Distal radius fractures
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Non-operative treatment of displaced distal radius fractures leads to good functional outcomes, however at the expense of 40% subsequent surgeries.
ABSTRACT

Background: Although secondary displacement following closed reduction and plaster immobilisation is high, several guidelines still recommend non-operative treatment for displaced distal radius fractures with an adequate closed reduction.

Purpose: The purpose of this study was to evaluate functional outcomes, measured with the Disability of the Arm, Shoulder and Hand (DASH) questionnaire, in non-operative treated patients with displaced distal radius fractures and an adequate closed reduction confirmed on radiograph.

Materials and methods: From a retrospective database, we reviewed non-operative treated adult patients with an unilateral displaced distal radius fracture and adequate closed reduction confirmed on radiograph. The primary outcome was the DASH score at 12 months. DASH scores were prospectively collected pre-trauma and at three, six and 12 months. Secondary outcome was the number of subsequent surgeries due to secondary displacement or a symptomatic malunion, and their possible predictors. Additionally, the difference in DASH scores between patients who were treated due to secondary displacement and asymptomatic malunion was compared.

Results: One-hundred and sixteen patients were included. The median age was 62 years and 79% was female. Fractures were classified according to the AO/OTA classification as follows: AO/OTA type A (49%), AO/OTA type B (3%), AO/OTA type C (48%). After 12 months the median DASH score was 15. Forty-six (40%) patients underwent subsequent surgery due to a secondary displacement or symptomatic malunion. No significant differences in DASH scores between patients who were treated non-operatively and patients who received subsequent surgery were found. Younger patients were more likely to undergo subsequent surgery. Patients with a symptomatic malunion had significant higher DASH scores compared to patients with secondary displacement.

Discussion: Non-operative treatment of displaced distal radius fractures after adequate closed reduction confirmed on radiograph leads to acceptable functional outcomes after 12 months, however, at the expense of 40% subsequent surgeries.
INTRODUCTION

One in six fractures at the Emergency Department is a distal radius fracture.\textsuperscript{1,2} Almost two-third of these fractures are displaced and need to be reduced.\textsuperscript{3} For displaced distal radius fractures treated with an adequate closed reduction, there is no consensus whether these patients should be provided surgery or not. Both non-operative treatment with plaster immobilisation and open reduction and internal fixation show good functional results.\textsuperscript{4-7} Although, secondary displacement following closed reduction and plaster immobilisation is ranging between 43 and 60\% and increasing with age\textsuperscript{8-10}, several International Guide lines still recommend non-operative treatment for displaced distal radius fractures with an adequate closed reduction.\textsuperscript{11-15} The ideal treatment for initially displaced distal radius fractures should aim on proper alignment, no secondary displacement leading to subsequent surgery and the optimum functional outcomes. Despite the fact that several authors proposed predictors for secondary displacement, we are still not able to predict which fractures are prone for secondary displacement.\textsuperscript{8,10,16} And therefore we are still not able to guide the decision to operate or not based on these predictors. To give guidance to this discussion, patient reported outcome measures should be taken into account.

The purpose of this study was to evaluate functional out comes, measured with the Disability of the Arm, Shoulder and Hand (DASH) questionnaire, of non-operative treated displaced distal radius fractures with adequate closed reduction confirmed on radiograph. Secondary, we aimed to determine the rate of subsequent surgeries due to secondary displacement or a symptomatic malunion, and their possible predictors.

METHODS

Study design

From a retrospective database, we reviewed adult patients with a unilateral displaced distal radius fracture and adequate closed reduction confirmed on radiograph, treated between 2007 and 2011. The setting was a teaching hospital in the Netherlands. Adequate closed reduction was defined, according to the Dutch National Guidelines\textsuperscript{12}, as ≥15° radial inclination, <5 mm loss of radial height, <20° volar angulation, <15° dorsal angulation, and an intra-articular gap or step-off <2 mm.
Inclusion criteria were adult patients with an unilateral displaced distal radius fracture, caused by a high or low energetic trauma, and an adequate closed reduction confirmed on radiograph, who were treated non-operatively with plaster immobilisation. Patients were treated with a below elbow cast for four to six weeks. Patients were seen at the outpatient clinic one to two weeks after the initial trauma and after four to six weeks when the plaster was removed. Exclusion criteria were primarily operatively treated patients. The primary outcome was the DASH scores at 12 months. Secondary outcomes were the number of subsequent surgeries due to secondary displacement or symptomatic malunion and their possible significant predictors. Additionally, the difference in DASH scores between patients who were treated due to secondary displacement and a symptomatic malunion were compared.

Data collection

Demographic data included gender, age at trauma, injured side, dominant hand, AO/OTA fracture classification and presence of a concomitant fracture of the distal ulna. Intraoperative data including dorsal or volar approach and plate removal during follow-up were also recorded. All fractures were classified according the AO/OTA fracture classification on standard posteroanterior and lateral radiographs.

DASH scores were prospectively collected pre-trauma and at three, six and 12 months. The DASH score is a 30item, Patient Reported Outcome Measure (PROM), which measures disability in patients with musculoskeletal disorders of the upper limb. The lowest score is zero, indicating no disability, and the highest score is 100, indicating severe disability. The pre-trauma DASH score was collected during the Emergency Department visit and corresponded to the situation in which the patients was not yet injured.

Lastly, subsequent surgeries due to secondary displacement or a symptomatic malunion were recorded. Secondary displacement was defined as loss of reduction during plaster treatment resulting in a position of < 15° radial inclination, > 15° of dorsal angulation or > 20° of volar angulation, > 3 mm positive ulnar variance or > 2 mm of articular step-off or gap, which required surgical treatment. Symptomatic malunion was defined as union of the fracture in a position with the same radiographic measurements as mentioned above, causing notable pain or disability. These patients were treated with a corrective osteotomy. Patients undergoing subsequent surgery due to secondary displacement or a symptomatic malunion were included if the operation was performed within one year following the initial trauma.
 Statistical analysis

Data were analysed using SPSS, version 22.0 (Chicago, Illinois, USA). Descriptive analysis was performed to compare baseline characteristics. For continuous data, medians and interquartile ranges (nonparametric data) were calculated. Normality was determined by using the Shapiro-Wilk test (if p>0.05 data was normally distributed) and, in addition, a visual check was performed by plotting the data distribution in a histogram. Categorical data were tested with a Chi-square test or a Fischer Exact test (when the expected count was less than 5). Differences between continuous data were tested with a Mann-Whitney U test (not-normally distributed).

To analyse possible significant predictors for subsequent surgery, variables with p<0.10 in univariate analysis were entered into multivariable analysis using binary logistic regression. Missing repeated measurements data for DASH scores were imputed using median imputation for missing pre-trauma DASH scores and last observation carried forward (LOCF), first observation carried back ward (FOCB) and interpolation for missing DASH scores at three, six and 12 months.

 RESULTS

A total of 116 adult patients were included. The median age at trauma was 62 years (IQR 50–71) and 79% of the patients were female. Of all patients, 39% experienced a trauma of the dominant hand. There were 49% AO/OTA type A, 4% AO/OTA type B and 47% AO/OTA type C fractures. Sixty-three patients had a concomitant fracture of the ulnar styloid process and five patients had a concomitant distal ulna fracture (Table 1). The median pre-trauma DASH score was zero (IQR 0–0). DASH scores at three months after trauma were the highest and afterwards decreased. The median DASH score at 12 months was 15 (IQR 5.8–28) (Table 2). Missing DASH scores ranged from 14.7% pre-trauma to 50.9% at 12 months.

Fifty-two patients had secondary displacement or a malunion (45%), of which 46 (40%) patients underwent subsequent surgery; 31 patients (67%) due to secondary displacement and 15 patients (33%) due to a symptomatic malunion. Six patients had an asymptomatic malunion and did not receive secondary surgery.
Table 1. Baseline demographics

<table>
<thead>
<tr>
<th></th>
<th>Total N = 116</th>
<th>Non-operative treatment N = 70</th>
<th>Subsequent surgery N = 46</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (years (IQR))</td>
<td>62 (50-71)</td>
<td>64 (56.8-73)</td>
<td>58.5 (45.8-64)</td>
<td>0.004</td>
</tr>
<tr>
<td>Female patients (%)</td>
<td>92 (79.3)</td>
<td>59 (84.3)</td>
<td>33 (71.7)</td>
<td>0.103</td>
</tr>
<tr>
<td>Injury to dominant side (%)</td>
<td>44 (39.3)</td>
<td>28 (41.2)</td>
<td>16 (36.4)</td>
<td>0.611</td>
</tr>
<tr>
<td>AO/OTA classification (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type A</td>
<td>57 (49.1)</td>
<td>36 (51.4)</td>
<td>21 (45.7)</td>
<td></td>
</tr>
<tr>
<td>Type B</td>
<td>4 (3.5)</td>
<td>0 (0)</td>
<td>4 (8.7)</td>
<td>0.052</td>
</tr>
<tr>
<td>Type C</td>
<td>55 (47.4)</td>
<td>34 (48.6)</td>
<td>21 (45.7)</td>
<td></td>
</tr>
<tr>
<td>Fracture of ulna (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>48 (41.4)</td>
<td>32 (45.7)</td>
<td>16 (34.8)</td>
<td></td>
</tr>
<tr>
<td>Ulnar styloid process</td>
<td>63 (54.3)</td>
<td>34 (48.6)</td>
<td>29 (63)</td>
<td>0.333</td>
</tr>
<tr>
<td>Distal ulna</td>
<td>5 (4.3)</td>
<td>4 (5.7)</td>
<td>1 (2.2)</td>
<td></td>
</tr>
</tbody>
</table>

Values presented in bold are statistically significant. N: number; IQR: inter quartile range

Table 2. Median DASH-scores during follow-up

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Non-operative treatment</th>
<th>Subsequent surgery</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-trauma (IQR)</td>
<td>0 (0-0)</td>
<td>0 (0-0)</td>
<td>0 (0-6.5)</td>
<td>0.360</td>
</tr>
<tr>
<td>3 months (IQR)</td>
<td>28.5 (16-48)</td>
<td>28 (16.8-46.5)</td>
<td>29.5 (15-49.5)</td>
<td>0.815</td>
</tr>
<tr>
<td>6 months (IQR)</td>
<td>18.5 (8.8-34.3)</td>
<td>18 (8-28.5)</td>
<td>23 (9-43.8)</td>
<td>0.474</td>
</tr>
<tr>
<td>12 months (IQR)</td>
<td>15 (5.8-28)</td>
<td>15.5 (5-25)</td>
<td>15 (6.5-39.5)</td>
<td>0.388</td>
</tr>
</tbody>
</table>

Values presented in bold are statistically significant. IQR: inter quartile range

(Figure 1). In 22 patients, the secondary displacement was treated with a volar locking plate (71%). The other nine patients were treated by a dorsal approach. All of the patients with secondary displacement were operatively treated within one month after the initial trauma, at an average of 2 weeks. The patients with a malunion were mostly treated with a dorsal locking plate (80%). In 20%, a volar locking plate was applied. The median time after trauma at which a corrective osteotomy for a symptomatic malunion was performed was 20 weeks (IQR 7 to 33 weeks). In 5% of these patients, plate removal was performed subsequently.
Non-operative treatment versus subsequent surgery

No significant differences in baseline characteristics were found between non-operatively treated patients and patients who underwent subsequent surgery, expect for age at trauma ($P = 0.004$) (Table 1). The multivariable analysis identified age as a significant predictor for subsequent surgery (OR 0.961; 95% CI 0.934–0.988; $P = 0.005$). Younger patients were more likely to undergo subsequent surgery compared to older patients.

After three ($P = 0.815$), six ($P = 0.474$) and 12 ($P = 0.388$) months, no significant difference in DASH scores between the two groups were found (Figure 2). Moreover, the change in pre-trauma DASH scores and DASH scores after 12 months was not significantly different ($P = 0.941$).

From the 46 patients who underwent subsequent surgery, patients with a symptomatic malunion had significantly higher DASH scores at three (median DASH score secondary displacement 24, symptomatic malunion 43) ($P = 0.033$), six (median DASH score secondary displacement 15, symptomatic malunion 43) ($P = 0.011$) and 12 (median DASH score secondary displacement 11, symptomatic malunion 43) ($P = 0.005$) months compared to patients with secondary displacement (Figure 3).
Figure 2. DASH-scores during follow-up: non-operative treatment versus subsequent surgery.

Figure 3. DASH-scores during follow-up: secondary displacement versus symptomatic malunion.
DISCUSSION

There is no consensus whether patients with initially displaced distal radius fractures treated with adequate closed reduction should receive non-operative or operative treatment. Since guidelines still recommend non-operative treatment in these patients, the purpose of this study was to evaluate functional outcomes in non-operative treated patients with displaced distal radius fractures with an adequate closed reduction confirmed on radiograph.

Non-operative treatment of patients with displaced distal radius fractures with an adequate closed reduction confirmed on radiograph leads to acceptable functional outcomes after 12 months, measured with the DASH score. However, non-operative treatment correspondingly leads to a high percentage of subsequent surgery (40%). Nevertheless, we found no significant differences in DASH scores after 12 months between patients treated non-operatively and patients that received subsequent surgery due to secondary displacement or symptomatic malunion. From the patients who underwent subsequent surgery, patients with a symptomatic malunion had significantly higher DASH scores at three, six and 12 months, compared to patients who underwent surgery because of secondary displacement. During the 12-month follow-up, we found that DASH scores were the highest three months after trauma and afterwards decreased. This development in DASH scores is supported by the literature. The DASH score in the group that underwent subsequent surgery was higher until six months follow-up compared to the group that was treated non-operatively, however the difference was not significantly different during the entire follow-up. Similar DASH scores at three, six and 12 months for non-operatively treated patients with an initially displaced distal radius fracture have been reported.

Patients with a symptomatic malunion had significantly higher DASH scores during the entire follow-up compared to patients with secondary displacement. This difference could be caused since patients with a symptomatic malunion were treated on a median of 20 weeks following trauma and patients with a secondary displacement were all operatively treated within one month after the initial trauma. Good to satisfactory results have been reported after corrective osteotomy of distal radius malunion. However, these studies focused on the long-term functional outcomes, while the last follow-up moment in our study was at 12 months after the initial trauma. Consequently, this could indeed introduce bias, since we measured at a different postoperative follow-up time.
The age at trauma was significantly different between the two groups and a younger age was also a significant predictor for subsequent surgery. This is in contrast with the literature, where an increase in secondary displacement is associated with an increase in patient age and therefore the development of a malunion. However, we only included the patients with symptomatic malunions, thus the patients with malunions with functional impairments or severe pain who would benefit from a corrective osteotomy. It is known that in elderly patients an inadequate radiographic reduction seems not to correlate with disability. So, where elderly patients have a malunion which is asymptomatic, younger patients could have a malunion which is symptomatic due the higher functional demands. This could be the fact for our study, in which six patients with a mean age of 75 years had an asymptomatic malunion, and we did not analyse those patients in this study.

This study has some limitations. First, because this was a retrospective study, we had missing data. DASH scores were not complete during the entire follow-up. This was especially the case at 12 months follow-up. The missing data could be explained by patients not completing the entire follow-up because they had no complaints and considered the outpatient visit unnecessary. This would have given an overestimation of the DASH score at 12 months. However, data could also be missing because patients with a lot of complaints have gone to other hospitals. This would instead have given an underestimation of the DASH score at 12 months. Therefore, we chose to impute the missing data by using a missing data method for repeated measurements. Additionally, due to the retrospective character there could be bias in the decision to operate on patients with secondary displacement or a symptomatic malunion. Second, the pre-trauma DASH score was collected at the Emergency Department when the patient was already injured. This could have given an underestimation of pre-trauma DASH score and may explain why the median pre-trauma DASH scores was zero, while we know that the DASH score in the normative population is ten. Lastly, more aspects should be kept in mind in the decision making process. For example, no information was available on the occupation of the patient and the preference of the patient and surgeon. It is unknown how this could have influenced the decision making for subsequent surgery.

Although non-operative treatment of displaced distal radius fractures after adequate closed reduction confirmed on radio graph leads to acceptable functional outcomes after 12 months, 40% of these patients undergo subsequent surgery. Although several authors proposed predictors for loss of reduction, we are still
not able to predict which fractures are going to secondary displace and should therefore be treated primarily operatively.\textsuperscript{8,16} The ideal treatment should result in eventual healing with proper alignment, no secondary displacement leading to subsequent surgery and the best functional outcomes. Moreover, no subsequent surgery means a faster recovery that could help people of working age to return to their job earlier and thereby reducing indirect costs. And for the elderly patients, reducing the length of independency gives them a higher change to return to their pre-injury level of functioning.\textsuperscript{26} Currently two prospective randomised trials, which are determining the functional outcomes of non-operative treatment compared to ORIF for displaced extra-articular (VIPER trial)\textsuperscript{27} and intra-articular (VIPAR trial)\textsuperscript{28} distal radius fractures, are recruiting patients. These trials could help solve the lack of consensus on displaced distal radius fracture management in the future.
REFERENCES


