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ORIGINAL STUDY

Corrective osteotomy of the distal radius : dorsal or volar approach, closing or opening wedge

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The radiological outcomes of 31 corrective osteotomies for malunion of the distal radius were assessed. The procedure re-established normal anatomy in the majority of cases. There was no significant difference in outcome between the dorsal and the palmar approach, but more secondary procedures for hardware removal were necessary with the dorsal approach.

Keywords : distal radius malunion ; corrective osteotomy ; dorsal approach ; volar approach.

INTRODUCTION

Malunion of the distal radius following a dorsally displaced fracture causes pain, malfunction of the distal radioulnar joint (DRUJ) and the radiocarpal joint, and cosmetic problems. Radial shortening and abnormal tilt impair the congruency and stability of the DRUJ and create ulnar impingement, with loss of mobility, loss of grip strength and pain. To relieve symptomatic malunion, a corrective osteotomy of the distal radius can be necessary. The literature on indications and techniques of corrective osteotomy is abundant. For the dorsally displaced fractures, the recommended technique is an open wedge osteotomy through a dorsal approach introducing a corticocancellous strut graft. Since reliable and stable fixation devices are now available, osteotomies can also be performed through a volar approach. Instead of lengthening the radius with a graft, some authors recommend a closing wedge osteotomy in association with a procedure on the ulna.

In the current study, we evaluated the pre- and postoperative radiographs of a single centre cohort and compared the outcome following volar versus dorsal approaches and closing versus opening wedge osteotomies. The aim was to compare the different techniques in terms of the correction achieved.

MATERIALS AND METHODS

Patients

We included 31 patients in this retrospective study. The inclusion criteria were : (a) malunion of a distal radius fracture, (b) Colles type initial fracture and (c) a full set of radiological films available (preoperative and follow-up anteroposterior and lateral radiographs). There were 11 men and 20 women. The average age was 44 years (range : 16 to 76 years) ; 21 were operated on the left wrist and 10 on the right wrist. Average time between

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trauma and corrective surgery was 3 years and 10 months (range : 3 months to 30 years). The mean time of radiological follow-up was 7 months (range : 6 to 18 months).

Surgical technique

All operations were performed by the senior author (LDS). The techniques described by Fernandez (2) were followed. Opening wedge osteotomy with interposition of corticancellous iliac-crest graft was performed in 22 patients (one in combination with a Sauvé-Kapandji and one with a Darrach procedure), one with interposition of cancellous graft from the proximal ulna ; eight closing wedge osteotomies were performed (4 in combination with a Sauvé-Kapandji procedure and 4 combined with an ulnar shortening osteotomy). The approaches were volar in 21 patients (14 opening wedge osteotomies, 7 closing wedge osteotomies) and dorsal in 10 (9 opening wedge osteotomies and 1 closing wedge). For the ulnar procedures an additional approach was used.

Evaluation

Preoperatively and at the final clinical assessment, standard anteroposterior and lateral radiographs were taken. On the anteroposterior radiographs, two measurements were used to evaluate the malunion : radial inclination and ulnar variance. The presence or absence of an ulnar styloid fracture was noted. Radial inclination was measured as the angle between a line drawn parallel to the distal articular surface and a line drawn perpendicular to the long axis of the radius. The ulnar variance was measured between a line tangential to the lunate facet of the radial articular surface, perpendicular to the long axis of the radius and a line tangential to the distal extent of the ulnar head, and perpendicular to the long axis of the radius.

On the lateral radiographs the dorsal tilt was measured, in degrees, as the angle formed by the intersection of one line perpendicular to the longitudinal axis of the radial shaft and a second line drawn through the apices of the palmar and the dorsal rims of the radius.

We divided the cohort firstly into two subgroups : dorsal or palmar approach ; secondly into two subgroups : opening or closing wedge osteotomy

Statistical analysis

Paired samples t-test was used to determine preoperative and follow-up differences of each angle. The level of significance was set at $p < 0.05$.

RESULTS

Radiographs demonstrated an improvement in dorsal tilt, radial inclination and ulnar variance (table I). The average preoperative dorsal tilt was 12° (SD ± 14°). Postoperatively, the average tilt was -6° (SD ± 10°) ($p = 0.0000003$). The radial inclination improved from 18° (SD ± 8°) to 21° (SD ± 8°) ($p = 0.009$). The ulnar variance improved from an average of 2 (SD ± 3mm) to 0 (SD ± 2mm) ($p = 0.00002$).

Eleven patients had removal of their implants. Seven of them had a dorsal approach (70% hardware removal) and four had a volar approach (19% hardware removal) (Fisher exact test : $p = 0.013$ and Chi-square test : $p = 0.006$). Two revision operations had to be performed : the first for implant failure, the second due to nonunion.

There were no significant differences in the final radiological outcome between the group with a dorsal approach versus the group with a volar approach, nor was there any difference between the group with a closed wedge osteotomy and the group with an opening wedge osteotomy (table II).

The only significant difference was seen in the preoperative value of the radial inclination (more severely disturbed in the dorsal approach group, and in the opening wedge osteotomy group) and a significantly greater correction of the radial inclination in the opening wedge osteotomy group.

DISCUSSION

Fractures of the distal radius are common. Despite increasing evidence that an anatomical reduction is required in young and demanding patients, poor reductions and prolonged immobi-

Table I.

	Normal value (± SD)	Preoperative value (± SD)	Follow-up value (± SD)	P-value
Dorsal tilt[1]	-10° (± 6°)	12 (± 14°)	-6° (± 10°)	0.0000003*
Radial inclination[1]	22° (± 3°)	18 (± 8°)	21° (± 8°)	0.009*
Ulnar variance[3]	neutral	2 (± 3 mm)	0 (± 2 mm)	0.00002*

lizations are nevertheless still widely accepted. Malunion results in radial shortening and disruption or incongruency of the radiocarpal and distal radioulnar joint. All this leads to pain, cosmetic changes and poor wrist function.

The indications for corrective osteotomy are pain and disability one year from the original injury, radial shortening greater than 3 mm, and articular step-off of 3 mm or greater and a dorsal tilt of more than 20°. These criteria are only guidelines and indications have to be reconsidered and adapted to each patient.

The corrective surgery should correct the deformity in all planes (restoration of the radial length, dorsal tilt, radial inclination and rotation) and deal with the distal radioulnar joint (stabilization, resection or arthrodesis). A meticulous surgical technique is necessary. The dorsal approach seems obvious and was historically the first to be described. However the anatomy with an irregular surface and the close proximity of the overlying extensor tendons make the procedure demanding. Restoring the length of the radius and correcting the axes with a single corticocancellous graft – usually from the iliac crest – is not always simple. Interference with the implant material is rather the rule than the exception and Fernandez (*2*) recommended routine removal of the dorsal plate. In contrast the volar side of the radius is flatter and accepts a fixation device more easily. Prommersberger and Lanz (*8*) described the volar approach for corrective osteotomy with a conventional volar plate and a structural corticocancellous iliac bone graft. Later the fixed angle plate became available and was first used in fractures (*5*), later on also in osteotomies (*4*) and could be used with cancellous grafts or even bone substitutes. In contrast a closing wedge is more straightforward to correct the anatomy, while an additional surgery on the ulna is required : resection of the distal end (*7*) or ulnar shortening (*10*) can deal with the length discrepancy. We had the opportunity to have a substantial cohort in which the different techniques were applied. We started with the conventional dorsal approach with an opening or closing wedge osteotomy, switched towards the volar approach with opening osteotomy and finally to the volar approach with a closing wedge osteotomy and ulnar shortening.

Table II.

	N	Rad. Inclination			Ulnar Variance (UV)			Dorsal tilt		
		Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
Closed	8	22.95 (7.96)	22.0 (9.93)	-0.95 (5.07)	2.7 (2.88)	-0.4 (1.27)	-3.4 (3.86)	-19.5 (8.93)	8.6 (7.5)	26 10.20)
Open	23	16.7 (6.85)	21.1 (6.82)	4.4 (5.98)	2.1 (2.52)	0.0 (.199)	-2.4 (2.55)	-9.6 (14.67)	4.8 (10.99)	17.6 (14.97)
p value	NA	0.04*	0.78	0.032*	0.57	1	0.4	0.08	0.37	0.12
Dorsal	10	13.9 (7.91)	18.5 (8.54)	3.35 (8.29)	2.3 (2.10)	0 (1.45)	-2.3 (2.62)	-8.1 (15,2)	8.1 (8.9)	15.8 (12.39)
Volar	21	20.4 (6.57)	22.7 (6.89)	2.3 (5.82)	2.3 (2.84)	-0.1 (2.01)	-1.7 (2,99)	-14.1 (13.3)	4.6 (10.81)	19.7 (17.07)
p value	NA	0.02*	0.15	0.69	1	0.89	0.59	0.27	0.38	0.52

In this survey we could demonstrate that closing wedge osteotomies could achieve similar radiographic outcomes as opening wedge osteotomies. We also did not find a significant difference between the dorsal versus volar approach for the radiographic parameters at the final outcome, but significantly more patients required removal of hardware in the dorsal procedures. This has lead to the final conclusion that a closing wedge osteotomy of the radius, through a volar approach with an additional shortening of the ulna is now our preferred technique. The harvesting of an iliac bone graft can thus also be avoided.

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