Amount of ulnar resection is a predictive factor for ulnar instability problems after the Sauvé-Kapandji procedure

A retrospective study of 44 patients followed for 1–13 years

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Background The Sauvé-Kapandji procedure can result in instability of the proximal ulnar stump.

Patients and methods We reviewed 44 patients (mean follow-up time 6 (0.6–13) years) to investigate predictive factors for ulnar instability after Sauvé-Kapandji operation. We used several scores including an instability score specifically designed for this study.

Results Patients with a longer proximal ulnar stump had significantly lower instability scores, significantly better Mayo Modified wrist scores and DASH scores, and also less pain than those with shorter proximal ulna.

Interpretation If the shortening of the proximal stump is less than 35 mm, a reliable improvement in motion and a high patient satisfaction can be expected. The risk of a painful ulnar instability is related to the amount of resection, and can be reduced by creating a long upper ulnar stump.

Chronic disorders of the distal radio-ulnar joint (DRUJ) lead to ulnar wrist pain in combination with limited forearm rotation (Bowers 1999). Several operations such as resection arthroplasty (Darrach 1942), hemiresection arthroplasty (Watson and Manzo 2002), hemiresection interposition arthroplasty (Bowers 1992), arthrodesis of the DRUJ in combination with a pseudarthrosis of the distal ulna (Sauvé and Kapandji 1936), or ulnar head prosthesis (van Schoonhoven et al. 2000) have been advocated to improve this impairment. Among these salvage procedures, the Sauvé-Kapandji operation has become increasingly accepted and is presently the most popular procedure for chronic DRUJ disorders in Germany (Carter and Stuart 2000, Daecke et al. 2005). However, problems of discomfort at the proximal ulnar stump are not infrequent and are presumably related to instability of the stump (Nakamura et al. 1992). Although the issue of ulnar instability is widely known, its definition varies and it cannot be measured reliably—either clinically or radiographically.

The aim of this retrospective study was to identify specific characteristics of ulnar instability and to evaluate the role of instability as a predictive factor for the outcome of the Sauvé-Kapandji procedure.

Patients and methods

Patients

Data on 55 patients (56 wrists) who underwent the Sauvé-Kapandji procedure between January 1989 and August 2002 were assessed retrospectively. 2 patients had died and 5 others (6 wrists) were lost or unable to return for follow-up. 3 other cases were excluded due to concomitant impairment (contracture after compartment syndrome, wrist arthrodesis, partial paralysis following ulnaris nerve injury). One other patient was excluded

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Table 1. Diagnoses in 44 patients treated by the Sauvé-Kapandji procedure

Diagnosis	No. of patients
Arthrosis of DRUJ [a] after radius fracture	13
Dislocation of DRUJ after radius fracture	16
Arthrosis of DRUJ after combined forearm fracture	5
Primary arthrosis of DRUJ	2
Dislocation of DRUJ after growth plate injury of radius	2
Dislocation of DRUJ after infantile osteomyelitis of radius	1
Madelung deformity	3
Hereditary multiple exostoses disease	1
Rheumatoid arthritis	1

[a] DRUJ: distal radio-ulnar joint.

Table 2. Instability score (range: 0–100 points), containing 7 questions (1–7) specifically pertaining to DRU joint-related dysfunction, and 5 questions (8–12) concerning symptoms associated with ulnar instability. The score for each question ranges from 1 (best) to 5 (worst)

Item	Scale
Difficulty in:	
1. Turning on/off a tap (faucet)	1–5
2. Pressing down a door handle	1–5
3. Using a screwdriver	1–5
4. Turning a stiff key	1–5
5. Opening a new screw-top jar	1–5
6. Wringing a dishcloth	1–5
7. Lifting a heavy suitcase (from the floor to a chair)	1–5
8. Pain only at ulnar side of the wrist at rest	1–5
9. Pain only at ulnar side of the wrist during manual work	1–5
10. Click at rotation of forearm (e.g. changing a light bulb)	1–5
11. Pain and click at rotation of forearm	1–5
12. Sensation of instability in the operated forearm	1–5

because the Sauvé-Kapandji procedure was secondary to implantation of a radial-head silastic prosthesis after Essex-Lopresti injury. This left 44 patients (27 women) for our study. Their median age at the time of surgery was 52 (15–80) years. Ulnar wrist pain and reduction of forearm rotation was the presenting complaint in all cases. The median period of time with preoperative pain was 1.6 (0.1–13) years. Most patients (29/44) had arthrosis or chronic dislocation of the DRUJ subsequent to distal radial fracture (Table 1). The patients were assessed clinically at a mean of 6 (0.6–13) years after surgery.

Assessment of clinical data

At follow-up we evaluated pain, subjective assessment and function (Welk and Martini 1998), and patients were particularly questioned about pain at the ulnar stump. Clinical assessment included the range of motion (ROM) of the wrist, forearm and elbow (measured with a goniometer). The clinical examination was performed by one single surgeon who was not involved in the operative procedure. In 6 patients the preoperative ROM was not documented in the records. Grip strength was only measured at follow-up (Jamar dynamometer; Asimow Engineering, Los Angeles, CA). To evaluate combined postoperative results, we used the DASH score (0–100, with 0 representing the best value) (Hudak et al. 1996) and the Mayo Modified wrist score (100–0, with 100 representing the best value) (Lamey and Fernandez 1998).

For the instability score, patients were asked to answer a (non-validated) questionnaire specifically designed for this study which contained questions on symptoms related to ulnar instability—such as pain at the proximal ulnar stump after manual work, and also clicking and a sensation of forearm instability. Moreover, 7 questions specifically pertaining to DRUJ-related motion and dysfunction were added on the basis of the DRUJ questionnaire of Lindau et al. (2002) (Table 2).

Data on the preoperative condition, complications and further operations on the affected site were obtained from hospital records and confirmed by consulting each patient.

Assessment of radiographic data

Standard posteroanterior and lateral pre- and postoperative radiographs of the wrist were obtained and compared with the radiographs taken on follow-up. 2 patients refused follow-up radiographs. The preoperative radiographic features evaluated included: ulnar variance (Palmer et al. 1982), distal radial angulation, distal radial inclination, degeneration of the radio-carpal joint (Knirk and Jupiter 1986), and degeneration and subluxation of the DRUJ. Postoperative and follow-up radiographs were assessed for ulnar variance, length of distal ulna, gap of ulnar pseudarthrosis, gap between ulnar stump and radius (unloaded in pronation) (Palmer et al. 1982), union of DRUJ, and changes in radiographic appearance over time. In the case of elbow pain, standard radiographs of the elbow were taken in two planes and assessed for signs of degeneration.

The study was approved by the institutional review board and all subjects gave their informed consent to participate.

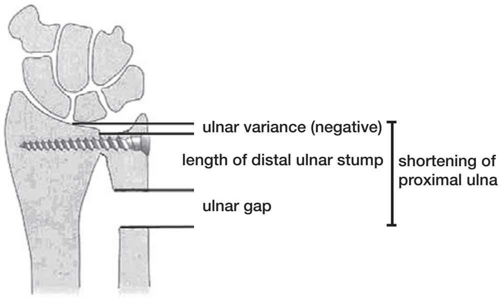
Surgical technique and postoperative management

All operations were performed by the consultant, or by a trainee under his supervision. A tourniquet was used and the operation was performed under general or regional anesthesia. The DRUJ was exposed through a curved dorso-ulnar incision. Superficial branches of the ulnar nerve were protected and the retinaculum was incised between the extensor carpi ulnaris (ECU) and the extensor digiti minimi tendon. The distal ulna was exposed between the two tendons and the osteotomies were performed approximately 3 and 4.5 cm proximal to the wrist level, depending on individual anatomy including ulnar variance. In patients with ulnar-plus variance, the resected segment was longer than in patients with ulnar-minus variance. The ulnar segment was resected along with the periosteum. The ulnar head was then hinged away from the radius and both articular surfaces were decorticated. Finally, the ulnar head was positioned against the radius in slightly ulnar-minus variance and fixated by an AO-malleolus screw. Pronator quadratus was sutured into the pseudarthrosis at the ECU tendon sheath. In operations performed after 2000, fixation was carried out using a cannulated screw.

All patients received a palmar splint for 3 weeks. Physiotherapy was started within the first few postoperative days and continued for a period of approximately 2 months.

Statistics

In accordance with the DASH score, the instability score was calculated by the equation: instability score = ((sum of responses / 12) –1) × 25.



Calculation of shortening of the proximal ulna (distance between wrist and proximal ulnar stump).

To compare short-term and long-term results, all patients were split along the rounded mean into two groups. Group A (n = 24) consisted of all patients at less than 6 postoperative years and group B (n = 20) at at least 6 postoperative years. For calculation of predictive factors for ulnar instability, shortening of the proximal ulna (distance between wrist and proximal ulnar stump) was defined as negative postoperative ulnar variance plus length of the distal ulnar stump plus ulnar gap (Figure). Either the Wilcoxon test or the paired t-test was applied to compare preoperative and postoperative parameters (e.g. intra-individual comparison of pre- and postoperative ROM). To estimate predictive factors (length of distal ulna, gap of ulnar pseudarthrosis and shortening of the proximal ulna) for instability and outcome, we used a regression analysis. For binary dependent variables (pain, subjective assessment and function), a logistic regression analysis was performed and a linear regression analysis was used for continuous dependent variables (instability score, DASH score and Mayo wrist score). Results of the regression analysis were presented as regression coefficient/odds ratio (OR) and 95% confidence interval (CI). A two-tailed p-value equal to or less than 0.05 was considered significant. All tests were without alpha adjustment. Data analysis was performed with SPSS for Windows version 11.0.1.

Results

Pain, subjective assessment and function

At follow-up, 18 of the 44 patients were free of pain and a further 18 patients experienced pain only during heavy work. 7 patients reported pain

Table 3. Median pre- and postoperative range of motion (ROM) and standard deviation (SD) for evaluated patients

Degrees	No. of patients	Preoperative ROM degrees	No. of patients	Postoperative ROM degrees	P-value Wilcoxon test
Supination	38	45 (SD 61)	44	80 (SD 20)	< 0.001
Pronation	38	70 (SD 30)	44	80 (SD 17)	< 0.001
Flexion	38	60 (SD 40)	44	60 (SD 32)	0.003
Extension	38	60 (SD 30)	44	70 (SD 28)	< 0.001
Radial deviation	36	20 (SD 20)	44	25 (SD 10)	0.001
Ulnar deviation	36	20 (SD 20)	44	30 (SD 8)	< 0.001

during daily activity and 1 patient experienced pain at rest. 5 patients reported specific pain at the distal ulna, equivalent to ulnar instability. Due to the limited number of these patients (n = 5), no statistical analysis was performed. Subjective assessment of operative outcome was rated as excellent in 22 patients, improved in 20, and the same in 2. In no cases was the rating worse. Regarding function, 22 patients reported having unlimited function. 20 other patients mentioned that they were careful not to overly exert their arm, and they experienced restrictions during physical exercise. 2 patients had to change their jobs. In both cases, ulnar shortening exceeded 50 mm (53 and 56 mm).

Clinical assessment

ROM improved concerning supination ($p < 0.001$), pronation ($p < 0.001$), flexion ($p = 0.003$), extension ($p < 0.001$), radial ($p < 0.001$) and ulnar deviation ($p < 0.001$) (Table 3). Mean postoperative rotation of the involved forearm was 160° (SD 30°) as compared to 170° (SD 20°) for the unaffected site. Flexion/extension and radial/ulnar deviation were reduced compared to the opposite arm (mean 25° and 7°, respectively). Grip strength of the affected arm was 16 (SD 7.7) kg versus 20 (SD 7.7) kg for the opposite arm.

Scores

Postoperative DASH score rated 24 (SD 20) points for all patients. The average Mayo Modified wrist score was 76 (SD 17) at follow-up. Altogether, 7 patients had an excellent result, 16 a good result, 11 a fair result and 8 a poor result. The average postoperative instability score was 29 (SD 24) points.

Factors predictive of ulnar instability

A significant relation between the shortening of the proximal ulna and the instability score or the clinical outcome was found by regression analysis (Table 4). A short proximal ulnar stump was associated with a higher score in the instability questionnaire. The fact that the instability score also showed a significant relation to clinical outcome indicated that inferior clinical outcome was mainly due to ulnar instability as a result of shortening.

A short proximal ulnar stump was associated with a higher instability score (OR 0.94, CI 0.09–1.8), with a lower Mayo Modified wrist score (OR –0.09, CI –1.7 to –0.53) and a higher DASH score (OR 0.77, CI 0.06–1.48). The risk of pain (OR 1.1, CI 1.0–1.2), of inferior subjective assessment (OR 1.1, CI 1.0–1.2) and of impaired function (OR 1.1, CI 1. –1.2) was also higher for a short proximal ulnar stump (Table 4). With every 1 mm of proximal ulnar resection, the risk of pain increased significantly by 10%. Furthermore, shortening of the proximal ulna proved to be a stronger factor for prediction of outcome than the length of the distal ulnar stump. We found no association between the radio-ulnar gap and instability or outcome ($p > 0.05$; data not shown).

Radiographic assessment

The ulnar variance decreased from 3 (SD 4) mm preoperatively (range –10 to 14 mm) to –0.8 (SD 2.3) mm postoperatively (range –12 to 2 mm). The length of the distal ulnar segment was 29 (SD 6) mm (range 16–45 mm) and the pseudoarthrosis gap was 14 (SD 4) mm (range 2–25 mm). Average shortening of the proximal stump was 45 (SD 8) mm (range 27–62 mm). For all patients with a

Table 4. Regression analysis of factors predicting ulnar instability. Relation between pain, subjective assessment, function, DASH score, Mayo Modified wrist score, instability score and radiographic features of the distal ulna. Regression coefficient/odds ratio (95% CI)

Outcome value	Length of distal ulna	Gap of ulnar pseudarthrosis	Shortening of proximal ulna	Instability score
Pain [a] Occurrence of pain = 1 Reference category: no pain at all = 0	1.07 (0.97–1.18) p = 0.12	1.15 (0.98–1.34) p = 0.07	1.10 (1.01–1.20) p = 0.03	1.09 (1.03–1.55) p = 0.004
Subjective assessment [a] Improved, same or worse = 1 Reference category: excellent = 0	1.09 (0.98–1.20) p = 0.1	1.26 (1.05–1.51) p = 0.01	1.12 (1.02–1.23) p = 0.01	1.06 (1.02–1.10) p = 0.004
Function [a] Impaired function = 1; Ref. category: no limitation in function = 0	1.09 (0.99–1.20) p = 0.09	1.07 (0.93–1.23) p = 0.32	1.09 (1.00–1.19) p = 0.04	1.05 (1.01–1.09) p = 0.009
DASH score [b]	0.62 (-0.32–1.56) p = 0.2	1.33 (-0.08–2.67) p = 0.05	0.77 (0.06–1.48) p = 0.03	0.66 (0.50–0.81) p< 0.001
Mayo Modified wrist score [b]	-1.11 (-1.86–-0.37) p = 0.004	-1.12 (-2.31–0.07) p = 0.07	-1.09 (-1.65–-0.53) p< 0.001	-0.45 (-0.65–0.25) p< 0.001
Instability score [b]	0.85 (-0.26–1.96) p = 0.1	1.08 (-0.61–2.77) p = 0.2	0.94 (0.09–1.80) p = 0.03	

[a] logistic regression analysis to [b] linear regression analyses

follow-up longer than 6 years, hypotrophy of the distal ulna and rounding of the end of the proximal stump was noted. Adaptation in shape between the end of the proximal stump and radius were seen in some cases. Changes in radiographic appearance had no clinical relevance.

In 13 cases, the follow-up radiographs showed osteoarthritis of the radio-carpal joint (grade 2–3, Kellgren and Lawrence (1957)). The DASH score of these patients was 28 (SD 17) as compared to 22 (SD 21) in the patients without radiographic signs of osteoarthritis (p = 0.4). The mean follow-up for patients with osteoarthritis was 4.7 years, and it was 6.5 years for patients without osteoarthritis of the radio-carpal joint (p > 0.05). We found no significant relationship between radial inclination or angulation and subjective, objective or combined results (p > 0.05). There were also no significant differences between group A (short-term) and group B (long-term) concerning subjective, objective and combined results (p > 0.05).

Further surgery und complications

Metalware was removed in 16 patients at their request, due to local discomfort. Metal hardware was also removed in 2 of the 5 patients with specific pain in the ulnar stump. Other complications such as nonunion, neuroma or reflex sympathetic dystrophy (RSD) did not occur in this group. 1 symptomatic nonunion of the DRUJ with consecutive fracture of the fixation screw was observed. Arthrodesis was repeated and bony fusion was achieved. Asymptomatic nonunion of the DRUJ was found in 3 other cases and no further therapy was necessary. After 2000, when the fixation technique changed, no more nonunions were found. The ulnar gap was bridged by heterotopic ossification in 1 patient 2 months after surgery, and was treated by segmental resection of the ulna. 3 patients had diminished sensation within the territories of the dorsal cutaneous branch of the ulnar nerve. 1 patient had symptoms of RSD for 6 months after surgery. 2 patients reported pain at the elbow. Radiographically, 1 of them who was suffering from multiple exostoses disease was starting to develop osteoarthritis of the radio-humeral joint 10 years after the surgery.

Discussion

We found a significant relationship between shortening of the proximal ulnar stump and clinical results. A short proximal ulnar stump was associated with a lower Mayo Modified wrist score, a higher DASH score and increased risk of pain. We have found no other studies that have investigated this relationship. Our findings suggest that the ulnar gap and distal ulnar segment should be kept as short as possible. In our patients, there was a rather high variation in the amount of ulnar resection and this allowed us to demonstrate the association between amount of resection and outcome. Our conclusion that ulnar resection should be limited is in accordance with Kapandji's proposal. He recommended creating an ulnar gap of 10–12 mm and a distal segment of 2.5–3.0 cm (Kapandji 1992). Rothwell et al. (1996) recommended resection of 8–10 mm of bone, 1 cm proximal to the head of the screw across the DRUJ, and Millroy et al. (1992) performed the osteotomy even more distally. If the gap is too small, however, bridging of pseudarthrosis occurs, as described by Lamey and Fernandez (1998) and as observed once in our study. If the distal segment is too small, compromised guidance of the stabilizing ECU might counterbalance the effect of the increased length of the proximal segment. On the basis of what is written in the literature and our own results, and keeping in mind the risk of destabilizing the ECU and the necessity of achieving fusion of the DRUJ, we would recommend performing the distal osteotomy directly proximal to the ulnar head. To prevent bony bridging of the pseudarthrosis on one side, and to achieve maximal stability of the proximal ulna on the other side, the pseudarthrosis gap should be approximately 10 mm. Thus, we would recommend an approximate shortening of the proximal ulna of 35 mm.

Our findings on the negative outcome of extended ulnar resection raise the question of the origin of inferior results. In the Sauvé-Kapandji procedure, this resection is performed to create a new joint, but segmental resection compromises the distal anchorage of the ulna (Nakamura et al. 1992). Thus, the potential complication of this operation—and a major concern for the surgeon—is the issue of instability of the proximal ulnar stump (Nakamura et al. 1992). The term "ulnar instability" for certain conditions related to the Sauvé-Kapandji procedure is not clearly defined in the literature. According to Sanders et al. (1991), the clinical sign of ulnar instability is "complaint of pain at the pseudarthrosis site while lifting with the forearm in supination". Other definitions are "pain over the proximal ulnar stump", "painful click or painless click", or variations of these (Nakamura et al. 1992, Carter and Stuart 2000, Minami et al. 2000, Sawaizumi et al. 2001, George et al. 2004). Clinical evaluation of ulnar instability is even more problematic than defining it. In the study of Rothwell et al. (1996), instability was tested clinically by "prominence of the end of the ulnar shaft when the pronated forearm is lifted against gravity". Lamey and Fernandez (1998) determined ulnar stump instability by the palpated motion of the stump as the patient alternately contracts and relaxes the forearm muscles. Both clinical evaluations are potentially biased by low inter-rater agreement and high inter-individual variation (i.e. thickness of the forearm). Sawaizumi et al. (2001) pointed out that no radiographic test has been proven to measure ulnar instability, since it is believed to be a dynamic problem. We also found no association between radio-ulnar distance and outcome. Consequently, we condensed these multiple findings concerning the condition of ulnar instability into one instability questionnaire. Since it is impossible to measure ulnar instability reliably, either clinically or radiographically, the best means of detecting this condition seems to be a questionnaire consisting of specific questions covering the function of the intended pseudarthrosis after Kapandji's procedure which corresponds to the function of the original DRUJ.

Our results confirm that there is a significant relationship between symptoms of instability evaluated by the questionnaire (instability score) and shortening of the proximal ulnar stump or clinical outcome. Thus, inferior results in patients with extended ulnar resection are mainly related to instability of the proximal ulnar stump. The more the ulnar was resected, the more likely it was that ulnar instability became symptomatic in our patients. In our study, only 5 of 44 patients complained of pain at the ulnar stump. However, reports of unspecific pain or limited function in additional patients in our study were most likely due to ulnar instability.

Other modifications of the Sauvé-Kapandji procedure (such as suspension tendoplasties) have also been described as preventing instability. However, except for the findings of 1 study (Minami et al. 1995), evidence of these modifications are still pending (Minami et al. 1995, Lamey and Fernandez 1998, Sawaizumi et al. 2001). Other techniques such as fixation of the pronator quadratus to the proximal ulnar stump undoubtedly play an important role in preventing forearm instability, but we could not assess this hypothesis since fixation was performed in every patient.

Besides instability of the proximal ulnar stump, impairment due to initial injury or possible degeneration of concomitant joints must also be considered to have a possible influence on outcome. In our study 13 patients showed osteoarthritis of the radio-carpal joint, which obviously cannot be a result of the Sauvé-Kapandji procedure. However, we were not able to show a significant relationship between the occurrence of osteoarthritis and inferior outcome.

In summary, on the basis of the specific instability questionnaire, we found a significant relationship between ulnar shortening, ulnar instability and clinical results. Our findings demonstrate that the potential risk of developing a painful and unstable ulna can be reduced by creating a short ulnar stump.

Author contributions

WD conception, idea and surgery. AKM surgery. SS statistical work. NAS conception, independent clinical and radiographical evaluation.

No competing interests declared.

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