

Associations Between the Fracture Type and Functional Outcomes After Distal Radial Fractures Treated With a Volar Locking Plate

Kęstutis Braziulis¹, Rytis Rimdeika¹, Rima Kregždytė², Šarūnas Tarasevičius³

¹Department of Plastic and Reconstruction Surgery, Medical Academy, Lithuanian University of Health Sciences,

²Department of Preventive Medicine, Medical Academy, Lithuanian University of Health Sciences,

³Department of Orthopedics and Traumatology, Medical Academy, Lithuanian University of Health Sciences, Lithuania

Key Words: distal radius; volar locking plate; wrist; fracture; fracture type.

Summary. *Objective.* The aim of this study to investigate the associations of fracture type, age, and gender with hand function after distal radius fractures treated with a volar locking plate at a 6-month follow-up.

Material and Methods. A total of 120 patients with displaced distal radius fractures were included into the study. They were operated on using a volar locking plate system. All the fractures were classified according to the AO classification, and the patients were divided into 3 groups by the fracture type. The range of motion and grip strength were evaluated at the 6-month follow-up. Multivariate linear regression analysis was used to evaluate the associations of age, gender, and fracture type with the score of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. The DASH questionnaire was completed as an outcome measure.

Results. A total of 28 patients experienced type A fractures; 70 patients, type B fractures; and 22 patients, type C fractures. No statistically significant difference regarding age and sex among the groups was observed. At 6 months after the surgery, the mean DASH score for type A, B, and C fractures was 16, 13, and 32, respectively ($P=0.01$). After the surgery, the radiographic parameters such as the volar tilt and the ulnar variance were significantly worse in the patients with type C fractures. Grip strength and the range of motion of the contralateral healthy hand at the 6-month follow-up were significantly better than those of the operated hand. The linear regression analysis showed that the type C fracture was the only factor significantly associated with lower DASH score.

Conclusions. The patients with type C fractures treated with a volar locking plate had a worse wrist function as compared with the patients type A and B fractures at the 6-month follow-up. The postoperative hand function was significantly associated only with the type C fracture, while age and gender had no significant impact.

Introduction

Distal wrist fractures are one of the most common fractures in elderly adults and are caused by low-energy trauma (1, 2). The options for treatment usually depend on the fracture type. Nondislocated fractures are treated conservatively; however, for dislocated fractures, operative treatment using K-wires, external fixation devices, or plates is indicated (3). During the last decade, locking plates have been recognized as an optimal and most commonly used treatment method for dislocated distal radius fractures (4, 5). It has been reported that a complete functional recovery after distal radial fractures treated using a locking plate can be achieved in 90% of patients (6).

An accurate restoration of the joint line has been reported to be an important factor affecting the function after the operative treatment of distal radial fractures (7). However, in severe, multifragmental fractures, it is challenging to perform a precise re-

construction. Thus, fracture severity may be associated with a poorer functional outcome. Karnezis et al. (8) investigated 30 patients with distal radius fractures treated with closed reduction and K-wires fixation and found an association between more severe distal radial fractures and poorer wrist function after the treatment. However, to our knowledge, there are no studies in the literature regarding an association between radiological fracture severity and a functional outcome in patients with distal radial fractures treated using locking plates.

The aim of our study to investigate associations between fracture type, age, and gender and hand function after distal radius fractures treated with a volar locking plate at a 6-month follow-up.

Material and Methods

A total of 265 patients with distal radial fractures, who were treated operatively in the Clinic of Plastic and Reconstructive Surgery and the Clinic of Orthopedics and Traumatology, Hospital of Lithuanian University of Health Sciences, from January 1, 2012, to December 31, 2012, were screened. After exclusions and dropouts, the data of 120 patients were used

Correspondence to K. Braziulis, Department of Plastic and Reconstruction Surgery, Medical Academy, Lithuanian University of Health Sciences, Eivenių 2, 50161 Kaunas, Lithuania
E-mail: kestutisbr@gmail.com

for a functional and radiological analysis. Closed reduction and cast immobilization were performed for all the patients immediately after the admission according to the protocol of the institution. After the fracture reduction, a 2-side x-ray examination of the wrist was performed and evaluated. The patients with the fractures in which dorsal angulation was less than 10° , volar tilt less than 25° , and shortening of radius less than 2 mm were treated conservatively. The remaining patients with distal radial fractures were treated surgically with volar locking plates.

The data of patients who underwent surgery were used for the functional outcome analysis. The patients were preoperatively classified according to the AO radiological grading system (9) and were divided into 3 groups (type A, B, and C fractures). According to this grading system, the type A fracture is extra-articular, and this fracture affects neither the articular surface of the radiocarpal nor the radioulnar joints. The type B fracture is partially articular, and this fracture affects a portion of the articular surface, but the continuity of the metaphysis and the epiphysis is intact. The type C fracture is completely articular, and this fracture affects the joint surfaces (radioulnar, radiocarpal, or both) and the metaphyseal area (9). The patients with previous distal radial fractures in the same hand were not included into the study.

All the patients underwent surgery under regional anesthesia using a tourniquet and a typical carpal approach (10). The intraoperative reposition of the fracture was controlled under x-ray, and fractures were fixed using self-locking volar plates and screws (Changzhou Kanghui Medical Innovation Co., Ltd). After surgery, the wrist was immobilized for a period of 2 weeks. Active finger and forearm rotation was allowed on the first postoperative day. The patients' x-ray follow-up was scheduled at 4 weeks, 6 weeks, and 6 months after the surgery. A postoperative x-ray examination included the measurements of radial inclination, ulnar variance, and volar tilt. The wrist function was investigated at 6 months after the surgery. The functional analysis included the measurements of grip strength and range of motion (extension-flexion, radial-ulnar deviation, pronation-supination) of the wrist and the forearm, and the results were compared with those of the opposite nonoperated wrist. Additionally, the wrist function was investigated using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (11). The DASH questionnaire consists of 30 items pertaining to difficulties to perform physical activities, symptom severity, and the effect of the injury on social activities, self-image, work, and sleep. Each question has 5 response options. A score is calculated, and the disability of the patient is expressed on a scale from 0 to 100, with 100 being the worst result. A minimum of 27 items must be answered for the result to be valid and to calculate the DASH score. A change of 10

points in the mean DASH score after an intervention is considered as a minimally important change (12).

Permission to conduct this study was obtained from the local Ethics Committee (BE-2-32).

Statistical Analysis. The primary effect variable, used for power and sample size calculation analysis, was the functional DASH score. Assuming a difference of 10 in the means, the SD of 10 for groups, and aiming for the power of 0.90 and the type 1 error of 0.05, 22 patients were required in each group.

The central tendency and dispersion of normally distributed data were described by mean and standard deviation. One-way ANOVA was used to compare means among groups. The post-hoc Bonferroni test was used for multiple comparisons between groups. Repeated measures ANOVA was applied to compare the DASH score between the hands as well as among the fracture types. Multivariate linear regression was used to evaluate the associations of the factors (age, gender, and fracture type) with the DASH score. The chi-square test was used for the analysis of categorical data.

Data were analyzed with the SPSS 17 program for Windows. A *P* value of <0.05 was considered statistically significant.

Results

The demographic characteristics of the patients grouped by the fracture type are shown in Table 1. The patients in all the 3 groups were matched by age and gender. The DASH score for type C fractures was 32 and for type A and B were 16 and 13, respectively ($P<0.001$).

The comparison of the postoperative accuracy of reposition among the groups showed that the patients with type C fractures had a significantly worse postoperative radiological position of the fracture (volar tilt and ulnar variance) as compared with patient who experienced type A and B fractures (Table 2). The wrist function was worse in the patients with type C fractures than those with type A and B fractures.

The comparison of the functional outcome between the fractured wrist and the contralateral healthy one showed a significantly worse function for the operated hand than the contralateral healthy hand at the 6-month follow-up (Table 3).

The type C fracture was the only factor in the regression analysis significantly associated with the lower DASH score (Table 4).

Table 1. The Demographic Characteristics of Patients by the Fracture Type

Variable	Fracture Type			<i>P</i>
	A (n=28)	B (n=70)	C (n=22)	
Gender, n (%)				
Men	1 (0.82)	10 (8.26)	3 (2.47)	0.262
Women	27 (22.31)	60 (49.58)	19 (15.70)	
Age, mean (SD)	62 (13.28)	65 (11.75)	63 (12.13)	0.198

Table 2. Postoperative Radiological Position of the Fracture for the Operated Wrist

Variable	Fracture Type			P
	A (n=28)	B (n=70)	C (n=22)	
Volar tilt, °	7.79 (2.69)	6.19 (4.12)	3.65 (3.96)*	0.001
Ulnar variance, mm	-0.68 (1.13)	-0.46 (0.80)	0.95 (1.23)*	<0.001
Radial inclination, °	21.07 (1.38)	20.87 (0.93)	20.45 (0.84)	0.089

Values are mean (standard deviation).

* $P < 0.05$ compared with A and B.

Discussion

Our study showed that more severe distal radial fractures, evaluated radiologically, were associated with a worse postoperative functional outcome of the wrist. There are a few possible explanations of our findings. In case of a more complicated comminuted distal radial fracture, surgery is challenging and not always successful in achieving an ideal reconstruction in terms of articular congruity. This was the case in our study, where we observed significant differences in the volar tilt and the ulnar variance depending on the fracture type after surgery, i.e., type C fractures were reconstructed less

Table 4. Multivariate Linear Regression Analysis in Respect to the Disabilities of the Arm, Shoulder and Hand Scale Score

Variable	Unstandardized Coefficient		95% Confidence Interval for B	P
	B	SE		
Age	0.13	0.12	-0.10; 0.38	0.271
Gender	2.13	4.45	-6.61; 11.36	0.633
Fracture type	6.97	2.08	2.90; 11.34	0.001

precisely as compared with type A and B fractures. We assume that the problems in achieving the correct reconstruction of the fracture might have a direct influence on a worse functional outcome at 6 months after surgery.

It is still a debate in the literature if the severity of the fracture has an impact on the results of outcome after distal radial fractures. There are studies reporting associations between the severity of intra-articular fractures and the onset of postoperative arthritis. Knirk and Jupiter (13) investigated patients who experienced distal radial fractures with any joint incongruence after surgery and observed a 91% rate of postoperative degenerative changes in the joint. Similarly Kreder et al. (14) reported that the risk to develop posttraumatic arthritis increased up to 10 times in case of articular incongruence after distal radial fractures. Despite an observed as-

Table 3. Functional Analysis of the Fractured Wrist and the Contralateral Healthy Hand

Variable		Fracture Type			P
		A (n=28)	B (n=70)	C (n=22)	
Flexion, °	Operated hand	52 (15.24)	58 (10.08)	47 (13.72)*	0.001
	Contralateral healthy hand	69 (9.29)	70 (94)	64 (13.34)*	0.015
P		<0.001	<0.001	<0.001	
Extension, °	Operated hand	59 (12.61)	59 (11.08)	59 (9.04)	0.965
	Contralateral healthy hand	66 (11.03)	69 (6.89)	72 (7.33)*	0.037
P		<0.001	<0.001	<0.001	
Ulnar deviation, °	Operated hand	27 (4.67)	30 (10.33)	28 (5.80)	0.336
	Contralateral healthy hand	30 (2.88)	31 (6.34)	31 (3.19)	0.711
P		0.021	0.009	0.030	
Radial deviation, °	Operated hand	18 (2.94)	20 (12.52)	20 (5.79)	0.667
	Contralateral healthy hand	19 (2.13)	26 (16.86)	22 (4.21)	0.054
P		0.009	0.001	0.109	
Supination, °	Operated hand	75 (6.54)	72 (14.93)	72 (8.09)	0.593
	Contralateral healthy hand	79 (4.14)	76 (12.67)	75 (5.21)	0.309
P		0.009	<0.001	0.043	
Pronation, °	Operated hand	73 (8.96)	72 (10.55)	73 (3.80)	0.771
	Contralateral healthy hand	78 (3.55)	75 (10.07)	79 (3.55)	0.093
P		0.002	<0.001	<0.001	
Power, kg	Operated hand	25 (13.01)	22 (9.14)	21 (11.43)	0.376
	Contralateral healthy hand	30 (7.46)	30 (5.48)	29 (9.16)	0.959
P value		0.001	<0.001	<0.001	

Values are mean (standard deviation).

* $P < 0.05$ compared with A and B.

sociation between the incongruence of the joint line and the development of postoperative arthritis, the data regarding its clinical expression are still controversial. Goldfarb et al. (15) investigated patients with distal radial fractures, who were treated with a volar plate and followed up for 15 years, and did not find any associations between patients' complains and the severity of posttraumatic arthritis despite a decreased range of motions in patients with more severe arthritis. However, other authors found associations between the severity of posttraumatic arthritis and worse function and even quality of life. Gruber et al. (6) investigated patients with intra-articular distal radial fractures for a period of 6 years and found an association between radiocarpal posttraumatic arthritis and poorer DASH and SF-36 scores. Fernandez et al. (16) also reported that patients with arthritis had significantly lower scores of the physical component summary than those without radiocarpal arthritis. Our results suggest that the fracture type could be used as a prognostic factor predicting higher risk to develop postoperative arthritis and may be associated with poor long-term functional outcome in patients with distal radial fractures.

The weakness of our study is that our patients were followed up too short to detect the differences in the development of posttraumatic arthritis. Moreover, it has been showed that 6 months after trauma is not always sufficient for patients to regain

a full function and subsequent improvement may be observed later. This is in line with the results of the study by Leung et al. (17), who reported that clinical results after articular distal radial fractures continuously improved up to 24 months postoperatively. The study by Krede et al. (14) found that functional improvement continued up to 12 months postoperatively. In our study, at 6 months after surgery, the differences in the parameters of the wrist function among the groups were observed, with the worst wrist function being in the group of patients who experienced type C fractures. We think that the wrist function after distal radial fractures should improve in all the groups investigated, but the patients who sustained a more complicated type C fracture will have a worse wrist function than those with type A and B fractures due to the possible development of posttraumatic arthritis.

Conclusions

The patients with type C fractures treated with a volar locking plate had a worse wrist function as compared with the patients type A and B fractures at the 6-month follow-up. The postoperative hand function was significantly associated only with the type C fracture, while age and gender had no significant impact.

Statement of Conflict of Interest

The authors state no conflict of interest.

References

1. Brogren E, Petranek M, Atroshi I. Incidence and characteristics of distal radius fractures in a southern Swedish region. *BMC Musculoskelet Disord* 2007;31:8:48.
2. Bengtner U, Johnell O. Increasing incidence of forearm fractures. A comparison of epidemiologic patterns 25 years apart. *Acta Orthop Scand* 1985;56:158-60.
3. Laino DK, Tejwani N. Indications for operative fixation of distal radius fractures: a review of the evidence. *Bull NYU Hosp Jt Dis* 2012;70:35-40.
4. Mattila VM, Huttunen TT, Sillanpää P, Niemi S, Pihlajamäki H, Kannus P. Significant change in the surgical treatment of distal radius fractures: a nationwide study between 1998 and 2008 in Finland. *J Trauma* 2011;71:939-42; discussion 942-3.
5. Chung KC, Shauver MJ, Birkmeyer JD. Trends in the United States in the treatment of distal radial fractures in the elderly. *J Bone Joint Surg Am* 2009;91:1868-73.
6. Gruber G, Zacherl M, Giessauf C, Glehr M, Fuerst F, Liebmann W, et al. Quality of life after volar plate fixation of articular fractures of the distal part of the radius. *J Bone Joint Surg Am* 2010;92:1170-8.
7. Mehta JA, Bain GI, Heptinstall RJ. Anatomical reduction of intra-articular fractures of the distal radius. An arthroscopically-assisted approach. *J Bone Joint Surg Br* 2000;82:79-86.
8. Karnezis IA, Panagiotopoulos E, Tyllianakis M, Megas P, Lambiris E. Correlation between radiological parameters and patient-rated wrist dysfunction following fractures of the distal radius. *Injury* 2005;36:1435-9.
9. Müller ME, Nazarian S, Koch P, Schatzker J. The comprehensive classification of fractures of long bones. Berlin Heidelberg: Springer-Verlag; 1990.
10. Orbay J, Badia A, Khoury RK, Gonzalez E, Indriago I. Volar fixed-angle fixation of distal radius fractures: the DVR plate. *Tech Hand Up Extrem Surg* 2004;8:142-8.
11. Solway S, Beaton DE, McConnell S, Bombardier C. The DASH outcome measure user's manual. 2nd ed. Toronto: Institute for Work & Health; 2002.
12. Gummesson C, Atroshi I, Ekdahl C. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. *BMC Musculoskelet Disord* 2003;16:4:11.
13. Knirk JL, Jupiter JB. Intra-articular fractures of the distal end of the radius in young adults. *J Bone Joint Surg Am* 1986;68:647-59.
14. Kreder HJ, Hanel DP, Agel J, McKee M, Schemitsch EH, Trumble TE, et al. Indirect reduction and percutaneous fixation versus open reduction and internal fixation for displaced intra-articular fractures of the distal radius: a randomised, controlled trial. *J Bone Joint Surg Br* 2005;87:829-36.
15. Goldfarb CA, Rudzki JR, Catalano LW, Hughes M, Borrelli J Jr. Fifteen-year outcome of displaced intra-articular fractures of the distal radius. *J Hand Surg Am* 2006;31:633-9.
16. Fernandez JJ, Gruen GS, Herndon JH. Outcome of distal radius fractures using the short form 36 health survey. *Clin Orthop Relat Res* 1997;341:36-41.
17. Leung F, Tu YK, Chew WY, Chow SP. Comparison of external and percutaneous pin fixation with plate fixation for intra-articular distal radial fractures. A randomized study. *J Bone Joint Surg Am* 2008;90:16-22.

Received 17 January 2013, accepted 30 September 2013