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Original article

Usefulness and reliability of two- and three-dimensional computed tomography in patients older than 65 years with distal humerus fractures

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ABSTRACT

Background: Distal humerus fractures are difficult to characterise and to classify according to the AO system. In this multicentre study, our objectives were to assess the usefulness of computed tomography (CT) and to measure intra-observer and inter-observer reliability according to observer experience.
Materials and methods: An online survey of professional practice was performed using a questionnaire based on a clinical case. Participants were asked to determine the AO classification using radiographs then to reappraise their answers after the addition of CT images. For the reliability study, 16 observers in five centres evaluated radiographs and CT scans of 26 distal humerus fractures. They used the radiographs to determine the AO classification and assess the main fracture characteristics then reappraised their findings after adding the CT images. The radiographs and 2D CT images were read twice at an interval of 2 weeks, and during the second reading, 3D CT images were available also. At least 1 month later, the same observers performed similar readings 2 weeks apart (radiographs and 2D CT images at the first reading and addition of 3D CT images at the second reading).
Results: Correct fracture classification was achieved in 95% of cases with the CT images compared to only 73% with the radiographs. CT led to diagnostic and therapeutic changes in 90% and 25% of cases, respectively. Inter-observer reliability was poor for both AO classification and fracture characteristics, not only with the radiographs and 2D CT images, but also with the added 3D CT images. In contrast, intra-observer reliability improved after the addition of 3D CT images. Assessment accuracy was influenced by image quality and geographic origin of the observer but not by observer experience.
Conclusion: CT improves diagnostic accuracy and, in some cases, changes the surgical strategy. In our study of a large number of observers, CT did not improve inter-observer agreement about the study variables. Intra-observer agreement was improved by 3D CT but not by 2D CT. Accuracy was not influenced by years of observer experience but was dependent on image quality, proficiency with computer-based tools and, above all, image observation and interpretation.
Level of evidence: Level III.

Distal humerus fractures account for 5% of all fractures in patients older than 60 years of age [1]. The frequency of distal humerus fractures is predicted to increase 3-fold over the next 20 years [2–4].

The imaging studies performed in the emergency setting are often of limited quality. The result is poor reliability of fracture characterisation and classification, which hinders comparisons of published case-series studies [5]. Computed tomography (CT)-based imaging is available in most emergency centres and provides

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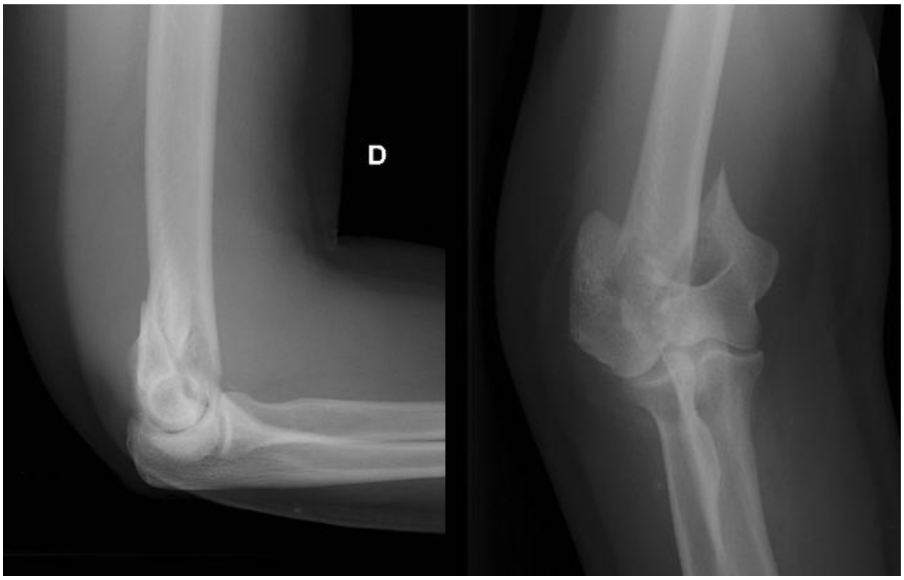

Fig. 1. The antero-posterior and lateral radiographs used for the practice survey.

a more accurate assessment of articular fractures [6,7]. A recently introduced technique is three-dimensional (3D) imaging derived from two-dimensional (2D) CT scans or obtained by modelling. This technique has been reported to improve intra-observer and inter-observer reliability in assessing distal humerus fracture characteristics without improving determination of the fracture type in the most widely accepted classification systems [8,9].

The objectives of this study of distal humerus fractures are to evaluate the usefulness of CT imaging via a survey of professional practice and to conduct a multicentre evaluation of inter-observer and intra-observer reliability of 2D and 3D CT imaging for AO classification and fracture characteristic assessment. In addition, we evaluated whether observer experience and image quality influenced inter-observer and intra-observer reliability and whether adding 3D CT imaging affected therapeutic decisions.

1. Material and method

For the practice survey, a questionnaire based on a clinical case was put on a website (Limesurvey; http://www.limesurvey.org). The patient was a 78-year-old self-sufficient woman who lived at home and had an unremarkable medical history. She had a fracture of the right distal humerus with no vessel or nerve injury. Antero-posterior and lateral radiographs of the elbow were available (Fig. 1).

The first part of the online questionnaire collected data on surgeon experience, AO fracture classification [10], and whether additional imaging studies were needed. In the second part of the questionnaire, a CT view in the coronal plane and two 3D CT reconstructions were shown (Fig. 2). Participants were asked to reappraise the AO classification based on these additional images.

For the multicentre reliability study, we invited five hospitals to participate. These five centres contributed a total of 26 sets of imaging studies inpatients older than 65 years of age with distal humerus fractures. Each set comprised antero-posterior and lateral radiographs of the elbow, thin-slice (< 1.25 mm) 2D CT images, and multiplanar 3D reconstructions. At the emergency department, a whole-body CT scan was performed in 8 patients and a CT scan centred on the elbow in the remaining 18 patients. 3D reconstructions were obtained directly, either from the native images in 20 patients or from images subjected to pre-processing, notably using bone filters. The images showed all three elbow-joint bones, without subtraction of the proximal portions of the two forearm bones. Osirix 32b® software was used to analyse the images in DICOM format [11]. The 16 independent observers who participated in the study fell into three groups: 5 were senior residents, 5 were clinical fellows, and 6 were senior surgeons with more than 10 years of surgical traumatology practice. The observers were asked to classify each fracture in one of the nine AO system groups (A 1 to 3, B 1 to 3; and C 1 to 3). Diagrams of the AO classification with descriptions of each fracture group and subgroup taken from the original publications were available throughout the evaluation [10]. The participants were asked to assess the following fracture characteristics: articular comminution, metaphyseal comminution, fracture line in the coronal plane, strictly intra-articular fracture, and articular surface comminution. They were also asked to recommend a surgical strategy among the following: non-surgical treatment, internal fixation with its type (isolated screw fixation, one plate, or two plates), joint replacement surgery, and addition of a bone graft. Finally, the participants rated image quality as inadequate, acceptable, or optimal.

All 16 observers evaluated all 26 fractures, using the radiographs and 2D CT images. At least 2 weeks later, they re-evaluated the same fractures using not only the radiographs and 2D CT images, but also the 3D reconstructions. At least 1 month later, the observers re-evaluated the 26 fractures, using the radiographs and 2D CT images first then, 2 weeks later, the radiographs and the 2D and 3D CT images.

Statistically, the kappa coefficient measures agreement among observers, after correction for the effect of chance [12,13]. The kappa coefficient provides information on inter-observer and intra-observer reliability for each study variable. We measured inter-observer reliability based on the first set of two evaluations and intra-observer reliability based in the second set of two evaluations. The kappa coefficient values were categorised as follows [13]: 0.00 to 0.20, slight agreement; 0.21 to 0.40, fair agreement; 0.41 to 0.60, moderate agreement; 0.61 to 0.80, substantial agreement and 0.81 to 1.00, almost perfect agreement. A Kappa coefficient value lower than 0 indicates complete disagreement and a value of 1 complete agreement. We computed the percentage of concordant