Assessment of Sauvé-Kapandji procedure as a treatment for malunited distal end radius fractures with limited forearm rotation

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Background
The most common cause of residual wrist disability after fracture distal radius involves shorting of the radius and ulnar side of the wrist. The three basic conditions responsible for pain associated with limitation of forearm rotation are incongruency, impaction, and instability of the distal radioulnar joint. Sauvé-Kapandji procedure is a simple procedure to restore forearm rotation and to relieve pain.
Aim
To evaluate the results of Sauvé-Kapandji procedure for management of distal radioulnar joint disruption after malunited distal radial fracture with shorting to restore forearm rotation and relieve pain.
Patients and methods
A total of 15 patients with painful and limited forearm rotation owing to malunited distal end radius fracture were treated with Sauvé-Kapandji procedure. There were nine males and six females, with a mean age 45 years, with range from 25 to 70 years. They were followed up for a mean time of 16 months, with range 12–24 months.
Results
All arthrodesis sites were united at a mean time of 11.2 weeks (range, 8–15 weeks). Preoperative pronation/supination arc was 57.5°, (range, 35–90°), and postoperative arc was 140°, (range, 120–155°) (*P*Ë 0.05). Preoperatively, the pain was 6.3 on numeric rating scale for pain (range, 5–8). Postoperatively, the mean score was 2, with range from 1 to 4 (*P*Ë 0.05). At 12-month follow-up, grip strength measured 86% of the contralateral side compared with 47.9% preoperatively (*P*Ë 0.05). All 15 patients were functional with respect to daily household activities, eleven previously working patients were back to work, and all patients felt that their postoperative status has a significant improvement over their preoperative status.
Conclusion
Sauvé-Kapandji procedure is simple and effective in restoring pronation and supination, diminishing wrist pain, and increasing function in patients with limited painful forearm rotation as a result of malunited distal radius fracture with disruption of inferior radioulnar joint.

Keywords:
distal radius, forearm rotation, malunion, Sauvé-Kapandji

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Introduction

Fracture of distal radius is a well-known injury seen by all orthopedic surgeons. Accordingly, malunion of this fracture is frequently met in practice.

Malunited and shorting distal radius could be presented with limited supination and pronation, deformity, diminished hand function, and pain. Distal radius malunion tends to occur in shortening owing to the unbalance between long flexor and extensor tendons of the hand and wrist that cross the fracture site [1,2]. With malunion, the sigmoid fossa will take a different relation with the head of ulna resulting in inappropriate distal radioulnar joint (DRUJ) orientation and function. Malunion of distal radius with significant shortening results in disruption of the triangular fibrocartilage complex [3]. So, malunion of distal radius with significant deformity makes DRUJ incongruent, and unstable, with impaction of ulnocarpal joint. The wrist disability associated with previous conditions will be manifested with pain and limitation of forearm rotation in addition to ulnar prominence [4]. Actually, to restore the anatomical relation between the distal radius and ulna after posttraumatic malunited radial shorting, this could be achieved either by ulnar shorting or radial lengthening, which is extremely

difficult. Sauvé-Kapandji procedure simply corrects the distal radioulnar relation, restores forearm rotation, and relieves pain.

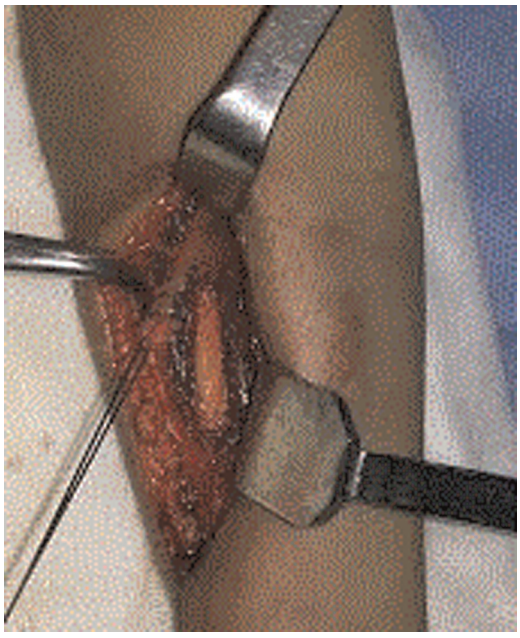
Patients and methods

This prospective study was conducted between March 2012 and January 2016 at Suez Canal University Hospital on patients presenting with established malunited fracture lower end radius, with disruption of DRUJ, and painful restricted range of supination–pronation movement. Approved by Ethical committee faculty of medicine, Suez Canal University. They were treated by DRUJ arthrodesis with resection of a segment of ulna proximal to neck to create pseudoarthrosis for forearm rotation (Sauve-Kapandji procedure). The study included patients with prominent distal ulna, unstable DRUJ, radially deviated hand, and limited painful pronation and supination, which impaired their work and daily activities. We excluded patients with complex regional pain (two), advanced radio-carpal degenerative changes (one), serious medical comorbidities (one), and aged patients with very low physical demands (two). This resulted in six wrists in six patients excluded from 23 patients. The procedure was done for 17 patients, and they were followed up for at least 1 year postoperatively, between 12 and 24 months, with a mean of 16 months. Two patients were lost during follow-up, so there were 15 patients (15 wrists) available for the study. There were nine male patients and six female patients. Their age ranged between 25 and 70 years, with average age of 45±14.5 years. All patients have malunited sustained fracture lower end radius with shorting at least 5 months before presentation, and the time between initial injury and presentation ranged between 5 and 16 months, with average of 8.2 months. Five patients had associated injuries and were treated for other injuries before presentation. Two of them had fracture femur which was treated with interlocking nail. One had sustained ipsilateral fracture femur and tibia, which were treated with nailing. The fourth has sustained trochanteric fracture, which was fixed with dynamic hip screw (DHS). The fifth was a patient with multiple trauma and had sustained head injury and abdominal injury, who was treated by exploration and splenectomy and was admitted in ICU for 2 weeks. A total of 14 fractures were treated by conservative means of closed reduction and cast. One patient was treated by closed reduction and incorporated pins in cast. All patients were presented to us after ending their treatment for the primary injury by deformity and painful limited supination and pronation.

Operative procedure

Each operation was done under general or regional brachial plexus anaesthesia. The involved arm is exsanguinated and tourniquet applied after intravenous antibiotic is administrated. A longitudinal incision is made over the sixth extensor compartment beginning slightly radial to ulnar styloid and extending proximally for about 6 cm. The fifth dorsal wrist extensor compartment is opened. The extensor retinaculum is incised and raised off the radius, and DRUJ making a retinacular flap ulnar-sided based. The DRUJ is entered and the articular surfaces of the sigmoid notch and ulnar head are debrided up to raw cancellous surfaces. The ulnar neck is exposed subperiosteally, and a segment of the ulna proximal to its neck was resected. As our patients had positive ulnar variance, a greater segment than usual of ulna was resected so that when the head is repositioned to its neutral relation with the distal radius, the resulting gap between proximal and distal ulnar stumps was at least 1 cm. This gap is considered sufficient to create pseudoarthrosis necessary for pronation and supination. The opposing articular surfaces of the ulnar head and sigmoid notch are denuded to cancellous bone (Fig. 1). The ulnar head and the sigmoid notch are positioned against each other in neutral rotation with restoration of normal longitudinal relationship between distal radius and ulnar head. A k-wire is driven through the skin, and the ulnar head up to the radius, and the position is checked out fluoroscopically. A 3.5-mm screw was driven through head ulna and radius in a lag fashion

Figure 1



The ulnar articular surface is denuded to cancellous bone.

to compress the arthrodesis site in parallel with the k-wire. The first k-wire helped prevent tilting of the head during screw advancement. This wire was kept in its position to control rotation and provide an additional fixation and to be removed when union had occurred. The resected bone was added to the fusion site. The ulnar edge of pronator quadratus muscle is advanced into the osteotomy site and sutured to the ECU sheath, to help control the proximal ulnar stump. A longitudinal segment of flexor carpi ulnaris tendon was divided from the tendon proximally and kept attached distally. A hole is drilled in the proximal ulnar stump near to its free end. The proximal free end of the tendinous flap was then introduced through the hole created in the proximal ulnar stump and then sutured over itself. Closure was done afterward and a long-arm splint was applied.

Postoperative management

The long-arm splint was kept in place for 2 weeks, and then a short-arm cast was applied until there is radiographic evidence of fusion. We evaluated healing radiographically by the presence of bridging bony trabeculae on anteroposterior and lateral radiograph views, as well as clinical evaluation regarding the presence of tenderness with direct palpation of the site of arthrodesis. When radiographic evidence of union appeared, we remove the cast and the additional k-wire. Preoperatively and at the final clinical assessment, we took measurements of the angles representing the range of supination, pronation, the forearm rotation arc, flexion, extension, and the grip strength as a percentage to the contralateral side. We used numeric rating scale (NRS), as a tool for pain evaluation. The patient determined his/her pain intensity score on a scale of 0 to 10 (NRS), with 10 representing the worst pain and 0 referring to no pain [5]. We made range-of-motion measurements with a standard goniometer. Grip strength was measured at the time of presentation and at the last follow-up using Jamar Hydraulic Hand Dynamometer (Saehan Corporation, Masan, South Korea) and was reported as a percentage to the maximal strength of the normal contralateral side. Overall wrist assessment was done using modified Mayo wrist score preoperatively and at the final follow-up visit at least 1 year postoperatively.

Statistical analysis

We used a paired samples *t* test to compare between preoperative and follow-up measurements for range of supination, pronation, and forearm rotation arc, NRS pain scores, grip strength, and modified Mayo wrist score. The level of significance was set at *P* value less than 0.05. The software used for statistical analysis was SPSS (SPSS 19 Inc., Chicago, Illinois, USA).

Results

There were 15 wrists in 15 patients (nine males and six females) available for final follow-up at a mean of 16 months (12–24 months). Their mean age was 45 years (25–70 years), and eight (53%) wrists were in the dominant hand. The mean time from original fracture to operation was 8.2 months (5–16 months). Union was defined radiologically by the presence of bony trabeculae crossing the arthrodesis site. This was achieved in 14 (93.3%) patients at a mean of 13.2 weeks (10–19 weeks). We had to ask for computed tomography scan in two patients to confirm union; however, it was not our routine. One patient could not achieve union at arthrodesis site and bone graft was done for her.

Average tourniquet time was 48 min. Average operation time including hemostasis and closure was 66 min. The average amount of intraoperative ulnar resection was 16.4 mm (range, 11–20 mm). Table 1 shows preoperative and postoperative ulnar variance. Table 2 shows significant improvement in wrist motion and forearm rotation at final follow-up when compared with preoperative condition. Average NRS pain scores, modified Mayo wrist scores, and grip strength as a percentage of the contralateral side all improved significantly as shown in Table 3.

We noted complication in four (26.6%) patients. Proximal ulnar stump instability was noticed by three patients, where two of them experienced complex regional pain syndrome (CRPS), which was

Table 1 Preoperative and postoperative ulnar variance

	Preoperative	Postoperative	Change
Ulnar variance (mm)	5.6±2.6	–0.8±1	6.4±2.2*

Values are given as mean±SD. *Significance (*P*Ë 0.05).

Table 2 Preoperative and postoperative wrist motion

	Preoperative	Postoperative	Change
Supination	33.6±14	66.4±14.6	32.1 ±18.3*
Pronation	23.9±5.9	73.6±4.6	49.6±6.9*
Supination–pronation arc	57.5±18.8	140±14.4	82.5 ±21.9*
Flexion	35±19.3	47±15.6	12±17.2*
Extension	44±20	59±22	15±20.3*
Flexion-extension range	79±19.8	106±19.1	27±19.5*

Values are given as mean±SD. *Significance (*P*Ë 0.05).

cured by physiotherapy. This complication did not affect the patient satisfaction or function. Another patient developed nonunion at the arthrodesis site, which required revision with iliac bone grafting. The patient achieved sound union later on with fair function.

All patients reported improved function and appearance of their wrists. There was overall satisfaction in all of them. A total of 11 patients returned to their work (Figs 2–5).

Discussion

Malunited distal radial fracture may lead to chronic disruption of the inferior radioulnar joint, resulting in ulnar pain, instability, subluxation, dislocation, reduced grip strength, and decreased range of movement.

Table 3 Preoperative and postoperative functional measures

	Preoperative	Postoperative	Change
Grip strength	47.9±27.4	86±9	38.2±19.7*
NRS pain	6.3±1	2±0.96	4.3±0.6*
MMW score	43.9±14.6	82.5±13.7	38.2±10.3*

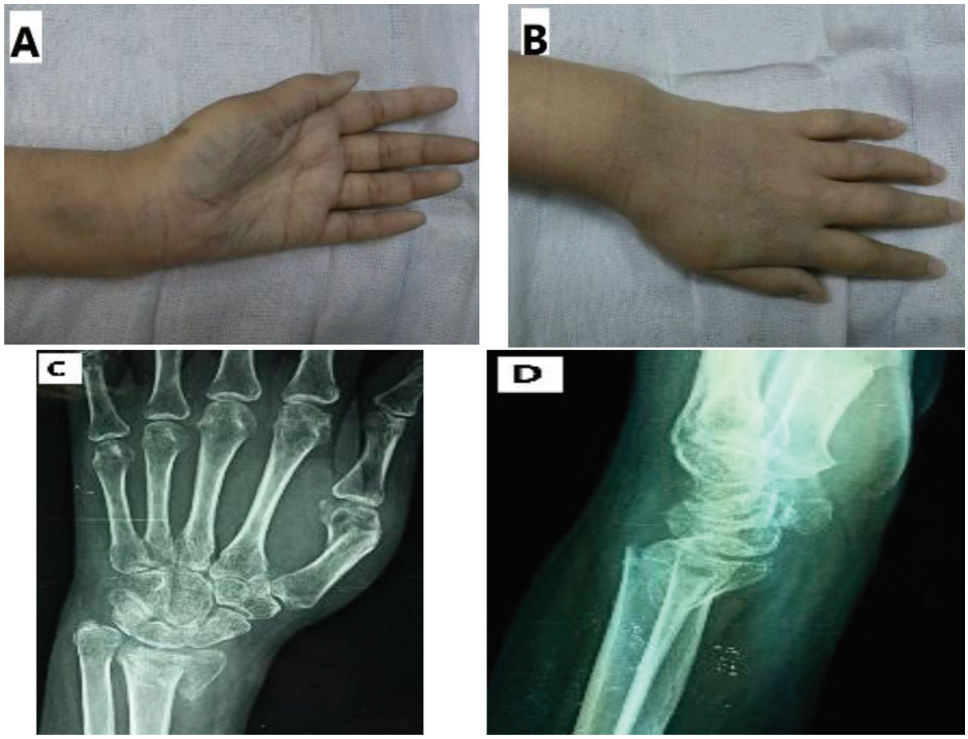
Values are given as mean±SD. MMW score, modified Mayo wrist score; NRS, numeric rating scale. Grip strength as a percentage to normal side. *Significance (PË 0.05).

Malunion of the fracture itself may lead to posttraumatic osteoarthrosis and positive ulnar variance and further disruption of the anatomy.

Any method of treatment aims to achieve a reasonable wrist function free of pain. Different types of distal radius corrective osteotomy had been proposed by different authors to regain the near-normal anatomy. The anatomic criteria that make a good functioning wrist may differ from one author to another [6]. Although the functional outcome may be unrelated to radiological picture [7,8], certain radiological criteria remain as important determinants for wrist function. The loss of radial inclination, volar tilt, and disturbance in the length of the radius relative to the ulna represent the most important determinants for the wrist function [6,9,10].

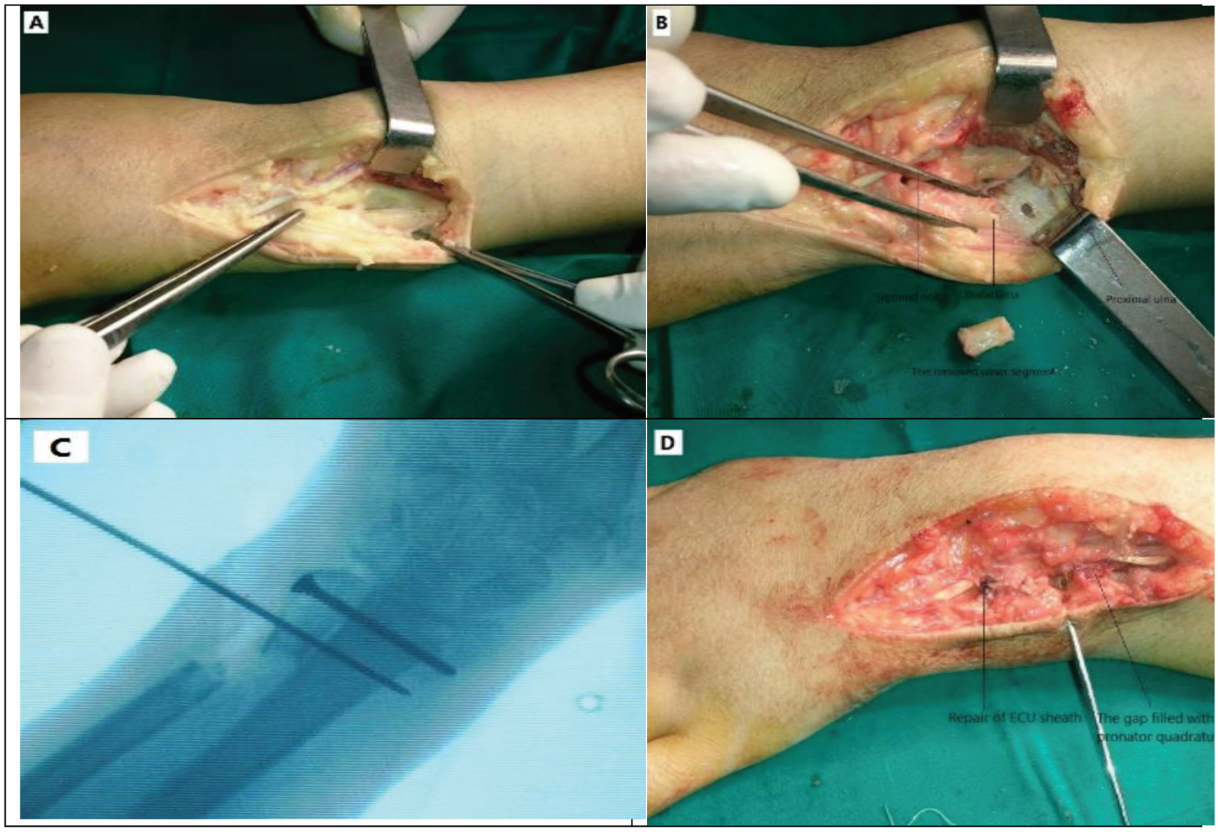
DRUJ injury due to fracture lower end radius can worsen the end outcome whatever the radiological parameters [11]. Moreover, malunion of distal radial fractures has negative effects on DRUJ and forearm rotation [3,12] [13]. Malunited lower radius usually occurs with collapse and loss of radial inclination. This pathology leads to relative positive ulnar variance with

Figure 2



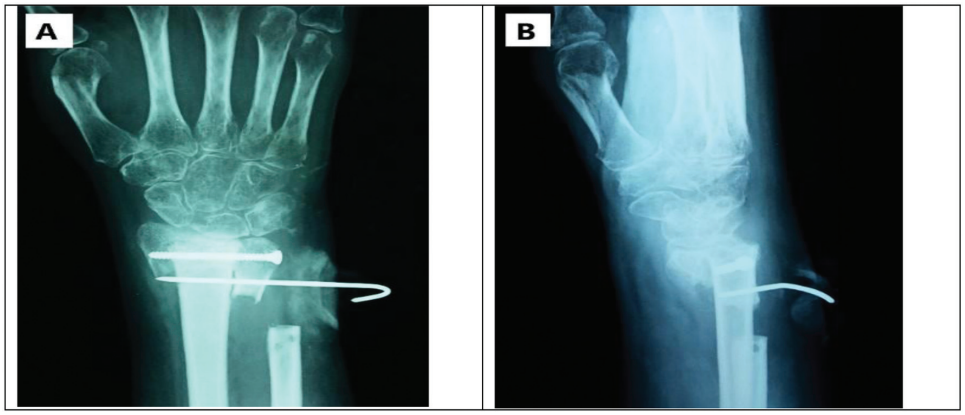
56 years old female patient with mal united fracture left distal radius. She complained of limited forearm rotation and disfigurement. She was presented to us more than five months after her initial injury which was treated conservatively. She was treated by Sauve-Kappandji technique 6 months after trauma. A and B show pre-operative appearance with radial deviation. There was limited forearm rotation (pron/sup: 50/0/20), wrist pain on NRS: 8, flexion/extension: 20/0/40. MMWS: 35, Grip strength: 35% of the contralateral side. C and D the pre-operative x-rays showing radial shortening, radial deviation, and distal ulnar impingement on the carpus.

Figure 3



A: shows surgical exposure of distal ulna and DRUJ dorsally. B: shows the segment removed from the ulna. C: shows intra-operative fluoroscopic photo of fixation of the distal ulna to distal radius after roughening of the sigmoid notch and radial part of ulnar head. D shows repair of the ECU tendon sheath, repair of pronator quadratus to the sheath filling the gap between proximal and distal ulnar stumps.

Figure 4

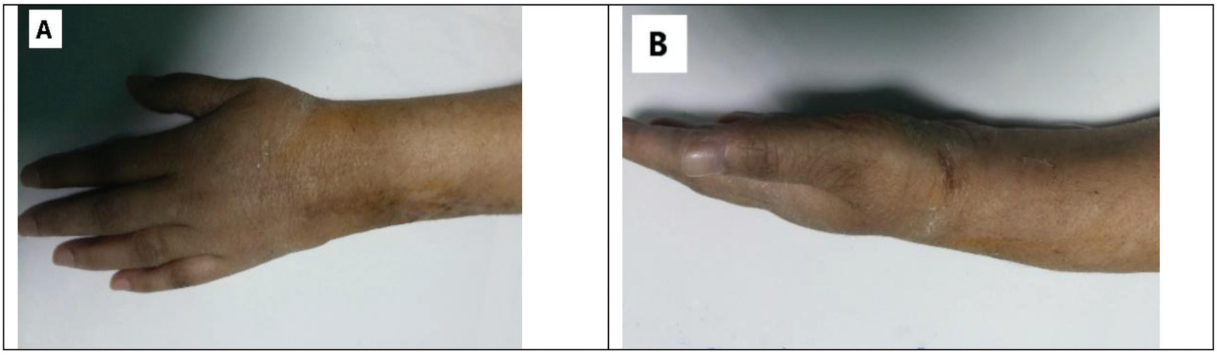


Eight-week post-operative X-rays at time of removal of k-wire. (A): is postero-anterior view showing correction of ulnar height and radial deviation. Also, it shows evidence of union or crossing trabeculae at the site of fusion, so removal of wire was done. (B): shows lateral view with stable.

loss of radial length. Consequently, impaction of ulna against carpus ensues. This deformity results in loss of grip strength, DRUJ malfunction with limited rotation, pain, and unsightly wrist [3,12].

With corrective distal radius osteotomy, it could be difficult to address both the angular deformity and length simultaneously. This may lead to persistence of ulnar impaction and DRUJ malfunction in many patients [14–16]. However, the treatment options of a multitude of pathologies remain rather restricted, including arthroscopic debridement, the Darrach resection, Bowers interposition arthroplasty, and the Sauvé-Kapandji procedure. The latter procedure

Figure 5



(A & B): Post-operative images of the hand and wrist with corrected radial deviation and healing of the wound, The forearm rotation (pron/sup: 80/0/60), wrist pain: 2, flexion/extension: 40/0/65, MMWS: 80, grip strength: 75% of the contralateral side.

addresses pain arising from the DRUJ by solid arthrodesis of the joint. It is able to correct excessive positive ulnar variance by shortening of the ulna, and it can restore rotation of the forearm by creating a pseudarthrosis [17]

Kapandji himself defined posttraumatic stiffness and reduced range in the pronation/supination arc of movement of the forearm associated with malunited fractures of the distal radius as a major indication for the Sauvé-Kapandji procedure [18].

As a result, alternative treatment options that aim at regaining relative length of radius and ulna have been suggested as isolated ulnar shortening osteotomy [19], and Sauve-Kapandji technique [20].

Our operative time was 66 min in average, which is lower than that reported for distal radius corrective osteotomy by Wada *et al*. [16]. They reported 130 min for wedge osteotomy, which increased when ulnar shortening osteotomy was added. It is also shorter than that reported for isolated ulnar shortening osteotomy by Srinivasan *et al*. [19], as they reported 81 min.

The mean time for achieving union in our study was 13.2 weeks, which is comparable to that reported for corrective osteotomy [21,22] and to the results reported for isolated ulnar shortening osteotomy [18].

The complication of our study was 26.6% in total, and the patients were managed simply without affection of their overall satisfaction, except for one (6.7%) patient who required reoperation. Reoperation for patients with corrective osteotomy was done frequently for removal of hardware especially dorsal plating [14,17]. Moreover, residual ulnar sided symptoms may require another operation as ulnar shortening osteotomy for ulnar impaction [20]. Peterson *et al*. [23] in a study for correction of malunited distal radius by volar plate did Sauve-Kapandji procedure for DRUJ dysfunction.

The limitation to this study was the relatively small number of patients and short time of follow-up. Longer follow-up period may be required for younger patients given the risk of developing degenerative wrist arthritis [24].

In conclusion, Sauve-Kapandji is a reasonable solution for patient with malunited distal radius and limited forearm motion.

Case presentation

A 56-year-old female patient with malunited fracture left distal radius. She complained of limited forearm rotation and disfigurement. She was presented to us more than 5 months after her initial injury which was treated conservatively. She was treated by Sauve-Kapandji technique 6 months after trauma.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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