

Effect of patient age on malunion of operatively treated distal radius fractures

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Radiological outcomes of 200 distal radius fractures following surgical treatment were retrospectively assessed to investigate whether malunion was more frequent in older patients. Malunited fractures were classified into four types : malunion with dorsal or palmar displacement, malunion with incongruity of the radiocarpal joint and malunion with radial shortening. Most fractures were treated with percutaneous K-wire fixation (n = 139) and volar plates (n = 50). Thirty-five percent of fractures were found to be malunited. In patients over 65 years of age, malunion was present in 54 % of the cases. Mean age of patients with malunion was 60 and without malunion 51 years. Patients with dorsal displacement and radial shortening were older than those with palmar displacement and radiocarpal incongruity.

Keywords : distal radius fracture ; malunion ; plate fixation ; K-wire ; age.

INTRODUCTION

One of the methods to treat displaced distal radius fractures is manipulation and plaster cast immobilization, but fractures can be unstable. The risk of secondary displacement increases with advancing patient age (15,16). In elderly patients, more than half will present loss of reduction (2,12,19).

Surgical treatment to prevent fracture redisplacement is most frequently done with K-wires, external fixators or plate and screws. Good radiological

results were obtained in elderly patients after fracture stabilization with a volar plate with locking screws (21). K-wire fixation in elderly patients was reported by some authors as not being efficient (13,22), while others found no loss in reduction (27).

There are no fixed criteria for malunion. How much deformity is acceptable varies from one study to another and depends on patient age and activity level. In low-demand patients over 60 years of age, restoration of normal anatomy after a fracture is not always necessary to achieve a good outcome (29). In selected patients older than 65 years, 30° dorsal tilt and 5 mm increase in ulnar variance can be accepted (12). Earnshaw *et al* considered fracture reduction to be acceptable if dorsal tilt did not exceed 10° and radial shortening 5 mm (measured from the radial styloid process) (3). In young adults Fernandez advised not to accept more than 10° dorsal tilt, 2 mm increase in ulnar variance and less than 15° radial inclination (4).

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The purpose of the present study was to find out if the radiological outcome after surgical fixation was influenced by age.

METHODS

Radiographs of all distal radius fractures managed operatively in Ghent University Hospital between May 2008 and April 2010 were retrospectively assessed. Only patients with closed epiphyseal plates were included. A total of 207 patients were operated on. In seven cases radiographic outcomes could not be determined because patients had gone to another hospital for further treatment. Radiographs of 200 distal radius fractures were evaluated. Information on age, gender, side, mechanism of injury and treatment method could be collected from the electronic files.

It was noted on digitized radiographs of the distal radius fractures whether fractures were intra- or extra-articular and whether initial fracture displacement was palmar or dorsal. Ulnar variance was measured on preoperative radiographs, on postoperative radiographs taken immediately after surgery and at the time of bone healing (at least one month postoperatively). When available, ulnar variance was also measured on films of the opposite normal wrist. Palmar tilt was determined on preoperative lateral radiographs and at the time of bone healing. Measurements were done with the method described by Kreder *et al* (14).

Radiographic outcomes at the time of bone healing were categorized into five groups: without malunion, with dorsal, palmar or radiocarpal malunion or with radial shortening. In wrists with dorsal malunion, dorsal tilt measured more than 10° (i.e. palmar tilt was smaller than -10°) (fig 1). In fractures with palmar malunion, palmar



Fig. 1. — A wrist with dorsal malunion in a 59-year-old woman (a, b)

Table I

Results of radiographic measurements		SD
Mean palmar tilt on preoperative radiographs (N = 180) :	-14° (range : -58°, +48°)	17
Mean palmar tilt at the time of bone healing (N = 200) :	5° (range : -21°, +28°)	10
Mean ulnar variance on preoperative radiographs (N = 180) :	+ 2 mm (range : -3, +15)	3
Mean ulnar variance on the first postoperative day (N = 196) :	0 mm (range : -4, + 6)	2
Mean ulnar variance at the time of bone healing (N = 200) :	+1 mm (range : -4, + 12)	2
Mean ulnar variance of normal wrists (N = 73) :	0 mm (range : -5, + 4)	2

tilt was greater than 16° and/or a palmar shift of the fracture of more than 2 mm was present (10) (fig 2). In wrists with radiocarpal malunion or incongruity of the articular surface of the radiocarpal joint, intra-articular step-offs greater than 2 mm were present. Palmar tilt ranged between 16° and -10° and there was no palmar displacement of the fracture (fig 3). The fourth type of malunion, radial shortening, was present in wrists without intra-articular incongruity or dorsal or palmar displacement, but with an increase in ulnar variance of more than 2 mm in comparison with the opposite uninjured wrist or with the first postoperative film (fig 4). Radiographs of the uninjured contralateral wrist were available in 73 cases.

Statistical analysis was done with SPSS software. Mann-Withney U test was used to find out if malunion was more frequent with increasing age. The Kruskal- Wallis test was used to find out if the different types of malunion were influenced by age. The Chi -Square test was used to find out if malunion was affected by gender, fracture type, energy of the trauma or treatment. The Pearson correlation test was used to find an association between age and reduction loss.

RESULTS

Two hundred wrist fractures were evaluated in 128 women and in 64 men. Eight patients had bilateral fractures. Seven of those had a simultaneous bilateral fracture and one sustained a fracture of both wrists with a two months interval. Mean age of the patients was 54 years (range : 16-96 yrs). Mean age of women was 59 and of men 54 years. The left wrist was fractured in 113 wrists. Seventy-three fractures were extra-articular. Sixty-nine of those were dorsally displaced, one palmarly, two were undisplaced and in one the type of initial displacement was not reported. Of 127 intra-articular fractures, 93 were dorsally

displaced, 28 palmarly, three undisplaced and in three cases information on the initial displacement was missing.

The results of the measurements of the radiographic parameters are presented in table I. Malunion was present in 69 wrists (35 %). Mean age of patients with malunion was 60 and without malunion 51 years ; the difference was significant ($p < 0.001$). Malunion with dorsal displacement was present in 19 wrists (mean age : 68 years), malunion with palmar displacement in 17 (mean age : 53 years), malunion with radiocarpal incongruity in 16 (mean age 51 years) and radial shortening in 17 (mean age 65 years). The difference in age between these groups was significant ($p = < 0.0001$). Malunion was present in 54% of wrists in patients over 65 years of age ($n = 53$), versus 28% in patients 65 years old or younger.

Correction of ulnar variance immediately after surgery could not be maintained in all wrist fractures. Mean difference in ulnar variance between the first postoperative day and at the time of bone healing was 1 mm (range : -4 to +7 mm) (SD : 1 mm). Reduction in ulnar variance correlated significantly with age ($R = 0.34$, $p < 0.001$).

Malunion was present in 47 women (36%) and in 22 men (32%) ; the difference was not significant ($p = 0.75$). Dorsal and palmar malunion were more frequent in women and radiocarpal malunion in men, but these differences were also not significant ($p = 0.12$).

Malunion was present in 16 extra-articular fractures (22%) and in 53 intra-articular fractures (42%). This difference was significant ($p = 0.01$). Mean age of patients with extra-articular fractures was 55 years and with intra-articular fractures 54 years. In extra-articular fractures, mean age of patients with malunion was 55 years and in intra-articular fractures 54 years.

nion was 65 and without 51 years, and in intra-articular fractures 58 and 50 years, respectively. Mean increase in ulnar variance between initial radiographs and films taken at the time of bone healing, was similar for intra- and extra-articular fractures (1 mm).

An associated fracture of the distal head of the ulna was present in 19 wrists ; the fracture of the distal radius was found to be malunited in 63% of those. In wrists without ulnar head fracture, malunion was present in 31% : the difference was significant ($p = 0.01$).

The distal radius fracture was caused by a simple fall in 107 wrists (59%). The mechanism of injury was a fall from a few steps, from a bicycle or during ice skating in 35 cases (19%) and in 41 (22%), the fractures were sustained in a high-energy trauma (traffic accident, fall from a height). The mechanism of injury was not reported for 17 fractures. Patients who sustained a high-energy trauma were younger

than patients with a medium or low-energy trauma, 42 versus 58 years respectively ($p < 0.0001$). Ninety percent of fractures sustained in a high-energy trauma were intra-articular. Forty-three percent of men were involved in a high-energy injury and only 11% of women. Malunion was not more frequent in wrist fractures from a high energy trauma ($p = 0.14$), but the palmar and radiocarpal malunion types were more frequent ($p = 0.01$).

Percutaneous K-wire fixation was used in 139 fractures (70%). Fifty patients were treated with a volar plate, seven with an external fixator, one with a dorsal plate and one with screws. Two had a combined treatment : in one a palmar plate and a dorsal plate were used and in another a palmar and a dorsal plate in combination with an external fixator. K-wires were used in 135 dorsally displaced fractures and in 4 without displacement. One K-wire was introduced through the radial



Fig. 2. — A distal radius fracture in a 61-year-old man healed with palmar malunion (a, b)



Fig. 3. — Radiocarpal malunion in a 38-year-old man (a, b)

styloid process and one or two dorsal K-wires intrafocally (7,25). In 17 fractures all K-wires were introduced intrafocally (11). Volar plates were used in 19 dorsally displaced, in 27 palmarly displaced and one undisplaced fracture. In three cases the volar plate was inserted without distal screws and in the other fractures, angle stable screw fixation was used.

Malunion was present in 47 wrists stabilized with K-wires (34%) and in 13 with a palmar plate (26%). The difference was not significant ($p = 0.38$). However, the type of malunion in fractures treated with K-wires was different from those operated with plates. Palmar tilt malunion was seen in 12 wrists treated with K-wires and only in one treated with a plate. Dorsal tilt malunion was found in 18 fractures stabilized with K-wires and only in one treated with a plate. Radial shortening was present in 12 fractures stabilized with K-wires and in three with a plate. Radiocarpal incongruity was more frequent

in fractures treated with a plate than with K-wires – 8 and 5 respectively. This can be explained by the fact that palmar plates were more frequently used to stabilize intra-articular fractures sustained in a high-energy trauma than were K-wires. Twenty-nine percent of fractures treated with a plate were caused by a high-energy trauma versus only 15% of fractures managed with K-wires. External fixators were used six times to stabilize high-energy trauma fractures and only once in a low or medium-energy trauma fracture. All wrists treated with an external fixator had malunion (four palmar, one radiocarpal malunion and two radial shortening).

When wrists treated with K-wires were evaluated separately, mean age of patients with malunion was 62 years and without malunion 50 years ($p < 0.0001$). In fractures stabilized with a palmar plate, mean age of patients without malunion was 52 and with malunion 56 years, but the difference was not significant ($p = 0.39$).

DISCUSSION

The results of the present study cannot be easily compared with others in literature because different methods exist to measure radiological parameters, particularly radial shortening. Ideally, this should be measured as the difference in length between the distal radius and ulna at the level of the distal radio-ulnar joint and not from the radial styloid process, because the latter method does not correlate with functional outcome (28). Ulnar variance should be compared with the contralateral wrist to minimize misinterpretation due to anatomical variations (17).

There is also a large variation in criteria for malunion. In the study of Nesbitt *et al*, reduction was considered acceptable if loss of radial length did not exceed 2 mm (measured from the radial styloid process), loss in radial inclination was not more than 5°, loss in palmar tilt did not exceed 10° or articular step-offs were not greater than 1 mm (19). In the study of Earnshaw *et al*, criteria for an acceptable reduction were less than 10° dorsal angulation and less than 5 mm of radial shortening (measured from the radial styloid process) (3). For Beumer and McQueen, reduction was considered acceptable when volar or dorsal tilt did not exceed 10°, radial shortening was not more than 3 mm and carpal alignment was present (2). In the study of Makhni *et al*, criteria for adequate reduction were

less than 10° dorsal displacement or less than 25° volar angulation, articular step-offs smaller than 2 mm, and less than 5 mm radial shortening (it was not explained how radial shortening was measured) (16). Mackenney *et al* considered malunion if dorsal angulation measured more than 0° and/or ulnar variance was greater than 3 mm (15). In the present study, the criteria proposed by Fernandez were used to define malunion (more than 2 mm increase in ulnar variance, more than 10° dorsal tilt and intra-articular step-offs of more than 2 mm) (4), except that radial inclination was not used, because it did not correlate as well with outcome as the other parameters (9,26) and a volar tilt of more than 16° and/or volar shift of the fracture greater than 2 mm were also considered as malunion.

Despite the variations in criteria, it is clear that increasing age is associated with more fracture instability and malunion in distal radius fractures treated non-operatively (15, 16). In the present study it was also found that patients with malunion after surgical treatment were older than those without malunion. The influence of age on malunion was greater for K-wires than for volar plates with locking screws. However, a reliable comparison between the two treatment methods cannot be made, as more fractures sustained in a high-velocity trauma were treated with a volar plate than with K-wires.



Fig. 4. — A wrist fracture in a 79-year-old female with radial shortening (a,b) in comparison with the normal wrist (c)

In the present study, 35% of surgically treated wrist fractures were malunited, and the proportion reached 54% in patients over 65 years of age. Higher percentages of malunion are reported in series in which distal radius fractures were treated with manipulation and plaster cast immobilization. In a study by Nesbitt *et al*, 54% of fractures did not achieve an adequate reduction (19). In another study, malunion was found in 71% of fractures after finger-trap traction or manual manipulation followed by plaster cast immobilization (3). In another study on patients more than 65 years old, 83% of fractures healed in a malunited position after closed reduction (2). Lower percentages of malunion are reported after treatment with volar plates with locking screws. Ten percent of patients with a mean age of 53 years with a dorsally displaced distal radius had malunion following volar plating (23). In other studies with only elderly patients, malunion could be avoided (1,6,21). Radial shortening of 2 mm or more was present in 57% of female patients over 60 years of age treated with extra-focal K-wire fixation (13). In the present study, similar percentages of malunion were found in patients over 60 years of age treated with K-wires.

In the present study, malunion was more frequent in intra- than in extra-articular fractures. This can be explained by the fact that intra-articular incongruity cannot be present in extra-articular fractures. The influence of increasing age was still present when intra- and extra-articular fractures were evaluated separately. Increase in ulnar variance after surgical fixation was similar in intra- and extra-articular fractures. Radiological results of intra- and extra-articular fractures were similar in a study in which fractures were stabilized with a volar plate with locking screws (24). Also in the study of Nesbitt *et al*, loss of reduction was not greater in intra- than in extra-articular fractures (19).

Malunion can be categorized as dorsal, palmar and intra-articular malunion (5); malunion with only loss in radial length can occur as well. This type of malunion was more frequent in elderly patients. Young male patients were more at risk for radiocarpal malunion. These patients were more frequently involved in severe accidents and the resulting fractures were more complex and difficult

to treat. Ninety percent of fractures sustained in a high-energy trauma were intra-articular. Palmar malunion can occur following K-wire fixation of dorsally displaced fractures. Palmar overcorrection has been reported with the Kapandji technique (10, 18,20). A volar plate is indicated in fractures presenting palmar displacement after correction of the dorsal tilt.

It can be concluded that malunion of distal radius fractures following surgical fixation is more frequent in elderly patients, especially after treatment with K-wires. More than half of patients over 65 years of age in the present study had malunion. However, most of these patients will have no complaints, as the risk of functional problems caused by malunion decreases with increasing age (8,9).

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