Author's response to reviews

Title: Indications for computed tomography (CT-) diagnostics in proximal humeral fractures: a comparative study of plain radiography and computed tomography

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Author's response to reviews: see over
Dear Doctor Edmunds,

thank you very much for your helpful review of our paper and the reviewer comments. Naturally, we re-checked the whole paper again and addressed all comments. In particular, we added a more detailed description of our score evaluation of the radiographic modalities with reference to the literature. A response to the comments (sentence by sentence) is also attached to this mail. We also performed formatting changes of the manuscript. We changed the abbreviations in the title and the abstract and included statements for competing interests, author contributions and acknowledgements in the text. We added Erich Lingenfelter as a co-author because he participated in evaluation of radiographs and CT scans, corrected the manuscript and approved the final manuscript.

We do not wish to submit the manuscript to another journal and hope that the actual version is acceptable for publication in the journal BMC Musculoskeletal Disorders.

Sincerely,

Christian Bahrs, MD
Response Comments

Question 1, Reviewer 1
The only question that is in the back of my head is why the radiographs were performed at different institutions and why the quality was different. It seems that this is another variable which was not normalized for.

Answer 1, Reviewer 1:

It was the aim of our study to compare different diagnostic imaging methods (conventional plain and digital radiography, CT) and different views (Scapula-Y and axillary view and different presentation methods of the CT 2D/3D on screen and films), which are commonly used in clinical practice.

We explained this in the method section and the manuscript was not changed:

The study was performed with IRB approval in two university trauma centers. In this prospective study a consecutive series of 44 patients with acute proximal fractures that presented to the two university centers were included. No patients were excluded during this time period from the study.

In the first center 22 patients with a proximal humeral fracture (16 female/ 6 male, median age 64 years, range 36-94 years) were diagnosed with conventional analogous plain radiography with an AP view (66-70 kV/12.5-16 mAs) with the patient standing and the arm extended and an axillary view (66-70 KV/5-8 mAs) with the patient sitting and a minimum of 60° abduction of the arm in analogous technology and automatic exposure (Polydoros 50 s®, Siemens, Erlangen, Germany). Afterwards a standardized CT with the patient supine (Somatom Sensation 16®, Siemens, Erlangen, Germany) with MPR reconstruction of the data set and 2 D and 3 D imaging was performed. 2 D CT was carried out with a slice thickness of 0.75 mm in the osseous window. The 3 D reconstruction was performed with 1 mm layers. Films with 60 images for the 2 D-CT and 12-15 pictures for 3D reconstructions were printed and provided for viewing.

In the second center, for 22 patients with a proximal humeral fracture (17 women/5 men, median age 73 years, range 36-84 years), conventional digital radiography was applied with an AP view and a scapular Y-view with the patient standing
(Device Polydoros Sx 50®, Siemens, Erlangen, Germany, Tube Optilix 150/30/50 C, Memory Foils System PCR Eleva Philips Electronics®, Hamburg, Germany). Then, a 2 D and 3 D presentation after MIP reconstruction of the dataset (Siemens sensation 64®, Erlangen, Germany) with automatic individual adaptation was provided. Utilizing special software equipment, it was possible to assess each section of the CT-scans individually and from different directions with on-screen workstations. 2 D CT was carried out with a slice thickness of 0.75 mm in the osseous window. The 3 D reconstruction was performed with 1 mm layers. In general, 60 pictures for the 2 D-CT and 12-15 for the 3 D-reconstructions were analyzed. The different radiographic views and CT techniques, different viewing methods, and different processing methods were used at each center, and therefore each center was considered as a separate group and both centers were compared with each other. Nevertheless, the consistency of some AP views of the two centers were analyzed and were comparable.

All conventional X-rays were collected, scanned and analyzed with a processing program AutoCAD 2000® (Autodesk GmbH München, Germany). According to the literature we defined the area of the proximal humerus as the square of the longest diameter of the epiphysis.

The percentage of the overlap surface of the proximal humerus by the surrounding osseous structures (acromion, lateral clavicula, coracoid, glenoid) were calculated and documented for the AP view, scapular Y- and axillary views. Because of multiplanar visualization of the proximal humerus, there was no overlap in CT diagnostics.

**Question1 Reviewer 2:**
They do not reach this goal because the developed method for assessment for image quality is based on a subjective scale of 1-4, which is not, since it is a new method, appropriately described in the method section.

This is a helpful advice. We specified the scaling of the technical quality and the assessment of the relevant structures with reference to the two scores from the literature that we used for the study. We changed the methods section of the paper accordingly.
From: They scored the technical quality of the two views of the conventional X-rays separately and of the CT-scans and the identifiability of five relevant structures of the shoulder joint and the proximal humerus using a scoring system from 1 (excellent) to 4 (inadequate). Average scores over all three investigators and two views were calculated for conventional and CT-diagnostics for assessment of technical quality and identifiability of relevant anatomical structures. The following five structures were defined to be relevant: a) the greater tuberosity (on AP view), b) the glenoid and the humeral head (on AP view and axillary view/scapular Y-view), c) the coracoid (on axillary view/scapular Y-view), d) the lesser tuberosity (on axillary view/scapular Y-view) and e) the subacromial space (on AP view).

To: They scored the technical quality of each of the two views of the conventional X-rays and the CT-scans separately. According to an imaging analysis score of Leschka et al. and the European guidelines on quality criteria for diagnostic radiographic images we defined the essential parameters for the assessment as film density, contrast and sharpness of the relevant structures. The used scoring system consisted of 4 grades (1 = excellent, 2 = good, 3 = fair, and 4 = inadequate).\(^1,2\) For the assessment of the relevant structures the following five structures were defined to be relevant: a) the greater tuberosity (on AP view), b) the glenoid and the humeral head (on AP view and axillary view/scapular Y-view), c) the coracoid (on axillary view/scapular Y-view), d) the lesser tuberosity (on axillary view/scapular Y-view) and e) the subacromial space (on AP view).

The essential parameters for the analysis of the relevant structures were the complete and clear presentation, the ability to estimate the degree of comminution and the degree of displacement. The scoring system consisted again of 4 grades (see above).

Average scores over all three investigators and two views were calculated for conventional and CT-diagnostics for assessment of technical quality and identifiability of relevant anatomical structures.

Question 2 Reviewer 2:
In the result section, significant differences, according to the authors, are meant to be found in osseous overlap, assessment of relevant structures and the Neer classification for fractures of the proximal humerus, but no p-values are given in the text or in the figures.

Answer: This is correct. According to the description of the statistical methods we added the p-values in the text of the result section.

Question 3 Reviewer 2:
Page 6, line 172-174, the authors discuss significant differences in assessment of relevant structures. These structures have not been presented in detail in the result section. Results that have not been presented should not be discussed.

Answer 3 Reviewer 2:
This is correct. We deleted the sentence, because the structures were not presented in detail in the result section.

In particular, the lesser tuberosity and the glenoid and the humeral head and the coracoid could be significantly better judged on the axillary view than on the scapular Y-views.

Question 4 Reviewer 2: The authors arrive at the conclusion "CT is indicated when conventional radiological projections are not sufficient to fully appreciate the various fracture elements or the number of parts according to Neer." This guideline
is difficult for the treating physician to follow because he or she might not have the experience to know when the image quality is suboptimal. In addition, the authors mention therapy regime in the conclusion, this is not an issue in this manuscript. The authors should stay focused on what can be seen, or not be seen, on the various modalities. This is a good and constructive advice. Therefore, we deleted the treatment comment and focused the conclusion.

We changed the Conclusion

from

Our results suggest that a clear representation of the relevant bony structures such as greater tuberosity, glenoid and humeral head and lesser tuberosity are required. Only with a clear representation of the relevant bony structures, the conventional diagnostics is suitable for planning any therapy regime. We believe that a CT is indicated when conventional radiological projections are not sufficient to fully appreciate the various fracture elements or the number of parts according to Neer.

to:
Our results suggest that a clear representation of the relevant bony structures such as greater tuberosity, glenoid and humeral head and lesser tuberosity are required. If image quality impairs fracture visualisation or osseous overlap prevents the visualisation of the fractured structures, conventional radiography is not sufficient. In such a situation, we believe that a CT should be performed.