Original Research Article

Effect of an ulnar styloid Base unrepaired fracture on outcome after plate fixing of a distal radus fracture

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Received: 11-12-2020 / Revised: 19-01-2021 / Accepted: 09-02-2021

Abstract

Background: The impact of an unrepaired ulnar styloid base fracture on recovery after internal fixation of a distal part of the radius fracture is uncertain. To test the hypothesis that there is no difference in wrist motion or function scores between those with an untreated fracture of the ulnar styloid base and those without ulnar fracture, we assessed a series of patients with an internally fixed fracture of the distal part of the radius. **Methods**: In a prospective study of plate-and-screw fixation of distal radial fractures, two cohorts of seventy-six matched patients, one with a fracture of the ulnar styloid base and the other without ulnar fracture, were retrospectively analysed. They matched patients for age, sex, type of AO fracture, and mechanism of injury. The two cohorts were analyzed at six, twelve and twenty-four months postoperatively for differences in motion, grip strength, pain, the Gartland and Werley score, arm, shoulder, and hand score disabilities, and the Short Form-36 score. Sixty-four patients with < 2mmof displacement of a ulnar styloid base fracture were compared with forty-nine patients with greater displacement in a second analysis. With the use of regression analysis and the probability ratio test, differences between cohorts and cohorts were determined over time. **Results:** No significant differences were found at any of the follow-intervals between patients with an unrepaired fracture of the base of the ulnar styloid and those without ulnar fracture. However, at six months, there was a trend towards lower grip strength (71 percent [on the contralateral side] compared to 79 percent; mean difference, 28 percent [95 percent confidence interval= 215.3 percent to 20.6 percent]; p= 0.03) and lower bending (54 compared to 59; mean difference, 25[95 percent confidence interval= 211.7 to 20.8]; p= 0.02) and ulnar deviation (32 compared with 59). There were no significant differences in any measurement of the tested outcome between patients with a displacement of an unrepaired fracture of the ulnar styloid base and patients with less displacement. **Conclusions**: After treatment of a distal radial fracture with plate-and-screw fixation, an unrepaired fracture of the base of the ulnar styloid does not appear to influence function or outcome, even when the ulnar fracture was initially displaced ≥2mm.

Keywords: ulnar styloid, distal radial, fracture, plate fixing, unrepaired fracture.

Introduction

Several classifications of distal radius fractures were described based on morphological patterns, intra-articular extension, comminution degree and injury mechanism [1]. The classification is based on the presence or absence of an articular extension of the distal radial fracture to the radio-carpal or distal radio-ulnar joint, and an associated ulnar styloid fracture [2]. These large ulnar styloid fractures include at least part of the origin of the triangular fibrocartilage complex and may be an alternative to an intra-substance tear of the triangular fibrocartilage complex when setting the distal part of the radius to a displaced fracture. There are few data available to clarify the debate between those who believe that a fracture of the ulnar styloid base contributes to the potential for reduced forearm rotation, arthritis, pain and chronic instability of the distal radio ulnar joint [3-5] and those who do not [6, 7].Some authors have suggested that features like the size and displacement of the ulnar styloid fracture fragment may predict distal radioulnar joint instability [8-11]. Using data from a prospective study of open reduction and plate fixation of distal part of the radiusfractures, we retrospectively compared patients ' matched cohorts with and without an untreated ulnar styloid base fracture to test the null hypothesis that an ulnar styloid fracture does not affect wrist function and arm-specific state of health. In a second analysis, we tested the null hypothesis that there is no difference in wrist function and health status between patients with an ulnar styloid base fracture displacement of 2 mm and patients with a less displaced fracture.

Materials and Methods

The study was conducted at department of orthopedics, Government General Hospital, Nizamabad. The patients included in this study represent a subset of patients from a large prospective cohort study conducted for another purpose. Between April 2016 and March 2018, a prospective multicenter cohort study of open reduction and plate-and-screw fixation of distal part of the radius fractures enrolled 280 patients. The inclusion criteria were eighteen years of age or older, open reduction and internal plate-and-screw fastening within ten days of the injury, and no prior open reduction and internal fastening. Exclusion criteria included general or local conditions that adversely affect bone physiology, such as tumor, hyperparathyroidism, and imperfect osteogenesis; multiple traumatic injuries (Severity Injury Score > 13) [12]; co-registration in another study; and history of drug or alcohol abuse.We considered 252 patients for inclusion in the current study after excluding 21 patients with inadequate preoperative radiographs and two patients with bilateral fracture. Based on clinical experience with the repair of ulnar styloid fractures in galeazzi and distal radial fractures combined with our

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understanding of the anatomy of the origin of the triangular fibrocartilage complex, we made the otherwise arbitrary decision to consider any fracture involving 75% of the total height of the ulnar styloid process as an ulna fracture. Thus fractures were all sufficiently large to qualify for rigid fixation. The ulnar styloid fracture fragments were measured with the use of a calibrated measuring tool on posteroanterior and lateral digital radiographs. Ulnar-sided fractures were classified as (1) absent (108 patients), (2) with styloid tip (17 patients), (3) with styloid base (116 patients), (4) with ulnar neck (11 patients), and (5) with ulnar diaphysis (2 patients). Fractures at multiple levels (e.g., the ulnar neck and styloid, or the ulnar neck and head) were classified according to the fracture's closest element. Fractures that accounted for < 75 percent of the height of the ulnar styloid were relatively rare and easily distinguished from the large.There were 152 women and 98 men averaging fifty-five years of age (range, eighteen to eighty-three). The left wrist was involved in 179 patients and 12 (10.6 per cent) of them were on the dominant side. The right arm was involved in 121 patients, and 115 (95 percent) of them were on the dominant side. The initial injury resulting from a drop from standing height in149 patients was a higher-energy injury such as one sustained in a drop from a height, a motor-vehicle collision, or a drop in 63 patients during sports; and in 13 had an unknown cause.Patients with a fracture of the ulnar neck were much more likely to be female and older (Table 1). There have been no other significant differences in demographic and injury-related factors among patients with no ulnar fracture, those with ulnar styloid base fracture, those with ulnar styloid tip fracture and those with ulnar neck fracture.Of the 129 distal fractures of the ulna, nine (6.9%) were treated with open reduction and internal fixation; the sixteen included nine ulnar styloid fractures, five ulnar neck fractures and styloid fractures and two diaphysal ulnar fractures. The decision to carry out the open reduction and internal fixation depended on the surgeon's or center's preference and did not correspond to the injury or radiographic appearance characteristics. Patients who received surgical treatment for the ulnar fracture were excluded from this study.

Table 1: Patient Demographics and Injury Patterns

Ulnar Fracture	No.	Male (no. [%])	Mean Age (yr)	Fracture on Dominant Side (no. [%])	AO Type (no. [%])			Open Fracture (%)	Low-Energy Injury (no. [%])
					A	B	C		
None	108	34 (31.5 %)	52	56 (51.8 %)	39	12	61 (56.4 %)	3	45 (41.6%)
Styloid tip	17	7 (41.1 %)	51	9 (52.9 %)	6	2	8 (47 %)	0	9 (52.9 %)
Styloid base	116	46 (39.6 %)	53	61 (52.5 %)	42	6	69 (59.4 %)	1	63 (54.4%)
Ulnar neck	11	2* (18.1 %)	61**	5 (45.4 %)	9	1	7(63.4 %)	2	6 (54.5 %)

*Patients with an ulnar neck fracture were significantly more likely to be female (p = 0.039, Fisher exact test). **Patients with an ulnar neck fracture were significantly more likely to be older (p < 0.01, Kruskal-Wallis test).

Matched Cohorts

Patients with Ulnar Styloid Base Untreated Fracture Compared to patients with No Ulnar Fracture in 215 patients with an untreated ulnar styloid base fracture or no ulnar fracture, 164 (76.2%) had a six-month assessment, 159 (73.9%) had a 12-month assessment and 156 (72.5%) had a 24-month assessment.A design for the case-study was used. From the group of patients with a minimum of twelve months of follow-, two cohorts of 49 patients-one with an untreated fracture of the ulnar styloid base and the other with no ulnar fracture were matched on the basis of (1) sex, (2) twelve-age groups, (3) injury mechanism (a fall from a standing height compared to a higher-injury mechanism), and (4) fracture type according to the AO classification (A, B, or C) with use of a frequency matching technique [13]. There were no significant differences between these two matched cohorts as to the injured side, whether the injury was on the dominant side[14], Fernandez classification, open injury, pre-accident work, medical illness, concurrent injury, smoking history, interval between injury and surgery, operational approach, primary carpal tunnel release, supplemental stabilisation (Kirschner wire or lag screw), or use of bone graft (Table-2).

Table 2: Descriptive Data of the Matched Cohorts

	Ulnar Fracture*	No Ulnar Fracture*	P Value
Fracture side			
Left	29 (59.1%)	22 (44.8%)	0.63
Right	21	24	
Fracture on dominant side			
Yes	19 (38.7%)	23 (46.9%)	0.62
No	25	24	
Ipsilateral injury			
Yes	9 (18.3%)	9(18.3%)	1.00
No	36	36	
Mean interval (std.) from injury to surgery (days)	3.2±2.6	4.3± 2.9	0.32
Type of plate			
2.4 mm	20 (40.8%)	19 (38.7%)	0.28
3.5 mm	29 (59.1%)	26 (53%)	
Other	3 (6%)	6 (12.2%)	
Surgical approach			
Dorsal	7 (14.2%)	7 (14.2%)	0.74
Volar	41 (83.3%)	40 (81.6%)	
Dorsal & volar	2 (4%)	2(4%)	
Prior pinning or external fixation			
Yes	5 (10.2%)	6(12.2%)	0.82
No	39	39	

*The values are given as the number with the percentage in parentheses except where otherwise indicated.

Four patients had complications, including loss of reduction in one, loosening of a screw requiring a second operation to remove the screw in one, a superficial infection requiring irrigation and debridging reoperation in one (without ulnar fracture in the cohort) and a rupture of the extensor pollicis longus tendon in one (with an ulnar styloid fracture).

Minimal Displacement Compared to Greater Displacement of Ulnar Styloid Base Fractures

In a separate analysis, we considered a full cohort of 115 patients with untreated ulnar styloid base fractures, not just those in matched pairs. Of those 115 patients, 98 were analyzed with a follow-up period of at least six months. Of the 98 patients, 49 had a fracture that was observed to be displaced < 2 mm on radiographs of injury and 54 had a fracture with displacement of some 2 mm. 36 Patients with a minimally displaced fracture (73.4 per cent).

Of the patients with < 2 mm displacement of the ulnar styloid base fracture, 29 were females, and 20 were males. The average age was 56 (range, from twenty to eighty-three years). The original injury resulted from a drop in 26 patients from a standing height (a low-energy injury), a higher-energy injury in 9 patients, and an unknown cause in 16 patients. None of the fractures were associated with an upper-limb injury or an ipsilateral wound.

Of the patients with the ulnar styloid fracture displacement of about 2 mm, twenty-six were female and twenty-three were male. The average age was 53 years (range, from twenty-one to seventy-nine years). The original injury resulted from a fall in twenty patients from a standing height, a higher-energy injury in nineteen patients, and an unknown cause in nine. All fractures were closed, and there was no injury in the ipsilateral limb of any of the patients.

There were no significant differences in the baseline characteristics between those two cohorts.

Clinical Evaluation

Each patient was evaluated at six, twelve, and twenty-four months after the surgery according to the Gartland and Werleysystem[15]. Patients also completed the Arm, Shoulder, and Hand Disabilities (DASH) and Short Form-36 (SF-36) [16-19] questionnaires and assessed their pain both at rest and in motion on a 10-point visual analog scale at each follow-up.

Radiographic Evaluation

The distal part of the radius alignment was measured on posteroanterior and lateral X-rays using commercial software (e-Film). Ulnar inclination, palmar tilt, ulnar variance, and articular congruity were measured using the Kreder et al. standardized techniques [20]. It was not possible to measure ulnar variance and articular step-off in millimeters, because the radiographs were digital and unscaled. Instead we used a new technique to measure ulnar variance and articular step-off in reference to the capitalate's measured length.We investigated and found this technique reliable, but our work has not yet been published. On posteroanterior radiographs, the length of the capitalate was measured using the guidelines described by Nattrass*et al.* [21]. Ulnar variance with the interval expressed as a ratio to the length of the capitate was reported as positive or negative. Radiographic signs of osteoarthritis were rated, with use of the system of Knirk and Jupiter, as grade 0 (no arthritis), grade 1 (slight joint-space narrowing), grade 2 (marked joint-space narrowing with osteophyte formation), or grade 3 (bone on bone with osteophyte and cyst formation) [22].

Statistical Analysis

Patients with an untreated ulnar styloid base fracture were compared with those with no ulnar fracture to assess differences in wrist function and health status at six, twelve, and twenty-four months after the operation. The probability ratio test was used to test the null hypothesis that there would be no difference between the two cohorts in terms of wrist function and health status. Twenty-two parameters were assessed at each time interval (six months, 12 months) (each motion and radiographic measurement, grip strength, rest pain, moving pain, gartland and werley score and physical component scores, DASH score, arthritis grade, return-to-work status, and complications within 24 months) were assessed at each time interval (six months, 12 months and 24 months) and regressed on two indicator variables (ulnar fracture and followup time) and one interaction term (ulnar fracture and time). The interaction term was included to determine whether there was a potential time dependent ulnar fracture effect. In one overall linear regression model, the repeated measurements of each patient were pooled and analyzed together for each outcome. This approach makes it possible to assess the overall effect of an untreated fracture of the ulnar styloid base and time on the outcome while taking into account all available data and avoiding multiple analysis at each follow-up point. Furthermore, it allowed us to quantify the effect of one factor (such as ulnar fracture) within the same model at each moment of follow-up.

The probability ratio test was used to study the overall effect of an ulnar styloid fracture on each of the twenty-two separate outcome parameters: the full regression model's maximum probability estimate (including ulnar fracture, time, and interaction term) was compared to a null regression model (time only) to determine whether adding the ulnar fracture variable would mean adding the ulnar fracture variable.

A significant value of this test reflects a significant difference in outcome due to the presence of an ulnar styloid fracture. In a similar fashion, to determine the overall time effect on outcome, the full regression model was compared with a model without the" time' variable. The significance of multiple testing with the use of a bonferroni correction was adjusted. A p-value of < 0.001) was deemed significant. Then, using the Wald test, we used the same full regression model to determine the effect size and timing (six, twelve, and twenty-four months).

A post hoc power analysis was performed using repeated-variance analysis as a model for our approach. A sample size of 49 patients per group was determined to provide > 99 per cent power to detect a minimum 10-point difference in the DASH score with a known standard deviation. A similar approach was used in a second analysis to determine any differences in wrist function and health status between patients with a < 2 mm displaced ulnar styloid fracture and those with greater initial displacement of the fracture.

The descriptive analysis of the entire database was accomplished using the exact Fisher test and the Kruskal- Wallis test. Baseline group comparison of the matched cohorts was done using the exact Fisher tests.

Results

Matched Cohorts

Fracture of the Ulnar Styloid Base Compared with No Ulnar Fracture

Effect of Time on Outcome

Patients with untreated ulnar styloid base fracture and patients with no ulnar fracture both had significant improvements in wrist bending and extension arc, wrist bending, wrist extension, forearm rotation arc, pronation, supination, radioulnar deviation arc, radial deviation, ulnar deviation, grip strength, and DASH and Gartland and Werley scores between six months Effect of an Untreated Ulnar Styloid Fracture.Base on Outcome According to the likelihood ratio test, a fracture of the ulnar styloid base had no significant effect on the overall outcome. However, when compared with the patients with no ulnar fracture, the patients with an untreated fracture of the ulnar styloid base had a trend toward less grip strength at six months (71% [of that on the contralateral side] compared with 78%; and less flexion (46 compared with 50; mean difference, -4º (95% confidence interval = -11.2º to -0.7º; p = 0.02) and ulnar deviation (16compared with 18; mean difference, 2º (95% confidence interval =-7º to -0.1º; p = 0.05)at twenty-four months (Table-3).

Table 3: Clinical Outcomes in the Matched Cohorts

	6 Month				12 Month				24 Month			
	Ulnar Fracture		No Ulnar Fracture		Ulnar Fracture		No Ulnar Fracture		Ulnar Fracture		No Ulnar Fracture	
	Mean & Std	% of Contralat. Side	Mean & Std.	% of Contralat. Side	Mean & Std.	% of Contralat. Side	Mean & Std.	% of Contralat. Side	Mean & Std	% of Contralat. Side	Mean & Std	% of Contralat. Side
Range of motion (deg)												
Flexion-extension	96 ± 24.6	81	101 ± 24.3	81	108 ± 25.6	82	111± 22.5	84	108 ± 26.6	82	112 ± 27.2	86
Flexion	43 ± 15.6	77	46 ± 15.6	78	45 ± 18.9	82	48 ± 15.6	83	46 ± 14.9*	81	50 ±16.6*	85
Extension	46 ± 16.3	87	44 ± 12.6	86	49 ± 15.2	90	51 ± 18.9	91	48 ± 19.6	89	52 ±21.5	91
Pronation - supination	121 ± 26.9	92	132 ± 25.6	94	133 ± 23.6	92	136 ± 25.9	93	134 ± 22.2	92	139 ±23.3	96
Pronation	59 ± 16.6	91	62 ± 10.0	92	62 ± 11.9	92	66 ± 13.6	93	64 ± 16.6	92	68 ±18.8	98
Supination	51 ± 14.9	90	56 ± 12.4	92	57 ± 13.3	94	59 ± 13.6	95	57 ± 19.9	94	61 ±20.2	94
Radioulnar deviation	38 ± 12.6	77	42 ± 11.9	79	45 ± 11.5	91	47 ± 12.3	92	45 ± 19.8	91	49 ±21	96
Radial deviation	11 ± 3.2	76	14 ± 3.6	77	15 ± 3.3	91	13 ± 5.6	89	14 ± 9.6	91	17 ±7.6	93
Ulnar deviation	15 ± 5.5	79	13± 2.9	77	17 ± 1.9	92	18 ± 3.6	92	16 ± 5.5**	90	18 ±5.4**	95
Grip strength (kg)	19± 9.3	71***	19 ± 9.6	78***	21 ± 3.6	81	22 ± 4.5	82	21 ± 4.5	81	25 ±3.6	92
Pain at rest (1-10)	0.5 ± 0.9		0.9 ± 0.6		0.4 ± 0.01		0.5 ± 1.2		0.5± 0.9		0.8 ±0.8	99
Pain in motion (1-10)	1.2 ± 0.9		1.5 ± 1.1		1.1 ± 1.0		1.3 ± 1.9		1 ± 1.2		1.2 ±1.9	92
Score (points)												
Gartland and Werley	3.6 ± 2.9		3.6 ± 3.2		2.9 ± 1.6		3.1 ± 2.3		2.7 ± 3.2		3 ±1	
DASH					10.6 ± 9.6		10.9 ± 4.9		6.8 ± 5.5		7.6 ±3.9	
SF-36 physical					39.9 ± 9.8		40.0 ± 10.2		42± 7.8		43.6 ±7.9	
SF-36 mental					41.2 ± 8.3		42 ± 7.6		43 ± 7.9		45.8 ±8.9	

*Difference in flexion at 24 month -4º (95% confidence interval = -11.2º to -0.7º; p = 0.02). **Difference in ulnar deviation at 24 month, - 2º (95% confidence interval =-7º to -0.1º; p = 0.05). ***Difference in grip strength at six months,-6% (95% confidence interval =-15.3% to-0.6%; p = 0.03).

Radiographic Evaluation

There were no significant differences in volar angulation, radial inclination, or ulnar variance of distal radial fracture at any follow-up interval between the groups (Table-4). In 4 patients with an untreated fracture of the ulnar styloid base and in three patients with no ulnar fracture (p= 0.49), an intra-articular step-off was seen at one year.

Table 4: Radiographic Outcomes in the Matched Cohorts*

	6 Month		12 Month		24 Month	
	Ulnar Fracture	No Ulnar Fracture	Ulnar Fracture	No Ulnar Fracture	Ulnar Fracture	No Ulnar Fracture
Volar angulation	3 (-20 to 9)	5 (-16 to 20)	5 (-11 to 23)	5 (-16 to 22)	4 (-26 to 16)	6 (-18 to 19)

(deg)						
Radial angulation (deg)	13 (10 to 20)	14 (11 to 22)	14 (11 to 22)	14 (11 to 22)	14 (11 to 22)	14 (11 to 23)
Ulnar variance**	0.05 (-0.09 to 0.09)	0.002 (-0.16 to 0.26)	0.007 (-0.11 to 0.21)	0.03 (-0.13 to 0.19)	0.03 (-0.13to 0.19)	0.04 (-0.11 to 0.20)

*The values are given as the mean with the range in parentheses. **Ulnar variance is expressed as a ratio (ulnar variance:length of capitate).

Displacement of the Fracture of the Ulnar Styloid Base

Displacement of Ulnar Styloid Base Fracture No significant differences were observed between patients with < 2 mm of displacement of unrepaired ulnar styloid base fracture and patients with < 2 mm of displacement with respect to any outcome measurement at six, twelve, or twenty-four months following surgery (Table-5).

Table 5: Clinical Outcomes According to Ulnar Fracture Displacement*

	6 Month				12 Month				24 Month			
	<2 mm		≥2 mm		<2 mm		≥2 mm		<2 mm		≥2 mm	
	Mean & Std	% of Contralat. Side	Mean & Std.	% of Contralat. Side	Mean & Std.	% of Contralat. Side	Mean & Std.	% of Contralat. Side	Mean & Std	% of Contralat. Side	Mean & Std	% of Contralat. Side
Range of motion (deg)												
Flexion-extension	99 ± 23.3	80	101 ± 25.6	82	107 ± 32.3	87	110 ± 26.6	88	109 ±22.6	82	113 ± 26.4	87
Pronation-supination	122 ± 28.9	92	133 ± 32.6	92	136 ± 28.9	95	135 ± 25.6	98	134 ± 20.4	95	140 ± 21.2	95
Pronation	59 ± 12.6	93	61 ± 22.3	93	62 ± 22.6	96	65 ± 33.2	100	65± 12.9	96	69 ± 9.1	95
Supination	51 ± 22.2	91	56 ± 28.9	90	57 ± 18.9	94	58 ± 18.9	97	57 ± 23.6	93	62 ± 13.9	95
Radioulnar deviation	38 ± 12.3	77	42 ± 12.9	78	45 ± 20.8	88	47 ± 16.6	78	45 ± 18.7	94	49 ± 15.3	88
Grip strength (kg)	19 ± 2.9	90	19 ± 2.6	88	21 ± 16.6	84	22 ± 19.8	88	21 ± 2.9	90	25 ± 15.4	87
Pain at rest (1-10)	0.6 ± 0.9		0.9 ± 0.5		0.5 ± 0.6		0.5 ± 1.9		0.6 ± 1.2		0.7 ± 1.1	
Pain in motion (1-10)	1.2 ± 0.9		1.5 ± 1.2		1.1 ± 1.6		1 ± 1.3		1.3 ± 1.6		1.1 ± 1.8	
Score (points)												
Gartland and Werley	3.6 ± 2.6		3.6 ± 1.6		2.8 ± 2.2		3.1 ± 3.6		2.7± 2.8		2.9 ± 3.5	
DASH					10.8 ± 3.6		11.3 ± 9.8		6.8 ± 3.6		7.2 ± 15.6	
SF-36 physical					39.8 ± 5.6		41.5 ± 13.6		42 ± 12.5		43.6 ± 7.6	
SF-36 mental					41.2 ± 6.9		43.6 ± 12.3		43 ± 11.8		45.8 ± 7.7	

***There was no significant difference between groups for any outcome measure

Discussion

In our study of patients who had been treated with open reduction and internal fixation for an unstable fracture of the distal part of the radius, we were unable to show any differences between the outcomes for patients who had an untreated fracture of the ulnar styloid base and those for patients without ulnar fractures. It must be stressed, however, that we have not assessed the stability of the distal radioulnar joint either clinically or radiographically, and we can provide only circumstantial evidence that there were no differences in instability between patients with and those without ulnar styloid base fractures.

Several authors were reported that identified fracture of the ulnar styloid base as a potential cause of inferior outcomes in patients with a distal part of the radius fracture[7-10]. One issue was the stability of the distal radioulnar joint since the triangular fibrocartilage complex originates from the styloid base and the repair of a styloid base fracture can restore the distal radioulnar joint stability [23]. May *et al*. addressed the issue of distal radioulnar joint instability, which they diagnosed with distal radial fracture in fourteen of 166 patients. Eleven of the 14 instable patients had an ulnar styloid base fracture. They concluded that fractures with a substantial displacement at the base of the ulnar styloid and ulnar styloid fractures (defined as > 2 mm) are risk factors for the development of distal radioulnar joint instability. Like other authors, we assessed wrist function and overall outcome (i.e., DASH scores) rather than distal radioulnar joint instability specifically, partly because distal radioulnar joint instability was not specifically assessed in the prospective cohort study from which these patients were drawn and partly because distal radioulnar joint instability is difficult to define. In a study of 272 patients with a distal part of the radius fracture, Stoffelen et al. reported a fracture of the ulnar styloid base in all thirteen patients with distal radioulnary joint instability. They noted that patients with an ulnar styloid base fracture were having worse outcomes than patients with no ulnar styloid fracture. Ruch et al. found that those treated with the forearm in fixed supination had slightly better outcomes among patients with a displaced ulnar styloid base fracture than those treated with tension-band cabling of the ulnar styloid base fracture. There was no difference in outcome in a clinical trial in

which the fracture of the distal part of the radius was treated with cast immobilization and the ulnar fracture was randomized for treatment with repair (of the triangular fibrocartilage complex or a large ulnar styloid fracture) or not to be treated [24]. Several issues make interpretation of those data complicated. Firstly, it is not clear how the distal radioulnar joint can be defined and objectively measured and in many studies the authors used indirect measures such as wrist function and overall result. Second, there are many other factors with distal radial fracture being itself a prominent treatment that may not have been adequately accounted for in previous analyses. Third, if the ulna is not also fractured, it is reasonable to assume that distal radial fractures with significant displacement must result in some failure of the triangular fibrocartilage complex. This assumption is supported by Lindau *et al*. [25]'s observation of injuries to the triangular fibrocartilage complex in nearly 80 percent of patients with distal radial fracture who had been evaluated arthroscopically as well as by Richards *et a*l. [26]'s observation that injury to the triangular fibrocartilage complex was associated with increased shortening and dorsal angulation of the fibrocartilage complex. Ulnar styloid base fracture is probably an alternative to intrasubstance failure of the triangular fibrocartilage complex, and both injuries are potential sources of distal radioulnar joint instability and decreased outcome, although this hypothesis has not been formally assessed to our knowledge. Indeed, the question of how large the ulnar styloid fracture should be to avoid the triangular fibrocartilage complex remains speculative, and our cut-off of 75% of the total ulnar styloid height were based on clinical experience and anatomy knowledge, but was otherwise arbitrary.Our study strengths include relatively consistent treatment methods (open reduction and plate-and-screw fastening of all distal radial fractures, with the majority volar plate fixation) and prospective collection of functional, health status, and complication data. There are several significant shortcomings, however. First and foremost, the instability of the distal radioulnar joint was not evaluated specifically and formally with either clinical examination or stress radiographs, and our primary study focus did not address the instability of the distal radioulnar joint. Instead, we assessed the movement, function and health status of the wrist as well as the lack of documented symptoms, complications and specific treatments. It is notable that after the six-month postoperative evaluation there was little improvement in any measure of function or state of health. Another weakness of our study is that the prospective cohort study contained no guidelines for internal fixation of large ulnar styloid fractures. We interpreted our data on the basis of our impression that internal fixation of the ulnar styloid was based on preconceived notions about indications for internal fixation of ulnar fractures and did not reflect specific differences in the distal radioulnar joint's preoperative or intraoperative instability; however, there may have been some selection bias in that nine patients had open reduction and internal fixation of a fracture of the ulnar styloid base. Additional weaknesses of the study include its retrospective nature (it was planned after the data was prospectively collected) and the unvalidated techniques used to measure ulnar variance on uncalibrated digital radiographs and the displacement of ulnar styloid fracture. Finally, it must be stressed that we compared patients with and without ulnar styloid base fractures without addressing the more difficult-to-quantify problems of distal radioulnar joint instability or the degree of injury to the triangular fibrocartilage complex. Despite the weaknesses of this study, our data suggest that patients with an ulnar styloid base fracture (displaced or not) can expect to regain wrist function and a health status similar to those of patients with no ulnar styloid fracture, at least when the distal radial fracture was treated with open reduction and plate-and-screw fixation. The differences approaching significance were small, were likely clinically irrelevant, and over time were inconsistent. This suggests that anatomical reduction and internal plate fixation of the distal part of the radius mitigates or diminishes the value of operational treatment of an ulnar styloid base fracture. After open reduction and internal fixation of the distal part of the radius, the indications for internal fixation of the ulnar styloid remain unclear. Since open reduction and volar plate fixation of the distal part of the radius (as used in most patients in this series) restores the volar metaphysal cortex, this can result in a better and more reliable radiographic alignment of distal radial fragments than that provided by external fixation, with which the volar cortex often remains in bayonet apposition[27, 28].

Although this study did not specifically assess the instability of the distal radioulnar joint, our finding that the results were not affected by a fracture of the ulnar styloid base could be explained by the improved inherent stability of the distal radioulnar joint resulting from the improved restoration of distal radial anatomy, which could provide a greater measure of congruity and capture. The presumed intact interosseous ligament of the forearm could also explain this.

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Conflict of Interest: Nil
Source of support:Nil