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CHAPTER 2

Reliability of the Robinson classification for displaced comminuted midshaft clavicular fractures

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Abstract

This study aimed to assess the reliability of the Robinson classification for displaced comminuted midshaft fractures. 102 surgeons and 52 radiologists classified 15 displaced comminuted midshaft clavicular fractures on anteroposterior and 30-degree caudocephalad radiographs twice. For both surgeons and radiologists inter-observer and intra-observer agreement significantly improved after showing the 30-degree caudocephalad view in addition to the anteroposterior view. Radiologists had significantly higher inter- and intra-observer agreement than surgeons after judging both radiographs ($\kappa_{\text{multirater}} 0.81$ vs. $0.56$; $\kappa_{\text{intra-observer}} 0.73$ vs. $0.44$). We advise to use two-plane radiography and to routinely incorporate the Robinson classification in the radiology reports.
INTRODUCTION

Classification systems for fractures serve as a basis for treatment choice and outcome prediction. Classification systems for clavicular fractures have been developed by Allman for the anatomical site, by Neer for the lateral third fractures, and by Craig for the lateral and medial third fractures. The Robinson classification has been established as the most appropriate classification method for the midshaft clavicular fractures with the highest prognostic value for treatment outcome in terms of union and non-union. The Robinson classification differentiates between two main types of midshaft clavicular fractures i.e., undisplaced (type A) fractures and displaced (type B) fractures (Figure 1). In daily practice, the differentiation between displaced simple comminuted fractures (type 2B1) and segmental comminuted fractures (type 2B2) is the most challenging. To our knowledge the reliability of the Robinson classification system for this distinction has not been analyzed. The aim of our study was to assess the inter-observer and intra-observer agreement on the Robinson classification for type B midshaft clavicular fractures among surgeons with an interest in fracture surgery and radiologists with an interest in skeletal imaging.

Figure 1  Robinson classification for midshaft clavicular fractures.
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MATERIAL AND METHODS

Radiographs

Fifteen displaced and comminuted midshaft clavicular fractures of adult patients were selected randomly from the electronic hospital registry. These fractures had been classified according to the Robinson clavicle fracture classification (Figure 1)\(^4\) by an expert panel consisting of 2 trauma surgeons and a radiologist. Both the anteroposterior (AP) trauma radiograph and the 30 degree caudocephalad radiograph of the fractures were retrieved from the medical records. For examples see Figure 2.

![Figure 2](image)

**Figure 2** Three series of anteroposterior (A) and 30-degree caudocephalad (B) radiographs of midshaft clavicular fractures.
Survey

The 30 radiographs of the 15 displaced and comminuted midshaft clavicular fractures were presented in an online survey developed with LimeSurvey 1.91+ software. For each fracture, the radiographs were presented on separate pages, starting with the AP radiograph and followed by the corresponding 30-degree caudocephalad radiograph. The respondents had to classify each midshaft clavicular fracture presented on the radiographs and were not able to revise previously given answers. Eight weeks after the initial assessment, the survey was presented again in a different case order to determine the intra-observer reliability.

Respondents

The online survey was performed in the Netherlands and Belgium amongst the clinical members of the Dutch Trauma Society, members of the Dutch Society of Radiology, and members of the muscular and skeletal imaging division of the Royal Belgian Society of Radiology in August 2011. Members of these societies with an active e-mail address were invited to participate in the survey. A reminder e-mail was sent if the respondent had not filled out the survey.

Statistical analysis

The inter-observer agreement on the Robinson classification for the AP radiographs and 30-degree caudocephalad radiographs was calculated using the free-marginal multirater kappa ($\kappa_{\text{multirater}}$) for categorical data\(^6\) for the respondent group as a whole and separately for surgeons and radiologists. The strength of the inter-observer agreement was determined using the table of Landis and Koch, that indicates kappa $\leq 0$ as poor agreement, 0.01 to 0.20 as slight agreement, 0.21 to 0.40 as fair agreement, 0.41 to 0.60 as moderate agreement, 0.61 to 0.80 as substantial agreement and 0.81 to 1.00 as almost perfect agreement.\(^7\) For each $\kappa_{\text{multirater}}$ the 95% confidence interval (95%-CI:) was calculated. If the 95%-CI’s for the $\kappa_{\text{multirater}}$ estimates of the surgeons and radiologists did not overlap, the inter-observer agreement between the respondent groups was considered statistically different.

The intra-observer agreement was calculated using Cohen’s kappa ($\kappa_{\text{intra-observer}}$) for each respondent. The mean intra-observer agreement was calculated for the group of respondents as a whole, and separately for surgeons and radiologists.
This was calculated for the AP radiographs and 30-degree caudocephalad radiographs. Differences between estimates of the intra-observer agreement for the two respondent groups (surgeons and radiologists) and for both types of radiographs (AP and 30-degree caudocephalad) were considered statistically significant if the 95%-CI’s did not overlap. All statistical analyses were performed using IBM SPSS version 20 (Statistical Package for the Social Sciences Inc., Chicago II, USA).

**RESULTS**

Of the 242 invited members of the Dutch Trauma Society 112 filled out the first survey (response rate 46.3%), of which 102 surveys were complete. Those 102 surgeons received the second survey after eight weeks, of which 66 were returned (response rate 64.7%). Of the second survey, nine were incomplete and therefore excluded, leaving 57 surveys for analysis (Figure 3). Of the 132 invited radiologists 53 returned the first survey (response rate 40.1%), of which 52 were complete. In the second round 35 of the 52 radiologists returned the survey (response rate 67.3%; Figure 3). The expert panel adjudicated the 15 midshaft clavicular fractures as 6 type 2B1 and 8 type 2B2 fractures.

**Inter-observer agreement on the Robinson classification**

The $\kappa_{\text{multirater}}$ values for agreement on the classification of displaced comminuted fractures in the total observer group ranged between 0.42 (moderate agreement) and 0.81 (almost perfect agreement) (Table 1). When more information was given by means of the 30-degree radiographs, the inter-observer agreement on classification was significantly higher than for the AP radiographs alone (Table 1). The inter-observer agreement between the radiologists tended to be better than between the surgeons, but the difference between the respondent groups was statistically significant only after reviewing the 30-degree radiographs.
Reliability of the Robinson classification

Figure 3  Flowchart of invitations sent and responses received.

Table 1  Multi-rater free-marginal kappa coefficients for inter-observer agreement on the Robinson classification in survey 1 and the intra-observer agreement between survey 1 and 2.

<table>
<thead>
<tr>
<th></th>
<th>Inter-observer agreement</th>
<th>Intra-observer agreement</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>Kappa</td>
</tr>
<tr>
<td>Surgeons + Radiologists</td>
<td>154</td>
<td>0.45</td>
</tr>
<tr>
<td>AP radiograph</td>
<td></td>
<td>0.63</td>
</tr>
<tr>
<td>30 degree radiograph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeons</td>
<td>102</td>
<td>0.42</td>
</tr>
<tr>
<td>AP radiograph</td>
<td></td>
<td>0.56</td>
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<tr>
<td>30 degree radiograph</td>
<td></td>
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<tr>
<td>Radiologists</td>
<td>52</td>
<td>0.52</td>
</tr>
<tr>
<td>AP radiograph</td>
<td></td>
<td>0.81</td>
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<tr>
<td>30 degree radiograph</td>
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</table>

N=number of respondents
Intra-observer agreement on the Robinson classification

The overall intra-observer agreement was fair to moderate for the combined respondent groups on classification of the AP and 30-degree radiographs respectively ($\kappa_{\text{intra-observer}}$ for AP: 0.31, for 30-degree: 0.55; Table 1). For both surgeons and radiologists, the intra-observer agreement on classification of the 30-degree caudocephalad radiographs was significantly higher compared to that of the AP radiographs. The reliability within observers seemed higher for the radiologists, but this difference was statistically significant only for the 30-degree radiographs (Table 1).

DISCUSSION

In this study we found that the inter-observer and intra-observer agreement on the Robinson classification of displaced and comminuted midshaft clavicular fractures was moderate. Additional 30-degree caudocephalad radiographs improved both the inter-observer and intra-observer agreement. Radiologists were found to classify these fractures more reliably than surgeons. Their intra-observer and inter-observer agreement was substantial after viewing the fractures on two-plane radiography.

Robinson validated his classification system in a group of five orthopaedic surgeons who reviewed 20 series of lateral, midshaft and medial clavicular fractures. He found substantial inter-observer agreement, with an overall mean kappa of 0.77. The intra-observer agreement was excellent with a mean kappa coefficient of 0.84 (range 0.69 to 0.88). In the present study, the estimated kappa coefficients were lower than those found by Robinson. This may be explained by the fact that the current study only focused on the distinction between type 2B1 and 2B2 fractures, whereas Robinson included all types of clavicular fractures. In our study, we deliberately did not include undisplaced or angulated midshaft clavicular fractures (type 2A1 and 2A2), because these types of fractures are uncommon in adults and have good union results without surgical intervention.

In our survey, the fractures were first classified based on an AP radiograph. Subsequently additional insight into the fracture characteristics were provided on a 30-degree radiograph. We therefore expected that observers would classify the fractures on the 30-degree radiograph more reliably. This assumption was confirmed
for the intra-observer and inter-observer agreement of both the surgeons and specialized musculoskeletal radiologists in our study.

The decision whether or not to operate midshaft clavicular fractures may depend on the physical abilities and wishes of the patient; nevertheless it is also based on the amount of shortening, displacement and comminution as judged on the radiograph. Displacement and comminution of the clavicle are the most important factors for determining the fracture type according to the Robinson classification. In the study of Jones et al.\textsuperscript{9} it was found that these fracture characteristics could reliably be assessed on AP and 30-degree caudocephalad radiographs, but shortening could not. Two other studies showed that the extent of shortening and dislocation ad latum might be underestimated if displayed on AP radiographs alone.\textsuperscript{10,11} The current study shows that the extent of comminution, as displayed in simple or wedge comminuted (2B1) and isolated or segmental comminuted fractures (2B2), is difficult to classify on both AP and 30-degree caudocephalad radiographs. The prognostic value of the Robinson classification as described by O’Neill et al.\textsuperscript{5} may therefore be overrated, because there is a possibility that the clavicular fracture is wrongly classified. In contrast to our study, Jones et al.\textsuperscript{9} found a moderate to strong inter- and intra-observer agreement for displacement and comminution on similar radiographs. However, in the study of Jones et al.\textsuperscript{9} only the presence of comminution was documented and not the degree of comminution as is necessary to differentiate between wedged and segmented comminuted clavicular fractures.

The Robinson classification has been stated to provide the most reliable prognostic information compared to the other classification methods for midshaft clavicular fractures.\textsuperscript{5,12} We found no other studies on the reliability of classification systems for clavicular fractures to compare our data with. Based on the results of our current study, we advise to use the Robinson classification. To optimize the inter-observer and intra-observer agreement, we recommend using two-plane imaging, as our results showed significantly higher overall inter- and intra-observer agreement after displaying the 30-degree radiograph. Furthermore, the reliability of the classification may be optimized by including the Robinson classification in the radiology reports on midshaft clavicular fractures, because our study suggests that radiologists may classify displaced comminuted midshaft clavicular fractures more reliably than surgeons. Implementing the Robinson classification in this manner may...
improve treatment decisions and optimize the prognosis and treatment outcome. The relatively low response rates (46% for the first survey and 65% for the second survey among the responders to the first survey) pose a limitation to this study. All participating respondents have judged radiographs of clavicular fractures before, because of their interest in trauma surgery or musculoskeletal radiology. The results of this study are therefore generalizable for those who treat midshaft clavicular fractures on daily basis. Response rates were sufficient to calculate inter- and intra-observer agreements.

In conclusion, midshaft clavicular fractures should be classified according to the Robinson classification on two-plane radiography to optimize treatment decisions. Furthermore, we advise to include the Robinson classification in the radiology reports on midshaft clavicular fractures to improve the fracture classification of displaced comminuted fractures.
REFERENCES


