ORIGINAL ARTICLE

Evaluation of instability factors in distal radius fractures

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Background: Fractures of distal radius are one of the most common fractures seen by physicians and account for 20% of all fractures seen in the emergency room. Various factors contribute in secondary displacement of fracture fragments after anatomic or near anatomic close reduction and cast immobilization in distal radius fractures. This study was designed to examine the correlation between radiographic outcomes in the closed treatment of unstable distal radius fractures and different risk factors. **Materials and Methods:** One hundred and fifty-seven patients were included in this prospective study. There were 107 women and 50 men; with a mean age of 51 ± 16.7 years (range: 20-86 years). During the follow-up in all radiographs, the following variables were analyzed as instability factors: (1) Age, (2) gender, (3) radial shortening, (4) dorsal comminution, (5) articular step-off, (6) radial inclination, (7) associated ulna fracture, and (8) dorsal angulation. **Results:** Based on the radiographic criteria for an acceptable reduction, 92 patients (58.6%) failed to maintain an acceptable reduction and classified as group I, while in 65 patients (41.4%), the postoperative radiographs were within an acceptable range and classified as group II. The mean age of patients in group I was higher than group II ($P < 0.001$). Radial shortening of more than 6.5 mm, loss of radial inclination of more than 6.5 degrees, and age above 52 at presentation were the most important predictive factors for instability. **Conclusion:** Among the variables, the most important predictors of redisplacement after an acceptable closed reduction were loss of radial height, loss of radial inclination, and age.

Key words: Distal radius fracture, instability, predictors, radiographic outcomes

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INTRODUCTION

Fractures of distal radius are one of the most common fractures seen by physicians and account for 20% of all fractures seen in the emergency room. In young adults, the fractures are typically the result of high-energy injuries, such as motor vehicular collisions and fall from height. In contrast, most of distal radial fractures in the elderly occur from low-energy injuries, such as a fall from a standing height.[1,2] Elderly female patients comprise the majority of patients with distal radius fractures. Standard posteroanterior and lateral radiographs of the distal radius and wrist are usually sufficient for diagnosis, classification, and decision making for treatment. The optimal treatment of distal radius fracture is controversial. However, in majority of instances, nonoperative treatment is selected at least initially.[1,3]

Instability is defined by redisplacement of the fracture site after it has been manipulated into anatomic position. Various factors contribute in secondary displacement of fracture fragments after anatomic or near anatomic close reduction and cast immobilization in distal radius fractures. Cooney *et al*., suggested that fractures with severe dorsal comminution and dorsal angulation greater than 20 have a significant chance of redisplacement after reduction.[4] Vaughan *et al*., emphasized on importance of dorsal angulation and radial shortening.[5] Makhni *et al*., considered that increase in age, significantly increases the rate of redisplacement.[6] Altissimi and Abbaszadegan *et al*., in two different studies, suggested that initial radial shortening of more than 4 mm is associated with increased rate of redisplacement after reduction.[7,8] Lafontaine *et al*., extended these concepts and suggested that dorsal angulation more than 20 degrees, presence of ulnar fracture, patient's age more than 60 years, dorsal comminution, and intra-articular fracture line as risk factors for fracture instability and believed presence of three or more of these parameters are correlated with loss of position despite cast immobilization.[9]

The aim of this study was to correlate further the radiographic outcome in the closed treatment of unstable distal radius fractures with these different risk factors.

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PATIENTS AND METHODS

From November 2010 to November 2012 there were 279 patients with distal radius fracture who were treated consecutively at our hospital. Standard initial treatment of displaced fractures were 5 kg of finger-trap traction followed by manual closed reduction of the fracture under intravenous sedation and immobilization by a forearm plaster-of-Paris cast with a moderate volar tilt and ulnar deviation. To be included in this study each patient had to have the following criteria: (1) Presence of three or more instability factors as described by Lafontaine *et al*., (presence of intra-articular fracture, dorsal comminution, associated ulna fracture, age 60 years or more, dorsal angulation more than 20 degrees), (2) skeletal maturity, (3) adequate plain radiographs in posteroanterior and lateral plane from the date of injury, after reduction; and 1, 2, 3, and 6 weeks after reduction, (4) unilateral distal radius fractures, (5) absence of previous deformity or fracture in either wrists, and (6) acceptable reduction based on initial post reduction films. According to Bini *et al*.,[10] after reduction, fractures with a radial shortening of less than 2 mm, a change in radial inclination of less than 5 degrees, less than 2 mm step-off, or loss of palmar tilt of less than 10 degrees (no extension more than neutral, or 0 degree) were considered acceptable. The contralateral uninjured wrist X-ray was made to evaluate the radial shortening and inclination with the injured site. Finally, 157 patients were included in this prospective study [Figure 1]. Institutional review board approval was obtained. There were 107 women and 50 men, with a mean age of 51 ± 16.7 years (range: 20-86 years). Post reduction radiographs were performed in the posteroanterior and lateral planes, after reduction, at 1, 2, 3, and 6 weeks after reduction. All radiographs were analyzed during the follow-up period with respect to dorsal comminution, angulation, radial shortening, articular step-off, and radial inclination. Measurements were independently made by two of the coinvestigators; any discrepancies that arose were referred to the principle investigator Mohammad Ali Tahririan (M.A.T), who was blinded to the name of the patients.

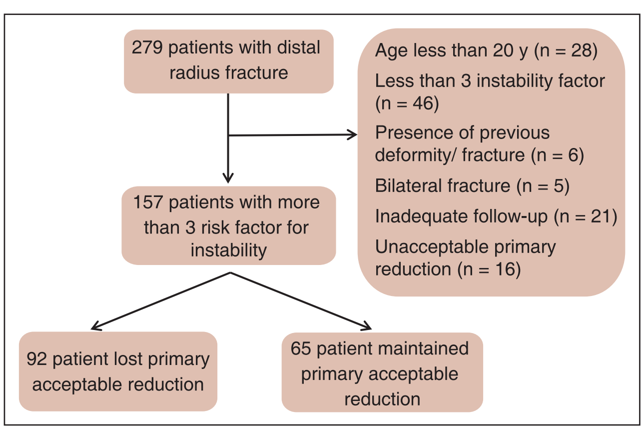

Figure 1: Summary of methodology for selecting patients

The following variables were analyzed as instability factors: (1) Age, (2) gender, (3) radial shortening, (4) dorsal comminution, (5) articular step-off, (6) radial inclination, (7) associated ulna fracture, and (8) dorsal angulation.

We preformed analysis using standard statistical computer software, that is, Statistical Package for Social Sciences (SPSS, version 15). We used chi-square test and Fisher's exact test to compare categorical data. Data were compared by using *t*-test and P-value of <0.05 was considered to be statistically significant.

RESULTS

A total number of 157 patients were studied. The mean age of the patients was 51 ± 16.7 years. Most of the patients were female, 107 (68.2%) compared to 50 (31.8%). The patients were followed-up for 6 weeks. Based on the radiographic criteria for an acceptable reduction, 92 patients (58.6%) failed to maintain an acceptable reduction and classified as group I, while in 65 patients (41.4%), the postoperative radiographs were within an acceptable range and classified as group II.

Failure to maintain an acceptable reduction mainly occurred within two weeks post reduction. The details of which are described in Figure 2.

Chi-Square tests revealed that the frequency of gender between the groups was not statically significant (P = 0.13), while the mean age of the patients in group I was 57.2 ± 15.2 years and in group II was 42.3 ± 14.9 years (P < 0.001).

Qualitative variables including dorsal comminution, associated ulna fracture, and intra-articular (radiocarpal) fracture were compared between the two groups. Chi-Square tests found no statically significance in the presence of dorsal comminution and associated ulna fracture between the two groups. It is noteworthy that the presence

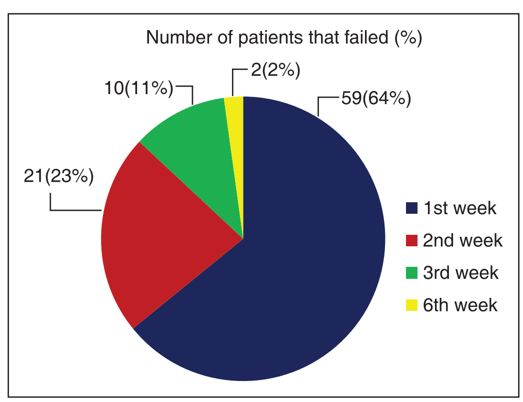

Figure 2: Number of patients who failed to maintain the reduction during follow-up

of intra-articular fracture was significantly more common in group II.

Among the continuous variables, in contrast to age, loss of radial height and inclination, the amount of dorsal angulation was not statistically significant between the groups [Table 1].

For prediction of probability of secondary displacement of an initially acceptable closed reduction of a distal radius fracture, a stepwise logistic regression analysis based on age, loss of radial height, and inclination was performed [Table 2]. According to this study, the most important predictors of redisplacement after an acceptable closed reduction were loss of radial height, loss of radial inclination, and age. As the amount of loss of radial height, loss of radial inclination and age were significantly different between the two groups ($P < 0.001$), for more accurate evaluation of predictability of redisplacement after an initially acceptable distal radius fracture reduction, reciever operating curve (ROC) curve was used [Figure 3 and Table 3].

According to the graph, area under the curve for loss of radial height, loss of radial inclination, and age was 0.78, 0.766, and 0.757, respectively; which shows their acceptable predictive value for secondary fracture displacement. In accordance with Figure 3, 6.5 mm loss of radial height, seems to be the best cut-off point, with the sensitivity and specifity of 68.5 and 81.5%, respectively. Similarly, 6.5

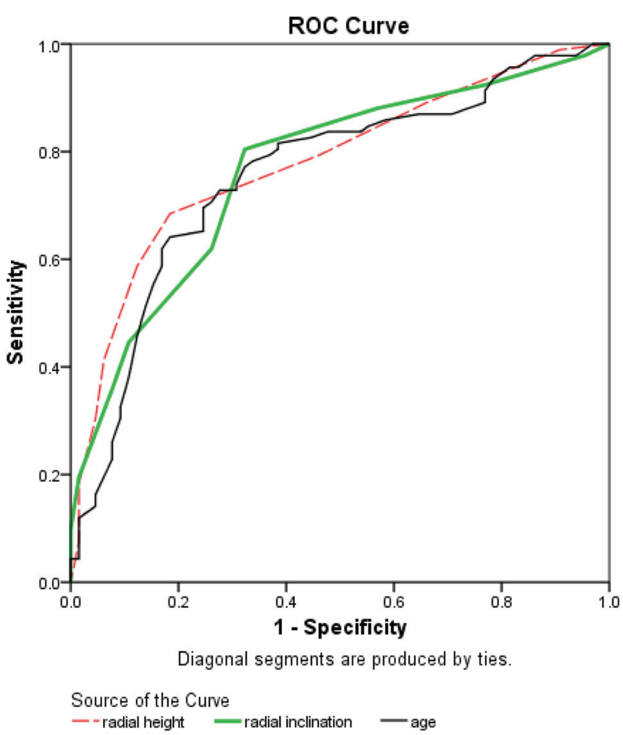

Figure 3: Reciever operating curve (ROC) curve for age, loss of radial height, and loss of radial inclination

degrees loss of radial inclination seems to be the best cut-off point, with sensitivity and specifity of 80.4 and 67.7%, respectively.

DISCUSSION

Fractures of the distal radius are among the most common injuries encountered in orthopedic practice. Initial treatment consists of closed reduction and immobilization. While anatomic reduction can usually be achieved by closed manipulation, there is a paucity of evidence as to the most appropriate method of immobilization or fixation. Our study focused on unstable distal radius fractures according to Lafontaine's criteria, managed by closed reduction and cast immobilization. We considered immobilization of the fracture for 6 weeks to be adequate.

Numerous clinical studies have reported the age as statically significant predictor for redisplacement.[1,6,11-13] The reported

Table 1: Distribution of variables between the groups

Variables	Group I (*n*=92)	Group II (*n*=65)	*P*-value
Dorsal comminution	65 (70.7%)	39 (60%)	0.08
Ulna fracture	61 (66.3%)	47 (72.3%)	0.21
Intra-articular	50 (54.3%)	48 (73.8%)	0.01
Loss of radial height (mm)	7.9±2.5	5.5±1.8	<0.001
Loss of radial inclination (degree)	8.3±2.5	6±2	<0.001
Dorsal angulation (degree)	23.4±3.5	22.9±3.9	0.389
Age (year)	57.2±15.2	42.3±14.9	<0.001

Table 2: Logistic regression analysis of quantitative and qualitative variables

	Wald	Sig	OR (odd's ratio)	95% confidence interval for OR	
				Lower	Upper
Age	10.193	0.001	0.937	0.901	0.975
Radial height	11.667	0.001	0.694	0.563	0.856
Dorsal comminution	0.220	0.639	1.315	0.418	4.134
Ina fracture	3.172	0.075	0.335	0.100	1.116
Radial inclination	10.449	0.001	0.711	0.578	0.874
Dorsal angulation	2.315	0.128	0.907	0.801	1.028
Intra articular	0.476	0.490	0.678	0.225	2.046
Gender	0.204	0.652	0.786	0.277	2.233
Constant	14.985	0.000	68380.447		

Table 3: Area under the curve of the main

Test result variable(s)	Area	Asymptotic (95% confidence interval)	
		Lower bound	Upper bound
Loss of radial height	0.780	0.707	0.852
Loss of radial inclination	0.766	0.692	0.841
Age	0.757	0.679	0.835

rate of redisplacement in unstable distal radius fractures after achieving an acceptable reduction, varied between 54 and 73%.[6,14]

Several studies have evaluated radiographic outcomes of patients with distal radius fracture who were treated nonsurgically. Nesbit *et al*., found age as the most important factor among Lafontaine's criteria for prediction of secondary displacement, and with regard to radiographic surveys, 48% of secondary displacements occurred within 2 weeks following closed reduction and splintage.[1]

Abbaszadegan *et al*., analyzed data for 267 patients with distal radius fracture who were managed with closed reduction and cast immobilization for 4 weeks. They found that the initial radial shortening, Lidström's classification, and age as the most important independent factors for the risk of redisplacement;[7] while Mackenney *et al*., believed that age and ulnar variance are the main predictors of early instability in distal radius fractures.[13] Hove *et al*., found that the initial dorsal angulation, radial length, and patient age were predictors of malunion.[12] Jenkins reported that significant radial shortening and loss of radial height at presentation, regardless of presence of intra-articular involvement and dorsal comminution are associated with redisplacement and malunion.[15]

Our study supports the contention that displaced fractures are difficult to hold and mostly redisplacement occurs within 2 weeks post reduction and cast immobilization. This is in accordance with other reports.[1,13] In this study; we demonstrated that presence of ulna fracture, intra-articular involvement, dorsal comminution, and the amount of dorsal angulation during the presentation were not statistically significant between the groups. Our study confirms the importance of loss of radial height, loss of radial inclination, and age as factors related to secondary displacement. These variables were analyzed independently and revealed that if we consider the 6.5 mm loss of radial height in comparison with uninjured side as the cut-off point, positive predictive value (PPV) and negative predictive value (NPV) would be 84 and 64.5% respectively. Similarly, 6.5 degrees loss of radial inclination seems to be the best cut-off point and accordingly PPV and NPV would be 77.9 and 71%, respectively. ROC curve for age, declares that risk for secondary displacement increases as age increases, and age equal to 52 year is the best cut-off point with PPV and NPV of 78.8 and 65%, respectively. Subsequently, these variables were analyzed together for predicting the radiographic outcomes more precisely.

Our data show that the presence of loss of radial height of more than 6.5 mm and loss of radial inclination of more than 6.5 degrees together in a patient with distal radius fracture, has 93% chance of secondary displacement; and if the patient's age is more than 52 years, the risk increases to 95.5%.

On the other hand, in a patient with a distal radius fracture who is less than 52-years-old, with primary loss of radial height of less than 6.5 mm and loss of radial inclination of less than 6.5 degrees after initial acceptable closed reduction, the chance of maintaining reduction in an acceptable range without displacement would be 84.2%.

Our quantitative data can be used by the surgeon to inform patient of chance of success with nonoperative treatment and to allow the patient to decide on treatment in a more refined and informed manner.

This study has inherent limitations. The main limitation of this study is that the results are based on radiographic analysis and clinical results are ignored. There may be patients with distal radius fracture whose final radiographs after union is unacceptable, but the patients function is not impressed significantly.[2,16-21] This is true especially in elderly and low demand patients. A second critique might be that this is a single center study, and the results may not be universal to all patient population.

In conclusion, this study identified the main predictive factors for secondary displacement in distal radius fractures. Radial shortening of more than 6.5 mm, loss of radial inclination of more than 6.5 degrees, and age above 52 years at presentation are the most important predictive factors. This may indicate that these patients should be treated with more reliable fixation device.

REFERENCES

1. Nesbitt KS, Failla JM, Les C. Assessment of instability factors in adult distal radius fractures. J Hand Surg Am 2004;29:1128-38.
2. Diaz-Garcia RJ, Oda T, Shauver MJ, Chung KC. A systematic review of outcomes and complications of treating unstable distal radius fractures in the elderly. J Hand Surg Am 2011;36:824-35.
3. 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.
4. Cooney WP 3rd, Linscheid RL, Dobyns JH. External pin fixation for unstable Colles' fractures. J Bone Joint Surg Am 1979;61:840-5.
5. Vaughan PA, Lui SM, Harrington IJ, Maistrelli GL. Treatment of unstable fractures of the distal radius by external fixation. J Bone Joint Surg Br 1985;67:385-9.
6. Makhni EC, Ewald TJ, Kelly S, Day CS. Effect of patient age on the radiographic outcomes of distal radius fractures subject to nonoperative treatment. J Hand Surg Am 2008;33:1301-8.
7. Abbaszadegan H, Jonsson U, von Sivers K. Prediction of instability of Codes' fractures. Acta Orthop Scand 1989;60:646-50.
8. Altissimi M, Antenucci R, Fiacca C, Mancini GB. Long-term results of conservative treatment of fractures of the distal radius. Clin Orthop Relat Res 1986:202-10.
9. Lafontaine M, Hardy D, Delince P. Stability assessment of distal radius fractures. Injury 1989;20:208-10.

10. Bini A, Surace MF, Pilato G. Complex articular fractures of the distal radius: The role of closed reduction and external fixation. J Hand Surg Eur Vol 2008;33:305-10.
11. Leone J, Bhandari M, Adili A, McKenzie S, Moro JK, Dunlop RB. Predictors of early and late instability following conservative treatment of extra-articular distal radius fractures. Arch Orthop Trauma Surg 2004;124:38-41.
12. Hove LM, Solheim E, Skjeie R, Sörensen FK. Prediction of secondary displacement in Colles' fracture. J Hand Surg Br 1994;19:731-6.
13. Mackenney PJ, McQueen MM, Elton R. Prediction of instability in distal radial fractures. J Bone Joint Surg Am 2006;88:1944-51.
14. Earnshaw SA, Aladin A, Surendran S, Moran CG. Closed reduction of colles fractures: Comparison of manual manipulation and finger-trap traction: A prospective, randomized study. J Bone Joint Surg Am 2002;84:354-8.
15. Jenkins NH. The unstable Colles' fracture. J Hand Surg Br 1989;14:149-54.
16. Souer JS, Lozano-Calderon SA, Ring D. Predictors of wrist function and health status after operative treatment of fractures of the distal radius. J Hand Surg Am 2008;33:157-63.
17. Cherubino P, Bini A, Marcolli D. Management of distal radius fractures: Treatment protocol and functional results. Injury 2010;41:1120-6.
18. Jaremko JL, Lambert RG, Rowe BH, Johnson JA, Majumdar SR. Do radiographic indices of distal radius fracture reduction predict outcomes in older adults receiving conservative treatment? Clin Radiol 2007;62:65-72.
19. Chung KC, Kotsis SV, Kim HM. Predictors of functional outcomes after surgical treatment of distal radius fractures. J Hand Surg Am 2007;32:76-83.
20. Young BT, Rayan GM. Outcome following nonoperative treatment of displaced distal radius fractures in low-demand patients older than 60 years. J Hand Surg Am 2000;25:19-28.
21. Stewart HD, Innes AR, Burke FD. Factors affecting the outcome of Colles' fracture: An anatomical and functional study. Injury 1985;16:289-95.

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