Modified Sauvé–Kapandji operation for treatment of chronic post-traumatic derangement of the distal radioulnar joint

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Background
Once the distal radioulnar joint (DRUJ) has been damaged, it is unlikely that normal anatomy and function can be restored. The Sauvé–Kapandji operation is a popular choice among the several surgical salvage operations available.
Patients and methods
Eighteen patients with chronic post-traumatic derangement of DRUJ were treated by a modified Sauvé–Kapandji operation (with extensor carpi ulnaris tenodesis). The mean age of patients was 30 years (range, 22–45 years). All patients presented with pain in DRUJ, impaired forearm rotation, and weakness of grip strength.
Results
Two patients were lost to follow-up and were excluded from the study. On using the modified Mayo wrist scoring system (at a mean of 16 months of follow-up), 12 patients had satisfactory outcome and four patients presented a fair outcome (but not poor). The severity of pain improved in all patients (no pain in nine, mild pain in six, and moderate pain in one). The forearm rotation improved in all patients. The mean grip strength improved from 35 to 81% of that of the unaffected side. Thirteen patients (81.3%) returned to their previous work and activity levels, whereas three patients (18.7%) returned to lighter work. Complications included ulnar stump instability in one patient (treated by flexor carpi ulnaris tenodesis), neuroma of dorsal sensory branch of the ulnar nerve (one patient), and gap ossification in three patients (it required excision only in one patient).
Conclusion
The Sauvé–Kapandji operation is a satisfactory salvage procedure for the treatment of chronic post-traumatic derangement in young active patients, as it can reliably restore rotation of the forearm and grip strength while relieving pain and maintaining a functional range of motion of the wrist. However, problems with pain and instability of the ulnar stump are not infrequent. Tenodesis of the extensor carpi ulnaris provides static stabilization by tethering the ulnar stump to the carpus.

Keywords:
arthrosis, chronic derangement, distal radioulnar joint, instability, Sauvé–Kapandji operation

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Introduction

The distal radius injuries can result in post-traumatic osteoarthrosis, chronic instability, and subluxation or dislocation of the distal radioulnar joint (DRUJ), leading to ulnar wrist pain, limited forearm rotation, grip weakness, and functional deficits [1]. Salvage procedures, such as the Darrach resection, interposition arthroplasty, and matched resection of the distal aspect of the ulna, provide generally satisfactory results in elderly patients with low functional demands on the wrist [2,3]. However, the results of such procedures in young active patients who place high functional demands on the wrist and forearm have been disappointing [2–4].

In recent years, several studies [5–8] have suggested that the Sauvé–Kapandji operation may be a better salvage procedure for the treatment of post-traumatic chronic derangement in young, active patients. However, problems with pain and instability of the ulnar stump are not infrequent.

The objective of this study was to describe the technique and report the results of a modified Sauvé–Kapandji procedure in which a tenodesis of the extensor carpi ulnaris (ECU) to the carpus was added in an effort to decrease the problem of proximal ulnar stump instability.

Materials and methods

During the period between January 2005 and March 2008, 18 patients with chronic post-traumatic derangement of DRUJ were treated at our institution by a modified version of the Sauvé–Kapandji operation. The mean age of the patients was 30 years (range, 22–45 years). Eleven patients were men and seven patients were women). All patients presented with pain in the DRUJ,

impaired forearm rotation, and weakness of grip strength. Pain was localized to the DRUJ (not to the wrist joint) and was elicited by rotation of the forearm and ballotment of ulnar head. The mean duration of symptoms was 1 year (range, 7 months–2 years). A course of conservative treatment had failed in all cases. The original injuries were old physeal injury of the distal radius (five patients), distal radius fractures (seven cases), Galeazzi fracture–dislocation (two patients), and isolated disruption of DRUJ (four patients). All had unilateral procedures. The dominant wrist was affected in 12 patients. Fourteen patients had high-demand jobs. Patients who required other combined procedures such as radial osteotomies and elderly patients (with low functional demands) were excluded from the study.

Patients were clinically evaluated using the wrist scoring system of the Mayo Clinic (modified to include rotation of the forearm) [8] (Table 1).

Pain was rated as mild, moderate, or severe [9] (Table 2).

The grip strength was measured using a Jamar dynamometer as kgF and was compared with that of the normal side.

Table 1 Modified Mayo wrist scoring system [8][a]

Category	Score (points)	Findings
Pain	25	None
	20	Mild
	15	Moderate
	0	Severe
Function	25	Able to return to employment
	20	Restricted employment
	0	Unable to work due to pain.
Pronation–supination (deg.)	25	$\geq$170
	15	141–169
	10	101–140
	5	61–100
	0	$\leq$60
Grip strength (% of normal side)	25	95–100
	15	75–94
	10	50–74
	5	25–49
	0	0–24

deg., degrees.
[a]A score of 90–100 points indicates an excellent result; 80–89 points, a good result; 65–79 points, a fair result; and <65 points, a poor result [8].

Table 2 Rating of pain [9]

Degree	Criteria
Mild	Occurs at extremes of active range of movement and does not bother the patient or interfere with activities of work or daily living
Moderate	Occurs during strenuous manual labor or causes some alteration in work activities but does not interfere with activities of daily living
Severe	Occurs during activities of daily living or at rest

Radiologic assessment

Preoperative standard posteroanterior and lateral radiographs were used to measure or document ulnar variance, radioulnar distance (in posteroanterior and lateral views), DRUJ subluxation or dislocation, and DRUJ arthrosis.

Operative technique

A longitudinal skin incision was made over the subcutaneous border of the ulna between the flexor carpi ulnaris (FCU) and ECU tendons, starting 5–6 cm proximal to the prominence of the ulnar head and ending at the level of the pisiform. The dorsal sensory branch of the ulnar nerve, which crosses the space between the tip of the ulnar styloid process and the pisiform, was carefully identified and protected. The sixth dorsal compartment of the wrist was dissected and retracted toward the radius. The pretendinous retinaculum was exposed and incised, and the distal aspect of the ulna was exposed. A 10–15-mm segment of the distal end of the ulna was marked for resection, leaving room for the placement of two screws distally. If there was positive ulnar variance, a correspondingly longer segment of the ulna was removed so that, when the ulnar head was recessed to neutral ulnar variance, the resulting gap would measure 10–15 mm. An oscillating saw was used to divide the ulna at the proximal end of the segment to be removed, and the distal fragment was levered out. The dorsal aspect of the capsule of the distal DRUJ was incised, and cartilage from the articular surfaces of the sigmoid notch and the ulnar head was denuded down to cancellous bone. The distal osteotomy was then completed, the periosteum in the region of the gap was meticulously resected, and the region was thoroughly irrigated to remove bone debris, to prevent the formation of ectopic bone in the gap. The cancellous bone graft, obtained from the resected segment, was packed into the area of the arthrodesis. The ulnar head was temporarily fixed to the sigmoid notch of the distal part of the radius with a single K-wire. Image intensification was used to ensure fixation in a position of neutral ulnar variance. Both cortices of the ulnar neck and the near cortex of the radius were drilled, and a 3.5-mm cortical screw was inserted. The lag-screw technique should not be used for this screw to avoid tilting the head of the ulna, which must remain parallel to the long axis of the ulnar shaft. The K-wire was removed and was replaced with a 3.5-mm cortical screw or a 4-mm cancellous screw. The pronator quadratus was mobilized and anchored into the defect left by the resected ulnar shaft to prevent bone bridging.

A 3.5-mm drill hole was drilled from the dorsoulnar aspect of ulnar shaft into the medullary cavity. The ECU tendon was split longitudinally and the radial half released at the ulnocarpal level. It was then reflected proximally, leaving it attached at the musculotendinous junction. This proximally based strip ~6–8 cm long was then passed into the medullary canal through the drill hole, retrieved at the distal stump of the ulna, and then sutured back onto itself in an interlacing fashion [9,10].

Postoperative care

A long-arm splint was applied for 3 weeks, after which gentle active forearm rotation in a short-arm splint for 3 weeks was encouraged. Full motion of the wrist was

allowed after bony fusion of DRUJ was confirmed radiologically.

Results

Excluding two patients who were lost to follow-up, the mean follow-up period was 16 months (12–24 months).

The overall clinical results using obtained using the modified Mayo wrist scoring system [8] were satisfactory in 12 patients (75%; all good, but none excellent), and unsatisfactory in four (25%; all fair).

Pain

Preoperatively, all patients complained of pain (severe in 12 and moderate in four). Postoperatively, the magnitude of pain improved in all patients (no pain in nine, mild pain in six, and moderate pain in one).

Range of movement

The mean supination improved from 17° (range, 0–40°) to 65° (range, 40–80°) at the latest follow-up. The mean pronation improved from 30° (range, 0–50°) to 75° (45–85°) at the final follow-up.

The mean wrist flexion improved from 45 to 55° and the mean wrist extension improved from 45° preoperatively to 50° at the final follow-up.

Grip strength

The mean grip strength improved from 15 kgF (range, 5–35 kgF; 35% of that of the unaffected side) to 35 kgF (range, 10–55 kgF; 81% of that of the unaffected side).

Work status

Thirteen patients (81.3%) returned to their previous work and activity levels. Three patients (18.7%) returned to lighter work.

Radiologic evaluation

(1) The DRUJ fusion rate was 100% and occurred within 10–12 weeks.
(2) Ulnar variance: 13 patients had preoperative positive ulnar variance with a mean of 3 mm (range, 2.5–8 mm). This improved postoperatively to a mean of + 0.1 mm (range, −2 to + 2).
(3) The mean preoperative radioulnar distance in postero-anterior radiograph was 14 mm and that postoperatively was 12 mm. There was no scalloping of the radius or impingement of the ulnar stump on the radius. In the lateral radiograph, the mean preoperative radioulnar distance was 8 mm and that postoperatively was + 0.9 mm. These measurements suggested improved stability of proximal ulnar stump.
(4) Two patients (12.5%) had a slight ossification at the ulnar pseudarthrosis, but this did not cause pain nor decrease forearm rotation. One patient (6.25%) showed extensive ossification that required operative excision with a satisfactory final result.

Complications and problems

(1) Painful neuroma of the dorsal sensory branch of ulnar nerve (required surgical treatment) occurred in one patient (6.25%).
(2) Dorsal instability of the proximal ulnar stump occurred in one patient (6.25%). This was treated with FCU tenodesis as a second procedure (with a fair final result).
(3) Gap ossification occurred in three patients (18.7%). It was excessive only in one patient, who required operative excision (with a satisfactory final result).
(4) Hardware removal was required in four patients (25%); in two patients for pain over heads of screws when they came in contact with a hard surface, and in two patients hardware were removed during additional surgery (one for neuroma and one for gap ossification; Figs 1 and 2).

Discussion

Once the DRUJ has been damaged, it is unlikely that normal anatomy and function can be restored [11]. The Sauvé–Kapandji operation is a popular choice among the several surgical options available [5,8]. This operation was designed to treat pain arising from the DRUJ because of fusion, to correct the ulnar variance by recession of the ulnar head, and to maintain the forearm rotation by creating pseudarthrosis [5,8,12]. Retaining the ulnar head allows for more normal transmission of force through the wrist. It has been shown that about 20% of axial load is passed through the ulnar carpus. The ulnar head is also important in the mechanism of action of ECU, which adds to the stability [5,7,8,13].

In the study by Carter and Stuart [5], the Sauvé–Kapandji operation was carried out for chronic post-traumatic derangement of DRUJ. Pain improved in 25 patients and remained unchanged in 10. Rotation of the forearm returned to within 7° of the uninjured side. Grip strength revealed a mean of 19.8 kgF (8–46%) on the operated side compared with 31.8 kgF (10–66%) on the contralateral side. Of the 18 patients, 12 were able to resume work after the operation.

In the study by Lamey and Fernandez [9], a modified Sauvé–Kapandji procedure with tenodesis of FCU to the carpus was used to treat chronic derangement of DRUJ in 18 patients. Pain relief was satisfactory, and the mean grip strength improved from 36% of that of the unaffected side preoperatively to 73% finally. Using the modified Mayo wrist scoring system, at a mean of 4 years and 2 months, six patients had an excellent result; seven, a good result; four, a fair result; and one, a poor result.

Minami *et al.* [13] treated 13 osteoarthritic wrists (eight primary and five secondary) using a modified version of the Sauvé–Kapandji procedure (with ECU tenodesis). Pain improved in all cases but pain was elicited over the ulnar stump by direct pressure in one patient. Both supination/pronation and flexion/extension improved significantly.

Figure 1

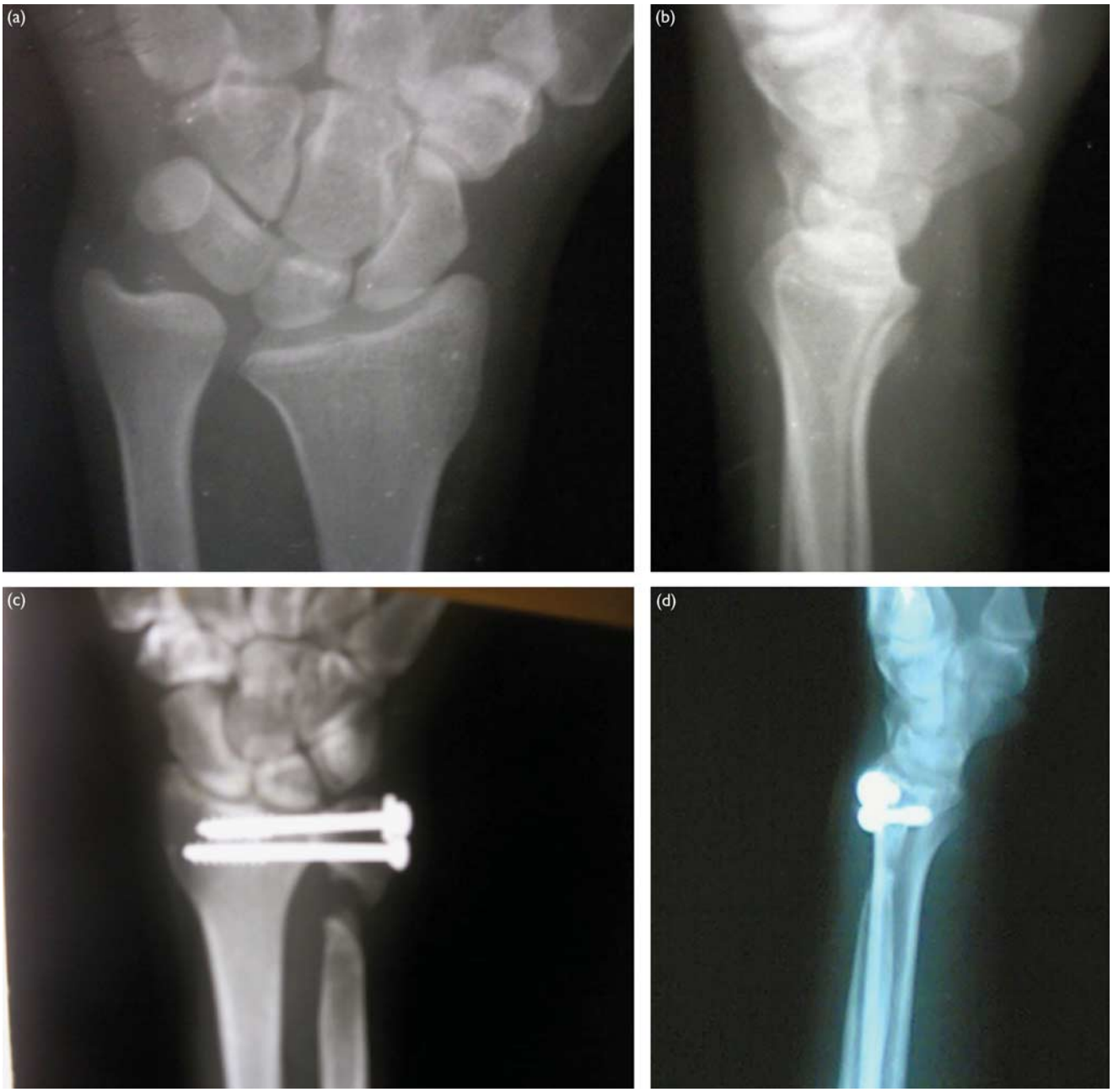
A 28-year-old male patient with chronic derangement of DRUJ secondary to a distal radius fracture, treated using a modified version of the Sauvé–Kapandji operation. The patient was followed up for 14 months and the final outcome was good. (a, b) Preoperative radiographs, (c, d) final radiographs.

Grip strength improved in all patients. Radiological alignment improved in both coronal and lateral planes.

In the present study, the severity of pain improved in all (no pain in nine, mild pain in six, and moderate pain in one). The forearm rotation improved in all patients. The mean grip strength was improved from 35 to 81% of that of the unaffected side. Thirteen patients (81.3%) returned to their previous work and activity levels, whereas three patients (18.7%) returned to lighter work. In the overall evaluation, 12 patients had a satisfactory outcome and four patients presented unsatisfactory (fair but not poor) results.

There are a number of articles on problems of the ulnar stump associated with the Sauvé–Kapandji procedure

Figure 2



A 34-year-old male patient with chronic post-traumatic disruption of DRUJ, treated using a modified version of the Sauvé–Kapandji operation. The patient was followed up for 12 months follow-up and a good clinical outcome was observed. (a, b) Preoperative radiographs, (c, d) final radiographs.

[5,6,14–16]. After the operation, the structures supporting the shaft of the ulna are the interosseous membrane (static), the tendons of ECU and FCU, and the pronator quadratus muscle (dynamic) [5,7,14].

Various modifications have been described to decrease the incidence of this problem and good results have been reported. (a) Kapandji [6] suggested that fashioning the ulnar gap as far distally as possible and creating a pseudarthrosis of about 10 mm would decrease the instability of the proximal ulnar stump. However, Lamy and Fernandez [9] found no correlation between the size of the ulnar gap and the outcome of the operation. (b) The pronator quadratus when released from the ulna and reattached to the ECU sheath in the area of resection, probably acts as a spacer helping to prevent radioulnar impingement during forearm rotation. Release of the pronator quadratus muscle from the ulna theoretically prevents it from actively contracting and narrowing the radioulnar space. However, its release from the ulna probably has a destabilizing effect on the ulnar stump in a dorsal–volar direction [9,17]. (c) Intraperiosteal resection has been advocated in an attempt to increase stability [5,18]. (d) Tenodesis of ECU, FCU, or both to the proximal ulnar stump provides static stabilization by tethering the ulnar stump to the carpus and discourages both dorsal displacement and radial convergence of the ulnar stump [9,16,19]. Because chronic derangement

in most patients noting discomfort at the proximal ulnar stump was caused by DRUJ dislocation, some authors [9,10] recently recommended additionally performing tenodesis to stabilize the proximal ulnar stump as a primary procedure during the Sauvé–Kapandji operation.

In the present study, none of the patients, except one, experienced symptoms of instability. This patient had dorsal instability of the ulnar stump that required FCU tenodesis as a second procedure. Minami *et al*. [10] used the same technique with no cases of instability. Lamy and Fernandez [9] reported residual volar instability in one of 18 patients treated using a modified Sauvé–Kapandji procedure with tenodesis of FCU, and he underwent tenodesis of ECU as a second procedure. These results suggested that tenodesis is a useful and reliable procedure to prevent instability of the ulnar stump after the Sauvé–Kapandji operation. However, the follow-up period should be longer because of the possibility of secondary stretching of the tenodesis.

Bridging heterotopic ossification of the pseudarthrosis is a complication that may require further surgery. Various measures have been described to decrease the incidence of this problem. The pronator quadratus on interposing probably acts as a spacer helping in the prevention of ossification [9]. In addition, extraperiosteal resection helps avoid this problem [12,14,15]; however, some surgeons [5,18] used the intraperiosteal technique, and their results indicated that there is no increased risk of ossification in the pseudarthrosis on using that technique. In the present study, gap ossification occurred in three patients (18.7%). It was excessive only in one patient who required operative excision with a satisfactory final result. Lamy and Fernandez [9] reported extensive gap ossification that required surgical excision in one patient.

A second operation was reported for various indications. Most common indications included removal of hardware because of symptoms from prominent metalware at the operation site, painful neuroma of the dorsal cutaneous branch of the ulnar nerve, excision of gap ossification, and instability of the proximal ulnar stump [3,5,9,13]. In this study, a second operation was required in four patients.

Comparing the results of the present study with those of other studies [5,9,14,15], most patients were better after the operation but a few still had some pain. It seems important to warn patients that relief from pain cannot be guaranteed and that residual pain associated with damage to the wrist sustained at the time of the injury may persist. It is clear that this is a good operation for restoration of forearm rotation, and it is advocated that mobilization in the immediate postoperative period is mandatory to achieve this objective. Grip strength was usually satisfactory, although most had some weakness. Residual mild to moderate pain causes some disability in the 'high-demand wrist'.

It is important to distinguish ulnocarpal pain from radioulnar pain. Patients who have ulnocarpal impaction syndrome without tenderness or degenerative changes at the radioulnar joint can be managed with ulnar shortening or recession. Patients are indicated for the Sauvé–Kapandji operation if they are young and active with high functional demands on the forearm and wrist and have pain that is localized to DRUJ (not to the wrist joint), exhibit impaired forearm rotation, and show radiologic evidence of DRUJ arthrosis or instability [5,9].

Conclusion

The Sauvé–Kapandji operation is a satisfactory salvage procedure for the treatment of post-traumatic chronic derangement in young, active patients, as it can reliably restore rotation of the forearm and grip strength while relieving pain and maintaining a functional range of motion of the wrist. However, problems with pain and instability of the ulnar stump are not infrequent. Tenodesis of the extensor carpi ulnaris provides static stabilization by tethering the ulnar stump to the carpus.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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