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Original Article

Are standard antero-posterior and 20° caudal radiographs a true assessment of mid-shaft clavicular fracture displacement?

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ABSTRACT

Aims: Decision-making in management of clavicle fractures is often based on the degree of displacement and shortening present on plain radiographs. We aimed to evaluate whether plain radiographs provide an accurate representation of the true displacement present, which can be difficult to image in orthogonal planes.

Methods: Consecutive high-energy trauma patients with midshaft clavicular fractures requiring further CT imaging of the thorax/abdomen for other associated injuries between 2009 and 2012 were evaluated. The plain radiographs and CT scan were both performed at initial presentation. Displacement and shortening of the clavicle fracture were assessed on the standard clavicle views and then compared with the axial images obtained from CT scans.

Results: 26 patients admitted following a high-energy trauma that necessitated CT scan of chest/abdomen/pelvis were included. All patients also underwent standard clavicle view radiographs at the same initial assessment. Displacement varied from 0 to 233%. Shortening was measured as between 0 and 29 mm. The displacement measured on the CT scan was a mean of 19% greater than the AP view and 11% greater than the 20° caudal. This difference was found to be statistically significant ($p = 0.019$) between the AP view and the axial view on CT. The difference between 20° caudal views did not extend to statistical significance ($p = 0.211$). There were no significant differences found between the two modalities on assessment of shortening.

Conclusions: Plain radiographs give an accurate representation of the shortening present in midshaft clavicle fractures. Displacement may be underestimated if the standard AP and 20° caudal views alone are relied upon.

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1. Introduction

Displaced fractures of the midshaft of the clavicle have historically been treated with largely conservative measures. Recent research has suggested that the operative fixation of certain fractures may lead to the decreased rates of non-union and better functional outcomes.¹⁻³ There is, however, no clear consensus for the relative indications of surgical fixation.

Different criteria have been described involving the degree of displacement of the fracture. The landmark Canadian Orthopaedic Trauma Society trial² advised operative management in fractures with complete displacement (translation with no cortical contact between fracture ends). Hill et al. suggested that shortening of >20 mm is associated with an increased risk of non-union and should as such be treated with surgical fixation.¹ A recent large study from the Royal Infirmary of Edinburgh has produced a composite model including displacement, comminution and patient smoking to produce a predicted risk of non-union in order to guide decision making for operative management.⁴

The measurement of true displacement of clavicle fractures is difficult due to the technical challenges of obtaining 2 orthogonal views with plain radiographs.⁵ If the main component of displacement is in the antero-posterior plane, this will be under-represented on the standard views. Recent work involving the use of a novel 4 view series of plain radiographs (2 standard views plus 45° cephalic and caudal tilt views) has demonstrated that the additional views result in an increased rate of a decision to treat fractures operatively.⁶ This is presumed to be due to an appreciation of the true antero-posterior displacement of the fracture when orthogonal views are obtained.

With modern trauma management and increased access to CT scanning, patients with significant trauma are often imaged with CT in the emergency setting to rule out thoracic, abdominal or spinal trauma. These axial CT images provide an opportunity to identify the true antero-posterior displacement of a concomitant clavicle fracture in a trauma patient. We aim to demonstrate the difference between the apparent characteristics of clavicle fractures on the standard trauma series with the true fracture displacement demonstrable on an axial CT slice.

2. Materials and methods

Standard radiographic imaging for the clavicle includes 2 views at our institution (AP and 20° caudal inclination). The database was searched to retrospectively identify all patients with acute clavicle fractures between 2009 and 2012 who were imaged using the above views. Patients were cross-referenced to identify those who required further computerised axial tomography (CT) of the thorax for associated traumatic injuries, performed concurrently at the initial presentation.

2.1. Radiographic measurements

All imaging was assessed through use of the Picture Archiving and Communication System (Sectra Workstation IDS5; Sectra

Fig. 1 – Radiograph demonstrating measurement technique used for assessment of shortening (s).

Fig. 2 – CT 3D reconstruction demonstrating measurement technique used for assessment of shortening (s).

Imtec AB, Sweden, 2009). Plain radiographs and axial CT imaging were assessed for shortening, displacement and presence of comminution.^{7,8} Shortening was measured in an absolute figure of millimetres, taken along the longitudinal axis of the clavicle. **Figs. 1 and 2** demonstrate shortening measured between ends of fracture in line with the diaphysis of the clavicle. Displacement was measured according to percentage of diaphyseal diameter, with displacement measured perpendicular to the longitudinal axis of the clavicle. **Figs. 3 and 4** demonstrate the measurements made perpendicular to the line of the diaphysis of the clavicle. Percentage translation is calculated as $(d'/d) \times 100$. Comparison was made between each of the two standard views and the axial images

Fig. 3 – Radiograph demonstrating measurement technique used for assessment of displacement.

Fig. 4 – CT 3D reconstruction demonstrating measurement technique used for assessment of displacement.

obtained from the CT scan. Measurements were made by 2 independent reviewers to verify correlation of results.

Statistical analysis was performed using SPSS 11.0 (SPSS Inc., Chicago, IL, USA) for Macintosh. The Wilcoxon signed rank test for non-parametric, related samples was used for analysis of statistical significance. Pearson's rho correlation co-efficient was used to test agreement between the reviewers. Unless otherwise stated, categorical variables are expressed as frequency (%), and continuous variables are expressed as mean (range) with $p \leq 0.05$ considered as statistically significant.

3. Results

Twenty-six consecutive trauma patients with midshaft clavicular fractures requiring further CT imaging of the thorax were identified between 2009 and 2012.

The mechanism of injury in each injury was sufficient to activate the trauma protocol; patient demographics are included in Table 1.

Displacement ranged from 0 to 233% as measured on the plain radiographs. On CT, the range was from 0 to 170%. The difference between displacement measured on plain radiographs and axial CT was a mean of 18.95% (range 0–123%; $p = 0.019$) greater on CT than the AP view and 10.81% (range 0–117%; $p = 0.211$) greater on CT than with the 20° caudal view.

Assessment of shortening did not reveal a significant difference between measurements made using plain radiographs and with axial CT. Shortening ranged between 0 and 20 mm on plain radiographs and between 0 and 29 mm on CT. The difference between shortening measured on plain radiographs and axial CT was a mean of 1.2 mm (0–7.8 mm) on the AP view and 0.1 mm (0–6.4) on the 20° caudal view.

Comminution was identified in the fractures of 14/26 patients. Each patient with comminution evident on plain films had this visible on the axial CT, with no additional comminution detected by CT whereas it was not visible on plain films.

Comparison between the two reviewers with use of the Pearson correlation coefficient demonstrated excellent inter-observer agreement for both plain radiographs ($r = 0.801$; $p < 0.01$) and for axial CT measurements ($r = 0.916$; $p < 0.01$).

4. Discussion

While the indication for operative fixation of displaced midshaft clavicle fracture has not yet been agreed upon, the current evidence would suggest that the degree of fracture displacement is a key factor to determining risk of non-union or poor clinical outcome.^{1–4} Assessment of displacement in clavicle fractures in the antero-posterior direction is challenging due to the anatomical position of the clavicle precluding an axial radiograph. Different techniques for obtaining radiographs have been suggested to give a closer indication of true displacement.^{5,6}

We hypothesised that the displacement and angulation of a clavicle fracture can be determined relatively easily in the cranial caudal plane with plain radiographs but the inability to achieve orthogonal views with plain radiographs of the clavicle would lead to a significant underestimation of the degree of displacement actually present in many clavicle fractures (illustrated in Figs. 5 and 6).

Although an attempt has previously been made at devising a series of clavicle radiograph views which improve the evaluation of deformity present following fracture,^{5,6} this has not been validated.

The findings of this study demonstrate a significant under-representation of the fracture displacement by 10.8% of the diaphyseal diameter, which supports the hypothesis. Comminution was demonstrated to be detectable with both plain film and axial CT imaging, suggesting no additional benefit in the additional view for this purpose. The interobserver correlation between the investigators was very good ($r > 0.8$ in both CT and plain XR), suggesting that the standardised measurement methods used gave reproducible results.

Fig. 5 – AP radiograph of a displaced left midshaft clavicle fracture.

Table 1 – Demographics of patients.

Male:female	10:3
Mean age/years (range)	47 (18–87)
Mechanism of injury/number	
Road traffic accident	15
Fall from height	7
Unrecorded	4

Fig. 6 – Axial CT slice of a displaced left midshaft clavicle fracture in the same patient as Fig. 5. Arrow indicates displacement of fracture ends.

It is unclear as to which deformity, shortening, angulation or displacement is associated with the highest incidence of non-union or poor clinical outcome; however, it would seem that posterior displacement of the lateral fragment could affect the rate of union and also potentially have a significant effect on compromising the thoracic outlet. This study suggests that consideration of the 3-dimensional morphology of the fracture should be taken in the assessment of displacement when relying on standard radiographs alone. However, it should be noted that while this method does allow a more accurate assessment of displacement in clavicle fractures, the application to the current literature must be with some caution. In the suggestion of limits of displacement, over which surgical treatment would be advocated, each trial has relied on measurements on plain radiographs, with any systemic error therefore potentially included. The question then arises: is it displacement in any plane that is important, or displacement only as measured with this technique? Common sense would suggest the former, although there are not yet the data to corroborate this.

The authors do not suggest that CT should be used to assess the true displacement of clavicle fractures, but clearly it can be helpful in the decision making when available in the

traumatised patient. CT potentially could be used in a further similar study to validate clavicle radiographic protocols.

5. Conclusion

Plain radiographs give an accurate representation of the shortening and comminution present in mid-shaft clavicle fractures. Displacement, however, may be underestimated if the standard AP and 20° caudal views alone are relied upon.

Conflicts of interest

The authors have none to declare.

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