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ORIGINAL ARTICLE

The short-term outcome of the modified Sauvé–Kapandji procedure regarding range of motion, carpal bone translation and bony shelf size

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Abstract The Sauvé–Kapandji (S–K) procedure is a common treatment for rheumatoid wrists, but in some cases severe bone destruction makes this operative modality difficult to perform, while also resulting in a poor outcome. A modified S–K procedure for these wrists has been reported, but the clinical outcomes of the modified procedure are unclear. This study evaluated 24 wrists in 20 patients who underwent the modified S–K procedure. The mean follow-up period was 34.5 months. The clinical assessments were range of motion, carpal bone translation and bony shelf size. The range of motion and carpal bone translation were similar to those produced by the S–K procedure. In regard to bony shelf size, wrists with an excessively large bony shelf tended to have a progression of carpal bone translation toward the palmar direction due to the residual malposition of the ECU tendon. The modified S–K procedure appears to be a safe and effective surgical alternative for the treatment of severely destroyed rheumatoid wrists. Although the modified procedure allows for the adjustment of the bony shelf size, it should not be used with wrists that have an excessively large bony shelf.

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Introduction

Rheumatoid arthritis (RA) frequently affects the wrist joint, and distal radioulnar joint (DRUJ) disorders such as arthritis and subluxation are a very common problem. A distal ulnar resection (the Darrach procedure) is used to treat DRUJ disorders in such patients [1]. The Sauvé–Kapandji (S–K) procedure, first reported in 1936, has since been developed and is widely used as a treatment for post-traumatic DRUJ disorders [2]. The translation of the carpal bones in the ulnar direction has been reported after the Darrach procedure [3], and the S–K procedure was applied to RA wrists as an alternative to the Darrach procedure in the 1990s [4]. There are reports of good clinical outcomes with the S–K procedure, and this procedure is now a common treatment for DRUJ disorders with RA [5–11].

Despite its value, however, the S–K procedure is difficult to perform in cases with severe bone destruction and absorption of the ulnar head. A modified version of the procedure (the modified S–K procedure) was developed for use in such instances [12]. The modified S–K procedure involves an osteotomy 30 mm proximal to the distal end of the ulna, a 90° rotation of the resected portion of the ulna, and insertion into the radius at the sigmoid notch. Fujita et al. [12] reported good clinical outcomes due to the advantage associated with the modified procedure, namely that width adjustment of the bony shelf is easy because this shelf is created by the distal portion of the ulna. The modified S–K procedure is an

alternative to the original S–K procedure for severely destroyed wrists.

The aim of this study was to assess the clinical outcomes of the modified S–K procedure for the treatment of wrists with severe bone erosion and destruction at either the ulnar head or DRUJ.

Materials and methods

Patients

Twenty-eight patients (33 wrists) underwent the modified S–K procedure from 2001 to 2008. Two patients (3 wrists) were excluded because the preoperative radiographs had been discarded, 1 patient (one wrist) was excluded due to death, 2 patients (3 wrists) were excluded because they relocated, and 3 patients (3 wrists) were excluded due to an insufficient follow-up period (<12 months). A total of 20 patients (24 wrists) were available for a follow-up period exceeding 12 months and were included in this study. Among the 20 patients, 3 patients (3 wrists) were males and 17 patients (21 wrists) were females. Seven patients (7 wrists) had an accompanying extensor tendon rupture. None of the patients had a history of treatment with a biological disease-modifying antirheumatic drug. The mean age of the 20 patients at the time of operation was 60.3 years (range 36–76 years). The mean duration of RA at the time of operation was 10.3 years (range 2–20 years). The mean follow-up period was 34.5 months (range 12–83 months). Two wrists were Steinbrocker stage II, 6 wrists were stage III, and 16 wrists were stage IV. Radiographic assessments included the bone destruction types as defined in the Schulthess classification, an evaluation of the progress of carpal bone translation, and the relationship between the width of the bony shelf and the progress of carpal bone translation [13]. The three types in the Schulthess classification [13] comprise type I (ankylosing type), type II (ostheoarthritic type) and type III (disintegrated type). This schematic classification system also classifies both type I and type II wrists as stable and type III as unstable. In this study group, 5 wrists were type I, 10 were in type II and 9 were in type III according to the Schulthess classification. Approximately 38% of the wrists (9 of 24) were therefore potentially unstable.

Ethics

All patients provided informed consent to participate in this study. The medical ethics committee at our hospital approved the study protocol.

Anesthesia

All operations were performed under intravenous regional anesthesia, except for one operation that was performed under general anesthesia.

Surgical technique

The modified S–K procedure was performed according to the previously reported protocol [12]. The surgical technique involves an osteotomy 30 mm proximal to the distal end of the ulna, the creation of a 10 mm-diameter drill-hole at the sigmoid notch, a 90° rotation of the resected portion of the ulna, insertion into the radius through the drill-hole, and fixation at that site using a poly-L-lactic acid screw. The extensor retinaculum is incised at the fourth compartment and the ulnar flap is divided into distal and proximal parts. The proximal half of the retinaculum is placed under the extensor tendon, while the distal half is placed over the tendon. Thereafter, the extensor retinaculum is sutured with overlap to work as a pulley. The mean operation time was 54.3 min (range 25–90 min). Six of the 7 wrists with an extensor tendon rupture underwent a transfer of the extensor indicis proprius tendon, while the remaining wrist underwent a free tendon graft of the palmaris longus tendon.

Clinical assessments

The clinical outcomes were evaluated by physical and radiographic examinations. The physical assessments evaluated the remaining range of motion (ROM) after the operation. The ROM measurement involved dorsiflexion, palmarflexion, pronation and supination before the operation and at the final follow-up. Radiographs of the wrist joints were obtained before the operation, just after the operation, and at the final follow-up. The radiographic parameters were calculated to evaluate the carpal bone translation, as previously described [14, 15]. Briefly, the carpal height ratio (CHR) was calculated by dividing the length of the carpal bones (B) by the length of the third metacarpal (A); the ulnar translation index (CTI) was calculated by dividing the length of the distance between the lateral cortex of the radius and the center of rotation (C) by the length of the third metacarpal (A); and the palmar carpal subluxation ratio (PCSR) was calculated by dividing the length of the distance between the dorsal cortex of the radius and the center of rotation (D) by the length of the third metacarpal (Fig. 1). The radiographic parameters were analyzed statistically. Furthermore, the width of the bony shelf created during the operation was measured by anterior–posterior radiographs just after the operation. The shelf width ratio (SWR) was calculated by dividing the

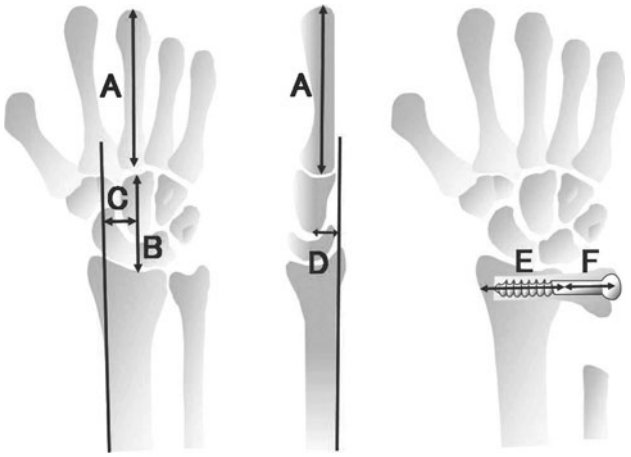

Fig. 1 Radiographic parameters. Carpal height ratio (CHR) = B/A; ulnar translation index (CTI) = C/A; palmar carpal subluxation ratio (PCSR) = D/A

length of the distance between the sigmoid notch and the ulnar end of the bony shelf (F) by the width of the radius at the sigmoid notch (E). A regression analysis was performed with the SWR and the changes in the CHR, CTI and PCSR parameters. The bone union between the radius and the resected portion of the ulna was determined by radiographs at the final follow-up. All of the clinical assessments were performed three times by the first author.

Statistical analysis

Differences between the groups were analyzed by Student's paired t test or unpaired t test. Correlations were determined by a linear regression analysis. A P value <0.05 was considered to be statistically significant.

Results

Bone union between the radius and the resected portion of the ulna was obtained in all wrists at the final follow-up.

Clinical assessment indicated that there was no significant change in the dorsiflexion, palmarflexion or pronation of the wrist joint, while supination was significantly increased at the final follow-up (Table 1A).

The CHR decreased and the CTI increased significantly. However, the PCSR did not increase (Table 1B). This means that both radiographic progression of carpal bone destruction and translation toward the ulnar direction were observed, whereas translation toward the palmar direction tended to vary, and no significant change was observed on average.

A regression analysis between the SWR and the differences in each parameter (CHR, CTI and PCSR) showed that there was a correlation between the SWR and the PCSR difference (Fig. 2). Carpal bone translation progressed in the palmar direction if the rebuilt bony shelf was excessively large ($r = 0.49$). The linear regression analysis showed that carpal bone dislocation may not progress in the palmar direction (no increase in PCSR) if the SWR is <0.77 according to the regression line (intersection point with the x-axis) (Fig. 3).

We divided the patients into two groups with PCSR changes for the following period: a palmar subluxation restored group ($n = 7$) and a palmar subluxation progressed group ($n = 17$). No remarkable difference was seen between the groups in regard to carpal height loss and carpal bone translation toward the ulnar direction.

Table 1 Clinical assessments and statistical analysis

	Before operation	At final follow-up	P value
(A) Range of motion (ROM)			
Dorsiflexion	28.7 (16.8)	24.0 (17.4)	0.39
Palmarflexion	28.7 (19.3)	27.8 (15.0)	0.86
Pronation	71.8 (22.4)	81.5 (21.3)	0.09
Supination	72.9 (23.4)	84.0 (13.4)	<0.05
(B) Radiographic parameters			
CHR	0.47 (0.07)	0.43 (0.06)	<0.01
CTI	0.35 (0.08)	0.37 (0.08)	<0.01
PCSR	0.25 (0.08)	0.23 (0.07)	0.13
			($n = 24$)

Values shown are mean (standard deviation). Statistical analysis was performed with Student's t test. There were no significant differences about the ROM except for supination. The CHR was decreased and the CTI was increased significantly ($P < 0.01$). However, the PCSR was not increased significantly ($P = 0.13$)

CHR carpal height ratio, *CTI* carpal translation index, *PCSR* palmar carpal subluxation ratio

Discussion

The S–K procedure is frequently used to treat DRUJ disorders in RA patients, and good clinical outcomes have been widely reported in the literature [6, 8–11, 16–19]. However, there have been few reports of the outcome of the modified S–K procedure [12].

Henmi et al. [20] reported that the CHR, CTI and PCSR did not change significantly at an average 17.4 month follow-up period. Fujita et al. [12] reported that no significant change was observed in the CTI at an average of 48 months after the operation, although no other parameters were shown in their report. However, the carpal bone translation toward the ulnar direction increased in our study group, as described in previous reports on the original S–K procedure [7, 8, 11]. Therefore, we consider the modified S–K procedure to be equivalent to the original procedure.

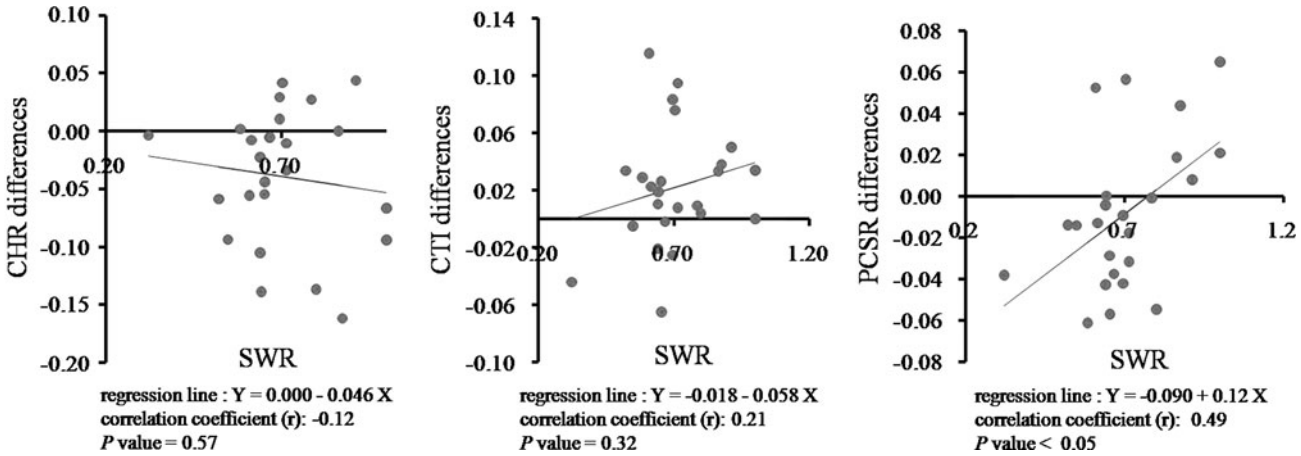

Fig. 2 Results for parameter differences. Each parameter difference was calculated by subtracting the preoperative value from the postoperative value. A negative CHR difference is indicative of bone destruction. A positive CTI difference indicates carpal bone translation towards the ulnar. A positive PCSR difference indicates carpal bone translation towards the palmar. There was a significant correlation between the SWR and the difference in PCSR ($r = 0.49$, $P < 0.05$)

Fig. 3 Carpal bone translation toward the palmar direction. Typical radiographs of the modified S–K procedure. This wrist had a large bony shelf just after the operation (SWR = 0.81). Carpal bone translation toward the palmar direction progressed over a 30-month period after the operation

In the current study, the postoperative ROM of the wrist joint tended to decrease in dorsi- and palmarflexion and increase in forearm rotation. These outcomes were also similar to those noted in previous reports [7, 8, 11]. However, in some cases, the ROM of forearm rotation decreased in comparison to that before the operation. Proximal radioulnar joint destruction may be one of the factors that causes ROM loss despite surgical treatment of the DRUJ.

Presently, a surgically treated wrist with a large bony shelf tends to show progression of carpal bone translation in the palmar direction. Reasons for this may include the position of the extensor carpi ulnaris (ECU) tendon. In RA wrists, the ECU tendon often becomes dislocated toward the ulnar and palmar direction, with extensor retinaculum attenuation and elongation due to synovitis, and it therefore sometimes works as a flexor tendon (Fig. 4a). An excessive large bony shelf makes it difficult to bring the ECU tendon up to the dorsal aspect of the bony shelf in this procedure (Fig. 4b). This insufficient reposition of the ECU tendon may be one of the factors that causes the progression of carpal bone translation toward the palmar direction (Fig. 4c).

Conceivably, even in the original S–K procedure, excessive large bone grafting to the DRUJ between the radius and the ulnar head should be avoided.

Surgically treated wrists with a large bony shelf may prevent carpal bone translation in the ulnar direction, but there was no significant evidence of this in the regression analysis. A certain bony volume may be required to prevent carpal bone translation toward the ulnar direction, but this optimal size could not be determined in this study.

The optimal size of the bony shelf needed to prevent palmar subluxation of the carpal bones was found to be less than 0.77 in SWR. Other benefits of the modified S–K procedure are that it can be easily performed and that bony shelf stability is normally adequate because the contact area with the radius is large [8].

The presumed disadvantage of the modified S–K procedure is the need to detach the ulnar head from the

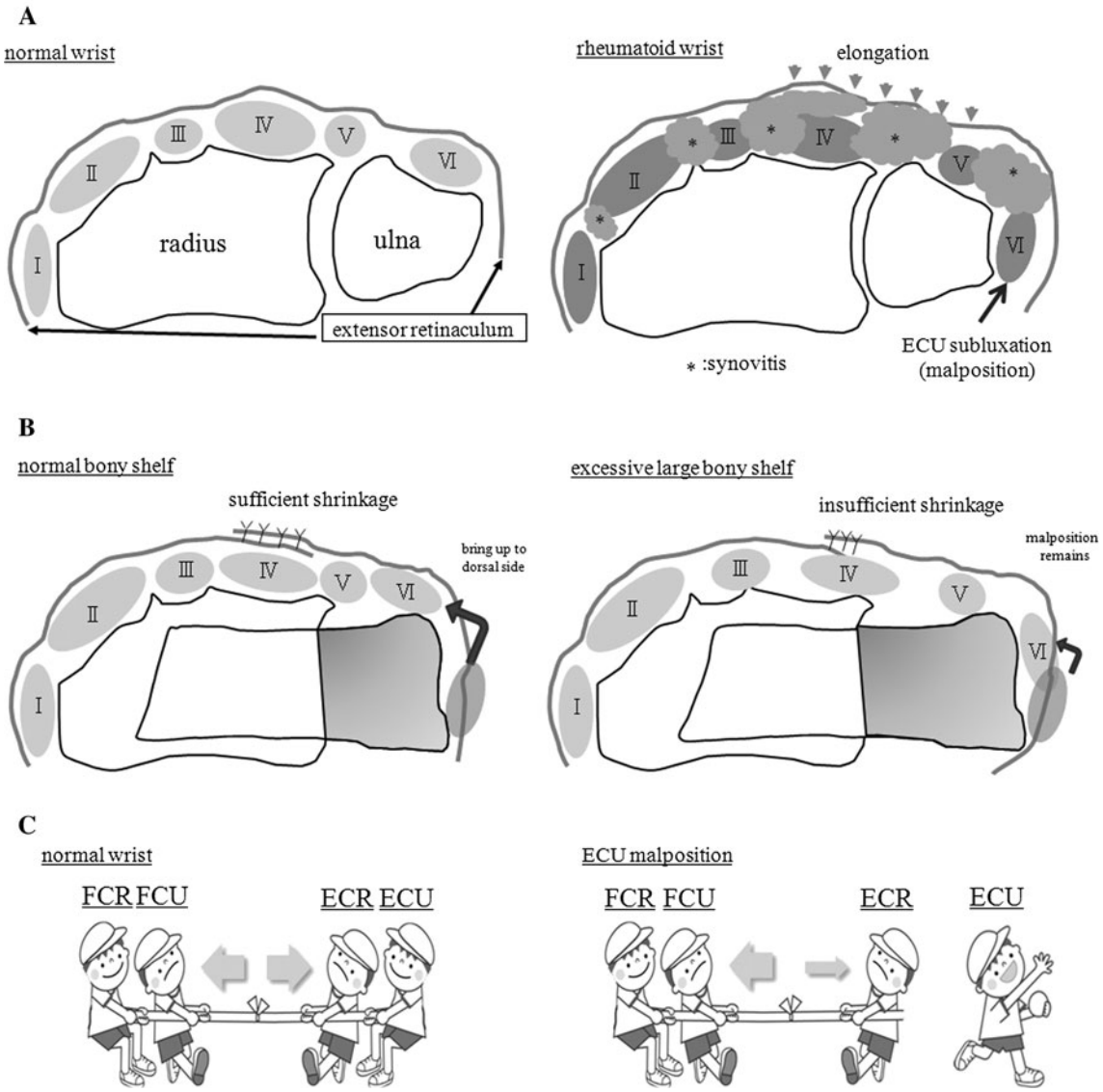

Fig. 4 An excessive large bony shelf induces ECU malposition. **a** Tenosynovitis with rheumatoid arthritis causes a loosening of the extensor retinaculum and thereby induces ECU subluxation. **b** The ECU is repositioned to the dorsal side when the bony shelf size is normal. However, an excessive large bony shelf causes insufficient reposition of the ECU. **c** The ECU malposition causes the tendon to become unbalanced at the wrist joint

surrounding soft tissue. This may compromise the balance of the ulnar side of the radiocarpal joint. However, postoperative wrist joint alignment is comparable to that of the original S–K procedure. Therefore, this disadvantage does not play an important role in the overall clinical outcomes.

The modified S–K procedure might contain a poor prognosis. However, the clinical outcomes of the modified S–K procedure in the current study were nearly equivalent to those of the S–K procedure in other reports [7, 9, 17, 21]. As a result, even when the original S–K procedure cannot be performed due to severe bone destruction, the outcome does not tend to be poor when the modified S–K procedure is used. The modified S–K procedure is thus considered to be another possible alternative modality for the treatment of severely destroyed wrists.

The current study has some limitations, including a small study population, a relatively short follow-up period (34.5 months), and a lack of RA activity assessment. However, the greatest limitations of this study are that no functional outcome research was conducted and no comparisons were made with other procedures. Further research with more patients is thus called for to confirm these findings.

Conflict of interest None.

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