio, and palmar subluxation. The clinical factors, such as dose of corticosteroids per day and laboratory examination data before surgery, including C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and rheumatoid factor (RF), did not influence the results of the surgery. The changes in these clinical factors were also statistically analyzed in relation to the Schulthess classification of preoperative radiographs of wrists reported by Simmen and Huber: Type I (ankylosis type), Type II (osteoarthritis type), and Type III (disintegration type). This study hypothesized that RLA with UHR would provide no significant improvement in Type III wrists. The results showed that RLA with UHR resulted in stable wrists with excellent pain relief and with limited, but temporary, functional ROM, suggesting that this procedure seems to be applicable for all types of wrists within this group of patients.

Key words Arthrodesis · Radiography · Rheumatoid arthritis (RA) · Wrist joint

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Introduction

Rheumatoid arthritis (RA) frequently involves wrist and finger joints.[1] A stable RA wrist at the radiologically early stage may be treated conservatively, or by open or arthroscopic synovectomy. However, in the advanced stage, RA wrists show a greater variety of disorders due to bone and joint destruction, including carpal collapse, dorsal subdislocation of the distal ulna, palmar subluxation of the radius and carpus, and radial rotation of the carpus. Moreover, these alterations may lead to ulnar deviation of the fingers and decrease the efficiency of the long extrinsic muscle–tendon units crossing the wrist, resulting in swan-neck deformities of the fingers.[2,3]

Radio-lunate limited arthrodesis (RLA), originally combined with ulnar head resection (UHR), is an established surgical intervention for radio-carpal instability of damaged RA wrists, and is designed to relocate the carpus to the radius and stabilize the wrist joint. In 1983, Chamay et al.[4] first reported encouraging results of RLA in four RA cases. Later, Linscheid and Dobyns[5] and Stanley and Boot[6] also reported favorable results of RLA in series of 16 and 15 RA wrists, respectively.

Ishikawa et al.[7] considered the usefulness of RLA to be its potential to correct the natural course of wrist joint destruction by RA. However, Della Santa and Chamay's[8] 5-year radiological review, based on both the Larsen classification modified by Alnot and Fauroux[9] and the Schulthess classification reported by Simmen and Huber,[10] of 26 RA wrists after RLA concluded that RLA can prevent dislocation of an unstable wrist, but could not prevent deterioration. They recommended RLA for intermediate Larsen–Alnot stages (2–4a), especially with Type II (osteoarthritis type) RA wrists.

This retrospective study evaluated the radiographic results of surgical RLA with UHR in association with preoperative disease activity and the Schulthess preoperative radiographic classification to determine the clinical effects of this procedure in three types of RA wrist.

Materials and methods

Patients

For this retrospective study, 29 RA wrists of 22 patients treated by RSL with UHR from 1990 through 2001 were reviewed. There were 21 women and 1 man, whose ages at surgery ranged from 38 to 75 years, and averaged 60.3 years. The average follow-up period after surgery was 62.3 months (Table 1). The RA activity in all the patients was considered to be under good control before and during surgical treatment. All patients had had continuous preoperative pain or synovitis at the wrist joint for at least 6 months. The radiographic grades of wrists in this study were 2–4a by Larsen's classification modified by Alnot and Fauroux.[9] The primary radiographic indications of RLA with UHR for RA wrists, according to Linscheid and Dobyns,[5] were as follows: (1) preservation of midcarpal joint space of at least 1 mm with minimal erosions; (2) radiocarpal joint space narrowing and erosions; (3) ulnar translation of carpus; (4) carpal collapse; (5) dorsal subluxation of the ulnar head. The midcarpal joint space between capitate and lunate should be preserved, and an adequate bone stock of the proximal carpal row and the distal end of the radius are required for RLA.

Table 1. Background of the patients involved in this study

No. of patients (wrists)	22 (29)
Male/female	1/21
Mean age at surgery (years)	60.3 (38–75)
RA duration (years)	11.7 (5–36)
Mean follow-up period (months)	62.3 (8–132)
Type of wrist (Schulthess classification)	
Type I (ankylosis)	8
Type II (osteoarthritis)	12
Type III (disintegration)	9 (wrists)

Surgical procedure

The surgical procedure for our version of RLA includes ulnar distal end resection, and synovectomy of radiocarpal and midcarpal joints. In the case of tendon rupture, a tendon graft using the tendon of the palmaris longus, or a tendon transfer using the extensor indicis tendon, is performed simultaneously. In order to prevent or slow down postoperative joint destruction, synovial pannus, which invades the bones, should be fully resected. If the intercarpal ligaments remain intact, they are preserved.

After trimming the articular cartilage of radial and lunate surfaces, a bone block (5–7 mm thick) taken from the distal end of the ulna is inserted between the lunate and the radius with slight distraction of the lunate, which results in decompression between the scaphoid and radius. This procedure also allows the scaphoid to rotate more freely about the lunate. To correct the palmar subluxation and ulnar deviation of the carpus, and maintain the carpal height (also described in Chamay et al.[4]), a bone block is inserted between the radius and the lunate. Finally, radio-lunate arthrodesis is achieved using two Shapiro's staples (usually 16×15 mm)[11] (Fig. 1).

Radiographic classification and clinical parameters

Preoperative radiographs of all wrists were classified into three groups according to the Schulthess classification[10] as

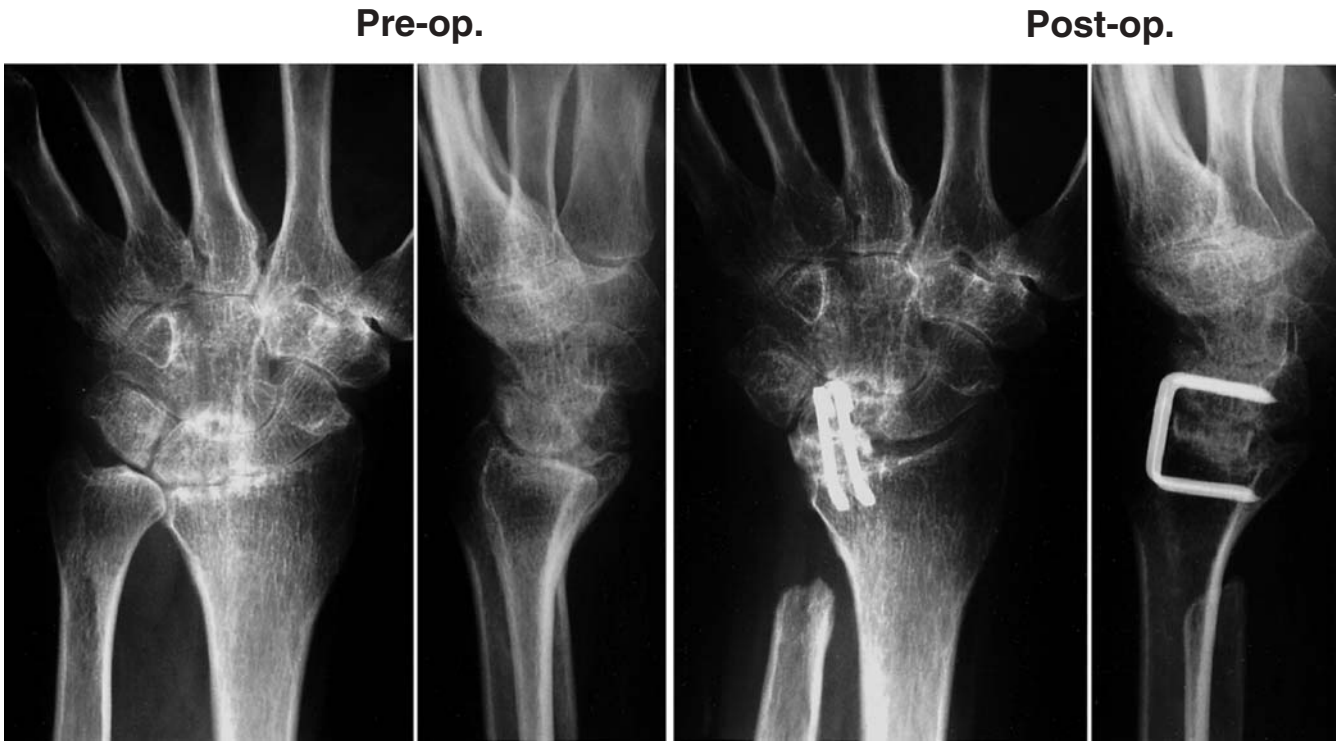

Fig. 1. Representative radiographs of a rheumatoid arthritis (RA) wrist before and after radio-lunate limited arthrodesis with Shapiro's staples

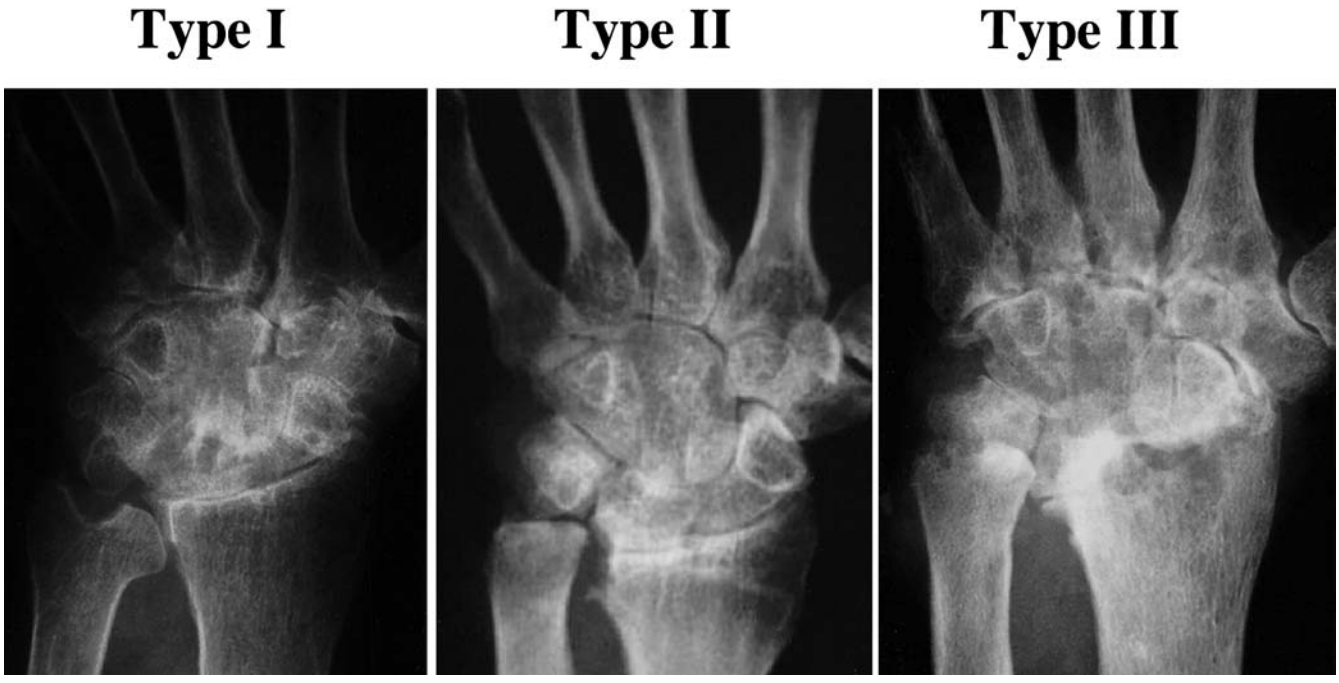

Fig. 2. Representative radiographs showing the Schulthess classification of RA wrists reported by Simmen and Huber. Type I, the ankylosis type, which has a tendency to progress into spontaneous ankylosis with rapid destruction of the joint surfaces; Type II, the osteoarthritis type, with signs of a secondary degenerative osteoarthritis; Type III, the disintegration type, which has lost radiocarpal or intercarpal integrity, alignment, and stability

Type I (ankylosis type), Type II (osteoarthritis type), or Type III (disintegration type) (Fig. 2). The clinical results of the surgery were evaluated by pre- and postoperative pain and range of motion (ROM), including dorsi-flexion, palmar flexion, and ulnar and radial deviation. Pain scores were recorded on a visual analog scale (VAS) in interviews with the patients at each postoperative examination (none, mild, moderate, or severe). The daily dose of corticosteroids and laboratory examination data before surgery, including C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and rheumatoid factor (RF), were examined as factors which might influence the outcome of the surgery.

Radiographic parameters

To evaluate the displacement of the carpal bones relative to the radius alignment, Youm's carpal height ratio (CHR),[12] Ishikawa's carpal–ulnar translation ratio (e/MC) modified from Chamay's ratio, and Ishikawa's palmar carpal subluxation ratio (h/MC)[7] were used for the measurement study based on frontal and lateral views of radiographs of the wrist (Fig. 3). To calculate postoperative changes in carpal height, CHR just after surgery was divided by CHR at follow-up (carpal collapse ratio, CCR). Two surgeons (KU and SO) made the radiographic measurement study without knowing the clinical results of the surgery.

Statistical analysis

Data were expressed as mean ± SD. Statistical analysis was performed by Student's *t*-test or the Mann–Whitney *U* test using StatView-J 5.0 (SAS Institute, Cary, NC, USA). *P* values <0.05 were considered to be significant.

Table 2. Number of wrists in each pain scale

	None	Mild	Moderate	Severe
* Pre-op. (%) (n = 26)	2 (7.7)	3 (11.5)	15 (57.7)	6 (23.1)
* Follow-up (%) (n = 28)	22 (78.6)	1 (3.6)	5 (17.9)	0 (0)

* $P < 0.0001$

Results

Preoperatively, 21 wrists (80.8%) had moderate or severe pain, and 22 wrists (78.6%) had no pain at the final follow-up. Pain scores improved significantly at the final follow-up ($P < 0.0001$) (Table 2). In 96.6% of the wrists (28 of 29 wrists) there was bone union between the radius and the lunate, suggesting the restoration of stable function in the wrist. Although the ROM of the wrist was reduced in flexion ($P < 0.05$), the average postoperative ROM of flexion of 43.1° allowed basic daily living activities such as handwriting and grooming. The limitations of pronation and supination caused by bone and joint destruction of the distal radio–ulnar joint were improved by resection of the distal end of the ulna (Table 3). There were no complaints about the cosmetic appearance of the wrist, although a complaint of ulnar stump pain was reported in one wrist by one pa-

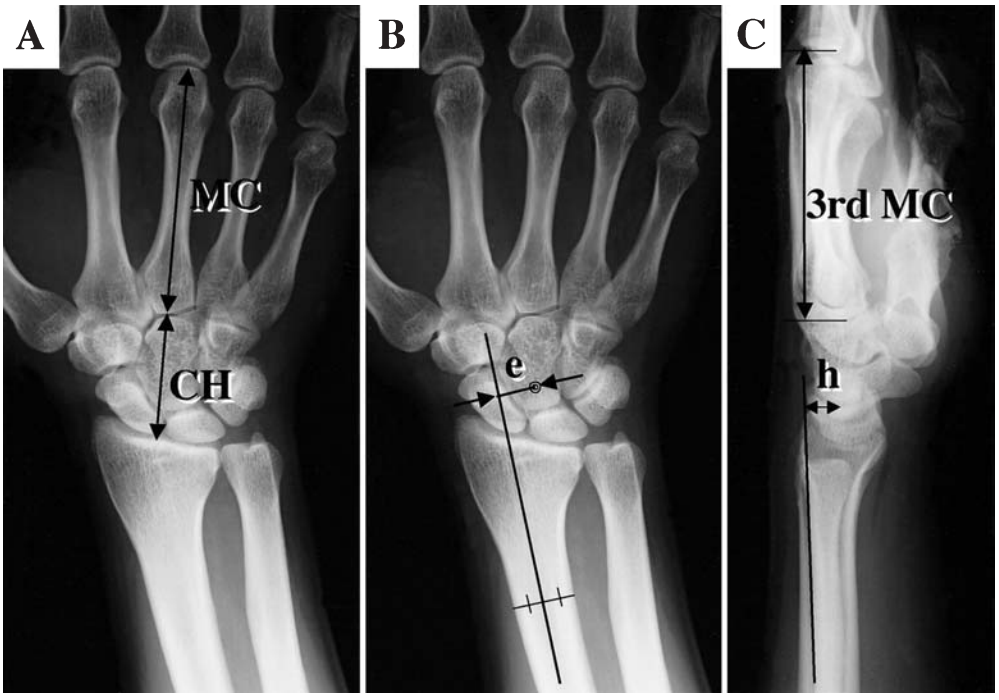

Fig. 3. Radiographic parameters used in the current study. **A** Carpal height ratio, after Youm et al.; CH/MC. **B** Carpal translation ratio, after Ishikawa et al.; e/MC. **C** Palmar carpal subluxation ratio, after Ishikawa et al.; h/MC

Table 3. Range of motion of wrist joints (degrees) before the operation and at final follow-up

	Pre-op			Follow-up		
	Flexion	Deviation	Rotation	Flexion	Deviation	Rotation
All cases (n = 29)	61.7 ± 31.1	25.4 ± 15.7	149.1 ± 29.8	43.1 ± 35.8*	17.3 ± 18.3	165.8 ± 28.5
Type I (n = 8)	50.0 ± 35.4	31.4 ± 28.2	153.6 ± 19.7	2.1 ± 3.9*	0.0 ± 0.0*	155.8 ± 54.4
Type II (n = 12)	66.3 ± 30.0	26.7 ± 11.5	140.0 ± 40.2	54.2 ± 29.1	22.0 ± 17.0	165.4 ± 14.7
Type III (n = 9)	63.6 ± 28.5	37.0 ± 15.7	157.9 ± 20.0	63.8 ± 33.2	17.3 ± 18.3	176.7 ± 5.2*

Flexion, dorsi-flexion plus palmar flexion; deviation, ulnar deviation plus radial deviation; rotation, pronation plus supination
* $P < 0.05$

tient, suggesting that care should be taken to minimize the amount of bone resection.

Radiographic examinations showed that CHR improved significantly after surgery ($P < 0.0001$), but it had decreased at the time of final follow-up ($P < 0.0001$). Carpal height in cases with higher preoperative Larsen's grades tended to decrease the most during the follow-up period. Both h/MC and e/MC also improved after surgery, but the difference was not significant. At the time of final follow-up, h/MC had not change significantly, but e/MC had increased significantly ($P < 0.05$) (Table 4). No significant correlations were noted between the radiographic parameters and laboratory data of the patients before surgery (data not shown).

The preoperative radiographs of the wrist were classified into Type I in 8 joints, Type II in 12 joints, and Type III in 9 joints according to the Schulthess classification. In the Type I wrists, 5 of the 8 wrists showed bony ankylosis at the final follow-up. In the Type II wrists, flexion arc (dorsi-felexion plus palmar flexion) and deviation arc (ulnar deviation plus radial deviation) had decreased at the final follow-up, but the difference was not significant. In the Type III wrists, flexion arc increased slightly and deviation arc decreased, but the differences were not significant. The rotation arc (pronation plus supination) increased in all types of wrist, and increased significantly in the Type III wrists.

Table 4. Changes in radiographic parameters

	Pre-op	Post-op	Follow-up
CHR	0.43 ± 0.05	0.47 ± 0.05*	0.42 ± 0.05*
e/MC	0.15 ± 0.06	0.14 ± 0.06	0.17 ± 0.08**
h/MC	0.19 ± 0.06	0.19 ± 0.05	0.19 ± 0.07

CHR, carpal height ratio; e/MC, carpal–ulnar translation ratio; h/MC, palmar carpal subluxation ratio
* $P < 0.0001$; ** $P < 0.05$

Changes in CHR, e/MC, and h/MC in each type of wrist are summarized in Tables 5–7, respectively. In Type I wrists, CHR did not change significantly after surgery. However, CHR decreased significantly in Type II ($P < 0.05$) and Type III ($P = 0.0001$) wrists after surgery. The CCR was significantly lower in the Type III wrists than in Type II wrists, suggesting that the cartilage destruction and

Table 5. Changes in carpal height ratio (CHR) in each type of wrist

Type of wrist	Pre-op	Post-op	Follow-up	CCR
Type I	0.44 ± 0.05	0.49 ± 0.04*	0.42 ± 0.05	0.89
Type II	0.43 ± 0.05	0.46 ± 0.05*	0.44 ± 0.05*	0.96 ┐**
Type III	0.42 ± 0.06	0.48 ± 0.06**	0.38 ± 0.05***	0.81 ┘

CCR, carpal collapse ratio
* $P < 0.05$; ** $P = 0.002$; *** $P = 0.0001$

Table 6. Changes in the carpal–ulnar translation ratio (e/MC) in each type of wrist

Type of wrist	Pre-op	Post-op	Follow-up
Type I	0.13 ± 0.06	0.10 ± 0.04*	0.17 ± 0.16
Type II	0.15 ± 0.06	0.16 ± 0.04	0.18 ± 0.05
Type III	0.13 ± 0.06	0.10 ± 0.04	0.17 ± 0.16*

* $P < 0.05$

Table 7. Changes in palmar carpal subluxation ratio h/MC in each type of wrist

Type of wrist	Pre-op	Post-op	Follow-up
Type I	0.21 ± 0.05	0.18 ± 0.04	0.19 ± 0.04
Type II	0.17 ± 0.06	0.18 ± 0.08	0.20 ± 0.06
Type III	0.21 ± 0.06	0.19 ± 0.05	0.19 ± 0.05

collapse of carpal bones and cartilage was more progressive in the Type III wrists. The e/MC increased significantly in Type III wrists after surgery, indicating the progression of ulnar translation of the carpus. The h/MC had not changed significantly in any type of wrist at the final follow-up.

Discussion

Because hand function impairment is often caused by the pain and instability of the wrist joint, the wrist is a key joint in treatment planning for hand and finger deformity and loss of function in RA.[3] At the early stage of the disease, open or arthroscopic synovectomy may be indicated when conservative treatment has failed. However, studies of the long-term outcome of surgery disclosed that synovectomy alone might not prevent the development of destruction in the wrist with RA.[13] In this study, UHR, which was a component of the RLA in all cases, is believed to have contributed to the postoperative improvement of the rotation arc.[14] However, postoperative collapse and ulnar translation of the carpus is a common problem with this procedure. Vincent et al.[15] first reported the effectiveness of the Sauvé–Kapandji procedure in the reconstruction of RA wrists. In their series, the procedure successfully achieved pain relief, lowered medication requirements, and reduced the "feeling of instability." Pronation and supination were retained, and flexion and extension were within functional ranges. Although this procedure might prevent ulnarward and palmarward translocation in wrists, it cannot prevent the progression of preexisting dislocation of the carpus. They concluded that in an RA patient with distal radio-ulnar problems and preexisting dislocation of the carpus, a distal ulnar resection accompanied by a wrist-stabilizing procedure would be indicated.

RLA is an established technique, first reported by Chamay et al. in 1983,[4] and based on kinematic studies of RA wrists which showed spontaneous radiolunate arthrodesis in 13% of the cases examined. Their indication for RLA required existing radiocarpal instability combined with dorsal subluxation of the ulnar head, pain, and synovitis, or radiocarpal instability combined with ulnar drift of the fingers. Later, they described the surgical procedure and reported excellent results of RLA on 21 RA wrists.[16] Linscheid and Dobyns[5] reported that RLA might: (1) relocate the lunate within the fossa of the radius to prevent further slide; (2) correct midcarpal malalignment; (3) correct radial deviation at the wrist; (4) maintain carpal height. Linscheid and Dobyns[5] did not specifically include pain relief in their list. The authors of this study believe that regardless of type, extensive synovectomy and denervation of the wrist branch of the posterior interosseous nerve[17] should accompany RLA in cases of severe inflammatory symptoms such as pain, swelling, or subluxation. These additional procedures probably contributed to the quality of pain relief in this study. Although the results of this study indicate that preoperative laboratory data did not correlate significantly with the outcome of the surgery, the RA activity of the patients was under good control.

Della Santa and Chamay[8] first applied the Schulthess classification reported by Simmen and Huber to evaluate the surgical outcome of RLA, and reported that RLA has a limited influence on the progression of radiological changes in the carpus. RLA only temporarily, and often incompletely, corrects wrist deformities, which progress at variable rates depending on the rheumatoid condition itself. For these reasons, they suggest RLA, with or without ulnar head resection, for wrists in the intermediate Larsen classification modified by Alnot (2–4a), especially with Type II wrists. The results of this study support that opinion.

In Type I wrists, there is the possibility of the spontaneous fusion of carpal bones, and a long-term functional range of motion cannot be expected. In our patients, 5 of the 8 Type I wrists developed bony ankylosis. When Type I wrists show ankylosis of the wrist joint and destruction of the distal radio-ulnar joint, UHR combined with synovectomy is indicated to improve wrist function in terms of pain relief and increased forearm rotation. When Type I wrists show midcarpal joint ankylosis and a preserved radio-carpal joint, RLA plus UHR would not be indicated, because this procedure results in a fixed wrist joint. In some Type I wrists,

however, it is difficult to distinguish Type I and Type II in preoperative radiographs. When partial ankylosis is seen between the carpal bones with preserved movement around the lunate, as in 3 of the 8 Type I wrists, RLA might contribute to the preservation of the limited but functional movement of the wrist joint.

Probably because RLA can preserve the mobility of the midcarpal joint of the wrist, Type II and Type III wrists showed a decreased, but still functional, range of motion after surgery. The postoperative CHR progressively decreased as the joint space narrowed, mainly due to cartilage destruction in Type II wrists, and bone and joint destruction in Type III wrists. However, the CCR in Type II was significantly higher than that in Type III at the final follow-up, suggesting that carpal collapse might be temporary, and not progressive, in Type II wrists. An increase in e/MC was seen in Type II wrists, but was not statistically significant. Thus, Type II wrists seem to have the best indication for RLA. The development of joint destruction is not prevented completely in Type III wrists, despite extensive synovectomy. Della Santa and Chamay did not indicate RLA for Type III wrists, and recommended total arthrodesis or total arthroplasty. In our series, RLA achieved good pain relief and a functional wrist despite the progression of carpal collapse. Even for Type III wrists, RLA can correct palmar subdislocation and radial rotation of the carpus, and also increase the carpal height at least temporarily. Although total wrist arthrodesis can achieve a painless and stable joint, most patients in the current study preferred a movable wrist. In keeping with these changing activities of daily life (ADL) demands, we consider that total wrist fusion should be avoided for the initial treatment, even in Type III wrists. The results of this study showed that e/MC increased after surgery in Type III wrists. This increased e/MC is partially explained by progressive intercarpal instability due to inflammation. In progressive instability of the wrist joint in Type III wrists, it might be important to fix the scaphoid to the radius, or the triquetrum to the radius and lunate, by K-wire, creating an ulnar shelf to prevent ulnar translation of the carpus. The unchanged h/MC in all types of wrist indicates that RLA can prevent further palmar subdislocation of the carpus within this midterm follow-up period. Continued careful observation of the course of the changes in h/MC is required, especially for Type III wrists.

There is a qualification to this indication of RLA for the treatment of RA wrists, which is that the midcarpal joint space between the capitate and the lunate, as well as the bone stock of the proximal carpal row and the distal end of the radius should be preserved. Taleisnik[18] suggested combined surgery of radiocarpal arthrodesis with midcarpal arthroplasty for severely damaged RA wrists. To preserve the motion of the midcarpal joint, the damaged head of the capitate was resected and replaced with a small implant. For a wrist with poor bone stock and destruction of the midcarpal joint (Larsen–Alnot 5a), or failed RLA, we consider total arthrodesis to be an optimal choice.

In conclusion, RLA for RA wrists provided excellent pain relief, good stability, and limited temporary functional mobility of the wrist joint in this group of patients. The lack of variety and the small number of patients are limitations in this study which preclude certain analyses. The Schulthess classification seems to be a useful instrument in predicting postoperative results. However, this impression requires further testing. When the midcarpal joint space and proximal carpal row was preserved, RLA was applicable for the three types in Schulthess classification, and Type II wrists showed the best results.

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