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ORIGINAL PAPER

Functional outcomes after the Sauvé-Kapandji procedure for distal radio-ulnar post-traumatic instability: a case-control comparison of three different operative methods of stabilization of the ulnar stump

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Abstract

Purpose This study was performed to elucidate the cause of proximal ulnar stump pain by comparing the clinical results and radiographic changes among three treatment groups involving different Sauvé-Kapandji procedures.

Methods Thirty-seven patients (38 wrists) with distal radioulnar joint disorders followed up for ≥ six months post-operatively were investigated. Patients were treated by one of three Sauvé-Kapandji procedures. In group A (13 wrists), the original Sauvé-Kapandji procedure was performed. Groups B (13 wrists) and C (12 wrists) involved different modified Sauvé-Kapandji procedures with stabilization of the proximal ulnar stump using the extensor carpi ulnaris tendon. At the final examination, we evaluated wrist pain, proximal ulnar stump pain, the ranges of forearm pronation/supination, grip strength, the grip strength ratio between the affected and unaffected sides, and the clinical evaluation score. Standard posteroanterior and lateral radiographs during rest and during maximal gripping were taken for each patient at the final examination, and radiographic parameters were measured.

Results Although significant differences in the frequency of ulnar stump pain were observed between group A and group B or C, no significant differences in wrist pain or the clinical evaluation score were observed. Moreover, no differences in the radiographic changes were noted among the three procedures.

Conclusion These findings suggest that proximal ulnar stump pain may be caused not by radial or dorsal deviation of the proximal ulnar stump but by other dynamic factors.

Keywords Sauvé-Kapandji procedure · Distal radioulnar joint · Ulnar proximal stump · Ulnar stump pain

Introduction

Disorders of the distal radioulnar joint (DRUJ), which are usually accompanied by rheumatic arthritis, osteoarthritis, and malunion of distal radius fractures, occasionally cause ulnar wrist pain. Although several surgical procedures have been proposed for the management of DRUJ disorders, the Sauvé-Kapandji procedure is a very useful option for relief of wrist pain, an increase in the range of forearm rotation, and improvement in grip strength in patients with various DRUJ disorders [1–10]. Pain over the proximal ulnar stump, however, frequently develops during forearm rotation or lifting of heavy objects after the surgery. This pain has been suggested to be caused by dynamic instability of the proximal ulnar stump secondary to resection of a small segment of the distal ulnar shaft [4, 11]. Tenodesis has been simultaneously performed with the Sauvé-Kapandji procedure to stabilize the unstable proximal ulnar stump and thus improve the proximal ulnar stump pain [9, 12–16]. Although satisfactory clinical outcomes have been observed by this method, the mechanism of pain relief remains unclear.

We have performed three different Sauvé-Kapandji procedures: the original procedure without stabilization of the proximal ulnar stump [1–6, 11] and two different modified procedures involving stabilization of the proximal ulnar stump with the extensor carpi ulnaris (ECU) tendon [9, 14, 17]. In the present study, the clinical results and radiographic changes

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were compared among these three techniques, and the cause of proximal ulnar stump pain is discussed.

Materials and methods

This retrospective, non-interventional case series was performed in Nippon Medical School Hospital. The patients' demographic data, medical histories, imaging findings, and follow-up data were extracted from the medical records.

Patients and surgical procedures

A total of 42 wrists of 40 patients with DRUJ disorders underwent the original or one of the two modified Sauvé-Kapandji procedures at our institution from February 1995 to January 2004. Patients who were followed up for < six months after the operation and who had rheumatoid arthritis were excluded from this study. Therefore, 38 wrists of 37 patients who underwent direct examination were evaluated. All surgical procedures were performed by one of the authors (T.S.).

The patients were treated by three different procedures (groups A–C). Patients in group A underwent the original Sauvé-Kapandji procedure [1–6, 11] without stabilization of the proximal ulnar stump. Patients in group B underwent a modified Sauvé-Kapandji procedure involving stabilization of the proximal ulnar stump with the ECU tendon, which was split in the central sulcus; the radial half was released at the musculotendinous junction and passed through a hole drilled in the proximal ulnar stump, reflected, and sutured to the remaining tendon at a distal site, while the proximal ulnar stump was suspended [17]. Patients in group C underwent a different modified Sauvé-Kapandji procedure involving stabilization of the proximal ulnar stump with the ECU tendon, which was split in the central sulcus to the ulnocarpal level from the musculotendinous junction; the released radial half was passed through a hole drilled in the proximal ulnar stump and sutured again to the remaining tendon [14]. In all groups, cancellous bone collected from the proximal ulnar shaft was grafted into the decorticated distal radioulnar joint and fixed with a screw and pin. In addition, a part of the pronator quadratus muscle was interposed in the resulting pseudarthrosis, and its fascia was sutured to the surrounding soft tissue. In groups B and C, tendon suturing was performed with the wrist in maximum volar flexion, while tension was manually applied to the tendon (Fig. 1).

Group A comprised 12 patients (4 male, 8 female; 13 wrists), group B comprised 13 patients (5 male, 8 female; 13 wrists), and group C comprised 12 patients (4 male, 8 female; 12 wrists). In group A, one patient with a bilateral DRUJ disorder underwent the original procedure in both wrists. The details of each patient in each group are shown in

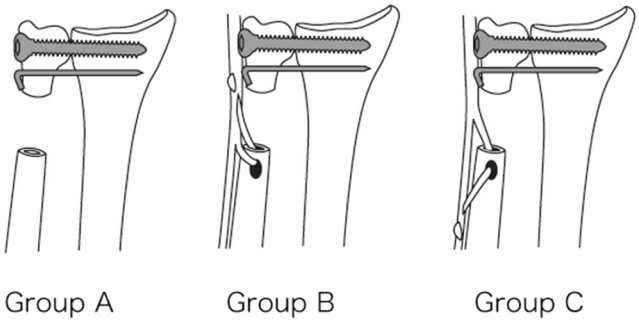

Fig. 1 Three different operative procedures in the present study. Group A: Conventional surgical procedure without stabilization of the proximal ulnar stump was performed. Group B: The radial half of the split extensor carpi ulnaris tendon was passed through a bone hole made in the proximal ulnar stump and sutured to the remaining tendon in an interlacing fashion, while the proximal ulnar stump was distally suspended. Group C: The radial half of the split extensor carpi ulnaris tendon was passed through a bone hole made in the proximal ulnar stump and sutured to the remaining tendon in an interlacing fashion at a proximal site. In each method, the fascia of the extensor carpi ulnaris tendon was sutured to the ulnar periosteum

Table 1. No significant differences were observed in age, sex, the range of rotation, the grip strength of the bilateral side, the grip strength ratio between the affected and unaffected sides as measured with a dynamometer (Jamar, Baran/Tec, Clifton, NJ), the follow-up period, or the cause of the DRUJ disorders among the three groups.

Post-operative evaluation

At the time of the final examination, we investigated wrist pain, proximal ulnar stump pain, the ranges of forearm pronation and supination, the grip strength, and the grip strength ratio between the affected and unaffected sides. Part of the clinical evaluation scoring system described by Inoue and Tamura [18] was modified by addition of stump pain to wrist pain in the pain items. Stump pain was classified as severe (presence of pain affecting daily activities), moderate (presence of pain not affecting daily activities), mild (absence of pain but presence of clicks), or none (absence of both pain and clicks) (Table 2).

Standard posteroanterior and lateral radiographs of each patient were taken at the final examination under two different conditions: the resting view (during rest with complete relaxation) and the dynamic view (during maximal gripping). The patients' forearms were always held in neutral rotation with the shoulders abducted and elbows flexed to 90° while taking the radiographs. On the posteroanterior images, we measured the remaining length of the ulnar head (ulnar distance, mm), the distance between the proximal ulnar stump and distal stump (ulnar gap, mm), and the minimum distance between the distal end of the proximal ulnar stump and distal radius (interosseous distance, mm). On the lateral images, we measured the minimum distance between the dorsal margin of the

Table 1 Pre-operative demographic data for the patients according to the operative procedure

	Total	Group A	Group B	Group C	*p* value
Patients (wrists)	37(38)	12(13)	13(13)	12(12)	
Age (years)	24-72	24-70	27-72	28-65	
Mean ± SD	46.5 ± 13.5	44.9 ± 14.3	47.9 ± 14.5	46.6 ± 12.5	0.86
Gender					
Female	24	8	8	8	0.95
Male	13	4	5	4	
Follow-up (months)	8-35	9-35	8-24	8-28	
Mean ± SD	16.9 ± 6.1	17.7 ± 8.0	15.5 ± 5.6	17.7 ± 6.1	0.66
The range of rotation at pre-operative survey	114.2 ± 29.3	110.4 ± 26.3	117.1 ± 34.3	115.3 ± 28.8	0.64
The grip strength on the affected side at pre-operative survey	18.8 ± 7.9	19.9 ± 7.4	18.4 ± 9.1	17.9 ± 7.6	0.84
The grip strength on the unaffected side at pre-operative survey	35.1 ± 7.2	35.4 ± 7.1	34.3 ± 8.4	35.7 ± 6.6	0.88
The ratio of the grip strength[a] (%)	52.4 ± 18.5	56.3 ± 18.4	51.4 ± 21.0	49.3	0.64
Disorder					
DRUJ Osteoarthritis	22	9	5	8	0.24
Fracture dislocation	14	3	7	4	
DRUJ dislocation	2	1	1	0	

Data are expressed as mean ± standard deviation (SD) *$p<0.05$; **$p<0.01$

[a] Compared with that of the unaffected side (%) at pre-oprative survey

distal radius and the dorsal margin of the proximal ulnar stump (dorsopalmar distance, mm) (Fig. 2).

One of the authors (T.S.) examined whether incorrect rotation of the wrist or forearm occurred during gripping. Two of the authors (T.S. and Y.T.) performed all radiographic measurements. Clinical and radiographic complications until the final evaluation were also investigated.

Statistical analysis

All data are presented as mean ± standard deviation. The Kruskal-Wallis one-way nonparametric test was used for statistical analysis of the data. All data were statistically analyzed with SPSS 20.0 software (IBM Corp., Armonk, NY). A p value of < 0.05 was considered statistically significant.

Results

Treatment results

The precise treatment results of each patient in each group are shown in Table 3. Wrist pain at the final evaluation was classified as none in ten wrists and mild in three in group A, none in ten and mild in three in group B, and none in nine and mild in three in Group C; improvement to mild or none was observed in all three groups without significant differences. Stump pain was classified as none in seven wrists, mild in three, moderate in two, and severe in one in group A; none in 12 and mild in one in group B; and none in all wrists in group C. Although no significant differences in wrist pain were observed, significant differences in ulnar stump pain were observed between group A and group B or C.

Table 2 Modified clinical evaluation scoring

Point	0	1	2	3	4
Pain (wrist)	Severe	Moderate	Mild	–	None
Pain (ulnar stump)	Severe	Moderate	Mild	–	None
Pro/sup	< 100°	100–120°	120–140°	140–160°	160–180°
Grip strength	< 25%	25–40%	40–65%	65–80%	> 80%

Excellent 15–16, Good 12–14, Fair 9–11, Poor < 8

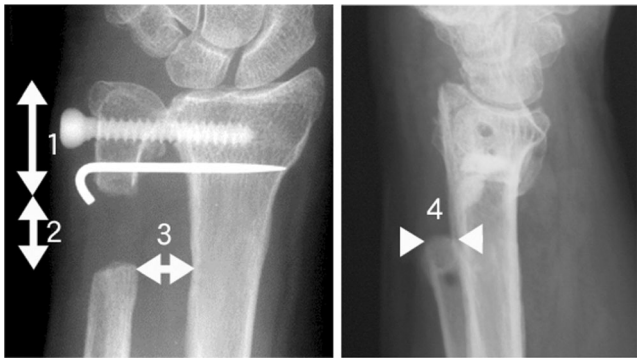

Fig. 2 Measurement methods on plain radiographs. 1 Ulnar distance (mm). 2 Ulnar gap (mm). 3 Interosseous distance (mm). 4 Dorsopalmar distance (mm)

The range of rotation at the final survey was 158° ± 22° in group A, 161° ± 18° in group B, and 162° ± 25° in group C. The grip strength compared with that on the normal side was 84.8% ± 12.9% in group A, 85.7% ± 14.7% in group B, and 83.9% ± 11.9% in group C. Marked improvement in the range of rotation and in the grip strength was observed in all three groups without significant differences.

Treatment results were excellent in seven wrists, good in three, and fair in three in group A; excellent in nine and good in four in group B; and excellent in eight and good in four in group C. No significant differences in the clinical evaluation score were observed between group A and group B or C.

Radiographic evaluation

The radiographic parameters of each patient in each group are shown in Table 4. No significant differences were observed among the three groups. The interosseous distance was slightly shorter in group A than in the other groups. However, these parameters were not significantly different among the three groups. The interosseous distance ratio also showed a slightly more marked standard deviation in group A but was not significantly different among the three groups.

Figure 3 shows radiographs of a patient, 41 year-old male, who had undergone conventional procedures (group A). At the final follow-up, 32 months post-operatively, he complained severe proximal stump pain. On the other hand, Fig. 4 shows radiographs of a patient, 53 year-old male, who had undergone a modified Sauvé-Kapandji procedure involving stabilization of the proximal ulnar stump with the ECU tendon in the wrist (group B). At the final follow-up, 12 months post-operatively, he had no pain on the proximal stump of ulna.

Table 3 Post-operative demographic data for the patients according to the operative procedure.

	Total	Group A	Group B	Group C	*p* value
The range of rotation at post-operative survey	160.2 ± 21.1	158.5 ± 21.8	160.5 ± 18.1	161.8 ± 24.9	0.91
The grip strength on the affected side at post-operative survey	29.5 ± 6.6	29.9 ± 5.9	28.8 ± 7.0	29.9 ± 7.2	0.77
The ratio of the grip strength[a] (%)	84.8 ± 12.9	85.7 ± 14.7	84.6 ± 12.8	83.9 ± 11.9	0.88
Pain (Wrist)					
None	29	10	10	9	0.99
Mild	9	3	3	3	
Moderate	0	0	0	0	
Sever	0	0	0	0	
Pain (Ulnar stump)					
None	31	7	12	12	<0.01
Mild	4	3	1	0	
Moderate	2	2	0	0	
Sever	1	1	0	0	
Clinical evaluation score					
Excellent	24	7	9	8	0.44
Good	11	3	4	4	
Fair	3	3	0	0	
Poor	0	0	0	0	

Data are expressed as mean ± standard deviation (SD) *p<0.05; **p<0.01

[a] Compared with that of the unaffected side (%) at pre-operative survey

Table 4 Analysis of the post-operative radiographs

Parameters	Total	Group A	Group B	Group C	*p* value
Ulnar distance (mm)	20.1 ± 2.3	19.9 ± 2.4	19.8 ± 2.4	20.5 ± 2.1	0.58
Ulnar gap (mm)	13.0 ± 2.1	13.7 ± 2.3	13.7 ± 2.3	12.4 ± 1.8	0.33
Interosseous distance					
At rest (mm)	8.7 ± 2.7	8.5 ± 4.0	8.9 ± 2.1	8.8 ± 1.4	0.86
At grip (mm)	8.0 ± 2.0	7.7 ± 2.8	8.1 ± 1.7	8.1 ± 1.3	0.82
Dorso-palmar distance					
At rest (mm)	1.0 ± 3.2	1.1 ± 3.6	0.9 ± 3.0	0.6 ± 1.6	0.99
At grip (mm)	0.9 ± 1.5	1.1 ± 1.6	0.6 ± 1.6	0.9 ± 1.6	0.71

Data are expressed as mean ± standard deviation (SD)

*$p < 0.05$; $p < 0.01$

Complications

In one wrist in Group A, limitations in forearm rotation developed 6 months after the operation, and plain X-ray examination showed re-bone union of the ulnar pseudarthrosis. This bone union was resected again together with the remained periosteum, and a tendon ball produced with the palmaris longus tendon was put in place. The limitations in forearm rotation rapidly disappeared. In group B, four wrists showed bone failure in the proximal ulnar stump, probably because of excessive tension of the ECU tendon, at a mean of 8.5 months (5–12 months) after the operation. Two of the four wrists were asymptomatic, but nonpainful clicks were observed in the other two wrists (Fig. 5). No wrists in group A or C showed such bone defects.

Discussion

The Sauvé-Kapandji procedure was originally described as a surgical treatment for disorders of the DRUJ caused by rheumatoid arthritis [1]. However, this procedure has since been widely performed not only to improve pain, range of motion, and grip strength in patients with DRUJ disorders accompanied by osteoarthritis but also as a salvage operation after failure of other treatment methods for DRUJ disorders or distal radius fractures [3, 6–9, 12, 19, 20]. Nevertheless, ulnar wrist pain around the artificially produced pseudarthrosis at the distal end of the ulnar shaft during motion has been known to occur [4, 11, 21].

Nakamura et al. [4] performed the Sauvé-Kapandji procedure in 15 cases and observed pain at the proximal stump of the ulna within three months after the operation in eight cases; four of these cases showed spontaneous disappearance of pain within six months after the operation, while the other four showed persistent pain. Minami et al. [11] observed stump pain in seven of 15 cases in an early series of patients treated by the Sauvé-Kapandji procedure without stabilization of the proximal ulnar stump; a stabilizing procedure of the proximal ulnar stump was added in five cases. These authors also found

Fig. 3 Plain radiographs of a patient, 41-year-old male, who had undergone conventional procedures (group A). At the final follow-up, 32 months post-operatively, he complained severe proximal stump pain

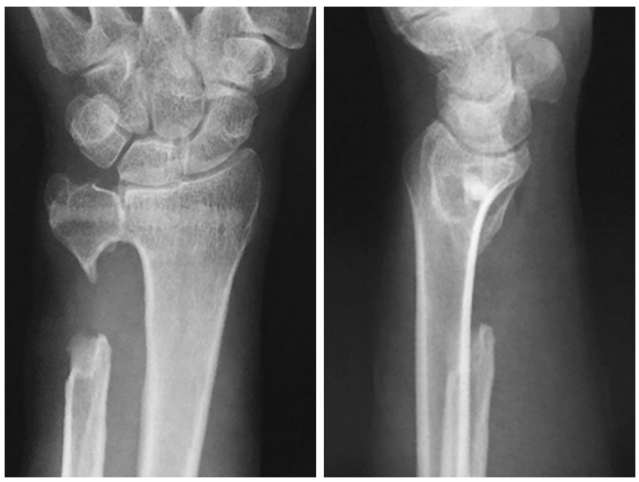

Fig. 4 Plain radiographs of a patient, 53-year-old male, who had undergone a modified Sauvé-Kapandji procedure involving stabilization of the proximal ulnar stump with the ECU tendon in the wrist (group B). At the final follow-up, 12 months post-operatively, he had no pain on the proximal stump of ulna

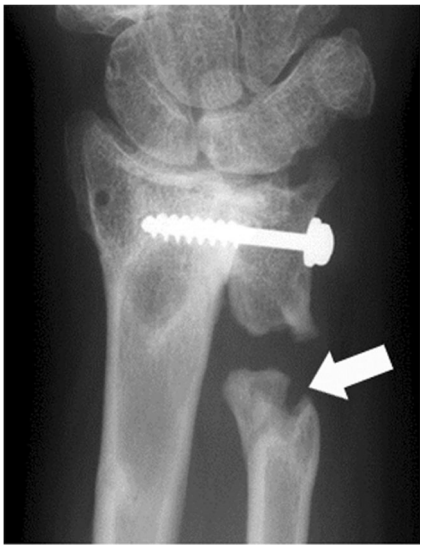

Fig. 5 Plain oblique radiographs 8 months post-operatively. In group B, four wrists showed bone failure in the proximal ulnar stump; this was probably due to excessive tension of the extensor carpi ulnaris tendon

post-operative radial deviation of the proximal ulnar stump on radiographs and speculated that this radial deviation was the cause of proximal ulnar stump pain.

To evaluate the association between radial deviation of the proximal ulnar stump and proximal ulnar stump pain, we compared changes in pain and radiographic findings between group A (treated by the original Sauvé-Kapandji procedure without stabilization of the proximal ulnar stump) and groups B and C (treated by this procedure plus stabilization with the ECU tendon). No significant differences in the deviation of the proximal ulnar stump were observed on radiographs between group A and group B or C, although ulnar stump pain was observed in 6 (46%) of the 13 wrists in group A but in only 1 (4%) of the 25 wrists in groups B and C. These findings suggest that stabilization in the proximal ulnar stump can control its instability but cannot correct dorsal ulnar deviation or dorsal displacement of the radius. In other words, proximal ulnar stump pain may be caused not by radial or dorsal deviation of the proximal ulnar stump but by other dynamic factors.

McKee and Richards [22] reported that the proximal ulnar stump approached the distal end of the radius (dynamic radioulnar convergence) because of antebrachial muscle contraction during maximal grip in patients treated by Darrach's procedure, resulting in direct contact (dynamic radioulnar impingement) in five of them. They suggested that this phenomenon occurs due to the lack of support by the DRUJ secondary to resection of the ulnar head, but they did not report the degree of convergence (mm). We also performed measurements using a similar method and observed radioulnar convergence (i.e., a decrease in the interosseous distance) on posterolateral radiographs during firm grip in all three groups. However, the degree of convergence was slight, and no wrists showed dynamic radioulnar impingement. Unlike Darrach's procedure, the Sauvé-Kapandji procedure preserves the ulnar head, which may function as a roof, avoiding direct force due to muscle contraction on the proximal ulnar stump.

To reduce the instability of the proximal ulnar stump, Kapandji [5] recommended shortening the pseudarthrosis distal to the ulnar shaft and placing it as distally as possible. However, Minami et al. [14] reported no association between the instability and the length of the ulnar head or the pseudarthrosis. Moreover, the fixation is technically difficult unless the length of the ulnar head (i.e., the ulnar distance) is about 20 mm, and excessively short pseudarthrosis induces a risk of re-bone union or impingement between the distal and proximal ulnar stumps.

Use of the ECU tendon to stabilize the proximal ulnar stump has frequently been reported in recent years [14, 17, 23, 24]. In the present study, the stabilization procedure differed between groups B and C. Initially, we expected that the procedure used in group B would achieve firmer stability because the tension of the split ECU tendon can be adjusted during its distal suspension, and we were concerned that the procedure used in group C would have weaker stabilization effects because the split ECU tendon is passed through a bone hole and only sutured to the remaining portion of this tendon. Clinical stability was obtained in both groups B and C, although bone defects in the proximal ulnar stump due to excessive tension of the ECU tendon were observed in group B. Minami et al. [25] also reported breakage of the drill hole in three of 12 wrists at the 95-month follow-up evaluation in a case series of patients treated by the modified Sauvé-Kapandji procedure (stabilization of the proximal ulnar stump with the ECU tendon). Moreover, they reported that these three patients had no residual wrist pain or ulnar stump pain during their clinical courses, which is consistent with our patients who had bone defects in the proximal ulnar stump in group B. These findings suggest that maintaining stability of the ulnar stump for a fixed period of time after surgery can therefore prevent any subsequent occurrences of stump pain, although breakage of the drill hole seems to be inevitable when stabilizing the proximal ulnar stump with the ECU tendon.

This study has three main limitations. First, our study focused on only a limited clinical situation because it was based on the original location of the proximal ulnar stump during forearm neutral rotation. The second limitation of the study is its retrospective design, which is susceptible to more bias than a prospective study. The third limitation is the small number of cases and short follow-up time. A prospective study for large number of cases for long follow-up periods would still be required to confirm the relationship between the clinical evaluation findings and the radiological parameters.

Conclusion

The stabilization in the proximal ulnar stump using the ECU tendon can control its instability but it can correct neither dorsal ulnar deviation nor dorsal displacement of the radius. In other words, proximal ulnar stump pain may be caused not by radial or dorsal deviation of the proximal ulnar stump but by other dynamic factors.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval According to the Public Health Japanese Law, approval from an institutional review board is not required for human non-interventional studies. All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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