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The Effect of Ulnar Styloid Fractures on Patient-Reported Outcomes After Surgically Treated Distal Radial Fractures

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Background: Ulnar styloid fractures (USFs) are often associated with distal radial fractures (DRFs). When unstable DRFs are treated surgically, any associated USF is most commonly left untreated. The purpose of this study was to evaluate the effect of a concomitant USF on outcome after surgical stabilization of a DRF.

Methods: Data from 2 randomized controlled trials on the treatment of unstable DRFs were pooled. The effect of a USF on the QuickDASH, EQ-5D, pain, and range of motion at 2 years was evaluated.

Results: Two hundred and eighty-one patients were included; 177 (63%) had an associated, untreated USF. An unadjusted analysis demonstrated no significant difference in functional or patient-reported outcome measures (PROMs) at 2 years between patients with or without a concomitant USF. When controlling for confounding factors, the presence of a USF did not predict change in any of the PROMs from baseline to 2 years. A concomitant USF also did not predict change in grip strength or range of motion, except for a small effect on extension (−4.1°; 95% confidence interval, −7.5° to −0.8°; p = 0.02), which probably does not have clinical relevance.

Conclusions: A USF in combination with a DRF does not affect PROMs, range of motion, or grip strength. We recommend that concomitant USFs be left untreated when treating a DRF with surgical fixation.

Level of Evidence: Prognostic Level I. See Instructions for Authors for a complete description of levels of evidence.

Distal radial fractures (DRFs) are one of the most common fractures and are associated with concomitant ulnar styloid fractures (USFs) in up to 65% of cases[1-3]. Conversely, 92% of all USFs occur in combination with a DRF[4]. Although surgical fixation of DRFs has become more common since the introduction of volar locking plates[5,6], there is no consensus on how to treat concomitant USFs[4,7]. It is also unclear whether an associated USF affects the outcome of a DRF[8-11].

Recently, we conducted 2 randomized controlled trials (RCTs) comparing clinical outcomes after surgical treatment of unstable DRFs. RCT 1 compared intra-articular fractures treated with either volar locking-plate or external fixation[12]. RCT 2 compared early or standard postoperative mobilization following treatment of extra-articular DRFs treated with volar locking-plate fixation[13]. In both RCTs, approximately 63% of the DRFs had a concomitant, untreated USF.

The purpose of this study was to pool data from these 2 RCTs to assess the effect of a concomitant USF on clinical and patient-reported outcomes 2 years after surgical fixation of an unstable DRF.

Materials and Methods

Enrollment

The patients included in this study were recruited from 2 RCTs conducted at our institution between 2009 and 2014[12,13]. The only difference in inclusion criteria was fracture classification. RCT 1 included only intra-articular fractures (OTA/AO type C2 and C3), whereas RCT 2 included only extra-articular fractures (OTA/AO type A3)[14]. Both trials included patients 18 to 70 years of age with an unstable DRF in need of surgical stabilization according to current guidelines[15], and included fractures with ≥1 of the following characteristics on presentation: >10° dorsal tilt, any volar

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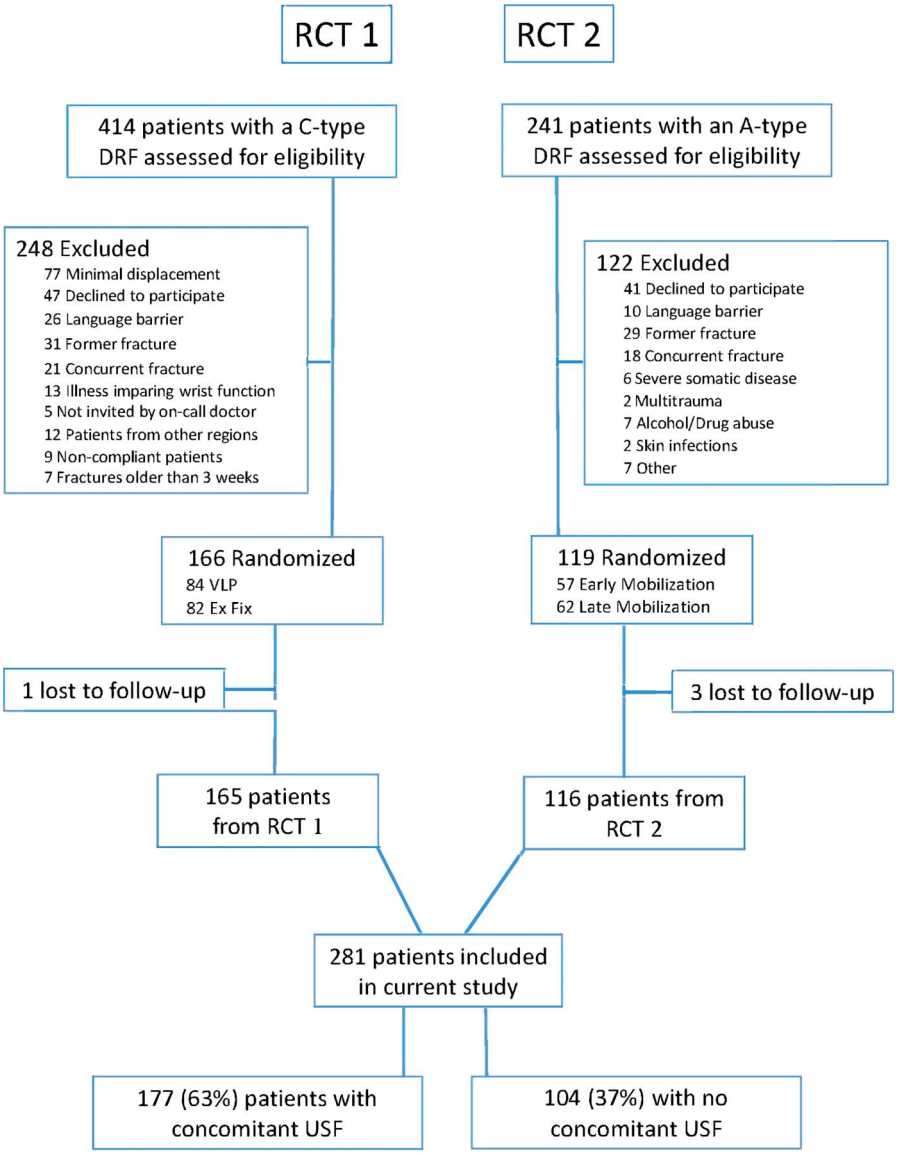

Fig. 1

Flowchart of patients recruited for the current study from the 2 previous randomized controlled trials (RCTs). DRF = distal radial fracture, USF = ulnar styloid fracture, VLP = volar locking plate, and Ex Fix = external fixator.

displacement, dorsal comminution, shortening of >3 mm, and/or an intra-articular step-off of >2 mm. Exclusion criteria included previous fractures in the contralateral or ipsilateral wrist, open fractures, mental illness that interfered with compliance, dementia, or drug abuse.

Patients included in RCT 1 were randomized to receive treatment either with a volar locking plate or an external fixator augmented with Kirschner wires. All patients in RCT 2 were treated with volar locking-plate fixation, but were randomized to either early mobilization and formalized physiotherapy or standard care, which involved a dorsal splint for 2 weeks followed by a home exercise program. All patients were clinically assessed at 6 weeks, 3 months, and 1 and 2 years postoperatively.

Outcome Measures

The primary outcome in both trials was the change in the QuickDASH, which is the shortened version of the Disabilities of the Arm, Shoulder and Hand (DASH) score. The questionnaire has been validated and translated into Norwegian[16]. QuickDASH scores range from 0 to 100 (100 being the worst). Secondary outcome measures used in both trials included patient-reported pain on a visual analogue scale (VAS) from 0 to 10 (10 being the worst), grip strength as measured in kilograms with a handheld dynamometer (Jamar Hand Plus+ Digital Hand Dynamometer; Patterson Medical), and range of motion measured in degrees by a goniometer in 6 planes (extension, flexion, pronation, supination, and ulnar and radial deviation). Lastly, the EuroQol-5 Dimensions (EQ-5D)

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provided an index of the health-related quality of life ranging from 0 (death) to 1 (perfect health)[17].

Ethics

The studies were approved by the institution's data protection officer and conducted according to the Declaration of Helsinki. Both RCTs were approved by the Regional Ethics Committee of Eastern Norway (RCT 1: 2009/1517; RCT 2: 2011/1393) and were registered at www.ClinicalTrials.gov (NCT01062997 and NCT02015468, respectively). All patients provided written informed consent before inclusion.

Statistical Analysis

Continuous data are described using the mean and standard deviation (SD), while categorical variables are presented as frequencies. Multivariable linear regression analyses were performed to assess the effect of a USF on the QuickDASH, VAS, and EQ-5D. To adjust for possible confounding, the following variables were included in the model: age at surgery, sex, time from injury to surgery (in days), duration of surgery (in minutes), Charlson Comorbidity Index (CCI), presence of an intra-articular fracture (yes/no), and method of surgical fixation (volar locking plate or external fixator). Regression coefficients are presented, with 95% confidence intervals (CIs). P values of <0.05 were considered significant. Statistical analyses were performed with SPSS for Windows (version 26; IBM).

Source of Funding

This study received no outside funding.

Results

Two hundred and eighty-one patients with a displaced DRF treated surgically were included in the study (Fig. 1). The mean patient age was 55 years (range, 19 to 70 years), and the majority of the patients were female (219, 78%). A concomitant USF was diagnosed in 177 (63%) of the patients. Most USFs involved the styloid tip (94, 53%) or styloid base (78, 44%) (Fig. 2). There were no significant differences in baseline characteristics between patients with or without a USF. There was a tendency toward more female than male patients to have experienced a concomitant ulnar fracture (p = 0.07), and therefore also a tendency that patients with a USF had lower baseline grip strength (p = 0.08). Patient demographics and characteristics are presented in Table I.

An unadjusted analysis demonstrated no significant difference in functional or patient-reported outcomes at 2 years between patients with or without a concomitant USF. There was a tendency toward slightly better extension (p = 0.06) and grip strength (p = 0.07) in patients without an ulnar fracture, but the difference was not clinically meaningful (difference in extension of 2.6° and difference in grip strength of 2.2 kg) (Table II).

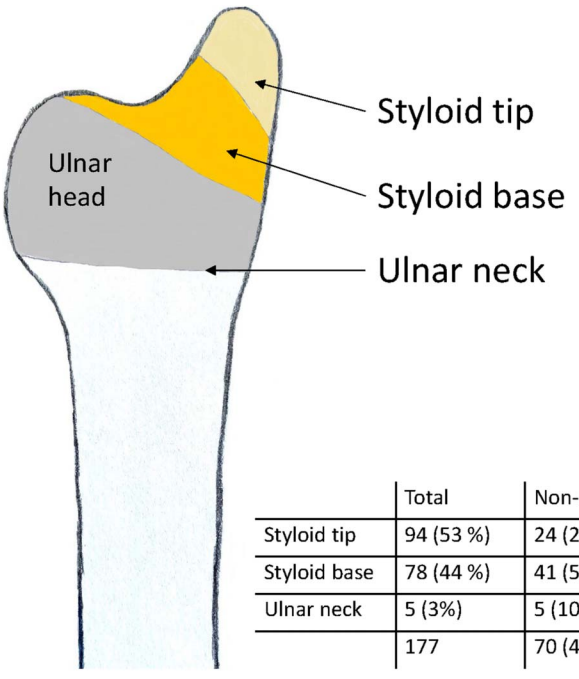
When controlling for confounding factors such as age, sex, method of fixation, fracture type, and time to surgery, the presence of an ulnar fracture did not predict the change in any of the patient-reported outcome measure (PROM) scores from baseline to 2 years (Table III). The main predictor for the change in a PROM score was age, with older patients doing better (having smaller change in PROM scores from baseline [pre-injury level] to 2-year follow-up). Younger patients reported more symptoms at 2 years. A concomitant USF also did not predict the change in grip strength or range of motion, except for a small but significant effect on extension, which probably does not have clinical relevance (Table IV).

When comparing outcomes between patients with a USF that achieved union and those with radiographic nonunion at the latest follow-up, no significant differences in 2-year change in PROMs or functional outcomes were found, except for a small statistically significant, but not clinically meaningful, reduction in supination of 3.6° (Table V).

Discussion

The main finding of this study was that a concomitant USF did not affect patient-reported outcomes or functional results 2 years after surgical fixation of an unstable DRF. Furthermore, nonunion of the USF did not affect outcome.

In contrast to our finding, a prospective study in Brazil compared 61 patients with a DRF combined with a USF and 30 patients with an isolated DRF and found that combined fractures were associated with more pain and a worse DASH score[18]. Similarly, a retrospective study of 184 surgically treated DRFs demonstrated worse pain and DASH scores for the patients with concomitant USFs at a mean follow-up of 12 months[8]. There was no difference in range of motion or grip strength between



	Total	Non-union
Styloid tip	94 (53 %)	24 (26 %)
Styloid base	78 (44 %)	41 (53 %)
Ulnar neck	5 (3%)	5 (100 %)
	177	70 (40 %)

Fig. 2

Classification of the ulnar styloid fracture associated with distal radial fractures[26]. Styloid tip fractures were most common, followed by fractures at the base of the styloid. Ulnar neck fractures were rare. Styloid tip fractures had the lowest nonunion rate.

TABLE I Baseline Demographics and Characteristics of 281 Patients Treated Surgically for a Displaced Distal Radial Fracture

	All Patients	Ulnar Fracture	No Ulnar Fracture	
	N = 281	N = 177 (63%)	N = 104 (37%)	P Value*
Age† *(yr)*	55.0 ± 11.6	55.6 ± 11.6	54.0 ± 11.6	0.3
Sex *(no. [%])*				0.07
Female	219 (77.9%)	144 (81.4%)	75 (72.1%)	
Male	62 (22.1%)	33 (18.6%)	29 (27.9%)	
Dominant side‡ *(no. [%])*				0.4
Right	248 (88.3%)	158 (89.3%)	90 (87.4%)	
Left	32 (11.4%)	19 (10.7%)	13 (12.6%)	
Injured side *(no. [%])*				0.7
Right	126 (44.8%)	81 (45.8%)	45 (43.3%)	
Left	155 (55.2%)	96 (54.2%)	59 (56.7%)	
OTA/AO fracture type *(no. [%])*				0.8
A fracture	116 (41.3%)	74 (41.8%)	42 (40.4%)	
C fracture	165 (58.7%)	103 (58.2%)	62 (59.6%)	
Reduced before surgery *(no. [%])*				0.2
Yes	251 (89.3%)	161 (91.0%)	90 (86.5%)	
No	30 (10.7%)	16 (9.0%)	14 (13.5%)	
Surgery type *(no. [%])*				0.6
Volar locking plate	200 (71.2%)	128 (72.3%)	72 (69.2%)	
External fixation	81 (28.8%)	49 (27.7%)	32 (30.8%)	
No. of days from injury to surgery§	7.8 ± 4.7 (0-26)	8.0 ± 4.6 (1-26)	7.4 ± 4.8 (0-24)	0.2
Surgical time§ *(min)*	62.4 ± 20.2 (20-160)	62.3 ± 19.5 (20-141)	62.5 ± 21.4 (21-160)	0.9
Grip strength† *(kg)*	31.1 ± 10.5	30.3 ± 10.3	32.6 ± 10.7	0.08
Preop. QuickDASH				
Mean ± SD	2.1 ± 6.0	2.3 ± 6.4	1.8 ± 5.4	
Median (range) [IQR width]#	0.0 (0-52) [2]	0.0 (0-52) [2]	0.0 (0-41) [2]	0.2**
Charlson Comorbidity Index *(no. [%])*				
0	225 (80.1%)	136 (76.8%)	89 (85.6%)	NS##
1	40 (14.2%)	28 (15.8%)	12 (11.5%)	
2	7 (2.5%)	5 (2.8%)	2 (1.9%)	
≥3	9 (3.2%)	8 (4.5%)	1 (1.0%)	

*Chi-square or Student t test except where indicated. †The values are given as the mean and standard deviation. ‡Data missing for 1 patient. §The values are given as the mean and standard deviation, with the range in parentheses. #IQR = interquartile range. **Mann-Whitney U test. ##NS = not significant when comparing column proportions.

the groups. That study had several limitations, including its retrospective design and nonrandomized treatment allocations, which may explain the discrepancy with the results of our prospective study.

Like our study, a retrospective, matched case-control study of 76 paired patients treated for a surgically displaced DRF with or without an associated USF did not find any effect of the USF on clinical outcome at 2 years[1]. Another study evaluated the effect of an untreated USF in patients treated for an unstable DRF with external fixation. After a minimum follow-up of 12 months, there was no difference in PROMs, range of motion, or grip strength between the groups[19].

Likewise, a retrospective study including 118 patients treated for a displaced DRF with use of a volar locking plate did not find any clinically important differences in outcomes between patients with or without a concomitant (untreated) USF[20]. These findings are supported by 2 meta-analyses evaluating the functional outcome of DRFs with or without associated USFs[9,11]. Both meta-analyses revealed a small, significant difference in DASH score favoring patients without an associated USF, which was unlikely to be clinically meaningful. Furthermore, the level of the USF fracture did not affect results. However, the authors found that the quality of the studies was poor, and the aggregate data analysis was limited by the

TABLE II Difference in Range of Motion, Grip Strength, and Patient-Reported Outcomes at 2 Years*

	Ulnar Fracture		No Ulnar Fracture		Mean Difference (95% CI)	P Value
	Mean (SD)	% of Uninjured Wrist	Mean (SD)	% of Uninjured Wrist		
Flexion	61.0 (12.3)	88.5	61.6 (11.1)	89.2	0.6 (−2.3 to 3.5)	0.7
Extension	68.3 (11.5)	93.2	70.9 (10.5)	98.1	2.6 (−0.1 to 5.3)	0.06
Pronation	86.8 (6.0)	97.3	87.5 (4.8)	98.1	0.6 (−0.7 to 2.0)	0.4
Supination	85.5 (10.6)	96.9	87.0 (6.9)	98.0	1.5 (−0.8 to 3.8)	0.2
Ulnar deviation	36.0 (12.1)	95.1	37.1 (12.7)	92.2	1.1 (−1.9 to 4.2)	0.5
Radial deviation	22.8 (9.4)	102.7	22.6 (8.4)	95.3	−0.2 (−2.5 to 2.0)	0.8
Grip strength	29.2 (9.6)	96.4	31.4 (10.5)	96.4	2.2 (−0.2 to 4.7)	0.07
QuickDASH	8.3 (13.9)	—	7.4 (13.8)	—	−0.9 (−4.3 to 2.5)	0.6
VAS	0.5 (1.4)	—	0.5 (1.3)	—	−0.1 (−0.4 to 0.3)	0.8
EQ-5D index	0.88 (0.23)	—	0.92 (0.16)	—	0.039 (−0.011 to 0.089)	0.1

*Range-of-motion values are given in degrees, and grip strength is given in kilograms. QuickDASH = abbreviated version of Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, VAS = visual analogue scale for pain, EQ-5D = EuroQol-5 Dimensions, SD = standard deviation, and CI = confidence interval.

heterogeneity of the patient populations, large variation in the type of DRF and treatment modalities, and different follow-up periods. As such, our study adds valuable prospective data to support the conclusions of these meta-analyses.

Given our finding of no difference in outcomes between patients with or without a USF, surgical fixation of a concomitant USF when treating a DRF with surgical fixation seems unwarranted. However, we did not have a control group of patients who underwent combined fixation of both the DRF and USF. Retrospective studies comparing conservative and surgical treatment of a concomitant ulnar fracture in patients treated with plate fixation for a displaced DRF suggest there are no differences in clinical and patient-reported outcome[21-23]. In addition, patients treated surgically for both fractures may have more subsequent unplanned surgeries compared with patients in whom the USF was left untreated[24].

Cha et al. retrospectively reviewed patients who underwent plate fixation for a DRF and nonoperative treatment of the concomitant USF[3]. Like us, they found no difference in clinical and patient-reported outcomes between patients whose USF united and patients who ended up with ulnar styloid nonunion. This is supported by a meta-analysis that did not find an effect of ulnar styloid nonunion on function in patients with a DRF[25].

Although the number of ulnar neck fractures was small (n = 5), all resulted in nonunion. These fractures involve a much larger bone fragment and direct involvement of the distal radioulnar joint, and further studies are needed to evaluate the proper treatment of these concomitant fractures.

Limitations and Strengths

Neither of the RCTs that provided the patients for this study were originally designed to evaluate the effect of a USF on

TABLE III Multivariable Regression Analysis of the Association Between Independent Risk Factors and Change in Patient-Reported Outcomes from Baseline to 2-Year Follow-up*

	Change in QuickDASH		Change in VAS		Change in EQ-5D Index	
Variable	Coefficient (95% CI)	P Value	Coefficient (95% CI)	P Value	Coefficient (95% CI)	P Value
Ulnar fracture	0.5 (−2.9 to 3.9)	0.8	0.07 (−0.3 to 0.4)	0.7	−0.05 (−0.097 to 0.005)	0.075
Age	−0.2 (−0.4 to −0.07)	0.005	−0.02 (−0.03 to −0.003)	0.02	0.005 (0.002 to 0.007)	<0.001
Sex	−1.6 (−6.0 to 2.8)	0.5	−0.4 (−0.8 to 0.05)	0.08	0.02 (−0.05 to 0.08)	0.7

*Adjusted for fracture type (A or C fracture), method of surgical fixation (volar locking plate or external fixator), time to surgery (days), surgical time (minutes), preoperative closed reduction, and Charlson Comorbidity Index. QuickDASH = abbreviated version of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, VAS = visual analogue scale for pain, EQ-5D = EuroQol-5 Dimensions, Coefficient = regression coefficient, and CI = confidence interval.

TABLE IV Multivariate Regression Analysis of the Association Between Independent Risk Factors and Change in Grip Strength and Range of Motion from Baseline to 2-Year Follow-up*

	USF (Vs. No USF)		Age		Female (Vs. Male)		Ex Fix (Vs. VLP)		CCI	
	Coeff. (95% CI)	P Value	Coeff. (95% CI)	P Value	Coeff. (95% CI)	P Value	Coeff. (95% CI)	P Value	Coeff. (95% CI)	P Value
Grip strength	−0.4 (−2.0 to1.3)	0.7	0.05 (−0.03 to 0.1)	0.2	0.3 (−1.9 to 2.4)	0.8	−2.8 (−5.0 to −0.6)	0.02	0.3 (−0.4 to 1.1)	0.4
Flexion	−0.5 (−3.9 to 3.0)	0.8	0.1 (−0.02 to 0.3)	0.08	−2.6 (−7.0 to 1.8)	0.2	0.2 (−4.3 to 4.7)	0.9	−0.9 (−2.5 to 0.6)	0.2
Extension	−4.1 (−7.5 to −0.8)	0.02	−0.01 (−0.2 to 0.1)	0.9	0.8 (−3.5 to 5.1)	0.7	−5.3 (−9.7 to −0.9)	0.02	−0.3 (−1.8 to 1.2)	0.7
Pronation	−1.0 (−2.7 to 0.8)	0.3	0.03 (−0.05 to 0.1)	0.4	1.2 (−1.0 to 3.5)	0.3	−1.8 (−4.1 to 0.5)	0.1	−0.3 (−1.1 to 0.5)	0.5
Supination	−1.1 (−3.7 to 1.5)	0.4	−0.01 (−0.1 to 0.1)	0.9	1.5 (−1.8 to 4.8)	0.3	−5.9 (−9.3 to −2.5)	0.001	−1.4 (−2.6 to −0.2)	0.02
Ulnar deviation	0.6 (−2.8 to 3.9)	0.7	0.01 (−0.1 to 0.2)	0.9	5.6 (1.3 to 9.9)	0.01	−0.1 (−4.5 to 4.3)	1.0	−0.5 (−1.9 to 1.1)	0.6
Radial deviation	1.5 (−1.1 to 4.1)	0.3	0.1 (0.0 to 0.2)	0.05	3.1 (−0.2 to 6.4)	0.07	−0.4 (−3.8 to 3.0)	0.8	−0.6 (−1.9 to 0.4)	0.2

*Adjusted for time to surgery (days), surgical time (minutes), and preoperative closed reduction. USF = ulnar styloid fracture, Ex Fix = external fixator, VLP = volar locking plate, CCI = Charlson Comorbidity Index, Coeff. = regression coefficient, and CI = confidence interval.

outcome after surgical treatment of an unstable DRF. Although patient demographic inclusion criteria were identical in the 2 RCTs, the treatment allocation was not. Half of the patients in RCT 1 were treated with an external fixator, and half of the patients in RCT 2 were allowed early mobilization (after 2 to 3 days). Although the 2 RCTs did not detect any differences in results between these treatment modalities, these differences could potentially have affected outcomes in our study. However, we adjusted for treatment allocation in the regression analysis, and these differences are therefore unlikely to have influenced our results substantially.

Furthermore, because of the nature of the interventions, blinding was not possible in either RCT. However, the assessors were blinded to treatment allocation at the time of follow-ups in RCT 2, which was possible because all patients received the same surgical intervention (volar locking plate).

None of the patients in either RCT underwent an arthroscopy or magnetic resonance imaging (MRI) to identify soft-tissue injuries that could potentially influence the results. Accordingly, some of the radiographic nonunions might have been fibrous unions.

In addition, the study was conducted at 1 institution in Norway, which may limit external validity.

The main strengths of the study are the large sample size, the prospective design, and low loss of follow-up.

Conclusions

We found that USFs in combination with DRFs did not affect PROMs, range of motion, or grip strength. Furthermore,

TABLE V Difference in Change from Baseline to 2-Year Follow-up in Patient-Reported Outcomes and Functional Results in 177 Patients with an Ulnar Fracture Associated with a DRF, According to Radiographic Union at Final Follow-up*

	Mean Change from Baseline (SD)§			Multivariate Regression Analysis†	
Variable	Ulnar Union (N = 107)	Ulnar Nonunion (N = 70)	P Value	Coeff. (95% CI)	P Value
QuickDASH	5.9 (13.0)	6.0 (13.7)	0.9	0.09 (−4.0 to 4.2)	1.0
EQ-5D index	−0.06 (0.22)	−0.07 (0.21)	0.8	−0.01 (−0.07 to 0.06)	0.8
VAS score	0.39 (1.3)	0.56 (1.6)	0.4	0.21 (−0.25 to 0.67)	0.4
Grip strength	−0.97 (6.3)	−1.2 (6.4)	0.8	0.42 (−1.5 to 2.4)	0.7
Flexion	−7.6 (13.5)	−8.6 (15.4)	0.7	−1.6 (−6.0 to 2.8)	0.5
Extension	−4.5 (14.2)	−5.9 (13.7)	0.5	−0.75 (−5.2 to 3.7)	0.7
Pronation	−3.2 (7.2)	−1.3 (7.6)	0.1	2.1 (−0.2 to 4.5)	0.07
Supination	−1.4 (7.4)	−4.9 (16.1)	0.054	−3.6 (−7.2 to −0.06)	0.046
Ulnar deviation	−1.2 (12.1)	−3.2 (15.8)	0.3	−1.1 (−5.3 to 3.1)	0.6
Radial deviation	0.90 (10.1)	0.40 (12.6)	0.8	0.035 (−3.4 to 3.5)	1.0

*SD = standard deviation, Coeff. = regression coefficient, CI = confidence interval, QuickDASH = abbreviated version of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, VAS = visual analogue scale for pain, and EQ-5D = EuroQol-5 Dimensions. §The values for grip strength are shown in kilograms, and the values for flexion, extension, pronation, supination, ulnar deviation, and radial deviation are shown in degrees. †Coefficients derived from multivariate linear regression analysis (ulnar union as the reference) adjusted for age, sex, fracture type, surgical treatment, time from injury to surgery, operative time, preoperative reduction, and Charlson Comorbidity Index.

nonunion of the USF did not affect clinical outcome. We recommend that concomitant USFs with stable distal radial ulnar joints be left untreated when treating a DRF with surgical fixation. ■

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