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Comparative Study of Internal Fixation of the Ulna and Distal Ulna Resection in Patients Older Than 70 Years With Distal Radius and Distal Metaphyseal Ulna Fractures

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Abstract

Background: Acute management of fractures of the distal ulna that are associated with fractures of the distal radius remains difficult, particularly in the elderly. **Methods:** In this study, we investigated whether internal fixation of the distal ulna is associated with a higher rate of complications than resection of the distal ulna in patients older than 70 years. Twenty-four consecutive patients were included in this study, 12 of whom had undergone open reduction and internal fixation (ORIF) of the distal ulna, and 12 who had undergone distal ulna resection. Patients were retrospectively assessed for range of motion, grip strength, pain, and radiographic appearance. The functional outcome was evaluated by the Mayo Wrist Score. Complications were classified according to the Classification of Surgical Complications. **Results:** There were no differences in patient demographics between the 2 groups, except patient age. Clinical evaluation showed no difference at follow-up; however, there were significantly more complications associated with ORIF compared with resection. **Conclusions:** The results from our study show that women older than 70 years with fracture of the distal radius and distal ulna have a higher rate of complications if ORIF of the distal ulna is performed. Patients should be warned, by surgeons, of this in cases where ORIF of the distal ulna is suggested.

Keywords: distal ulna fracture, distal radius fracture, complication, distal ulna and distal radius fractures, distal ulna resection

Introduction

Distal radius and distal metaphyseal ulna fractures have a 2-peak age distribution. The first peak includes children aged 5 to 14 years, and the second peak occurs in the elderly (65-85 years).[5,23] In childhood, the treatment of these lesions is performed by closed reduction and immobilization. However, in adult patients, nonoperative treatment for this pattern of injury is associated with a higher risk of complications, including nonunion or malunion of the radius.[1,15]

There are only limited data in the literature regarding the operative treatment of distal radius and ulna fractures in the elderly. Although unstable distal radius fractures can be managed with volar locking plates,[11,17] internal fixation of unstable distal ulna head and neck fractures can be challenging due to bone quality, comminution, and the size of the fragment.

Few studies have specifically addressed internal fixation of the unstable distal ulna.[7,14,20] While the authors of these studies have generally reported good outcomes, the age and functional needs of the patients were not considered. Darrach resection has been described as a salvage-type procedure for treating chronic conditions. However, a limited number of case series have reported satisfactory results using this procedure for fractures of the distal ulna at the same time as internal fixation of the distal radius.[19,21,22]

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To our knowledge, no studies have compared these different approaches for treating ulna fractures associated with distal radius fracture in a specific group of patients, such as the elderly. Therefore, this study aimed to compare the rate of complications after internal fixation or Darrach resection of the distal ulna in patients older than 70 years with distal metaphyseal ulna fracture associated with distal radius fracture. We specifically wanted to evaluate patients older than 70 years with distal radius and ulna fractures, as open reduction and internal fixation (ORIF) of the ulna is hypothesized to be associated with a higher rate of complications in this population than resection of the distal ulna.

Materials and Methods

For the purpose of this retrospective study, we reviewed medical records and invited for follow-up examination the identified patients older than 70 years who had been treated for distal radius and distal ulna fractures over a 7-year period at a large tertiary academic hospital. The inclusion criteria for this study were: (1) patients older than 70 years at the time of injury; (2) internal fixation of the radius with volar locking plate; (3) displaced ulna metaphyseal fracture treated with either ORIF or Darrach procedure; and (4) a minimum 6-month follow-up period. The exclusion criteria were: (1) patients younger than 69 years at the time of injury; (2) internal fixation of the radius with dorsal plate or external fixator; (3) ulna metaphyseal fracture treated nonoperatively; and (4) less than 6-month follow-up.

There was no randomization for whether ORIF or Darrach procedure was performed. The decision to perform ORIF or Darrach procedure was in accordance with surgeon preference. Patients were separated into 2 groups: group 1 (ORIF technique), defined as patients who fulfilled the inclusion criteria who were treated for fracture of the distal radius and distal ulna with ORIF (Supplemental Figures 1 and 2), and group 2 (ulna resection technique), defined as patients who fulfilled the inclusion criteria who were treated for fractures of the distal radius and distal ulna with resection (Supplemental Figures 3 and 4).

Complications

Complications were defined as any deviation from the expected postoperative evolution that caused pain, limited function, and/or required further treatment (operative or nonoperative).

Surgical Techniques

In all cases, the distal radius was exposed by the Henry approach. After the pronator quadratus muscle had been released, the fracture site was exposed and the volar locking plate was placed, which was initially fixed at the gliding hole to enable correct positioning after restoration of radial height. Indirect reduction using the plate as a template was performed for all fractures, and either locking pins or locking screws were placed to fix the subchondral bone.[3,4] No additional bone grafting in the radius was used for this series of patients.

Treatment

After the distal radius had been fixed, reduction of the distal ulna fracture was assessed under fluoroscopy. This evaluation allowed classification of the distal ulna fragment as either reduced or displaced. In the case of reduced distal ulna fractures, nonoperative treatment was chosen, with an above-elbow splint used 3 to 4 weeks postoperatively, depending on clinical evaluation of ulna healing and stability. After this period, limited forearm rotation was allowed for the next 2 to 3 weeks. These patients with nonoperative treatment at the ulnar fracture were excluded in the results of this study as is described in the exclusion criteria. Alternatively, in the case of a displaced distal ulna fragment, either ORIF or resection was performed. Displacement was defined as greater than 50% of the diameter of the bone, or displacement that restricted full rotation of the forearm. The distal ulna was exposed through an ulnar approach for both internal fixation and distal ulna resection. Ulna fixation was performed with plates (Supplemental Table 1). The decision to perform one of the procedures was made by the treating surgeon according to its preference.

Postoperative Period

After surgery, an above-elbow splint was used by patients for the first 2 weeks in the ORIF group (group 1) or 3 weeks in the Darrach resection group (group 2). At the same time, the rehabilitation protocol was started for each group of patients.

Assessment

Radiographic extra-articular parameters, including palmar tilt, radial inclination, radial height, and ulnar variance, were measured according to the guidelines described by Kreder and colleagues.[13] Intra-articular step-off (more than 2 mm) was evaluated during the postoperative period, and was registered as a dichotomous variable (Yes or No). Distal ulna fractures were classified according to the Q modifier of the AO Comprehensive Classification of Fractures[16] (Supplemental Figure 5). Q1 designates fracture of the ulnar styloid at its base; Q2, a simple fracture of the ulnar neck; Q3, a comminuted fracture of the ulnar neck; Q4, fracture of the ulnar head; and Q5, fracture of the ulnar head and neck.

Clinical evaluation was performed by 2 independent surgeons/researchers using a handheld goniometer to measure

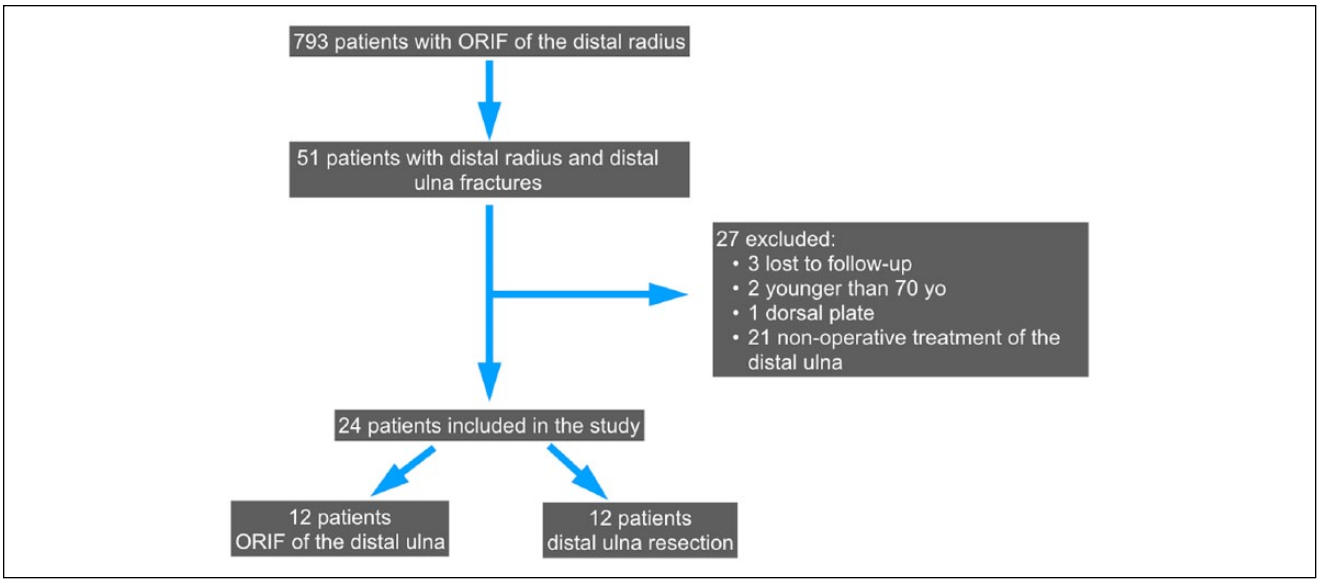

Figure 1. Flowchart of selection of patients.
Note. ORIF = open reduction and internal fixation.

the active range of motion (AROM) of the wrist in flexion, extension, radial deviation, and ulnar deviation. Active pronation and supination were also measured. Grip strength was measured with a dynamometer (Lafayette Hand Dynamometer, Lafayette, Indiana) and reported as the average of 3 attempts. Both AROM and grip strength were measured bilaterally, and compared with the healthy side.

Patient-reported outcomes were measured with the Mayo Wrist Score, combined with a visual analog scale (VAS) for pain (range: 0-10). Complications in general, as well as those related to the ulnar side, were recorded as dichotomous variables for each case (Yes or No). Each complication was classified according to the Classification of Surgical Complications.[9] Expertise of the involved surgeons was classified according to Tang classification.[24] Levels of experience are categorized as level I: nonspecialist, level II: specialist—less experienced, level III: specialist—experienced, level IV: specialist—highly experienced, and level V: expert (Supplemental Table 2).

Statistical Analysis

Continuous variables are presented as mean and standard deviation, and nominal and ordinal variables are presented as percentages. Numerical baseline data were compared between groups using a *t* test for independent samples, with ordinal and nominal variables compared using a chi-square test.

Postoperative radiograph measurements were compared between groups using a *t* test for independent samples, and intra-articular step was compared with a chi-square test. The AROM, the grip strength, the Mayo Wrist Score and, the VAS were compared with a *t* test for independent samples. Finally, the rate of complications and Tang classification between groups were compared using a chi-square test.

Results

During a 7-year period, 793 distal radius fractures were treated with ORIF in patients older than 18 years, including 51 patients (6% incidence) with distal radius and distal ulna fractures. Twenty-seven patients out of these 51 with distal radius and distal ulna fractures were excluded because they had undergone nonoperative treatment for the distal ulna fracture, or did not comply with the inclusion criteria. The remaining 24 patients fulfilled the inclusion criteria. Of these, 12 patients were treated with ORIF of the distal ulna (group 1) and the other 12 patients were treated with distal ulna resection (group 2; Figure 1). One patient who had undergone ORIF of the distal ulna died from an unrelated cause 5 years postoperatively. While this patient was included in the study, we were unable to evaluate her clinically. However, she had undergone 35 months of follow-up for radiographic and complication evaluation. There were 4 surgeons involved in the treatment of the patients included in this study. According to the Tang classification of levels of expertise, there were 2 surgeons of level II, 1 surgeon level III, and 1 surgeon level IV. One of the surgeons with Tang classification level II progressed to level III during the course of the study.

There were no significant differences between groups for baseline characteristics, including sex (all patients were women), time between fracture and surgery, follow-up period, and number of patients with open fractures. Age was

Table 1. Patient Demographics.

Variable	Group 1	Group 2	*P* value
Age (years)	74.9 (3.9)	78.7 (3.9)	**.03**[a]
Time between fracture and surgery (days)	9.3 (9.9)	9.4 (3.0)	.98
Dominant hand, (n [%])	6 (50)	6 (50)	1
Open fracture (n [%])	7 (58)	3 (25)	.1
Follow-up period (months)	37.2 (21.6)	34.7 (20.7)	.77
Radial height (mm)	1.1 (6.1)	6.3 (5.3)	.35
Radial inclination (degree)	9.3 (15.9)	11.4 (7.6)	.69
Ulnar variance (mm)	1.3 (5.6)	2.1 (3.5)	.7
Palmar tilt (degrees)	−16.1 (23.9)	−15.6 (13.6)	.95

[a]Significant difference between groups determined by *t* test for independent samples. Data for continuous variables are presented as mean and standard deviation. Boldface values express statistical difference.

Table 2. AO Classification and Q Modifier.

AO	A2	A3	C1	C2	C3	*P* value
Group 1	3 (25)	2 (16.7)	4 (33.3)	3 (25)	—	.1
Group 2	—	3 (25)	2 (16.7)	5 (41.7)	2 (16.7)	
Q modifier	1	2	3	4	5	*P* value
Group 1	—	6 (50)	4 (33.3)	1 (8.3)	1 (8.3)	1
Group 2	—	6 (50)	4 (33.3)	1 (8.3)	1 (8.3)	

the only variable that showed a significant difference between groups (Table 1). Neither the distribution of the distal radius fracture type nor the distal ulna type differed between groups (Table 2).

For the radiograph measurements, neither the postoperative nor final follow-up radiograph measurements showed statistical differences between groups (Table 3). There were also no differences between groups for AROM, grip strength, Mayo Wrist Score, or VAS (Table 4).

Complications in general were found in 7 patients in group 1, and only 2 complications were encountered in group 2 (Table 5). Complications, in general, showed a significant difference ($P = .03$). Tang classification for expertise showed no differences between groups ($P = .25$). Related to the ulnar side complication, out of the 12 cases, 4 patients in group 1 suffered a combined total of 6 complications, but no complication was observed in group 2. Complications related to ulnar side in the ORIF group comprised low ulnar nerve palsy, nonunion of the ulna fracture, loosening of the ulnar plate, superficial infection, complex regional pain syndrome, and, finally, pain and restricted motion of the distal radioulnar joint. Therefore, the rate of complications was significantly different between patients who had ORIF of the distal ulna and those who had distal ulna resection ($P = .028$; Table 6).

Table 3. Postoperative Radiograph Measurements.

Variable	Group 1	Group 2	*P* value
PO radial height (mm)	12.3 (4.33)	12 (3.24)	.9
PO radial inclination (degree)	25.5 (7.18)	21 (5.27)	.09
PO palmar tilt (degree)	7.4 (9.66)	8.3 (5.63)	.8
PO ulnar variance (mm)	0.5 (2.51)	Darrach	
FU radial height (mm)	12.9 (3.55)	12.3 (3.47)	.7
FU radial inclination (degree)	25.8 (7.27)	21.2 (5.69)	.1
FU palmar tilt (degree)	7.3 (9.27)	7.7 (5.21)	.9
FU ulnar variance (mm)	0.1 (2.47)	Darrach	
Articular step >2 mm (n [%])	0 (0)	2 (16)	.1

Note. Data for continuous variables are presented as mean and standard deviation. PO = immediate postoperative; FU = follow-up.

Table 4. Active Range of Motion and Grip Strength.

Variable	Group 1	Group 2	*P* value
Flexion (degree)	50.9 (8.1)	52 (17.1)	1
Extension (degree)	61.1 (8.2)	54.5 (16.2)	.2
Radial deviation (degree)	20.8 (11)	15.4 (6.7)	.2
Ulnar deviation (degree)	32.5 (9.3)	32.6 (9.7)	.8
Pronation (degree)	77.4 (11.4)	84 (5.4)	.1
Supination (degree)	78.4 (10.4)	83.8 (6.2)	.2
Grip strength (kg)	14.5 (5.4)	11 (3.1)	.08
Mayo Wrist Score	70.4 (23.3)	69.2 (16.6)	.9
VAS	0.4 (0.5)	1.4 (2)	.1

Note. Data are presented as mean and standard deviation. VAS = visual analog scale.

Discussion

The purpose of the present study was to determine whether ORIF of the distal ulna is associated with a higher rate of complications than resection of the distal ulna in patients older than 70 years with distal radius and ulna fractures. The results of this study showed that ORIF of the distal ulna was associated with more complications than resection of the distal ulna for this group of patients.

Displaced fractures of the distal radius are often associated with injuries of the ulnar side of the wrist, including triangular fibrocartilage complex and distal ulna fractures.[12] Although the ulnar styloid is more frequently fractured, metaphyseal ulna fracture is more common in patients older than 65 years.[5,23]

Osteoporosis is known to be a risk factor for distal radius fractures in patients older than 55 years.[18] The optimal treatment for osteoporotic distal radius fractures is controversial. While nonoperative treatment options can be performed, the nonoperative treatment of distal ulna and distal radius fractures is associated with poor function and complications such as nonunion, malunion, or radioulnar

Table 5. Distribution of Complications in General.

	Group 1	Classification of complications	Expertise classification	Group 2	Classification of complications[a]	Expertise classification	*P* value[b]
Patients with complications (n [%])	7 (58)			2 (8)			**.03**
Complications							
Patient 1	Low ulnar palsy	Grade IIIa	4				
	Radius implant failure	Grade IIIa					
Patient 3	Nonunion of the ulna	Grade I	4				
	Ulna implant loosening	Grade I					
Patient 4	CRPS	Grade I	3				
	Flexor tendon crepitation	Grade IIIa					
Patient 7	Flexor tenosynovitis	Grade IIIa	4				
Patient 8	Hematoma	Grade I	4				
	Superficial infection	Grade II					
Patient 9	CRPS	Grade I	2				
	Pain and restricted motion of the DRUJ	Grade IIIa					
Patient 11	Flexor tendon crepitation	Grade IIIa	3				
Patient 17				Flexor tendon crepitation	Grade IIIa	3	
Patient 24				Radius implant failure	Grade I	3	

Note. CRPS = complex regional pain syndrome; DRUJ = distal radioulnar joint. Boldface values express statistical difference.
[a]Classifications of complications according to Dindo et al.[9]
[b]Significant difference between groups determined by chi-square test.

Table 6. Distribution of Complications Related to Ulnar Side.

	Group 1	Group 2	*P* value[a]
Patients with complications (n [%])	5 (42)	0 (0)	**.028**
Complications			
Patient 1	Low ulnar palsy		
Patient 3	Nonunion of the ulna Ulna implant loosening		
Patient 8	Superficial infection		
Patient 9	CRPS Pain and restricted motion of the DRUJ		

Note. CRPS = complex regional pain syndrome; DRUJ = distal radioulnar joint. Boldface values express statistical difference.
[a]Significant difference between groups determined by chi-square test.

synostosis.[1,10,15] Biyani et al found that 53% of patients had limited forearm rotation and occasional pain.[1] Fifteen out of 18 patients evaluated by Biyani et al[1] underwent a nonoperative treatment course. In addition, all 4 patients in a study by McKee et al,[15] who were not operated upon, developed distal radius nonunion.

Internal fixation of distal metaphyseal ulna in elderly patients is technically demanding due to the size of the fragment, the comminution, and the quality of the bone affected by osteoporosis. Ring et al[20] conducted a study over 2 centers, and reported a series of patients with an mean age of 51 years with fractures of the distal radius, who had been treated with a condylar blade plate due to unstable fracture of the distal ulna. Although they reported good functional results at an average follow-up of 26 months, the rate of secondary surgery was 30%, mostly for ulnar hardware removal. In their series, 3 out of 24 patients suffered distal ulna nonunion, for which they required a second operative fixation procedure. Dennison[7] reported the results of 5 patients who were treated operatively for

both types of fractures with a 2.0-mm locking plate in the ulna. In this study, transient paresthesia of the dorsal sensory branch of the ulnar nerve was reported in 2 patients. It is important to note that none of the patients were older than 61 years, and pronation was moderately restricted (mean range of motion of 67°). Lee et al[14] reported results from the treatment of these injuries with a distal ulna hook plate with locking screws, observing good outcomes in 25 patients. Four patients required hardware removal, and 2 had transient paresthesia. Although 4 out of 25 patients underwent bone grafting in the distal ulna due to comminution and/or osteoporosis, only 1 suffered a delayed union with callus formation.

On the contrary, the Darrach procedure has been widely used, with several retrospective case series reporting satisfactory results in more than 75% of patients with posttraumatic distal radioulnar joint dysfunction.[6] However, there is limited information regarding distal ulnar resection for fractures of the distal ulna that are associated with distal radius fractures. Seitz and Raikin[22] reported results from 15 patients who underwent distal ulna resection during acute management of both distal radius and distal ulna fractures. They fixed the radius with external fixation and used the distal ulna as a bone graft to provide subchondral support to the distal radius. The results from all 15 cases showed a painless arc of motion, in addition to a grip strength of 88% of that of the contralateral side. Decreased grip strength was only reported in 1 case, which was due to more proximal resection of the distal ulna, as would be expected.[6] Ruchelsman et al[21] previously reported the results for 11 patients with a mean age of 62 years who underwent distal ulna resection at the same time as treatment for distal radius fracture. In 4 patients, ORIF with volar locking plate of the distal radius was performed, with external fixation with supplemental Kirschner wires (K-wires) performed in the other 7 patients. In all cases, tenodesis of the distal ulna stump with half of the extensor carpi ulnaris was performed to avoid instability. A nonindependent evaluation was performed an average of 42 months after surgery, with the mean wrist flexo-extension arc reported to be 105° and a mean pronation-supination arc of 158°. Furthermore, grip strength was measured at 90% of that of the normal contralateral side. None of the patients experienced complications or required a secondary surgical procedure.

More recently, Yoneda and Watanabe[25] reported the results of a case series of 23 patients aged over 70 years (mean 80 years) who underwent primary excision of the distal ulna with volar locking plate of the distal radius. Similar to our study, all fractures occurred in women. Although the mean follow-up period was 18 months, some patients in their study were only followed up for 3 months. At follow-up, the mean arc of flexo-extension was 121° and the wrist pronation-supination arc was 163º. The mean grip strength was 69% of that of the unaffected side. While no patients required secondary surgery, 4 patients in the study by Yoneda and Watanabe experienced ulnar side discomfort, and 1 reported ulnar pain.

Our study has several limitations. The first limitation is that due to the retrospective nature of the study, randomization was impossible, with all patients having been treated according to the surgeon's discretion. When surgeons perform their preferred technique, subconscious systematic bias, termed differential expertise bias, may be avoided.[8] The absence of randomization in our study may explain the age difference between the 2 groups. Although this likely affected the results, the difference in mean age between the groups actually strengthens the results of our study, as younger patients, with theoretically better quality bone, received ORIF. Moreover, given the relatively low incidence of cases with distal radius and distal ulna fractures, it was more feasible to perform a prospective observational study. Although retrospective studies may be associated with several sources of bias, it is difficult to evaluate interventions designed to compare low-incidence events in randomized controlled trials due to the small sample size. Designing trials with a large number of patients will be very difficult in terms of the time required to recruit patients, in addition to acquiring the necessary funding.[2]

Another limitation of the study was the low number of cases included. There are 2 explanations for the small sample size, the first of which is the low incidence of this type of injury associated with distal radius fractures (5% reported by Biyani[1] and 6% in our study) and second, the selective inclusion criteria defined in our study. Despite the low number of cases, the homogeneity of the patient sample in terms of age, type of injury, and treatment increases the validity of the study. Furthermore, our results could include type I statistical errors, as this is the only study to compare both treatments in this group of patients. However, we believe that our results provide clinical evidence which should be further tested in future studies.

Our study showed a higher rate of complications when ORIF of the distal ulna was performed in women aged over 70 years who required treatment for fracture of the distal radius and distal ulna. In accordance, we recommend that patients should be warned of this possibility when ORIF of the distal ulna is planned, as there was no difference in objective (AROM and grip strength) and subjective (Mayo Wrist Score and VAS) results between the 2 treatments.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This article does not contain any experimental studies with human or animal subjects.

Statement of Informed Consent

All patients gave the signed informed consent before the treatment, and the institutional review board approved the retrospective review of the medical charts.

Declaration of Conflicting Interests

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