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Fixation of the Volar Ulnar Corner in Distal Radius Fractures: A Comparative Study

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Abstract

Background: The purpose of this study was to compare outcomes of distal radius fractures with a volar ulnar corner (VUC) component treated with standard volar plating or by specific VUC fixation. This study investigated outcomes, radiographic measures, and specialty-based preference associated with surgical treatment of VUC injuries using VUC-specific fixation versus nonspecific VUC fixation. **Methods:** We retrospectively analyzed outcomes for 39 patients with a distal radius fracture with VUC component at a level-1 trauma center over 10 years, 2011-2021. Patients underwent either VUC-specific fixation with implants such as a volar rim plate, or with a standard volar plate. The primary outcome of this study was fixation failure and need for revision. Secondary outcomes included complication rate, radiographic alignment, and differences in fixation based on fellowship training. **Results:** Sixteen of the 39 patients studied had undergone VUC-specific fixation, with a significantly higher rate of use of VUC-specific fixation in fellowship trained hand surgeons compared with fellowship-trained trauma surgeons. There was no significant difference in loss of reduction, revision surgery, or complications. Radiographic measures were statistically similar between both groups postoperatively. Trauma trained surgeons had a significantly increased postoperative radial inclination versus hand-trained surgeons. **Conclusions:** This study suggests that not all VUC injuries require specific VUC fixation, and we may be overtreating distal radius fractures that have a VUC component. Fellowship-trained hand surgeons are more likely to employ VUC-specific fixation methods. Additional studies are warranted to determine whether other considerations such as dynamic testing intraoperatively are worthwhile.

Keywords: hand, anatomy, distal radius, fracture/dislocation, diagnosis, outcomes, research and health outcomes, wrist, treatment

Introduction

Distal radius fractures are among the most common fractures treated operatively by orthopedic surgeons and comprise an estimated 643 000 annual fractures in the United States, predominantly in the elderly.[1] With population that continues to age, the incidence rate will continue to rise. A volar ulnar corner (VUC) injury is defined as a separate volar fragment of the lunate facet that extends ulnarly to the sigmoid notch and is distal to the watershed line.[2] Although this fragment is present in a minority of these fractures, the VUC is considered the "critical corner" of the distal radius and presents a challenge to treat.[2,3] It is the keystone of both the distal radioulnar joint and radiocarpal joint and thus improper fixation results in altered mechanics of both joints.[3] Anatomical studies have found that the dimensions of the VUC are on average 19 mm by 3 mm, however with some variability as seen in Figure 1.[3,4] As a result, fixation using standard volar distal radius plating is difficult given its small size.[3,4] Studies have shown that failure to properly stabilize the VUC can lead to volar subluxation of the carpus and osteoarthrosis.[3,5,6]

The current options for fixing a VUC include volar plating, fragment-specific fixation with a wire or hook plate, or supplemental fixation with pinning or external fixation. Most distal radius fractures are treated with a standard volar locking plate, but recent studies have shown that this method of fixation may not adequately stabilize the VUC fragment.[5,7,8] Treating VUC fragments with the standard volar plating has been associated with volar carpal subluxation

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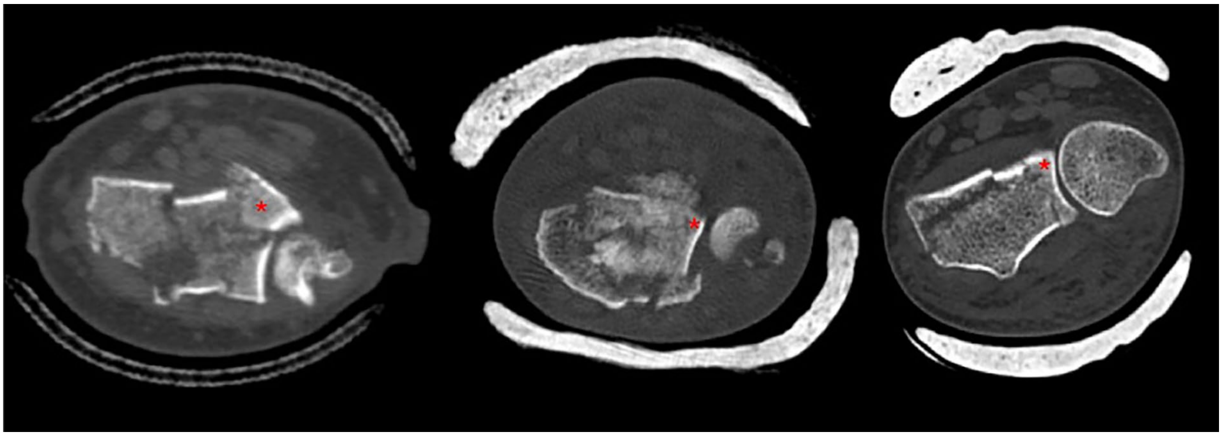

Figure 1. Axial computed tomography (CT) cuts for 3 different patients of distal radius fracture at the level of the volar ulnar corner (VUC). Asterisk indicates the VUC, which highlights the variation in size and shape of the fracture pattern for each patient.

and thus VUC-specific fixation has in some cases been designated for fragments distal to the watershed line.[9] While many studies have shown efficacy of VUC-specific fixation, some studies have described loss of reduction of the VUC fragment or even distal radioulnar joint instability in patients with small VUC fragments.[5] Using VUC-specific fixation such as a volar rim plate also subjects the patient to an additional surgery for removal of hardware.

To date, there has not been a study that directly compares the outcomes of distal radius fractures with a VUC component treated either with standard volar plating or by specific VUC fixation. In this study, we hypothesize that distal radius fractures with a VUC component fixed with specific VUC fixation as compared with those without specific fixation have no difference in postoperative outcomes as it relates to fixation failure and the need for revision. Secondarily, we believe that hand fellowship-trained orthopedic surgeons elect to perform VUC-specific fixation more frequently compared with trauma fellowship-trained surgeons.

Materials and Methods

This is an Institutional Review Board (IRB)–approved retrospective study performed at a level-1 trauma center over a 10-year period, 2011-2021. All distal radius fractures treated operatively were identified by CPT code (25609). Patients with VUC injuries were then identified via computed tomography scan, interpreted by 2 orthopedic surgery residents in their fourth and fifth years of training. Of 459 patients with operatively treated distal radius fractures, 55 (12.0%) had a VUC injury. Exclusion criteria included those with less than 6 weeks of follow-up, and open fractures. Patients less than 18 years old were also excluded from the study. After applying the exclusion criteria, 39 patients were included in the final analysis. Those with a VUC injury were then stratified by operative fixation method—either specific VUC fragment fixation or not (Figure 2)—and physician subspecialty. There were a total of 3 different fellowship-trained hand surgeons, and 4 different fellowship-trained trauma surgeons in this study. Fixation of the VUC was based upon surgeon preference. Primary outcome was fixation failure and need for revision. Secondary outcomes included complication rate and radiographic alignment. Bivariate analysis was performed examining continuous variables using independent samples *t* tests or Mann-Whitney U tests as dictated by distribution, and categorical variables by Pearson chi-squared or Fisher exact tests. Haldane-Anscombe adjustments were used to correct for categorical variables with an incidence of 0. Statistical significance was set at $P < .05$. Statistical analyses were performed using SAS Enterprise Guide 7.1® software (SAS Institute, Cary, North Carolina).

Results

Of the 39 patients included in final analysis, 26 were men (67%) and 13 were women (33%). Twenty-four were right-sided injuries (62%). Predominantly surgery was performed either the day of or immediately following the date of injury. The most frequent mechanisms of injury were falls (46%) followed by motor vehicle accidents (38%). Median follow-up was 4.35 months.

VUC Fixation

Of the 39 patients analyzed, 16 (41%) had VUC-specific fixation. There was no statistical difference with respect to age, sex, laterality, mechanism of injury, days from injury

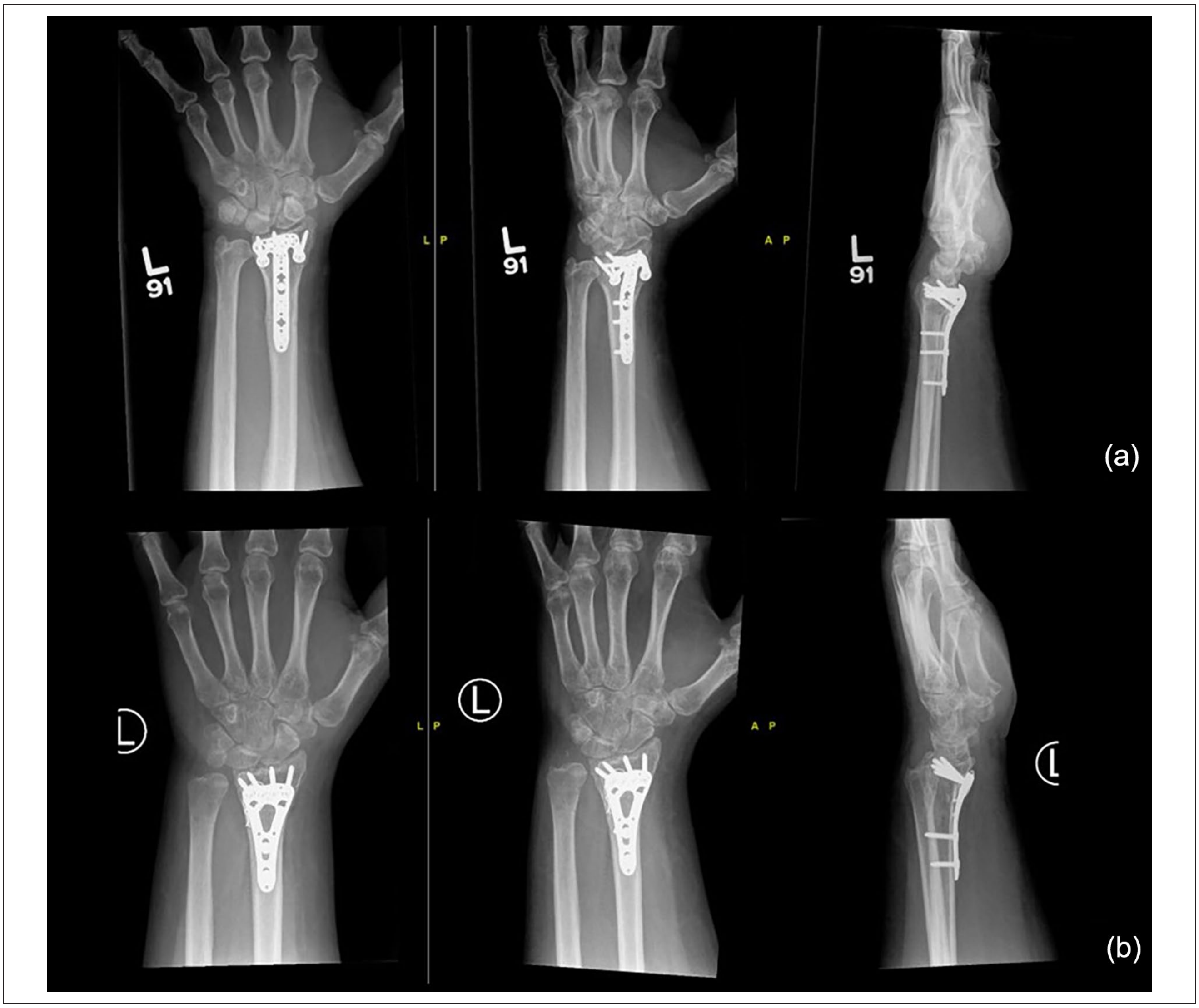

Figure 2. (a) A volar rim plate which extends distal to the watershed line, often used for volar ulnar corner–specific fixation. (b) A standard volar locking plate that does not extend distal to the watershed line.

to surgery, or preoperative volar tilt between the 2 groups (Table 1). There was, however, a statistically higher likelihood of VUC-specific fixation by fellowship-trained hand surgeons. Fifteen out of 16 patients treated by fellowship-trained hand surgeons were treated with VUC-specific fixation, as opposed to 1 out of 17 treated by fellowship-trained trauma surgeons treated with VUC-specific fixation (odds ratio [OR] = 34.29, P = .002). There was no statistical difference in the outcomes of either group based on VUC fixation (Table 2). Only 1 patient out of 39 (2.5%) experienced a loss of reduction due to inadequate fixation and volar escape during follow-up. This patient belonged to the group without VUC-specific fixation. The patient subsequently returned to the operating room 47 days after the initial surgery for revision fixation. The risk of having a loss of reduction was lower in the group with VUC fixation, however this was not significant (RR = 0.45, 95% confidence interval [CI], 0.02-11.9, P = .64). This was also the only patient that required a revision surgery. Five patients (22%) out of 23 in the group without VUC-specific fixation had complications not related to fixation. None of the 5 patients with complications had VUC-specific fixation; however, no statistical difference in this risk was identified (RR = 0.10, 95% CI, 0.01-1.99, P = .13). Radial inclination and volar tilt between the groups were also statistically similar postoperatively (18.40 ± 7.04 vs 17.41 ± 4.33, P = .53 and 8.67 ± 9.32 vs 7.93 ± 4.69, P = .72, respectively.)

Table 1. Demographics by VUC Fixation (N = 39).

Demographic	No VUC fixation N = 23 (59%)	VUC fixation N = 16 (41%)	Odds ratio (95% CI) *P* value
Sex			
Men	14 (61%)	2 (75%)	0.52 (0.13-2.12)
Women	9 (39%)	4 (25%)	*P* = .34
Age (y)	*M* = 43.48	*M* = 33.65	*P* = .042
	95% CI, 36.96-50.00	95% CI, 27.28-40.03	
	Range = 19-77	Range = 18-75	
	SD = 15.1	*SD* = 13.0	
Side			
R	14 (61%)	10 (63%)	0.93 (0.25-3.47)
L	9 (39%)	6 (37%)	*P* = .918
MOI			
Fall	10 (43%)	8 (50%)	No OR
MVA	9 (39%)	6 (38%)	*P* = .92
Pedestrian struck	3 (13%)	2 (13%)	
Crush	1 (4%)	0 (0%)	
Subspecialty			
Hand	7 (30%)	15 (93%)	34.29 (3.76-312.72)
Trauma	16 (70%)	1 (6%)	*P* = .002*
Days from injury to surgery	*M* = 4.61	*M* = 8.31	Wilcoxon *P* = .84
	Median = 1.00	Median = 2.00	*t* test *P* = .389
	Range = 0-30	Range = 0-54	
	SD = 8.18	*SD* = 12.70	
	IQR = 4.00	IQR = 7.50	
Inclination pre op	*M* = 14.63	*M* = 15.89	*P* = .602
	95% CI, 11.39-17.88	95% CI, 12.19-19.59	
	Range = −5.70 to 28.60	Range = 4.2-30.10	
	SD = 7.50	*SD* = 7.56	
Volar tilt pre op	*M* = 6.23	*M* = 6.82	*P* = .898
	95% CI, 0.09-12.37	95% CI, 0.02-13.6	
	Range = −23.70 to 35.50	Range = −14.3 to 26.60	
	SD = 14.20	*SD* = 13.89	

Note. Some columns do not sum to 100% due to rounding. VUC = volar ulnar corner; CI = confidence interval; RR = relative risk; IQR = interquartile range; SD = standard deviation; MOI = mechanism of injury; MVA = motor vehicle accident. Asterisk (*) notes a significant difference with $p<0.05$.

By Subspecialty

Orthopedic trauma surgeons treated 17 patients (44%) and orthopedic hand surgeons treated 22 (56%). There was a significant difference in age amongst patients treated by fellowship-trained hand surgeons and fellowship-trained trauma surgeons (35.6 ± 11.4 vs 45.6 ± 15.7, respectively). There was no significant difference in sex, laterality, mechanism of injury, days from injury to surgery, or preoperative radial inclination and volar tilt (Table 3). Hand surgeons were responsible for 15 of the 16 VUC fixations and were significantly more likely to use this fixation technique (RR = 0.03, 95% CI, 0.003-0.27, *P* = .002) (Table 4). The only loss of reduction to occur in the overall cohort was in the group treated by hand surgeons (RR = 0.41, 95% CI, 0.02-10.69, *P* = .54) but did not have VUC fixation, and performed the only revision in the overall cohort. The risk of complications was also not different based on surgeon subspecialty (RR = 2.14, 95% CI, 0.32-14.55, *P* = .44). Trauma trained surgeons had an average postoperative radial inclination of 20.09 ± 7.14, versus hand-trained surgeons who had an average of 15.10 ± 3.90. This was a statistically significant difference.

Discussion

The VUC of the distal radius is noted to be the "critical corner" of the distal radius. Studies have demonstrated that failure to adequately reduce and secure a volar fragment of the lunate facet has a propensity to carpal instability and leave patients prone to volar subluxation.[5] While

Table 2. Outcomes by VUC Fixation (N = 39).

	No VUC fixation N = 23 (59%)	VUC fixation N = 16 (41%)	Relative risk (95% CI) *P* value
Follow-up (months)	*M* = 7.27 Median = 4.35 Range = 1.47-28.77 *SD* = 6.48 IQR = 5.50	*M* = 6.64 Median = 5.02 Range = 2.20-14.33 *SD* = 5.35 IQR = 7.02	Wilcoxon *P* = .97 *t* test *P* = .86
Loss of reduction			
No	22 (96%)	16 (100%)	0.45 (0.02-11.9)
Yes	1 (4%)	0 (0%)	*P* = .64
Revision			
No	22 (96%)	16 (100%)	0.45 (0.02-11.9)
Yes	1 (4%)	0 (0%)	*P* = .64
Complications			
No	18 (78%)	16(100%)	0.10 (0.01-1.99)
Yes	5 (22%)	0 (0%)	*P* = .13
Radial inclination postop	*M* = 18.40 95% CI, 15.36-21.45 *SD* = 7.04 Range = 3.5-31.8	*M* = 17.41 95% CI, 15.8-19.0 *SD* = 4.33 Range = 12-28.30	*P* = .53
Volar tilt postop	*M* = 8.67 95% CI, 4.680-12.66 Range = −11.40 to 33.20 *SD* = 9.32	*M* = 7.93 95% CI, 6.19-9.67 Range = 0.7-16.00 *SD* = 4.69	*P* = .72

Note. Some columns do not sum to 100% due to rounding. VUC = volar ulnar corner; CI = confidence interval; RR = relative risk; IQR = interquartile range; SD = standard deviation; MOI = mechanism of injury; MVA = motor vehicle accident. Asterisk (*) notes a significant difference with $p<0.05$..

this incidence of this injury does not occur in most intraarticular distal radius fractures, a 2009 study by Souer et al[10] demonstrated that the prevalence of a VUC injury is as high as 13%

Our retrospective study found a similar incidence of VUC injuries in distal radius fractures as previously reported. At our institution, hand-trained surgeons tended to fix VUC injuries with VUC-specific fixation more often than trauma trained surgeons, and this was statistically significant. We found no significant difference between the cohort treated with VUC-specific fixation and those that did not. Only 1 of the 39 patients with a VUC injury required revision surgery. This patient did not have VUC-specific fixation. Complication rates were also similar with respect to VUC fixation.

Given the prevalence of the injury and potential implications of loss of reduction, specifically volar escape, which is most frequently reported, many techniques other than the standard volar plating have been devised. These range from specialized volar rim plates to fragment-specific fixation with lag screws, Kirshner wires, tension wiring or hook plates. Moore and Dennison[11] described the use of Kirshner wire used in a "spring wire" fashion for fixation in conjunction with a standard volar plate. Their series of 9 patients all patients achieved union without loss of reduction. Bakker and Shin[12] reported a series of 6 patients with VUC injuries treated with volar hook plate with fragment-specific fixation. Similarly, Chin and Jupiter[13] reported in 4 patients using wire loop fixation in conjunction with external fixation or Kwire fixation, O'shaughnessy et al[14] reported in 25 patients using volar hook plate, and Ruch et al[15] reported in 21 patients using volar plate with external fixation all with good results—no fixation failure. More recently, Naito et al[16] reported on the use of volar rim plates in distal radius fractures with volar rim fragments. Although this study was not specific to volar lunate facet fractures, their retrospective review of 32 patients with distal volar rim fractures treated with volar rim plating determined that a significant factor in the maintenance of reduction relied on an adequate buttress effect which specialized distal volar locking plate was successful at providing. As it stands, many fixation strategies have been demonstrated to show good maintenance of reduction of the VUC fragment. However, a common limitation with these studies is the small sample size presented. In addition, there was no control based on the nature of the study.

Volar ulnar corner–specific fixation is not without associated complications. Reported complications include

Table 3. Demographics by Surgeon Subspecialty (N = 39).

	Trauma N = 17 (44%)	Hand N = 22 (56%)	Odds ratio (95% CI) *P* value
Sex			
Men	9 (53%)	17 (77%)	0.33 (0.08-1.31)
Women	8 (47%)	5 (23%)	*P* = .226
Age (y)	*M* = 45.59	*M* = 35.59	*P* = .03
	95% CI, 37.54-53.64	95% CI, 30.8–40.3	
	Range = 19-77	Range = 18-75	
	SD = 15.65	*SD* = 11.4	
Side			1.43 (0.39-5.12)
R	10 (59%)	11 (50%)	*P* = .55
L	7 (41%)	11 (50%)	
MOI			No OR
Fall	7 (41%)	10 (45%)	*P* = 1.53
MVA	8 (47%)	8 (36%)	
Pedestrian struck	2 (12%)	3 (14%)	
Crush	0 (0%)	1 (5%)	
Days from injury to surgery	*M* = 4.47	*M* = 7.41	Wilcoxon *P* = .86
	Median = 1.0	Median = 1.5	*t* test *P* = .94
	Range = 0-30	Range = 0-54	
	SD = 8.03	*SD* = 10.7	
	IQR = 4.0	IQR = 3.0	
Radial inclination pre op	*M* = 16.04	*M* = 14.09	*P* = .405
	95% CI, 11.38-20.69	95% CI, 11.89-16.30	
	Range = −5.7 to 30.1	Range = 7.10-27.00	
	SD = 9.05	*SD* = 5.28	
Volar tilt pre op	*M* = 7.71	*M* = 5.58	*P* = .63
	95% CI, –0.92 to 16.34	95% CI, 1.51-9.64	
	Range = −23.7 to 35.5	Range = −14.3 to 20.40	
	SD = 16.78	*SD* = 9.73	

Note. Some columns do not sum to 100% due to rounding. CI = confidence interval; RR = relative risk; IQR = interquartile range; SD = standard deviation; MOI = mechanism of injury; MVA = motor vehicle accident. Asterisk (*) notes a significant difference with $p<0.05$..

tendon rupture, loss of fixation, tenosynovitis, and complex regional pain syndrome. Irritation and tenosynovitis necessitates that patients treated with distal plate fixation undergo a second procedure for removal of hardware.[3,6,10]

Although the above-mentioned studies demonstrate the ability of fixation techniques to maintain reduction, it is not explained why some VUC fragments that are not specifically addressed fail, and why some do not. In a biomechanical study using matched pairs of cadaveric upper extremities comparing wrists with a volar lunate facet fracture only to those with a volar lunate facet fracture with disrupted dorsal extrinsic ligaments cut, Bui et al[17] found that, after 500 cycles, wrists with volar fracture alone did not have a significant volar displacement compared with wrists without fracture. However, in wrists with dorsal extrinsic ligaments disrupted, there was significant volar displacement over both none fractured wrists and fracture alone wrists. These results are in concordance with our results which suggest that, although the importance of the VUC has been thoroughly described, there may be variations in VUC fractures or their operative treatment that necessitate specific fixation or predispose to failure as we did not find a significance in failure or complication rates between VUC fractures that had the lunate facet fragment specifically fixed versus those that did.

Several limitations to this study exist. As this is a retrospective study, there was no randomization and fixation was based on surgeon preference allowing bias in mode of fixation. In addition, determination of VUC injury was based on 2 orthopedic surgery resident's CT interpretation based on a uniform definition. This may have led to over or under diagnosis as there was no inter-/intraobserver reliability determined. Furthermore, while our study is among the largest for this topic, we may have been subject to a type II error. Finally, this study is limited by a small sample size that was used, as these data are from a single institution. Perhaps a meta-analysis or multicenter study would address this limitation.

Table 4. Outcomes by Surgeon Subspecialty (N = 39).

	Trauma N = 17 (44%)	Hand N = 22 (56%)	Relative risk (95% CI) *P* value
Last follow-up (months)	*M* = 7.87 95% CI, 4.19-11.55 Median = 4.27 Range = 1.47-28.77 *SD* = 7.16 IQR = 7.83	*M* = 5.86 95% CI, 2.83-8.90 Median = 4.43 Range = 2.20-14.33 *SD* = 3.94 IQR = 5.37	Wilcoxon *P* = .65 *t* test *P* = .45
VUC fixation			
No	16 (94%)	7 (32%)	0.03 (0.003-0.27)
Yes	1 (6%)	15 (68%)	*P* = .002*
Loss of reduction			
No	17 (100%)	21 (95%)	0.41 (0.02-10.69)
Yes	0 (0%)	1 (5%)	*P* = .54
Revision			
No	17 (100%)	21 (95%)	0.41 (0.02-10.69)
Yes	0 (0%)	1 (5%)	*P* = .54
Complications			
No	14 (82%)	20 (91%)	2.14 (0.32-14.55)
Yes	3 (18%)	2 (9%)	*P* = .44
Radial inclination postop	*M* = 20.09 95% CI, 16.43-23.76 Range = 3.50-31.80 *SD* = 7.14	*M* = 15.10 95% CI, 13.45-16.71 Range = 4.70-23.40 *SD* = 3.90	*P* = .01*
Volar tilt postop	*M* = 9.91 95% CI, 4.70-15.12 Range = −11.40 to 33.20 *SD* = 10.13	*M* = 5.81 95% CI, 4.06-7.57 Range = −7.6 to 16.00 *SD* = 4.19	*P* = .09

Note. Some columns do not sum to 100% due to rounding. CI = confidence interval; VUC = volar ulnar corner; RR = relative risk; IQR = interquartile range; SD = standard deviation; MOI = mechanism of injury; MVA = motor vehicle accident. Asterisk (*) notes a significant difference with p<0.05..

Conclusion

At our institution, fellowship-trained hand surgeons were more likely to use VUC-specific fixation versus fellowship-trained trauma surgeons. There was no association between VUC fixation and revision or complications. Although patients without VUC fixation had a higher complication rate, this was not statistically significant. This suggests that there may be variation in VUC fractures and necessitates further research into to what defines a clinically relevant VUC injury. This also indicates that we may be overtreating distal radius fractures with a VUC component with VUC-specific fixation. The typical volar rim plates used for fractures of the VUC do require eventual removal which necessitates a future surgery. It is worth considering, based on the results of our study, the use of a standard volar plate with dynamic testing intraoperatively after fixation. At that point, it may be determined whether additional fixation is required. Future studies may also examine how much the size or pattern of the VUC fragment matters when determining fixation method. A prospective randomized controlled trial comparing this group with a VUC-specific fixation group would be helpful for this distinction.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from all patients for being included in the study.

Statement of Informed Consent

Informed consent was obtained from all individual participants in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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