The clinical and non-clinical aspects of distal radioulnar joint instability after a distal radius fracture

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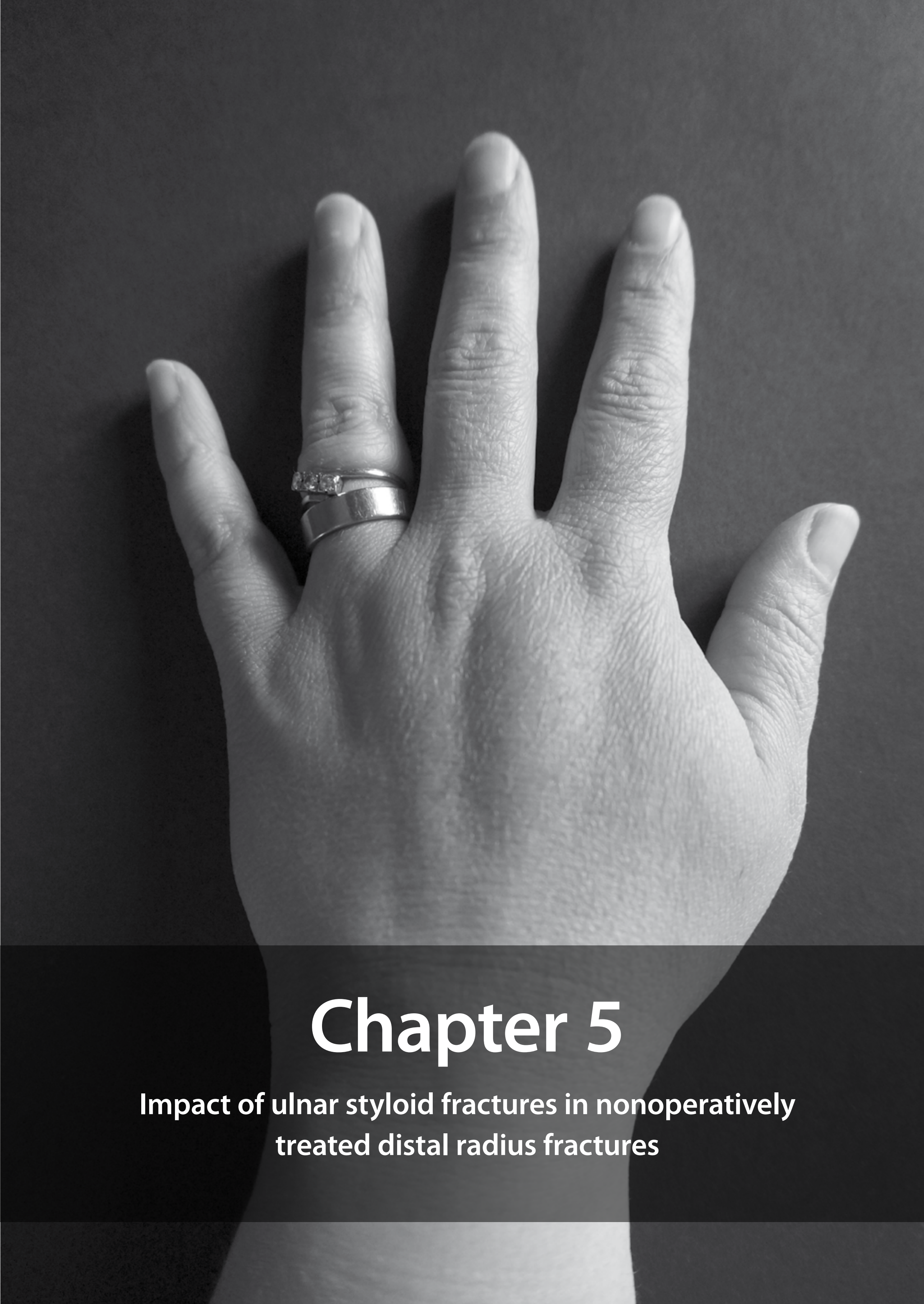
Issue Date: 2015-10-01

Part III

Acute treatment



Chapter 5

Impact of ulnar styloid fractures in nonoperatively treated distal radius fractures

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Eur J Trauma Emerg Surg 2013;39(2):151-57

ABSTRACT

Purpose: The effect of an ulnar styloid fracture (USF) on the stability of nonoperatively treated distal radius fractures (DRF) is unknown. The aim of this study was to evaluate the influence of USFs on the dislocation of DRFs treated by closed reduction.
Methods: Standardized radiographs of 100 nonoperatively treated DRFs were evaluated. DRFs with an USF were compared to DRFs without an USF with respect to dorsal tilt, radial inclination, and ulnar variance.
Results: We evaluated the radiographs of 100 DRFs in 99 consecutive patients, of whom 84 were women. An accompanying USF was present in 58 wrists, of which 49 were displaced. On the trauma radiograph, the USF group showed significantly more overall dislocation. After closed reduction, fracture position improved, and no significant differences in dislocation were observed between groups. After a mean of 42 days, radial inclination significantly decreased if an USF was present. When USF displacement was taken into account, significantly more ulnar variance occurred in the displaced USF group on the trauma and follow-up radiograph compared to the nondisplaced USF group and no-USF group.
Conclusions: The results of this study show that presence of an dislocated USF in patients with a DRF is associated with a worse position directly after trauma, and with recurrence of radial shortening after adequate reduction. These results warrant early radiologic follow-up in patients with reduced combined DRFs and USFs in order to evaluate the redislocation of the distal radius. Early detection of redislocation in these combined fractures may induce early surgical intervention.

INTRODUCTION

One in six patients who present with a fracture at the emergency department has a distal radius fracture (DRF).[1–3] Of those patients, 44–65 % also have an ulnar styloid fracture (USF).[4–7] Since the triangular fibrocartilage complex (TFCC) inserts on the base of the ulnar styloid[3, 8–10], distal radioulnar (DRU) joint instability may result when an USF is present, due to TFCC disruption.[11–16]

In only minimally dislocated DRFs, nonoperative treatment leads to a satisfactory anatomical end result[17], since the functional outcome of the DRF depends on restoration of the anatomy.[18–20] Several radiographic parameters may have prognostic value for the outcome of DRF treatment.[21, 22] Radial inclination could be useful for assessing the reduction adequacy of DRFs.[22, 23]. Ulnar variance and dorsal tilt have a negative influence on functional outcome[20, 24] and may alter the DRU joint.[18–20]

In operatively treated DRFs, the presence of an USF does not affect the outcome with respect to wrist function and DRU joint stability.[25–28] In nonoperatively treated patients with DRFs, Oskarsson et al.[6] suggested that a worse outcome resulted from a DRF in the presence of an USF after radial consolidation. Since corrections of acute dislocated fractures are less complex and produce better results than secondary osteotomies, we were interested in the relation between the presence of an USF and the amount of radial fracture dislocation in the acute phase and after short-term follow-up. Therefore, the aim of our study was to evaluate the influence of an USF on the extent of dislocation of a nonoperatively treated DRF, after adequate closed reduction. Our hypothesis was that nonoperatively treated DRFs with an USF show more dislocation on radiography directly after trauma and after short-term follow-up compared to DRFs without an accompanying USF.

PATIENTS AND METHODS

For this retrospective cohort study, all patients who had been diagnosed with a DRF that had been treated nonoperatively between May 2008 and February 2010 at a level-one trauma center, were selected from the hospital database. Demographic and clinical data were obtained from the database. Patients who met at least one of the following criteria were excluded from the study: (1) pathologic fracture; (2) previous wrist injury; (3) DRF treated without closed reduction; (4) missing or incorrect radiographs; and (5) follow-up of less than two weeks. Also, 35 patients with a DRF that underwent surgery after a secondary dislocation during the study period (of which 24 had an accompanying USF) were excluded from further analyses.

Treatment consisted of closed reduction of the fracture, in the acute setting, and immobilization by a plaster of Paris or fiberglass cast for six weeks. Standard follow-up was performed at 5–7 days, 2 and 4–6 weeks after trauma. The radiographs that had been taken directly after trauma, directly after closed reduction, and at the last follow-up, were analyzed.

Radiographic evaluation

On the standardized anteroposterior and lateral wrist radiographs, three radiographic parameters (dorsal tilt, radial inclination, and ulnar variance) were evaluated by one researcher (MvV) using Image Toolbox in Mirador V5 (iSoft Group PLC, Banbury, UK). Dorsal or palmar tilt was determined on the lateral view as the angle between a line connecting the volar and dorsal margins of the articular surface and a line perpendicular to the central axis of the radius[29] (Figure 5.1a). Radial inclination and ulnar variance were both determined on the anteroposterior view. Radial inclination was determined as the angle between a line perpendicular to the long axis of the radius and a line joining the radial and ulnar margins of the articular surface[23] (Figure 5.1b). Ulnar variance was determined as the distance, perpendicular to the central axis of the radius, between the cortical rim of the ulnar seat and the most proximal point on the distal articular surface of the radius[30] (Figure 5.1c). Positive ulnar variance indicated radial shortening; negative ulnar variance indicated radial lengthening. Normal values of dorsal tilt, radial inclination, and ulnar variance as compared to the ulna have previously been reported as 9° (range 2°–15°)[26], 24° (range 19°–29°)[23], and +0.9 mm (range –4.2 to 2.3 mm)[23] respectively.

Fracture type was classified according to the AO classification and patients were assigned to either the USF group or the no-USF group based on the trauma radiographs. Furthermore, displacement and the level of the USF were taken into account. Displacement of the USF was defined as a distance between the two fracture parts of 2 mm or more on the anteroposterior trauma radiograph.[26] USF level was either an ulnar styloid base fracture (if more than 75 % of the ulnar styloid was involved in the fracture fragment) or a tip fracture.[3]

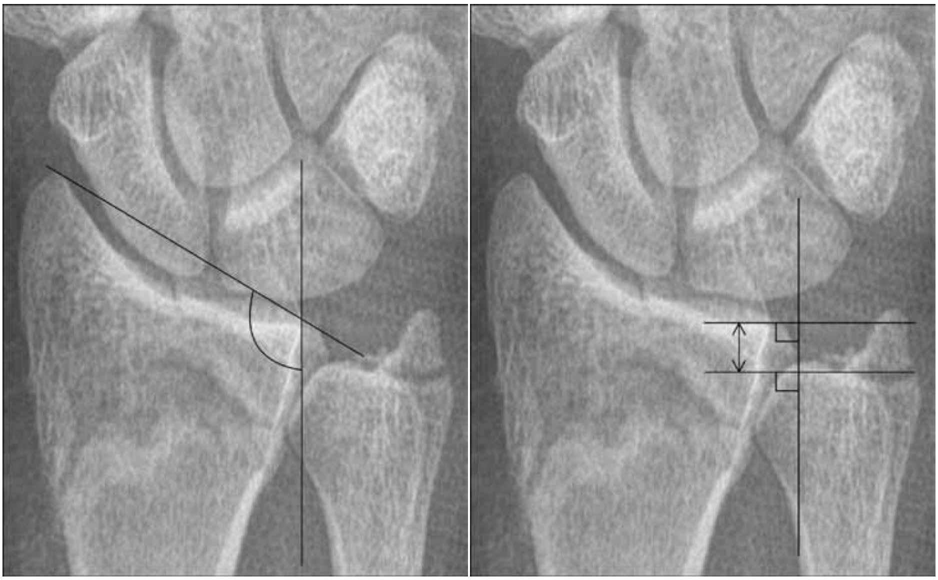
Effect of treatment

The effect of fracture reduction on each radiographic parameter (dorsal tilt, radial inclination, and ulnar variance) was defined as the difference between that parameter measured on the reduction radiograph and measured on the trauma radiograph prior to reduction (reduction effect = Xreduction - Xtrauma). The short-term effect of treatment was determined as the difference between the parameter measured on the last available follow-up radiograph and measured on the reduction radiograph (short-term effect = Xlast - Xreduction). For example, a short-term treatment effect for dorsal tilt of Xlast - Xreduction = 5 – 12 = –7 implied a 7° change in dorsal tilt.

a

Figure 5.1.
a Dorsal tilt was determined as the angle between a line connecting the volar and dorsal margins of the articular surface and a line perpendicular to the central axis of the radius.
b Radial inclination was determined on the anterioposterior view as the angle between a line perpendicular to the long axis of the radius and a line joining the radial and ulnar margins of the articular surface.
c Ulnar variance was determined on the anterioposterior view as the distance, perpendicular to the central axis of the radius, between the cortical rim of the ulnar seat and the most proximal point on the distal articular surface of the radius. Positive ulnar variance indicated radial
shortening; negative ulnar variance indicated radial lengthening

b c



Statistical analysis

The independent samples t test and one way analysis of variance were used for group comparisons of continuous data. Categorical data were analyzed and compared with the χ^2 test. Statistical significance was assumed for $P<0.05$.

RESULTS

During the study period, 282 patients with 283 DRFs were treated nonoperatively in our hospital. Of these patients, 183 met one or more exclusion criteria. The remaining 99 patients with 100 DRFs were subject to analysis in this study (Figure 5.2).

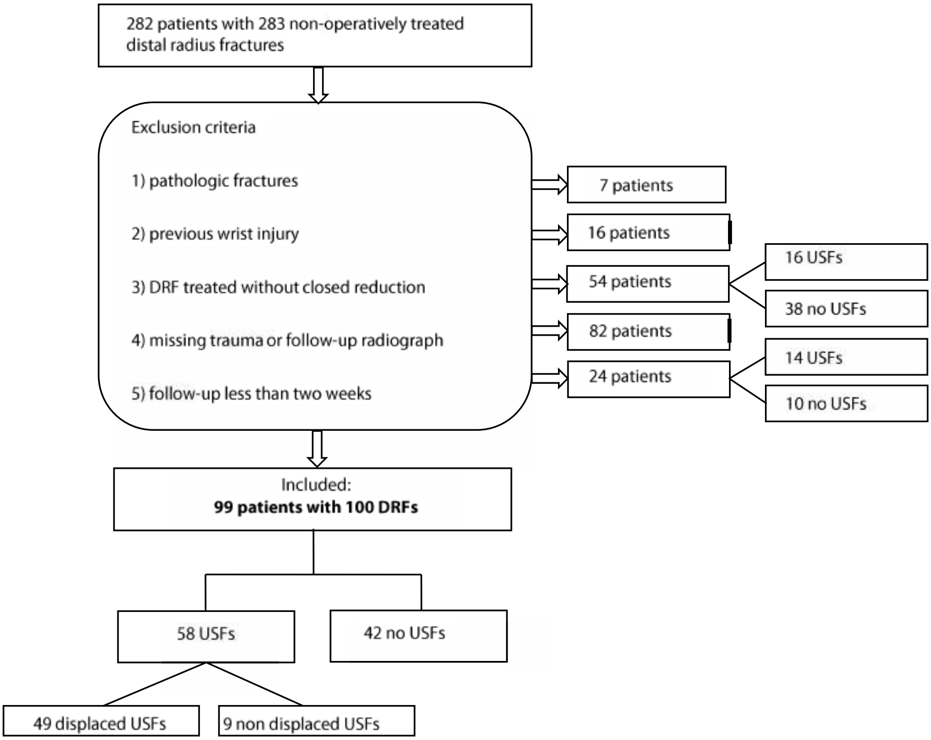


Figure 5.2. Flowchart of patients that had been diagnosed with distal radius fractures between May 2008 and February 2010 at a level-one trauma center

Patient characteristics

The study group included 15 men (15 %) and 84 women (85 %) with a mean age of 64.1 (SD 17.9) years. One woman suffered from a DRF in both wrists. Fifty DRFs (50 %) were located in the left wrist. Accompanying USFs were present in 58 wrists (58 %), of which 49 (84 %) were displaced and 49 (84 %) were base fractures. The USF and no-USF groups were comparable regarding age, gender, and fracture type (Table 5.1).

Presence of USF

Dorsal tilt, radial inclination, and ulnar variance after trauma and at the last follow-up were compared between the USF and no-USF group (Table 5.2). On the trauma radiograph, the USF group showed on average 3.8° less radial inclination and 1.9 mm more ulnar variance than the no-USF group (P = 0.03 and 0.04, respectively). The USF group had 4.7° more dorsal tilt on average than the no-USF group, but this difference was not statistically significant (P = 0.15). There were no statistically significant radiographic differences on the reduction radiograph between the USF and no-USF group. The final follow-up radiographs in the USF group showed on average 2.3° less radial inclination than those in the no-USF group (P = 0.03), and ulnar variance tended to be more positive in the USF group (mean difference 1.2 mm, P = 0.07), despite adequate reduction according to the reduction radiograph. Shortly after closed reduction, ulnar variance was on average 1.7 mm more improved in the USF group than in the no-USF group (P = 0.03). In the longer term, the relapse in ulnar variance was more extensive in the USF group, although this difference was not statistically significant (Table 5.3).

Table 5.1. Characteristics of 99 patients with 100 DRFs who underwent closed reduction, categorized according to the presence or absence of a USF

Characteristic		USF N = 58	No USF N = 42	P-value
Mean age (SD) in years		64,3 (18,7)	63,9 (16,9)	0,92
Gender, n (%)	Male	10(17)	5 (12)	0.46
	Female	48 (83)	37 (88)	
AO-classification, n (%)	23A	26 *(45)*	19 *(45)*	0.43
	23B	2 *(3)*	4 *(10)*	
	23C	30 *(52)*	19 *(45)*	
Mean follow-up (SD) in days		42.1 (29.0)	42.6 (44.4)	0.95

Results are presented as mean (SD)

USF displacement and level

To assess the effect of a displaced USF on the radiographic parameters, the USF group was subdivided into USFs with or without displacement and compared to the no-USF group (Table 5.4). Comparison of these three groups showed significantly more ulnar variance in the displaced USF group on the trauma and follow-up radiograph compared to the nondisplaced USF group and the no-USF group. The effect of the USF level on the radiographic parameters was evaluated in Table 5.5. Comparison of radiographic parameters between the ulnar styloid base fracture group and the ulnar styloid tip fracture group showed no significant differences.

Table 5.2. Radiographic evaluation of 99 patients with 100 DRFs who underwent closed reduction

Radiographic parameters	Trauma radiograph			Reduction radiograph			Last follow-up radiograph		
	USF N = 58	No USF N = 42	P-value	USF N = 58	No USF N = 42	P-value	USF N = 58	No USF N = 42	P-value
Dorsal tilt (°)[1]	18,7 (16,7)	14,0 (14,9)	0,15	−2,3 (8,2)	−2,7 (6,4)	0,777	2,0 (9,9)	0,7 (10,7)	0,52
Radial inclination (°)	10,0 (9,0)	13,8 (7,1)	**0,03**	20,1 (4,9)	23,2 (15,2)	0,145	14,3 (6,2)	16,6 (4,2)	**0,03**
Ulnar variance (mm)[2]	2,7 (4,8)	0,8 (3,9)	**0,04**	−0,9 (3,2)	−1,1 (3,0)	0,671	2,0 (3,4)	−0,8 (3,1)	0,07

Bold numbers indicate statistical significant outcomes of the tests. Radiographs were taken after trauma, after reduction and at last follow-up. Results are categorized according to the presence or absence of USF. Results are presented as the mean (SD)

[1] Negative values indicate palmar tilt, positive values indicate dorsal tilt.

[2] Positive values indicate radial shortening, negative values indicate radial lengthening.

Table 5.3. Reduction and short-term effects of reduction on radiographic parameters in patients with a DRF, categorized according to the presence or absence of USF

Radiographic parameters	Short-term reduction effect = $X_{reduction} - X_{trauma}$			Long-term reduction effect[1] = $X_{last} - X_{reduction}$		
	USF group N = 58	No USF group N = 42	P-value	USF group N = 58	No USF group N = 42	P-value
Dorsal tilt (°)	21,0 (17,2)	16,7 (15,1)	0,20	−4,3 (11,4)	−3,4 (10,5)	0,69
Radial inclination (°)	10,1 (8,6)	9,5 (14,8)	0,79	−5,8 (6,0)	−6,6 (14,8)	0,71
Ulnar variance (mm)	3,6 (4,4)	1,9 (3,0)	**0,03**	−2,9 (2,7)	−2,0 (2,3)	0,06

Bold numbers indicate statistical significant outcomes of the tests. Results are presented as the mean difference (SD)

[1] Negative values indicate that the position of the fracture was better on the reduction radiograph than on the last follow-up radiograph.

Table 5.4. Radiographic evaluation of 99 patients with 100 DRFs who underwent closed reduction

Radiographic parameters	Trauma radiograph				Reduction radiograph				Last follow-up radiograph			
	USF group Displaced N = 49	**USF group Non-displaced N = 9**	**No USF group N = 42**	**P-value**	**USF group Displaced N = 49**	**USF group Non-displaced N = 9**	**No USF group N = 42**	**P-value**	**USF group Displaced N = 49**	**USF group Non-displaced N = 9**	**No USF group N = 42**	**P-value**
Dorsal tilt (°)[1]	18,7 (15,2)	18,7 (16,0)	14,0 (14,9)	0,36	−3,3 (7,7)	3,0 (9,3)	−2,7 (6,4)	0,06	2,0 (9,9)	1,8 (10,5)	0,7 (10,7)	0,82
Radial inclination (°)	9,8 (9,4)	11,2 (7,0)	13,8 (7,1)	0,08	20,2 (5,2)	19,7 (3,4)	23,2 (15,2)	0,35	14,0 (6,5)	15,6 (4,2)	16,6 (4,2)	0,08
Ulnar variance (mm)[2]	3,2 (4,6)	0,2 (5,3)	0,8 (3,9)	**0,02**	−0,6 (3,2)	−2,5 (2,6)	−1,1 (3,0)	0,20	2,6 (3,2)	−0,9 (3,2)	0,8 (3,1)	**0,00**

bold numbers indicate statistical significant outcomes of the tests

Radiographs were taken after trauma, after reduction, and at last follow-up. Results are categorized according to the presence of dislocated or nondislocated USF or absence of USF. Results are presented as mean (SD)

[1] Negative values indicate palmar tilt, positive values indicate dorsal tilt.

[2] Positive values indicate radial shortening, negative values indicate radial lengthening.

Table 5.5. Radiographic evaluation of 99 patients with 100 DRFs who underwent closed reduction

Radiographic parameters	Trauma radiograph			Reduction radiograph			Last follow-up radiograph		
	USF base N=49	**USF tip N=9**	**p-value**	**USF base N=49**	**USF tip N=9**	**p-value**	**USF base N=49**	**USF tip N=9**	**p-value**
Dorsal tilt (°)[1]	20.1 (15.2)	10.8 (22.7)	0.12	−2.1 (8.3)	−3.4 (8.2)	0.66	2.3 (10)	0.2 (9.9)	0.56
Radial inclination (°)	9.8 (8.6)	11.0 (11.4)	0.72	20.0 (5.2)	20.6 (3.2)	0.73	13.8 (6.2)	16.8 (5.5)	0.18
Ulnar variance (mm)[2]	−2.7 (4.7)	−2.6 (5.2)	0.97	1.1 (3.1)	−0.2 (3.3)	0.27	−1.8 (3.4)	−3.1 (3.7)	0.29

Radiographs were taken after trauma, after reduction, and at last follow-up. Results are categorized according to the fracture level of USF. Results are presented as the mean (SD)

[1] Negative values indicate palmar tilt, positive values indicate dorsal tilt

[2] Positive values indicate radial shortening, negative values indicate radial lengthening

DISCUSSION

To our knowledge, this is the first report in the literature on the potential influence of an USF on early fracture stability in nonoperatively treated DRFs. The results of this study show that the presence of a dislocated USF in patients with a DRF is associated with a worse position directly after trauma and with recurrence of radial shortening after adequate reduction.

Positive ulnar variance is a significant negative influence on functional outcome after DRF.[31] If ulnar variance cannot be corrected adequately using closed fracture reduction, this may present an indication for operative reduction and fixation. However, in many patients, the positive ulnar variance will occur over time. In this study, ulnar variance occurred more frequently during follow-up in patients with an accompanying USF treated by closed reduction. Therefore, a fractured ulnar styloid can be regarded as a risk factor for positive ulnar variance, indicating the need for frequent follow-up radiographs in the two first weeks after closed reduction. The USF itself does not need operative fixation since, in operatively treated DRFs, an USF in itself does not affect outcome in terms of strength and function.[3,25,26, 28] Like all retrospective analyses, this study has limitations. Radiological measurements were performed in retrospect by one researcher who was not blinded for the presence of an USF, patients had to be excluded because of incomplete data, and some clinical data were lacking. In daily practice it is not common to take radiographs of the uninjured wrist, so a comparison with the uninjured contralateral distal radius in order to evaluate radial length was not possible in this study population. Another limitation of the study is that patients who had been primarily treated nonoperatively but were operated on during follow-up were not included in this study. It is expected, however, that the radiologic deviations after initial follow-up (before surgery) in those patients would be even larger than those seen in the present study group. The inclusion of these patients in the study would therefore have strengthened our findings. Because only one researcher performed all measurements, the interobserver variability could not be calculated. For the same reason, the measurements were not influenced by interobserver variability, and were therefore comparable in the analysis of all subgroups. Furthermore, comminution of the dorsal cortex was not taken into account, since it cannot be measured objectively on conventional radiographs. If dorsal comminution is present, the corrected position of the DRF after reduction is not mechanically supported. In conclusion, the presence of a dislocated USF in patients with a DRF is associated with a worse position directly after trauma and with recurrence of radial shortening after adequate reduction. The ulnar styloid significantly contributes to the stability of the distal radial fragment. Due to the decreased fracture stability in combined DRFs and USFs, the clinical implication of this finding is that the presence of a USF in patients with a DRF warrants early radiologic control after closed reduction. Redislocation may be considered an indication for early surgical fixation in order to prevent malunion and subsequent functional impairment.

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