We present the results of a retrospective series of 41 Sauve-Kapandji procedures carried out for complications of fractures of the distal radius. All the operations were undertaken by one surgeon with a mean follow-up of 32 months. A total of 37 patients was available for clinical review.

The indications for surgery were pain on the ulnar side of the wrist and decreased rotation of the forearm. Intraperiosteal and extraperiosteal techniques were used for resection of the ulna, with no difference in outcome. Patients were assessed for pain, rotation of the forearm and complications. A Mayo Modified Wrist Score was used.

Pain was improved in 25 of the 37 patients, and unchanged in ten. Rotation of the forearm returned to within 7° of the uninjured side. The results are discussed in relation to the presence of preoperative malunion of the distal radius, age and the functional outcome. Age is not a contraindication for this procedure.

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Injury to the wrist may result in derangement of the distal radio-ulnar joint and lead to deformity and degenerative changes. This often gives pain on the ulnar side of the wrist and limitation of rotation of the forearm with loss of function. The appropriate surgical method to treat these problems remains undecided. Suggested operations include the Darrach procedure and its modifications, pseudarthrosis of the distal ulna with or without fusion of the distal radio-ulnar joint, hemiresection/interposition arthroplasty, matched distal resections of the ulna and replacement arthroplasty. The most common treatment has been the Darrach procedure, but reports of instability of the wrist, weakness of grip, rupture of extensor tendons and ulnar carpal instability have cast doubt on its efficacy.

In 1921, Baldwin described the creation of a pseudarthrosis between the shaft of the ulna and its head and Sauve and Kapandji described arthrodesis of the distal radio-ulnar joint with creation of a proximal pseudarthrosis to maintain rotation of the forearm. In recent years, the Sauve-Kapandji procedure has been advocated as the operation of choice for derangement of the distal radio-ulnar joint in patients with 'high-demand' wrists, and in particular for post-traumatic problems of the distal radio-ulnar joint. It is thought that retaining the head of the ulna allows for more normal transmission of force through the wrist.

Although results are encouraging, the findings in only a few small series of post-traumatic disorders of the wrist treated by the Sauve-Kapandji procedure have been published. We now report our experience in 41 patients.

Patients and Methods

Between 1991 and 1998, 41 patients were operated on by the senior author (PRS) using the Sauve-Kapandji technique. All presented with pain in the distal radio-ulnar joint and impaired rotation of the forearm. All had unilateral procedures. Two patients had died and two were unable to attend for geographical reasons, leaving 37 available for retrospective review.

There were 11 men and 26 women, with a mean age of 55 years (31 to 86). The mean duration of follow-up was 32 months (3 to 94). All patients had developed wrist symptoms after trauma and 33 (89%) had sustained fractures of the distal radius of varying severity. In 14 patients (38%) the dominant wrist was involved and in 23 the non-dominant (62%). At the time of the original injury 19 (51%) were retired or unemployed and 18 (49%) were working.

Twenty-seven patients (73%) had the Sauve-Kapandji procedure alone, six (16%) had a Sauve-Kapandji procedure and fusion of the wrist, and four (11%) a Sauve-Kapandji procedure with a distal radial osteotomy.

The patients attended for outpatient review and sub-
jective and objective assessment of the function of the wrist. Preoperative data were obtained from hospital records and confirmed with each patient.

Pain was rated as mild if it occurred at the extremes of movement and did not interfere with daily activity, moderate if sufficient to cause alteration in work or leisure activities and severe if it occurred during activities of daily living or at rest. Subjective assessment of pain, rotation of the forearm and cosmesis was carried out, and the patients were asked if they would have the operation again under the same circumstances.

The ability to return to work after the operation was recorded as was functional restriction in the retired/unemployed patients.

The affected wrist was examined and compared with the contralateral side. The range of movement was measured with a goniometer and grip strength with a Jamar dynamometer (Asimow Engineering, Los Angeles, California) on the second setting with the humerus at the side of the body, the elbow at 90° of flexion, the forearm in neutral rotation and the wrist in neutral flexion/extension. Sensory loss or the formation of neuroma related to the dorsal cutaneous branch of the ulnar nerve were recorded as were prominent screws or wires, a painful ulnar stump or a stump ‘click’ on rotation of the forearm.

A Mayo Modified Wrist Score was used to evaluate the combined results (Table I). Residual pain, function, rotation of the forearm and grip strength gave a maximum of 25 points each. A score of 95 to 100 points indicated an excellent result, 80 to 90 good, 65 to 79 fair, and <65 points poor.

Standard preoperative posteroanterior and lateral radiographs of the wrists were used to assess ulnar variance, distal radial angulation and distal radial inclination, and degeneration or subluxation of the distal radio-ulnar joint. Postoperative radiographs were assessed for the length of the pseudarthrosis, ulnar variance, union of the distal radio-ulnar joint and ossification within the pseudarthrosis.

**Operative technique and postoperative management.** All procedures were carried out under general anaesthesia or regional block, with tourniquet control. The patient was positioned supine with the arm on a hand table, the surgeon sitting at the ‘head’. A skin incision was made along the subcutaneous border of the ulna and curved dorsally over its head to protect the dorsal cutaneous branch of the ulnar nerve, which was identified in the volar flap and protected throughout. The fifth extensor compartment was opened over the distal radio-ulnar joint and the tendon of extensor digiti minimi retracted to expose the capsule of the joint. This was opened to expose the surfaces and a final decision was made about the degree of ulnar shortening required to achieve a neutral or slightly ulnar-minus variance. The surface of the ulnar head and the sigmoid notch of the radius were debrided of any remaining articular cartilage using rongeurs and osteotomes, taking care to achieve appropriate rotation of the head.

The shaft and neck of the distal ulna were exposed between the tendons of the extensor (ECU) and flexor carpi

<table>
<thead>
<tr>
<th>Category</th>
<th>Score (points)</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>25</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Mild</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Severe</td>
</tr>
<tr>
<td>Function</td>
<td>25</td>
<td>Able to return to employment</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Restricted employment</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Unable to work due to pain</td>
</tr>
<tr>
<td>Pronation-supination</td>
<td>25</td>
<td>&gt;170</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>141 to 169</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>101 to 140</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>61 to 100</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>&lt;60</td>
</tr>
<tr>
<td>Grip strength (% of normal side)</td>
<td>25</td>
<td>95 to 100</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>75 to 94</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>50 to 74</td>
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<tr>
<td></td>
<td>5</td>
<td>25 to 49</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0 to 24</td>
</tr>
</tbody>
</table>

Table II. Numbers of patients (%) and the subjective outcome and assessment of their pain after surgery for post-traumatic disorders of the distal radio-ulnar joint

<table>
<thead>
<tr>
<th>Sauve-Kapandji procedure</th>
<th>Outcome</th>
<th>Assessment of pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Better</td>
<td>Same</td>
</tr>
<tr>
<td>Alone</td>
<td>19 (51)</td>
<td>6 (16)</td>
</tr>
<tr>
<td>Plus fusion</td>
<td>4 (11)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Plus osteotomy</td>
<td>2 (5)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Total</td>
<td>25 (68)</td>
<td>10 (27)</td>
</tr>
</tbody>
</table>

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ulnaris (FCU) muscles. Before 1996, the procedure was carried out with ulnar resection in the extraperiosteal plane. After Rothwell, O’Neill and Cragg had described their simplified method, an intraperiosteal technique was used. The resection is distal, 2 to 3 mm proximal to the head. The length of the resection is equal to the required ulnar shortening plus 10 to 12 mm which is the desired length of the pseudarthrosis. Resection was done with an oscillating saw without cooling the blade.

The prepared surfaces of the distal radio-ulnar joint were opposed, and the guide wire of an AO 3.5 cannulated screw (Synthes, Stratec Medical Ltd, Oberdorf, Switzerland) positioned centrally from the ulna into the distal radius. Only the first cortex, the ulnar cortex of the ulnar head, was drilled and tapped and a partially-threaded screw, of correct length, with a washer was inserted. There was usually good compression and a graft was not required, but cancellous bone from the ulnar resection can be added in or around the fusion site. A Kirschner wire of 1.6 or 2.0 mm diameter was passed through all four cortices from the neck of the ulna into the distal radius to achieve rotational stability. The capsule was closed with absorbable sutures. With the intraperiosteal technique, Rothwell’s method of closure was followed. With the extraperiosteal method the pronator quadratus was sutured to the sheath of ECU through the pseudarthrosis. Wound closure was with 4/0 polydioxanone sutures. A firm wool and crepe dressing was applied, the hand elevated, and immediate finger movement encouraged. A postoperative radiograph was obtained.

A short-arm cast was applied on the first postoperative day. Active and passive rotation of the forearm was started by the hand therapist. The range of forearm rotation was carefully supervised. The patient remained in hospital until full passive rotation was obtained, and active rotation was close to the full range. This was followed by outpatient supervision. The sutures were removed at two weeks and the cast at four weeks. No further radiograph was taken unless clinically indicated.

Figure 1 shows postoperative radiographs of two patients who had the Sauve-Kapandji procedure without corrective radial osteotomy despite moderate dorsal radial angulation.

Results

Clinical assessment. The results of subjective assessment of pain in the three subgroups of patients who underwent the Sauve-Kapandji procedure alone or with fusion or osteotomy are shown in Table II.

At follow-up 32 patients (86%) stated that rotation of their forearm had improved. The remaining five (14%) felt that there was little difference in rotation; two had the procedure alone, two also had a fusion and one an osteotomy. A total of 13 patients (35%) said that their wrists looked better, while 15 (41%) noticed little difference. Nine patients (24%) felt their wrist to be cosmetically worse, usually due to a more extensive scar. Most patients (32, 86%) stated that they would have the operation again.

Flexion and extension of the wrist and ulnar and radial deviation were measured. There was no difference between the normal and operated sides. The mean pronation on the operated side was 82.3° (45 to 95) compared with 89° (80 to 95) on the contralateral side. The mean supination on the
operated side was 89.3° (55 to 110) compared with 95.8° (90 to 110) on the contralateral side.

Analysis of grip strength revealed a mean of 19.8 kg (8 to 46) on the operated side compared with 31.8 kg (10 to 66) on the contralateral side.

Of the 18 employed patients, 12 were able to resume work after the operation and the mean time off work was eight weeks (1 to 26). The six patients who did not return to work had been off work since their initial injury. Four of these patients did manual work and their return was prevented by pain. Two other patients had retired. Three of these six patients stated that they felt that the operation was a success due to the increased rotation of the forearm.

There was no correlation between subjective or objective findings in the ten patients who were involved in litigation related to the original injury.

According to the Mayo Modified Score the overall result was excellent in ten patients, good in 12, fair in six and poor in nine. Only three patients with poor results had had one of the more complex procedures. Five patients with poor results stated that they felt that the operation had been successful, usually because of improved rotation of the forearm. Those with a poor result tended to be younger although this was not statistically significant (Fig. 2).

Complications. Five patients had sensory changes in the area served by the dorsal cutaneous branch of the ulnar nerve and one developed a neuroma. Nine patients had pain at the site of the ulnar stump, mild in seven cases and moderate in two. Six patients had symptoms from prominent metalware at the operation site. Eighteen patients had a ‘click’ at the site of the operation during movement, but only five found it uncomfortable.

Radiological assessment. The mean preoperative ulnar variance was +2.9 mm (-1 to +8) and the preoperative radial angulation ranged from 40° volar to 45° dorsal. Changes in the distal radio-ulnar joint were noted in 28 of the 34 radiographs available. The mean preoperative radial inclination was 23.1° (5 to 45).

Postoperatively, the mean ulnar variance was -0.5 mm (-5 to +2). The mean length of the pseudarthrosis was 12 mm (5 to 18). Four patients had nonunion of the fusion of the distal radio-ulnar joint, although none had symptoms. Five patients had minor ossification of the ulnar pseudarthrosis which did not cause symptoms. Three had intra- and two extraperiosteal resections.

We were unable to demonstrate any statistical correlation between either preoperative radial angulation or the length of the ulnar pseudarthrosis and the outcome. Both patients whose radiographs are shown in Figure 1 had good results.

Discussion

Once the distal radio-ulnar joint has been damaged it is unlikely that normal anatomy and function can be restored. The Darrach procedure has been the standard against which newer operations have been assessed, but both clinical and biomechanical studies have questioned its efficacy. Several authors have stated the importance of retaining the head of the ulna to prevent the carpal translocation or dislocation which may complicate Darrach’s procedure.

The Sauve-Kapandji procedure is designed to treat pain arising from the distal radio-ulnar joint by fusion, to correct the ulnar variance by recession of the ulnar head and maintain rotation of the forearm by creating a pseudarthrosis. There are strong biomechanical arguments for retaining the ulnar head, especially after trauma and ligamentous weakness of the radiocarpal joint. Conservation of the head maintains the triangular fibrocartilage complex to allow a more physiological transmission of forces from the hand to the forearm. It has been shown that approximately 20% of axial load is passed through the ulnar carpus and even minor derangements in this region can result in changes of load pattern. The ulnar head is also important in the mechanism of action of ECU, which further adds to stability.
Comparing our experience with that of others, we agree with Taleisnik\textsuperscript{10} that the Sauve-Kapandji procedure is satisfactory, but not infallible. Most studies detailing post-traumatic problems of the distal radio-ulnar joint treated by this operation claimed a high rate of pain-free wrists.\textsuperscript{10,22,24,25,28} In our study, most patients were better after the operation, but a significant proportion still had some pain. It seems prudent 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 occur. It is clear that this is a good operation for restoration of forearm rotation and we advocate mobilisation in the immediate postoperative period to achieve this objective. Close supervision of initial rehabilitation is essential and the patients spent a mean of 4.5 days (2 to 10) in hospital. Grip strength was usually satisfactory, although most had some weakness.

Only two-thirds of the employed patients were able to return to work. This is disappointing in comparison with previous studies. Those in heavy manual work were least likely to return. Residual mild to moderate pain causes disability in the ‘high-demand wrist’. This fact was reflected in the nine poor results as defined by the Mayo Modified Score. There were, however, only five patients who felt they had not benefited from the operation. The poor results were within our younger population and perhaps the procedure should be restricted in the young patient with high demands on the wrist.\textsuperscript{10,21,23,25} It has been argued that older people have poorer bone stock and skin condition, which compromise the procedure. Our findings do not support this; older patients had good results without a high rate of complications.

Much has been written about problems of the ulnar stump associated with the Sauve-Kapandji procedure. 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).\textsuperscript{32} After injury these structures may be damaged and, in particular, rupture of the interosseous membrane may lead to a very mobile ulna.\textsuperscript{10} Most authors have described problems with pain and clicking of the ulnar stump, but this is usually only a minor inconvenience.\textsuperscript{10,23,33,34} Our patients were seldom troubled by symptoms of instability, most only experiencing minor, if any, discomfort. Various modifications have been described to decrease the incidence of this problem and good results have been reported. Intraperiosteal resection has been advocated in an attempt to increase stability,\textsuperscript{28} as has tenodesis of the FCU to the carpus.\textsuperscript{25}

Although we could find no correlation between the size of the ulnar gap and the outcome of the operation it would seem logical that Kapandji’s recommendation of leaving a short distal ulnar fragment, fashioning the ulnar gap as far distally as possible and creating a pseudarthrosis of approximately 10 mm would reduce instability and retain grip strength. Bridging heterotrophic calcification of the pseudarthrosis is a complication which may require further surgery.\textsuperscript{10,22} We did not experience this problem and our results indicate that there is no increased risk of ossification in the pseudarthrosis when an intraperiosteal excision is carried out.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


