



Three-dimensional computed tomography is not indicated for the classification and characterization of calcaneal fractures



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ABSTRACT

This study determined inter- and intra-observer reliability for measurement of the angles of Böhler and Gissane, for the decision between surgical or conservative management and for the three mostly used classification systems for calcaneal fractures with the use of 2D-CT imaging versus 2D- and 3D-CT imaging.

A consecutive series of 38 fractures in 36 patients, treated at a level II trauma centre between 2005 and 2008, were evaluated in two rounds by five observers. We measured the inter- and intraobserver reliability for the Sanders', Zwipp and Essex-Lopresti classification systems using the kappa values as described by Cohen. The intraclass correlation coefficient as described by Shrout and Fleiss was used to analyze inter- and intra-observer reliability of the angles of Böhler and Gissane.

Usage of 2D-CT imaging interobserver reliability was fair for the Sanders' and Zwipp classifications and for measurement of the angle of Gissane, and it was moderate for measurement of the Essex-Lopresti classification system and measurement of the angle of Böhler. With the addition of 3D-CT imaging, the interobserver reliability was fair for the Sanders', Zwipp and Essex-Lopresti classification systems. The intraobserver reliability was fair for measurement of the angle of Gissane and it was moderate for the Sanders', Zwipp and Essex-Lopresti classification systems and for the measurement of the angle of Böhler.

The addition of three-dimensional CT imaging did not increase inter- and intraobserver reliability for the classification of calcaneal fractures. Authors commented they experienced no additional benefit from 3D-CT imaging for the assessment of calcaneal fractures.

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Introduction

The lack of standardized fracture classification hampers the comparison of different treatment strategies in the literature for calcaneal fracture treatment [1–3].

To determine whether or not a surgical approach is needed, the standard imaging of the calcaneus consisting of lateral and axial radiographs (Harris views) is usually not sufficient [4]. Because

of the complex anatomy of intra-articular calcaneal fractures computed tomography (CT)-imaging is frequently utilized, which improved our understanding of the fracture characteristics and helped standardizing management [5,6]. In the literature various different classification systems are used [3,7–9]. There are several studies evaluating the reliability of classifying calcaneal fractures based on two-dimensional (2D) CT reconstructions, showing only moderate Interobserver reliability. Only one study compares the intra- and inter-observer reliability of 2D- versus 3D-CT imaging [7].

The aim of this study was to evaluate the intra- and inter-observer reliability of 2D versus 3D-CT reconstructions of calcaneal fractures. We hypothesized that 3D-CT reconstructions would increase interobserver reliability, especially for deciding on conservative versus surgical management.

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Methods

Study subjects

We selected a consecutive series of 38 fractures in 36 patients with calcaneal fractures with 2D-CT scans of adequate quality (slice thickness of <2 mm) to reconstruct 3D images that have been treated at a level-2 trauma centre between 2005 and 2008. These 38 fractures were evaluated by five observers: one trauma fellow (XX), one orthopaedic surgeon (XX) and three general trauma surgeons (XX, XX, XX).

The images were evaluated in a blinded and randomized fashion. Two rounds of evaluation were compared with a 6 month interval: first, the combination of plain radiographs and 2D-CT was evaluated; then, two months later, the combination of radiographs and 2D- and 3D were evaluated. The use of 3D imaging alone was not analyzed because it is not usually used without having 2D scans available as well. These rounds were also used to evaluate intra-observer reliability.

Effect and outcome variables

Each observer was asked to classify the fractures according to the Sanders, Zwipp and Essex-Lopresti classification systems for calcaneal fractures [5,10,11]. Diagrams of the classification systems, as well as an appropriate description of each classification system taken from the original publications, were available during each evaluation session.

In addition, observers were asked to measure the angles of Böhler [12] and of Gissane [11], and to state if preferred management of the fracture was nonoperative or operative.

Statistical Analysis

The kappa values for evaluation of both the 2D-CT images (κ_{2D}) and with the addition of 3D-CT images (κ_{3D}) were calculated to estimate the reliability of the fracture classification by the same observer on separate occasions (intra-observer reliability) and by different observer on the same occasion (inter-observer reliability) [13]. It is the most commonly used statistic to describe agreement in a variety of intra- and inter-observer studies, since its introduction by Cohen in 1960 [14]. The kappa value is a chance-corrected measure of agreement comparing the observed measure of agreement with the level of agreement expected by chance alone. Inter-observer reliability among different observers was calculated with use of the multirater kappa measure described by Siegel and Castellan. Levels of agreement between and within observers were determined by the levels of clinical agreement for diagnosis described by Landis and Koch [13]: A κ less than 0.0 is regarded as “poor”, 0.0–0.20 “slight”, 0.21–0.40 “fair”, 0.41–0.60 “moderate”, 0.61–0.80 “substantial”, and greater than 0.80 “excellent”. We used the methods for evaluating the significance of differences between kappa values as described by Doornberg and Zurakowski [15]: values are significant when upper and lower boundaries of the respective 95% confidence intervals do not overlap.

Inter- and intra-observer reliability for measurement of the angles of Böhler and Gissane was calculated with the intraclass correlation as described by Shrout and Fleiss [16] for a two-way random effects model.

Statistical analysis was performed with SPSS software (version 20.0; SPSS, Chicago, Illinois). A power analysis performed with use of nQuery Advisor software (version 5.0, Statistical Solutions, Cork, Ireland) revealed that a minimum sample size of twenty-three fractures would provide 80% power ($\alpha = 0.05$; $\beta = 0.20$) to detect significant inter-observer agreement with use of the kappa coefficient.

Results

Sanders classifications

For classification according to type without subclasses, interobserver reliability was fair ($\kappa_{2D} = 0.22$) with the use of plain radiographs and two-dimensional computed tomography scans. With the addition of subclasses the interobserver reliability decreased to slight ($\kappa_{2D} = 0.18$).

After the addition of 3D reconstructions, interobserver reliability slightly improved for classification according to type without subclasses, however the categorical rating according remained fair ($\kappa_{3D} = 0.28$) with the use of plain radiographs, two- and three-dimensional computed tomography scans. With the addition of subclasses the interobserver reliability remained fair ($\kappa_{3D} = 0.29$).

Intraobserver reliability for classification according to type, without subclasses, was moderate ($\kappa = 0.46$). With addition of subclasses the intraobserver reliability remained moderate ($\kappa = 0.43$).

Zwipp classifications

For classification according to type, interobserver reliability was fair ($\kappa_{2D} = 0.23$) for the amount of fragments and fair ($\kappa_{2D} = 0.27$) for the involved articular surfaces, with the use of plain radiographs and two-dimensional computed tomography scans. Overall interobserver reliability was fair ($\kappa_{2D} = 0.25$).

Interobserver reliability decreased after the addition of 3D CT: for classification according to type, interobserver reliability was fair ($\kappa_{3D} = 0.22$) for the amount of fragments and fair ($\kappa_{3D} = 0.23$) for the involved articular surfaces, with the use of plain radiographs and two-dimensional computed tomography scans. Overall interobserver reliability was fair ($\kappa_{3D} = 0.23$).

Intraobserver reliability with use of the Zwipp classification system was moderate ($\kappa = 0.40$).

Essex-Lopresti classification

The interobserver reliability for all thirty-eight categories was moderate ($\kappa_{2D} = 0.50$) with the use of two-dimensional computed tomography imaging. With the addition of three-dimensional computer tomography reconstructions the interobserver reliability decreased to fair ($\kappa_{3D} = 0.33$).

The intraobserver reliability with use of the Essex-Lopresti classification system was moderate ($\kappa = 0.54$).

Fracture characteristics

Angle of Böhler

The interobserver agreement for the angle of Böhler was moderate ($\kappa_{2D} = 0.57$) with two-dimensional images and decreased to slight ($\kappa_{3D} = 0.19$) with the use of three-dimensional images.

Furthermore, there was a moderate intraobserver agreement ($\kappa = 0.45$).

Angle of Gissane

The interobserver agreement for the angle of Gissane was slight ($\kappa_{2D} = 0.11$) with two-dimensional images and increased to fair ($\kappa_{3D} = 0.22$) with the use of three-dimensional images.

The intraobserver agreement for the angle of Gissane was fair ($\kappa = 0.35$).

Indication for surgery

The interobserver agreement for making the decision between operative or nonoperative management was fair ($\kappa_{2D} = 0.28$) with

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