We reviewed 23 patients who had had 25 Darrach procedures for traumatic or post-traumatic disorders of the wrist at a mean follow-up of 75.5 months (36 to 121). The mean age at the time of operation was 61.1 years (34 to 82). All patients were reviewed in person. Assessment included a history, a questionnaire on patient satisfaction and a detailed physical examination. Standardised radiographs of both wrists were taken with the patient's hands in a resting position and during maximal grip.

Convergence of the distal ulnar stump towards the distal radius during maximal grip (dynamic radio-ulnar convergence) was seen in 14 wrists including five with actual contact (dynamic radio-ulnar impingement), but this produced symptoms in only two cases. The presence of dynamic radio-ulnar convergence did not correlate with grip strength, pinch strength, range of movement or wrist score, but was associated with increased length of excision of the distal ulna. Nineteen of the 23 patients were satisfied with the procedure.

Dynamic radio-ulnar convergence is common after the Darrach procedure, but is rarely symptomatic; resection of the distal ulna remains a reliable procedure in the older patient with pain and loss of movement. Excision of the lower end of the ulna should be restricted to the least required to restore full rotation.

PATIENTS AND METHODS

We identified 30 consecutive patients who had had the Darrach procedure between 1984 and 1990. Four had died and three were not traceable. We reviewed the remaining 23 patients who had a total of 25 Darrach procedures, two being bilateral.

All had excision of the distal ulna for problems related to trauma; those with rheumatoid arthritis were excluded from the study. There were 17 women and 6 men with a mean age of 61.1 years (34 to 82). The mean length of follow-up was 75.5 months (36 to 121). The dominant wrist was involved in 14 cases and the non-dominant side in 11. The primary injury was a fracture of the distal radius in 19, a fracture of the distal ulna in two, Galeazzi fracture dislocation in two and injury to the distal radio-ulnar joint in two. The indica-
tion for operation was pain in 14 cases, stiffness (particularly a decrease in rotation of the forearm) in ten, and a comminuted fracture of the distal ulna in one. The mean time from injury to the Darrach procedure was 8.5 months (0 to 62).

All patients had the same technique of operation, using a straight lateral approach between the tendons of the flexor carpi ulnaris and extensor carpi ulnaris. Care had been taken to protect the dorsal sensory branch of the ulnar nerve. After subperiosteal dissection, the distal ulna had been excised. The length of resection was at the discretion of the surgeon, and was the minimal amount required to restore full rotation, as tested during the operation. Eight associated procedures had been performed including extensor carpi ulnaris tenoplasty in two patients, osteotomy of the distal radius in two, capsular repair or plication of the distal radio-ulnar joint in three and extensor tendon release in one.

After operation, patients had been placed in a below-elbow cast to facilitate soft-tissue healing for a mean of 3.4 weeks (1 to 10). After removal of the cast physiotherapy had been given in each case and had included active and resisted exercises to increase grip and wrist strength and to improve the range of movement of both forearm and wrist. It had been continued on a formal basis until strength and motion had stabilised after which the patients had followed a home exercise programme.

Clinical evaluation. Each patient was seen, a detailed history taken and physical examination performed, including subjective assessment of the results of the operation and a questionnaire about 23 activities of daily living. They were also questioned regarding pain at rest, during forearm rotation and when gripping or lifting objects. The physical examination included the range of movement, measurement of grip and pinch strength and evaluation of instability of the distal radio-ulnar joint. The range of movement at the wrist was measured by goniometer. Grip and pinch strengths were measured in kilograms using a Jamar dynamometer (Bechtol 1954) and a Preston pinch gauge, and were also recorded as a percentage of the opposite, unaffected side.

We assessed instability of the distal radio-ulnar joint by ballotment of the distal ulna in a dorsal and volar direction with the radius stabilised by the examiner’s hand (the ‘piano-key’ sign). Palpable clicking or grating was recorded. Resisted rotation of the forearm and distal radio-
ulnar compression were also carried out and pain during these manoeuvres recorded. We used the Gartland and Werley (1951) scoring system for hand and wrist function in all patients.

**Radiological assessment.** Standard anteroposterior and lateral radiographs were taken for each patient, including 'resting' views, with the hands flat on the film and 'dynamic' views, with the patient maximally gripping a cylindrical object 2 cm in diameter. These radiographs were personally supervised by one of the authors (MDM) to ensure that there was no rotational change in wrist and hand position during gripping. The patient’s forearms were held in neutral rotation. The minimum distance between the lower end of the stump of the ulna and the distal radius was measured in the resting and the dynamic states. The difference between the two measurements represents the ‘dynamic radio-ulnar convergence’ (Figs 1 and 2). Contact between the bones was described as radio-ulnar impingement (Figs 2 and 3).

Ulnar translocation of the carpus was assessed by two methods. The ratio described by Youm et al (1978) is calculated from the midline of the distal ulna, so that radial migration of the ulna gives a false measurement. The
method described by Field et al (1993) uses the midline of
the distal radius as a reference point, so that radial migration
of the distal ulna has no influence on the calculation.

We measured the length of distal ulna resected as the dif-
ference in the length of the ulna on the preoperative and
immediate postoperative films. Any regeneration of the
distal ulna was identified by comparing the original postop-
erative films with those at the final follow-up. Evidence of
radiocarpal arthritis was identified by the presence of osteo-
phytes, narrowing of the joint space and/or cyst formation in
the radiocarpal joint, and graded according to the scale of
Knirk and Jupiter (1986). The ulnar border of the distal
radius was carefully examined for any evidence of subchon-
dral sclerosis or scalloping indicating impingement of the
distal ulna in that area.

Statistical analysis. We used Spearman’s test for rank cor-
relation for the analysis of correlation and Fisher’s exact test
for comparison of groups. Unless otherwise indicated, the
results are expressed as mean values plus or minus one
standard deviation.

RESULTS

Clinical results. For 21 of the 25 wrists the patients were
satisfied that the aims of the operation had been achieved,
and all but one said that they would undergo the procedure
again. Thirteen of the 16 patients who had worked before
operation were able to return to the same job. Six of the
seven who were retired resumed their preinjury level of
function or recreational activities. Only ten patients, how-
ever, felt that their wrist was ‘normal’ (Fig. 4). Overall, 19
of the 23 patients were satisfied with the results of the oper-
ation.

Eighteen wrists were rarely or never painful, four were
painful with heavy or unusual activity and three with mild
activity. None had pain at rest or at night (Fig. 5). Three
activities of daily living were commonly identified by
patients as causing problems; 13 had difficulty lifting heavy
objects, eight in opening jars with screw lids and seven in
turning door knobs. No other activity was found to be diffi-
cult by more than three patients. Using the Gartland and
Werley criteria for functional outcome, there were two
excellent, 18 good, two fair and three poor results.

We found no correlation between dynamic radio-ulnar
convergence and the wrist scores. Nine of 11 wrists without
dynamic radio-ulnar convergence had ‘satisfactory’ results
(Gartland and Werley good or excellent) as compared with
11 of 14 which did have convergence (p = NS). The patients
were satisfied in 10 of 11 cases with no evidence of dynamic
radio-ulnar convergence and in 11 of 14 with convergence
(p = NS). The mean grip strength was 73% and the mean
pinch strength 82% of the unaffected side. The presence of
dynamic radio-ulnar convergence did not correlate with
pinch or grip strength (Fig. 6). Four patients had pain on
resisted forearm rotation and four on distal radio-ulnar com-
pression, both correlating with the presence of distal radio-
ulnar impingement (p = 0.03 and p = 0.02, respectively).
These patients included two with dynamic radio-ulnar
impingement who were symptomatic and had ‘poor’ wrist
scores, but another three with impingement were satisfied
The movements at the wrist are listed in Table I.

**Associated procedures.** These did not influence the occurrence of dynamic radio-ulnar convergence.

**Radiological outcome.** Using the criteria of Youm et al (1978) all 14 patients with radio-ulnar convergence had evidence of ulnar translocation of the carpus, but with the method described by Field et al (1993) only two patients showed ulnar translocation. According to the criteria of Knirk and Jupiter (1986), 11 patients had no arthritic change in the radiocarpal joint, seven had mild, four had moderate, and three severe degenerative change. Moderate or severe arthritis correlated strongly with decreased grip strength ($p = 0.01$) and clinical outcome ($p = 0.01$). Dynamic radio-ulnar convergence was observed in 14 of 25 wrists, an incidence of 56%. Of these 14 patients, five showed radio-ulnar contact with scalloping of the distal radius and associated sclerosis as seen in the ulnar impingement syndrome, but only two had symptoms related to the wrist. Nine patients had convergence alone without impingement. Dynamic radio-ulnar impingement was correlated with an increasing amount of resection of the distal ulna ($p = 0.04$, Fig. 7). The mean ulnar shortening was 18.4 mm (9 to 28). Eight patients had evidence of distal regrowth of the ulnar stump or of reactive bone formation (mean 5.5 mm; 2 to 11). Regrowth of the distal bone did not correlate with convergence, the length of ulna resected or the wrist scores.

**Complications.** There were four complications. One wound infection responded to local debridement, one nonunion of an associated osteotomy of the distal radius required further internal fixation with bone grafting, a carpal tunnel syndrome responded to decompression and an injury to the dorsal sensory branch of the ulnar nerve resulted in a painful neuroma.

**DISCUSSION**

The Darrach procedure has been used to improve the range of movement and to decrease pain in the wrist after a variety of post-traumatic conditions. Concern has been expressed about distal radio-ulnar impingement (Bell et al 1985; Field et al 1993). We have measured the incidence of this problem and have shown that on forceful gripping of the hand, more than half of the wrists had convergence of the distal ulna to the distal radius.

A number of muscles in the forearm contract vigorously with a power grip. Some muscle tendon units, such as the flexor digitorum profundus to the index and middle fingers, originate on the ulna and are inserted on the radial side of the hand. Others such as the extensor carpi ulnaris originate on the radial side of the arm and are inserted on the ulnar side of the hand. The contraction of these muscles with the loss of the buttress effect of the radio-ulnar joint causes approximation of the lower end of the radius and ulna. We have termed this ‘dynamic radio-ulnar convergence’. Our study suggests that although distal radio-ulnar convergence is quite common it does not unduly influence the clinical outcome. Even distal radio-ulnar contact, the so-called ulnar impingement syndrome, gave symptoms in only two of five patients. The incidence of symptomatic radio-ulnar impingement was only 8% and was associated with excessive resection of the distal ulna. This complication is serious since it is difficult to treat. Further excision makes matters worse and other options such as radial shortening or soft-tissue repair are not universally successful.

The long-term results of the Darrach procedure were acceptable. Most patients were subjectively satisfied, with grip and pinch strength maintained at a high level.

A recent report (Field et al 1993) describes a higher rate of ulnar impingement syndrome after the Darrach procedure, but this may be due to the lack of postoperative immobilization or the younger age of the patients in their series. While it does not restore a ‘normal’ wrist in most patients, the advantages of the operation include technical simplicity, uncomplicated rehabilitation, and, when properly performed, a low rate of reoperation. More complex procedures advocated for post-traumatic disorders of the distal radio-

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**Table I.** Mean movements (degrees) at the wrist before and after operation

<table>
<thead>
<tr>
<th>Movement</th>
<th>Preoperatively</th>
<th>Postoperatively</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>52</td>
<td>55</td>
</tr>
<tr>
<td>Extension</td>
<td>66</td>
<td>65</td>
</tr>
<tr>
<td>Pronation</td>
<td>74</td>
<td>80</td>
</tr>
<tr>
<td>Supination</td>
<td>48</td>
<td>75</td>
</tr>
<tr>
<td>Radial deviation</td>
<td>Not measured</td>
<td>12</td>
</tr>
<tr>
<td>Ulnar deviation</td>
<td>Not measured</td>
<td>22</td>
</tr>
</tbody>
</table>

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Correlation of the length of time wearing a cast (weeks) with length of ulnar resection (mm) for patients with no convergence, convergence or impingement. A greater length of resection was associated with the development of distal radio-ulnar impingement ($p = 0.04$).

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Vol. 78-B, No. 3, May 1996
ulnar joint are associated with significant complications (Buck-Gramcko 1990).

Radio-ulnar convergence is common after the Darrach procedure, but is not associated with a poor outcome. Distal ulnar excision should be kept to the least amount required to restore full rotation. The operation is indicated in the older patient with pain and stiffness in the distal radio-ulnar joint.

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References
