RESEARCH ARTICLE

The Impact of Post-reduction Radiographs of Distal Radius Fractures on Treatment Decisions among Fellowship-trained Orthopedic Hand Surgeons and General Orthopedic Surgeons

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Abstract

Objectives: We aimed to assess the impact of post-reduction radiographic evaluation on treatment decisions by fellowship-trained hand and general orthopedic surgeons. We also evaluated the trend in distal radius fracture treatment between hand surgeons and general orthopedic surgeons.

Methods: We collected postero-anterior (PA) and lateral radiographs of a consecutive series of 72 patients with six potential treatment options to be reviewed by the surgeons in three steps. First, they reviewed the patients' age, sex, laterality, hand dominance, and pre-reduction radiographs. Two weeks later, they reviewed the same patients' post-reduction PA and lateral radiographs in different order. Finally, after another two weeks, they reviewed the patients' pre-reduction and post-reduction PA and lateral radiographs simultaneously.

Results: A total of 1,080 responses were analyzed without missing data. Treatment plans remained consistent across pre-reduction, post-reduction, and simultaneous presentations, indicating that post-reduction radiographs did not improve treatment agreement. Fellowship-trained hand surgeons were significantly more likely to select internal fixation than general orthopedic surgeons ($P < 0.001$). Within-group agreement was low (Kappa = 0.2), reflecting substantial variability in treatment choices. Intra-observer reliability between pre- and post-reduction presentations was nearly perfect (Kappa = 0.9, $P = 0.402$). Treatment decisions remained unchanged for 70% of hand surgeons and 72% of general orthopedic surgeons, while 13% opted for more invasive and 16% for less invasive approaches. The final treatment decisions in simultaneous presentations closely resembled those in post-reduction presentations for general orthopedic surgeons and pre-reduction presentations for hand surgeons, though the differences were not statistically significant.

Conclusion: Although there is a significant trend among hand surgeons toward internal fixation for distal radius fractures, there is great variance among hand surgeons and general orthopedic surgeons about the recommended treatment method for distal radius fractures. Additionally, post-reduction radiographs did not improve variation among surgeons.

Level of evidence: II

Keywords: Distal radius fractures, Fellowship-trained hand surgeon, General orthopedic surgeon, Post-reduction radiographs, Treatment decisions

Introduction

Distal radius fractures (DRF) are the second most frequent fracture seen in emergency departments,[1,2] and each year, more than 80,000 cases of this fracture are recorded in the United States.[3] The treatment plan is based on patient and physician variables, as well as the severity of the fracture; nonetheless, there is a lack of

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general agreement about the best treatment option.[4]

Controversies surrounding distal radius fracture treatment continue even after significant improvements in diagnostic modalities, classification systems, treatment techniques, and specific implant designs.[5–7] Except for nondisplaced distal radius fractures and coronal shearing fractures, there is little consensus on the type of fracture immobilization varying from splinting or casting to percutaneous pinning, external fixation, and plate fixation, alone or in combination.[8,9] Fracture classification using plain radiographs has fair inter-observer reliability,[10,11] a potential treatment variation source. Moreover, the DRF is often well-tolerated regardless of the treatment. The characteristics of the fracture may be more accurately assessed using computed tomography (CT) scanning and traction radiography. However, the routine use of CT scanning is neither common nor practical.[12–15]

Treatment choices depend on patient factors, fracture patterns, and the surgeon's preference[16–19] Surgeon factors are related to age,[17] sex,[18] the surgeon's subspecialty,[18,20] and the number of years in practice.[18] Moreover, knowing the patients' history affects the management plan more than providing the radiographs alone. Initial radiographs usually look worse than radiographs after the application of traction. In many centers, including ours, a displaced fracture is reduced initially with gentle traction in the emergency room, followed by splinting and referral to hand or trauma surgeons for definitive care. This variability motivated the current study to evaluate whether fracture reduction with traction affects the surgeon's decision on treatment strategy. Therefore, we aim to compare the role of pre- and post-closed reduction radiographs on the treatment choice for DRFs. We hypothesize that adding post-reduction radiographs does not significantly influence the treatment plan compared to analyzing pre-reduction radiographs alone. Our secondary hypothesis is that there is no difference in the choice of intervention between hand surgeons and general orthopedic surgeons.

Materials and Methods

Patients

Under institutional review board (IRB) approval, radiographs of a consecutive series of patients with displaced distal radius fractures were retrieved between October and November of 2021. All displaced extra-articular and intra-articular distal radius fractures categorized as OTA type 23 were included except OTA type 23A1, a nondisplaced extra-articular DRF. The exclusion criteria were inadequate or unsuitable radiographs, concurrent fracture, and patient age less than 18 years. One hundred fifty-two fractures from 152 patients were retrieved, of whom 47 were excluded due to poor radiographs, 26 due to age below eighteen years, and seven due to concurrent or pathologic fracture. Ultimately, 72 fractures in 72 patients were included. All radiographs were anonymized. We obtained four radiographs for each patient, including posteroanterior (PA) and lateral views before and after attempted closed reduction in the emergency room. Images were captured with the same radiographic image intensifier under a constant distance of 50 cm and were stored in the PACS.

Regarding our center's protocol for displaced distal radius fractures, all patients with displaced distal radius fractures received closed reduction under intravenous anesthesia by a senior orthopedic resident in the emergency room. Following reduction, a sugar-tong splint was applied, and the patient was hospitalized for further evaluation. After attempting a closed reduction in the ER, further radiographs were obtained. Demographic data are shown in [Table 1].

Table 1. Demographic data

Characteristic	N=72
Age (year)	
Mean:	40.7
SD:	16
Gender	
Male	23
Female	49
Hand dominance	
Right	69
Left	3
Side affected	
Right	29
Left	43

Treatment Plans

We prepared a treatment survey with six alternatives for distal radius fractures based on our standard of care. Based on a previous study by Fanuele,[19] we divided the treatment options into three major categories: 1) noninvasive treatment (Casting), 2) minimally invasive treatment (including percutaneous K-wire fixation, external fixation, and hybrid K-wire plus External Fixation), and 3) invasive fixation (plate fixation alone or plate with External Fixation). Each surgeon could choose only one of the six treatment alternatives for each fracture.

Radiographic Presentations

We created three PowerPoint presentation sets for the raters based on the study by Avery et al.14 The first presentation included pre-reduction PA and lateral views of 72 patients sequentially, each on a separate page, along with the age, sex, laterality, and hand dominance of the patient. The second set included post-closed reduction PA and lateral views of the patients in a splint, but the order was shuffled to differ from the first set. In the third set, each patient's pre-reduction and post-reduction PA and Lateral radiographs were presented to the raters simultaneously. Radiographs of displaced OTA type 23 fractures consisted of 15 A2, 14 A3, 4 B1, 5 B2, 8 B3, 9 C1, 12 C2, and 5 C3 cases.

Rating Timeline

We asked five fellowship-trained orthopedic hand surgeons and five independent general orthopedic surgeons from five academic centers to choose a treatment plan based on the radiographs. Raters were initially given the pre-reduction presentation to choose one treatment option out of six by rating on an Excel sheet.

Two weeks after receiving the first set of responses, we gave the same surgeons the second set of post-closed reduction radiographs of the same patients in random order. To decrease recall bias, we provided the second presentation only two weeks after receiving the first set of responses while requesting them to avoid referring to their initial responses.

After two additional weeks of receiving the second set of responses, the surgeons were asked to assess pre-reduction and post-reduction PA and lateral radiographs and rate the treatment option once again. The latter rating assessed whether combining pre- and post-reduction radiographs affects the treatment choice and whether pre- or post-reduction radiographs are more influential in decision-making.

Statistical Analysis

We calculated the inter-observer reliability for the pre-reduction, post-reduction, and combined presentations. Inter-observer reliability was calculated separately for the hand surgeons and general orthopedic surgeons. The degree of inter-observer agreement was determined using a generalized version of the Fleiss kappa statistic for different raters.[21]

To assess the significance of intra-observer variability, the McNemar test was used to match data and compare the change in responses from pre- to post-reduction. Due to the clustered structure of the data, the approach published by Durkalski et al.[22] was used to modify the McNemar test.

We used R software version 4.1.1 for statistical analysis. The threshold of significance was chosen at 0.05. In addition, a multinomial logistic model with mixed effects was used to examine the association between surgeons.

Results

A total of 1080 responses were analyzed with no missing data [Table 1]. The treatment plans did not significantly change among pre-reduction, post-reduction, and simultaneous presentations, demonstrating that the post-reduction radiographs could not have improved the treatment agreement. There was a significant tendency in fellowship-trained hand surgeons to select internal fixation in pre-reduction, post-reduction, and simultaneous presentations, compared to general orthopedic surgeons ($P < 0.001$). Within-group agreement was low (Kappa value = 0.2), indicating considerable variance among surgeons in choosing a treatment strategy.

Intra-observer reliability between pre- and post-reduction presentations was nearly perfect (Kappa value = 0.9; $P = 0.402$) [Table 2]. Treatment decisions of 70% of the hand surgeons and 72% of the general orthopaedic surgeons were unchanged between pre- and post-reduction presentations (1.9%, 51%, and 18%), whereas 13% of the hand and general orthopaedic surgeons switched to a more invasive procedure (1.1%, 0.3%, and 12%), and 17% of the hand surgeons and 15% of the general orthopaedic surgeons switched to a minimally invasive approach (5%, 0.8%, and 11%) [Table 2].

Table 2. The prevalence of decisions made by surgeons based on pre- and post-reduction radiographs and the relation between them (sum of * is 100% and sum of # is 100%, which is all treatment decisions by hand surgeons and orthopedic surgeons respectively)

			Post Reduction		
			Noninvasive	**Minimally Invasive**	**Invasive**
Pre-Reduction	**NonInvasive**	*Hand Surgeon*	(1.9%)*	(1.1%)*	(0.3%)*
		Orthopedic Surgeon	(0.6%)#	(2.0%)#	(0%)#
	Minimally Invasive	*Hand Surgeon*	(5.0%)*	(50.7%)*	(11.7%)*
		Orthopedic Surgeon	(2.2%)#	(65.3%)#	(11.2%)#
	Invasive	*Hand Surgeon*	(0.8%)*	(10.9%)*	(17.5%)*
		Orthopedic Surgeon	(0.6%)#	(12.0%)#	(6.2%)#

Based on pre-reduction radiographs, the treatment plans of the fellowship-trained hand surgeons were non-invasive for 4% of the patients, minimally invasive in 67% of the patients, and invasive in 29% of the patients, which changed to 8%, 62%, and 30% in the post-reduction radiographs, respectively. Based on pre-reduction radiographs, the treatment plans of general orthopedic surgeons were non-invasive in 2% of the patients, minimally invasive in 79% of the patients, and invasive in 19% of the patients, which changed to 3%, 79%, and 18% in the post-reduction radiographs, respectively. There were statistically significant differences between fellowship-trained hand surgeons and general orthopedic surgeons ($P = 0.02$). Hand surgeons expressed a greater interest in invasive treatment methods, including plate fixation [Tables 3, 4].

The treatment decisions made in the last step (simultaneous presentations) were similar to those made in the second step (post-reduction presentation) in orthopedic surgery and the first step (pre-reduction presentation) in hand surgery, but this similarity was not statistically significant.

Discussion

According to many studies, fellowship-trained hand surgeons tend to perform open reduction and internal fixation (ORIF) procedures[18,20,23] more than general orthopedic surgeons. Chung et al.[20] reported that patients treated by ASSH members are 2.8 times more likely to undergo ORIF than those treated by surgeons not members of the ASSH. The data for these studies came from Medicare, and the most significant limitation was that the researchers did not have access to radiographic findings or the severity of the fractures. As a result, bias is possible, as more complex fractures requiring ORIF might have been referred to hand surgeons. This bias is also evident in the other studies;[17,19,23] however, a survey-based study[18] reported remarkable interest in ORIF by hand surgeons. Our study showed a similar trend, with hand surgeons more inclined toward ORIF than general orthopedic surgeons during pre- and post-reduction radiograph presentations. This might be due to the hand surgeons' training and experience with ORIF or a higher threshold for acceptable postoperative radiographs.

Table 3. This table presents the frequency of decision changes among different surgeon groups when evaluating pre-reduction radiographs alone versus both pre- and post-reduction radiographs together. Specifically, 22.2% of nonoperative decisions made by hand surgeons remained unchanged after reviewing both radiographs, while 63% and 14.8% of cases initially classified as minimally invasive and invasive treatments, respectively, were revised to nonoperative management. Table 4 follows the same format as Table 3 but focuses on post-reduction radiographs

			Simultaneous pre- and post-reduction review		
			Noninvasive	**Minimally Invasive**	**Invasive**
Pre-Reduction Decision	**Noninvasive**	*Hand Surgeon*	22.2%	2.8%	2.5%
		Orthopedic Surgeon	33.3%	1.4%	2.8%
	Minimally Invasive	*Hand Surgeon*	63.0%	79.8%	44.2%
		Orthopedic Surgeon	66.7%	84.2%	59.7%
	Invasive	*Hand Surgeon*	14.8%	17.4%	53.3%
		Orthopedic Surgeon	0.0%	14.3%	37.5%
	Total		100%	100%	100%

Table 4. Incidence of change decision-making by surgeons regarding post-reduction and both radiography review

			Simultaneous pre- and post-reduction review		
			Noninvasive	**Minimally Invasive**	**Invasive**
Post-Reduction Decision	**Noninvasive**	*Hand Surgeon*	33.3%	6.6%	4.2%
		Orthopedic Surgeon	22.2%	3.2%	1.4%
	Minimally Invasive	*Hand Surgeon*	48.1%	73.2%	47.5%
		Orthopedic Surgeon	66.7%	87.1%	50.0%
	Invasive	*Hand Surgeon*	18.5%	20.2%	48.3%
		Orthopedic Surgeon	11.1%	9.7%	48.6%
	Total		100%	100%	100%

Several studies have indicated that conventional radiographs alone might be inadequate for fracture classification and surgical planning, and a CT scan is recommended in these instances.[24–27] Others have reported encouraging results using traction radiography to assess the extent of distal radius fractures.[14,15,28] However, our study showed that treatment strategy did not significantly change for both hand and general orthopedic surgeons between pre- and post-reduction. Even inter-observer agreement in the second and third steps did not improve substantially, inferring that providing more data about fracture morphology does not substantially change the treatment fracture displacement following reduction is relatively low, plan, which relies more on the surgeon's training and experience. Avery et al.[14] also reported that inter-observer reliability of both traction radiography and CT imaging were fair to poor, supporting our findings. However, this conclusion is in contrast to recent reports by Goldwyn[15] and Machado[28] on the use of traction radiography to improve inter-observer agreement on treatment selection.

Understanding the dynamic nature of the fracture and the alignment obtained by ligamentotaxis is speculative in proposing a minimally invasive intervention. Goldwyn et al.[15] found that traction radiography may be a suitable substitute for CT scans. They also concluded that the likelihood of and traction enhances reduction and alignment in most instances.

In a series of studies conducted in the United States, there was a substantial difference in treatment plans between general orthopedic surgeons and fellowship-trained hand surgeons.[18,20,23] Our results indicate that percutaneous K-wire fixation is the most popular option in both groups. However, non-invasive options were more popular in older studies.[19] Different findings might be due to the difference in fracture severity, resource limitations, departmental routines, cultural differences, and training received.

The small sample size of participating surgeons limits our study. However, we included orthopedic surgeons with different degrees of expertise from multiple centers to represent a diverse group of orthopedic surgeons. We had a large pool of patient vignettes larger than previous studies using traction radiography in distal radius fracture.[14,15,28] Using a sugar-tong splint after traction and closed reduction can obscure fracture pattern visualization, another limitation of our study, also shared by Goldwyn[15] et al.

Conclusion

In conclusion, there is substantial variation among orthopedic surgeons regarding the preferred treatment plan for a distal radius fracture. It seems that multiple factors, including fracture pattern, degree of training, level of expertise, the culture of the region, departmental routines, and availability of resources, substantially influence the variation. However, tractioned and post-reduction radiographs did not improve variation among surgeons. Future studies should assess the impact of variability in surgical decision-making on patient outcomes, recognizing its multifactorial nature and inherent role in clinical practice. Additionally, research should explore factors influencing changes in surgeons' decisions by analyzing demographic characteristics and employing questionnaires to identify underlying reasons.

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