The relationship between radiographic parameters and clinical outcome of distal radius fractures in elderly patients


Department of Orthopaedic Surgery, The Second Affiliated Hospital of Wenzhou Medical University, Wenzhou 325000, PR China

Department of Orthopaedic Surgery, The First Affiliated Hospital of Wenzhou Medical University, Wenzhou 325000, PR China

Department of Radiology, The Second Affiliated Hospital of Wenzhou Medical University, Wenzhou 325000, PR China

Article history:
Received 13 November 2014
Accepted 27 April 2015

Purpose of the study: Treatment of distal radius fractures in elderly patients is controversial. This study explored the relationship between radiographic parameters and clinical outcomes of patients with distal radius fractures following conservative treatment. The study was done using radiographic measurements of distal radius fractures in elderly patients.

Patients and methods: Ninety-two active, healthy patients with conservatively managed distal radius fractures were included in the study. Functional and radiographic assessments were made 1 year after injury. Fifty patients who underwent corrective osteotomy comprised the control group. Radiographic parameters and clinical outcomes were compared between the two groups. The correlation coefficients of the radiographic parameters were analysed using multiple regression.

Result: Radius height (RH), volar tilt (VT) and Mayo wrist and Disabilities of the Arm, Shoulder and Hand (DASH) scores in the experimental group were significantly superior to those of the control group. There was no significant group difference in radial inclination. Multiple regression analysis revealed that the most important factor affecting functional outcome was RH, followed by VT.

Discussion: RH and VT were significantly correlated with the clinical outcomes of conservative treatment of distal radius fractures. RH should be given foremost consideration in elderly patients. Preoperatively, surgeons should evaluate this parameter carefully and be prepared to treat injuries accordingly.

Level of evidence: Level IV retrospective study.

© 2015 Elsevier Masson SAS. All rights reserved.

1. Introduction

Distal radius fractures are among the most common fractures affecting elderly patients [1,2]. In cases of stable fracture, closed reduction and cast immobilization represent the primary choices for treatment [3,4]. Nevertheless, recent reports pertaining to the recommended treatment for elderly patients are equivocal [5–8]. Although there is general agreement regarding the close relationship between anatomy and function in younger patients [9,10], several researchers have suggested that elderly patients should be treated conservatively, even in the context of an unstable fracture pattern, because, in contrast to younger patients, fracture reduction is not associated with functional outcome in this population [8,11].

The correlation between radiological and functional results following distal radial fractures remains controversial. Several previous studies have shown that radiographic parameters do not correlate with self-reported disability [11,12], but others have indicated that radiographic parameters predict functional outcome [13–15].

We employed herein a retrospective comparative design to assess the relationship between radiographic parameters and functional outcome for distal radius fractures in elderly patients using conservative treatment. We also aimed to determine which treatment achieved optimal functional results.

2. Patients and methods

2.1. Study population and design

An observational, retrospective study design was implemented using data obtained from patient records and radiological follow-up examinations. We investigated all patients ≥ 60 years who were...
treated conservatively between 2008 and 2012 for displaced distal radius fractures in emergency wards. Data acquired from patients treated conservatively with closed reduction and cast immobilization were analysed retrospectively. Our institutional review board granted permission for this retrospective study.

Reduction was performed using a standard, intrafractured hematoma block with infiltration of 10 mL 1% Scandicain. Once an acceptable reduction was obtained, a non-circular below-elbow plaster cast was applied up to the metacarpophalangeal joints, with the wrist immobilized in neutral rotation with ulnar deviation and slight flexion. The mean time between injury and reduction was 3 h (range: 30 min–20 h). Radiographic examinations were performed every week, and immobilization was maintained for at least 4–6 weeks. Six weeks post-reduction, the cast was removed, and final standard radiographs were obtained. Corrective functional exercises were then undertaken by all patients. Patients in whom reduction was lost after 1–2 weeks (i.e., unstable fractures [16]; volar tilt < −10°, shortening ≥ 3 mm, articular step-off of 2 mm) were advised to undergo surgical treatment. Fracture reduction was performed by an orthopaedic senior resident. Patients who underwent secondary manipulation at any stage or whose fractures required a secondary surgical intervention were excluded.

A total of 92 active, healthy patients who underwent conservative treatment (15 males, 87 females) were included in the study (conservative group). Their mean age at the time of injury was 69 years (range: 60–94 years). The average follow-up time was 15 months (range: 12–24 months). All fractures were classified according to the Müller AO classification system as A2:18, A3:50, B2:5, C1:3, C2:10 or C3:6.

For the control group [15], we examined preoperative radiographic parameters and clinical outcomes of 50 patients ≥ 60 years of age who presented with malunion of distal radius fractures, with severe pain or wrist dysfunction that led to surgical treatment (corrective osteotomy) at our hospital (osteotomy group). The control patients were referred to our institution by a local practitioner or associate hospital.

2.2. Appraisal

All radiographs included acquisition of standardized, strict anteroposterior and lateral views of the wrist with the forearm in a neutral position. Standard radiographic assessment was performed every week for 6 weeks and then at 3, 6 and 12 months, and again as part of the final follow-up examination, which included assessment of radial height (RH), volar tilt (VT) and radial inclination (RI; Fig. 1). Digital radiographic assessment and AO fracture type classification were performed by two independent assessors using a computerized radiographic system (PACS). Simultaneously, functional outcome was evaluated, including a physician-reported Mayo wrist score (MWS; excellent: 90–100; good: 80–90; fair: 60–80; poor: < 60) [17] and self-reported measures of disabilities of the arm, shoulder and hand (DASH) [18]. Radiographic parameters and outcomes (MWS and DASH) in the conservative group were compared with those obtained preoperatively in the osteotomy group, and the correlations between radiographic parameters and clinical outcomes were analysed by multiple regression analysis.

2.3. Statistical analysis

Descriptive statistics were used to describe the basic characteristics of the patient groups. Data were analysed using Student's unpaired test and multiple regression and comparison analyses (Scheffe's F-test). A P value < 0.05 was taken to indicate statistical significance. Data are provided as means ± SD. Statistical analyses were performed using the SPSS for Windows software package (ver. 19; SPSS Inc., Chicago, IL, USA).

3. Results

The majority of the 92 distal radius fracture patients achieved good functional outcomes. Radiographic findings and clinical outcomes were recorded (Table 1). In the conservative group, RH was 9.33 ± 1.72 mm, VT was 0.837 ± 3.92° and RI was 11.18 ± 2.73°. The MWS was 79.48 ± 3.93 (excellent, n = 0; good, n = 59; fair, n = 33), and the DASH score was 9.54 ± 2.60. In the osteotomy group, RH was 4.55 ± 1.50 mm, VT was −7.76 ± 6.14° and RI was 10.48 ± 2.39°. The MWS was 57.46 ± 3.37, and the DASH score was 39.62 ± 3.99. Radiographic parameters (RH and VT), and clinical outcomes (MWS and DASH) were superior in the conservative versus osteotomy group, and there was no significant group difference in RI.

Multiple regression analysis revealed that radiographic parameters were positively correlated with functional results. In the conservative group, RH and VT were significantly correlated with the MWS and DASH score (Table 2). As shown in Figs. 2 and 3, the correlation coefficient (R) for RH and the MWS was 0.870, and

<table>
<thead>
<tr>
<th>C group</th>
<th>O group</th>
<th>t</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH (mm)</td>
<td>9.33 ± 1.72</td>
<td>4.55 ± 1.50</td>
<td>16.51</td>
</tr>
<tr>
<td>VT (°)</td>
<td>0.837 ± 3.92</td>
<td>−7.76 ± 6.14</td>
<td>8.96</td>
</tr>
<tr>
<td>RI (°)</td>
<td>11.18 ± 2.73</td>
<td>10.48 ± 2.39</td>
<td>1.52</td>
</tr>
<tr>
<td>MWS (point)</td>
<td>79.48 ± 3.93</td>
<td>57.46 ± 3.37</td>
<td>33.48</td>
</tr>
<tr>
<td>DASH (point)</td>
<td>9.54 ± 2.60</td>
<td>39.62 ± 3.99</td>
<td>−48.06</td>
</tr>
</tbody>
</table>

MWS: Mayo wrist score; DASH: Disabilities of the Arm, Shoulder and Hand Score; RH: radius height; VT: volar tilt; RI: radial inclination.
that for VT and the MWS was 0.690. The R values for RH and VT and for RH and the DASH score were 0.841 and 0.707, respectively (Figs. 4 and 5).

We arbitrarily categorized MWS in the conservative group as follows: MWS ≥ 80 = acceptable and MWS < 80 = unacceptable. These two subgroups were then compared to assess the tolerable range of radiographic parameters when patients received reduction treatment to achieve an acceptable functional outcome. In the conservative group, RH was significantly superior in patients with a MWS ≥ 80 (10.26 ± 0.88 mm) than for those with a MWS > 80 (7.67 ± 1.61 mm, P < 0.001; Fig. 4). Similarly, VT for patients was significantly superior in the conservative group patients with a MWS ≥ 80 (2.54 ± 3.04) than for those with a MWS < 80 (-2.21 ± 3.46, P < 0.001; Fig. 5).

### Table 2
Correlation between radiographic parameters and clinical outcomes in the conservative group (multiple regression analysis, P < 0.001).

<table>
<thead>
<tr>
<th></th>
<th>Mayo wrist score</th>
<th></th>
<th>DASH score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β, t, P value</td>
<td></td>
<td>β, t, P value</td>
</tr>
<tr>
<td>RH (mm)</td>
<td>1.984, 16.72, &lt; 0.001</td>
<td></td>
<td>-1.27, -14.77, &lt; 0.001</td>
</tr>
<tr>
<td>VT (◦)</td>
<td>0.691, 9.036, &lt; 0.001</td>
<td></td>
<td>-0.469, -9.407, &lt; 0.001</td>
</tr>
</tbody>
</table>

β: regression coefficient; RH: radius height; VT: volar tilt.

4. Discussion

Although stable distal radius fractures are typically treated conservatively, the past decade has seen changes in surgical practice and techniques. Indications for surgery have been extended and refined based on new insights into the pathophysiology of the distal end of the forearm and technological advances in implant design. However, there is still a lack of evidence supporting guidance for conservative and surgical treatments of this common upper extremity fracture [7,19]. In our study, the majority of patients achieved a good functional outcome. Therefore, it is our opinion that elderly patients could be treated conservatively even in the context of an unstable fracture pattern.

RH, VT and RI are the most commonly used radiographic parameters predicting functional outcome. However, there has been

Figs. 2 and 3. Scatter diagram of the correlation between the MWS and RH or VT in the conservative group. RH and VT were significantly correlated with the MWS. R correlation, R² contribution ratio.

Figs. 4 and 5. Scatter diagram of the correlation between the DASH score or RH and VT in the conservative group. RH and VT were significantly correlated with the DASH score. R correlation, R² contribution ratio.
Fig. 6. RH was significantly superior in patients of the conservative group with a MWS ≥ 80 compared with a MWS < 80. * Denotes a significant difference.

Fig. 7. VT was significantly superior in patients of the conservative group with a MWS ≥ 80 compared with a MWS < 80. * Denotes a significant difference.

controversy concerning the relative importance of each factor in influencing functional outcome. Tsukazaki et al. [20] showed that only VT correlated with functional outcomes; there was no correlation between RH and loss of grip strength or range of motion. In a study by Batra et al. [21], radial length was the radiographic parameter most strongly correlated with final functional outcome; loss of normal VT and RI were also associated with functional outcome but to a lesser extent. In our study, the R values for functional score and radiographic parameters differed; RH was superior to VT, but there was no significant difference in RI between the conservative and osteotomy groups. This indicates that RH is the most important radiographic determinant of final function, and loss of RH was associated with poor function. Restoration of VT also had a positive influence on functional outcome, but to a lesser extent. Kodama et al. [15] reported similar results: VT and ulnar variance were significantly correlated with clinical outcomes, although RH was not evaluated.

Radial shortening after distal radius fracture is among the major factors affecting wrist joint function. When the radius shortens, load on the ulnar increases, which can significantly alter the contact position and degree of stress, leading not only to traumatic arthritis (caused by increased stress in the contact area), but also to alterations in the conduction load, which can cause degenerative changes in the articular cartilage and affect the stability of the wrist joint [22]. In our study, patients with good functional assessment scores (MWS ≥ 80) had a RH ≥ 9.3 mm, whereas patients with poor function (MWS < 80) had a mean RH < 6 mm. We believe that doctors should focus on restoring RH after distal radius fracture. If patients have a RH < 9.3 mm on radiographic measurement after reduction treatment, reduction should be attempted once more only, with consideration of surgery to restore RH if necessary.

Normal variation of the VT ranges between 4° and 20° (mean = 11°) is directly related to the functional position of the wrist, and affects wrist dorsiflexion. If VT decreases below dorsal tilt, the contact surfaces of the radius and scaphoid lunate bone will cause dorsal displacement. With an increase in angle, displacement is more obvious. Pressure on the radiocarpal joint surface and contact area are also significant factors. Therefore, the dorsal area of the radiocarpal joint is under abnormally severe pressure for an extended period, resulting in ligament thinning and stretching. Therefore, the stability of the radiocarpal joint continues to decline and may lead to carpal joint dysfunction [23]. In our study, patients with good functional assessment scores (MWS ≥ 80) had a mean VT of 2.54°, whereas those with poor function (MWS < 80) exhibited a mean VT of −2.21°. Therefore, VT should be > 3° following reduction treatment of distal radius fractures.

Distal radius fracture, similar to femoral neck fracture, is frequently encountered by orthopaedic surgeons during daily clinical practice, particularly in elderly patients with underlying osteoporosis. Accordingly, standardisation of the treatment approach, such that orthopaedic surgeons can determine their treatment policy in accordance with common criteria, is required. Our study was limited by its retrospective nature; therefore, prospective trials are required.

5. Conclusions

The parameters of RH and VT were significantly correlated with clinical outcomes for patients with conservatively treated distal radius fractures. RH should be considered first in elderly patients.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

patients.


