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ONLINE ARTICLES

Does altering projection of the fractured clavicle change treatment strategy?

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Background: Shortening of the fractured clavicle is proposed and debated as an indicator for surgical intervention. There is no standardized or uniform method for imaging and measuring shortening. Different methods and techniques can lead to different measured outcomes. However, the question remains whether a difference in measured shortening using a different technique has any short-term clinical relevance in terms of treatment strategy. The aim of this study was to investigate whether a different projection of the same midshaft clavicular fracture would lead to a different choice in treatment strategy.
Methods: Thirty-six AO-OTA (Arbeitsgemeinschaft für Osteosynthesefragen–Orthopaedic Trauma Association) 15A.1-15A.3 midshaft clavicular fractures were digitally reconstructed into radiographs using both 15° caudocranial and 15° craniocaudal projections. The 72 projections were rated in random order by 23 orthopedic trauma or upper-extremity surgeons on the need for either conservative or operative treatment.
Results: On average, the raters altered their treatment strategy with a different projection of the same midshaft clavicular fracture 12.2 times among the 36 cases (33.9%), ranging from 5 times (13.9%) to 19 times (52.8%). A statistically significant increase in choice for surgical treatment was identified when using the 15° caudocranial projection ($P = .01$).
Conclusion: This study reveals the influence the projection of the midshaft clavicular fracture has on the surgeon's decision of treatment strategy. The decision changes from operative to nonoperative or vice versa in 33.9% of the cases.
Level of evidence: Survey Study Using Experts

Keywords: Clavicle; fracture; shortening; imaging; interobserver agreement; treatment strategy

In recent years, more evidence has emerged that surgical treatment of displaced and shortened midshaft clavicular fractures reduces the rate of nonunion and malunion, as well as increases patient satisfaction and return to work.[5,18,26,38,40,43] However, caution should be taken not to subject all patients to surgery because surgical treatment, irrespective of the type of fixation used, comes with its complications and disadvantages.[36,37] Identifying those patients who will benefit most from surgery remains challenging.

Numerous parameters are used to decide on treatment strategy. Classically, these are open fractures, neurovascular compromise, associated scapular neck fractures, and skin

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tenting.[5,15,22] More recently, age, dominance, activity level, displacement, and shortening are advocated as indicators for surgery.[4,12,33]

There are contradictory reports on whether shortening can be used as an indicator for surgery. Whereas some authors have reported that shortening of greater than 15-20 mm or greater than 15% is associated with worse union rates and functional outcomes when treated conservatively,[6,7,12,17,20,21,25,27,34] others have reported no association between shortening and functional outcome.[8,10,28]

Because there is no standardized and uniform method for measuring shortening, these reported associations, or lack thereof, are based on a heterogeneous group of methods. Assessment of shortening has been described using a tape measure,[25] tilted anteroposterior (AP) views of the clavicle (ranging from 45° craniocaudal to 45° caudocranial views),[6,9,21,32,34] AP panoramic views,[8,12,17,20,28] or computed tomography (CT) scans.[10]

These different methods lead to varying degrees of measured shortening.[2,31] For identification of shortening as a possible parameter in the treatment algorithm, as well as future research purposes, standardization of the radiographic techniques may be of great importance. However, the question remains whether a difference in measured shortening using a different technique has an effect on the surgeon's decision making. Therefore, the aim of this study was to investigate whether a different projection of the same midshaft clavicular fracture would lead to a different choice in treatment strategy.

Materials and methods

In this study, 15° caudocranial and 15° craniocaudal digitally reconstructed radiographs (DRRs) from 36 cases with AO-OTA (Arbeitsgemeinschaft für Osteosynthesefragen–Orthopaedic Trauma Association) 15A.1-15A.3 midshaft clavicular fractures from an existing database were used. These 2 projections were chosen because they are the views with the smallest difference in tilt away from the AP view in the range of views described in the literature to determine shortening. Furthermore, a recent study reported that the measured absolute shortening of the same fracture between these 2 projections was the smallest.[14] Therefore, it was reasoned that if a difference in treatment strategy between the 2 projections used was identified, it would be likely that the projection would also be influential between other views, including the AP view. An example of these DRRs is shown in Figure 1.

The 72 projections were randomly assigned a case number and uploaded onto a secure website (www.traumaplatform.org). To ensure high-quality images, an online survey tool was developed to evaluate radiographic images using an embedded DICOM (Digital Imaging and Communications in Medicine) viewer.

Fifty-five orthopedic and trauma surgeons in the Netherlands who were considered experts in the field of traumatology or upper-extremity pathology were approached via e-mail to participate in the study. In case of no response, 2 rounds of reminders, 2 weeks apart, were sent via e-mail.

All participants were shown 72 (36 paired) DRRs of the midshaft clavicular fractures and were asked how they would treat the fracture shown. The answer options were either "operative" or "conservative." No additional information on the case was presented to the raters. In this way, it was reasoned that all participants used their own frame of reference, ensuring the only variable in this study would be the different projection of the fractured clavicle.

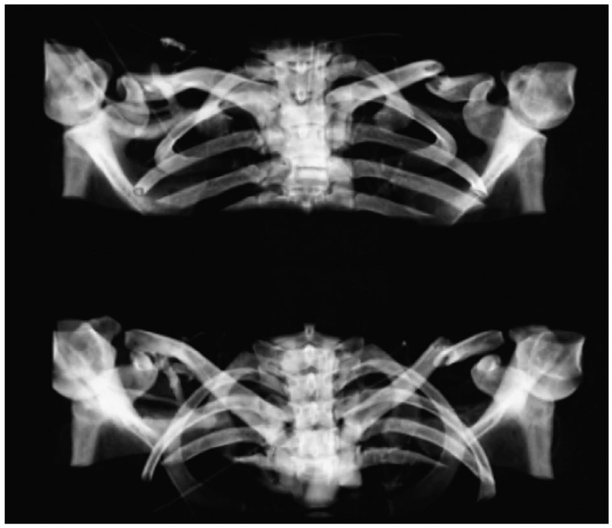

Figure 1 Example of digitally reconstructed radiograph of same clavicular fracture in 15° caudocranial view (*top*) and 15° craniocaudal view (*bottom*).

Statistical analysis

The number of changes in treatment strategy (ie, operative or conservative) between the different projections, as well as the number of times an operative treatment was chosen for each of the projections, was calculated. Descriptive statistics were used to summarize the data. Continuous variables were reported as median (range). Categorical variables were reported using frequencies. Interobserver agreement coefficients were calculated for the 15° caudocranial projection and 15° craniocaudal projection using Gwet's AC1.[41] Agreement coefficients were interpreted according to methods described by Landis and Koch[19] (<0, poor agreement; 0-0.20, slight agreement; 0.21-0.40, fair agreement; 0.41-0.60, moderate agreement; 0.61-0.80, substantial agreement; and 0.81-1.00, almost perfect agreement).

To evaluate the difference in agreement between observers between the 2 projections, the difference between the 2 correlated agreement coefficients was tested for statistical significance.[11] Statistical analyses were performed using the R package (version 3.4.2; R Foundation for Statistical Computing, Vienna, Austria). $P < .05$ was considered statistically significant.

Results

In total, 24 invited surgeons from 16 different hospitals completed the survey, resulting in a response rate of 44% (Table I). One of the participants responded "conservative" in all cases. Because this is not in accordance with the current standard of care, these results were excluded from further analysis. Thus, a total of 23 observers of 36 paired DRRs were analyzed.

Table I Characteristics of raters

	n
Specialization	
Orthopedic trauma	15
Shoulder	5
Other	3
Position	
Attending	21
Resident	2
Years in practice	
0-5	6
6-10	8
11-20	7
NA	2
No. of clavicles treated yearly	
0-5	3
6-10	4
11-20	9
21-40	7

NA, not applicable.

On average, the observers altered their treatment strategy with a different projection of the same midshaft clavicular fracture 12.2 times among the 36 cases (33.9%). This ranged from 5 times (13.9%) to 19 times (52.8%). Figure 2 shows the number of changes per observer.

All but 1 observer showed an increase in choice for surgical treatment of the midshaft clavicular fracture when using the 15° caudocranial DRR (Fig. 3). Overall, the participants elected for surgical treatment 415 times using the 15° caudocranial view and 251 times using the 15° craniocaudal view. The percentage agreement was 0.66 and 0.73, respectively.

Interobserver agreement based on the agreement coefficient was fair for the 15° caudocranial projection (Gwet's AC1 coefficient, 0.32; 95% confidence interval, 0.22-0.42) and moderate for the 15° craniocaudal projection (Gwet's AC1 coefficient, 0.52; 95% confidence interval, 0.37-0.68). Interobserver agreement was significantly different between the 15° caudocranial and 15° craniocaudal projections ($P = .01$). Respondent background was not identified to be influential on agreement.

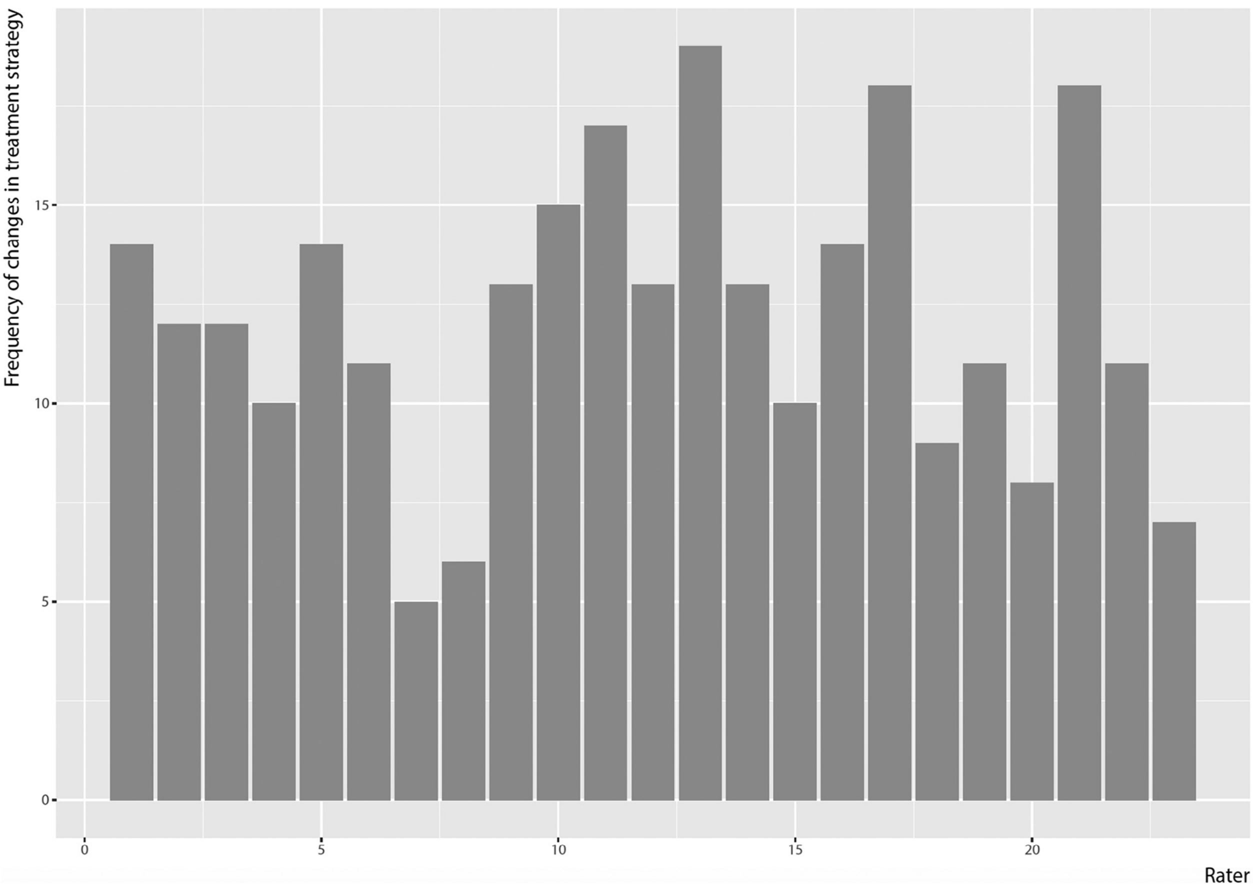

Figure 2 Number of changes in treatment strategy per rater.

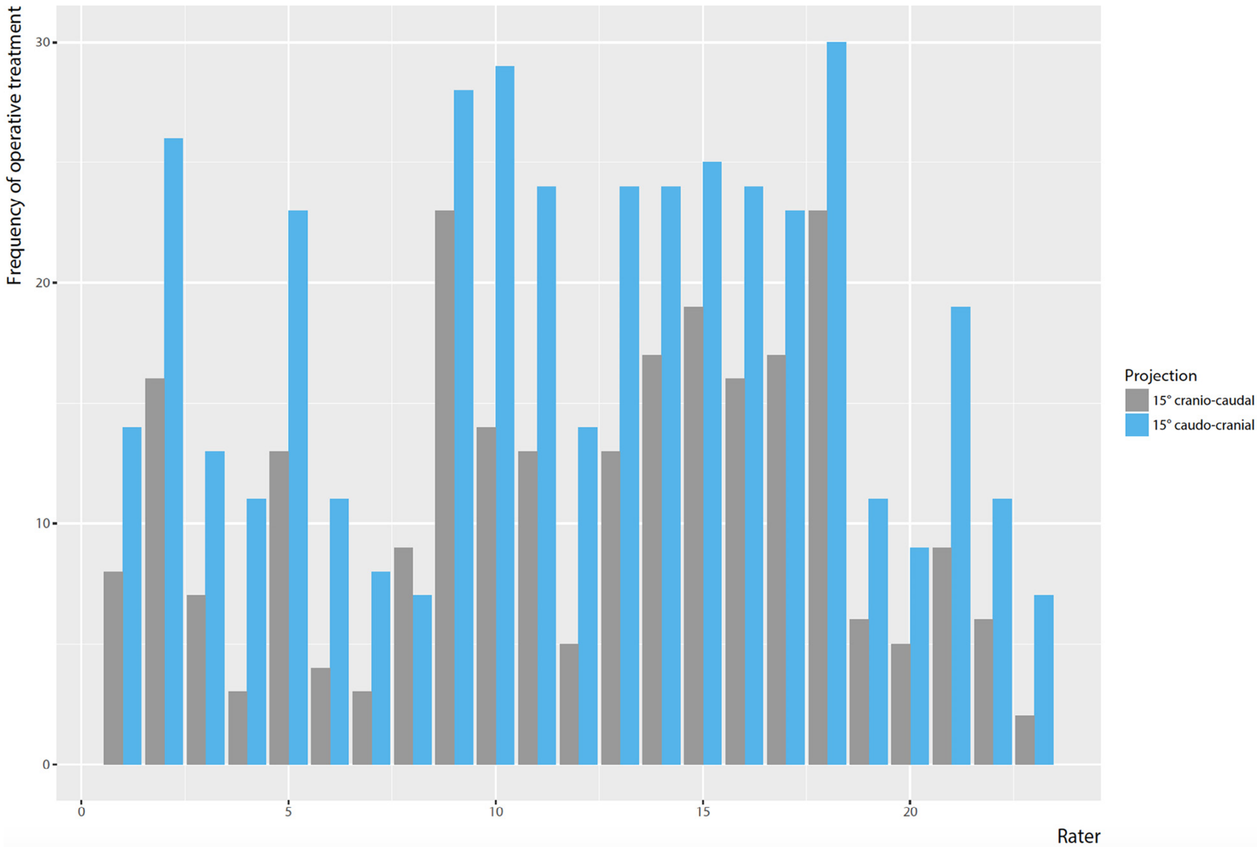

Figure 3 Number of times operative treatment was chosen by projection and rater.

Discussion

The goal of this study was to investigate whether a different projection of the same midshaft clavicular fracture would lead to a difference in choice of treatment strategy. The results of this study showed that, on average, the decision changed in 33.9% of the cases, solely based on the projection of the fractured clavicle. Because of the shape of the clavicle and frequently oblique fracture patterns, measurements can be challenging, as can the evaluation of shortening and displacement. Besides the direction of the x-ray beam, these measurements are subject to other variables such as patient positioning and method of measuring.[2,3,16,23,29-31]

It is interesting that we found an increased tendency to treat a midshaft clavicular fracture operatively when using the 15° caudocranial DRR. There are reports that the craniocaudal views are more accurate projections and that the caudocranial views show a low agreement with CT measurements.[2,29,31] Therefore, one would expect an increased amount of shortening and thus increased choice for surgical treatment with the 15° craniocaudal projection. The results of the present study also showed a statistically significant difference in agreement between the 15° caudocranial and 15° craniocaudal views in favor of the latter. It seems that it is not just the shortening that changes the surgeon's decision. In fact, it may be the projected displacement that causes this difference. This, however, is not in line with the findings of Wright et al,[42] who reported an underestimation of actual displacement on 20° caudocranial radiographs compared with the shortening measured on CT scans. Still, even the underestimated displacement on the caudocranial view may be more than on the craniocaudal view. Further research to answer this question is needed.

A question raised in recent publications is whether shortening is important as an indicator for surgery. Some authors have reported the degree of shortening, absolute or relative, is important,[6,7,12,17,20,25,27,34] whereas others have disputed this.[8,10,28,39] The latter groups have done so on the basis of similar functional outcomes but did not comment on other possibly important factors such as union rates, cosmetic satisfaction, or altered glenoid and scapular orientation that may increase the risk of future glenohumeral osteoarthritis.[13,24,35]

The strengths of this study include the use of DRRs to guarantee static conditions between the 2 projections of the fractured clavicle, the number of expert observers who participated, and the number of cases included. Some potential limitations have to be discussed. First, this study cannot differentiate whether it is shortening or displacement that is the most influential factor for choosing between treatment strategies. Second, more projections of the fractured clavicle could have been used. For example, a comparison between the 30° caudocranial projection and the AP projection might result in an even larger number of changes in treatment strategy.

However, with the 2 projections used in this study, a clear influence of different projections has been identified.

With the results of this study, we do not advocate the use of only 1 view of the fractured clavicle to base a treatment strategy on; it is merely to show the projection is influential on the decision-making process. Austin et al[1] investigated whether additional projections of the fractured clavicle would influence the surgeon's treatment decision. They added a 45° cephalic and caudal tilt to the standard 20° caudocranial tilt and AP views. Using a 4-view radiographic series, surgeons were more likely to treat clavicular fractures operatively. A possible explanation is the improved visualization of the anterior-posterior displacement of the fracture elements.

The plethora of projections currently used to base research questions or treatment strategies on do not seem interchangeable. An explanation for our results is that in current practice, other factors play a more prominent role in the treatment algorithm than shortening, partially because there is no uniform method for quantifying this even though a study by Jones et al[16] reported otherwise. This does not mean that shortening should be discarded but means that it is actually important to identify and use a uniform method of imaging and measuring shortening in the fractured clavicle to create comparable results for future research purposes.

Conclusion

This study shows the influence the projection of the midshaft clavicular fracture has on the surgeon's decision of treatment strategy. We found an increased tendency to treat a midshaft clavicular fracture surgically when using the 15° caudocranial view compared with the 15° craniocaudal view. The decision changed from operative to nonoperative or vice versa in 33.9% of the cases based solely on the projection.

Disclaimer

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