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Guesstimation of posterior malleolar fractures on lateral plain radiographs

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ABSTRACT

Background: Accurate assessment of articular involvement of the posterior malleolar fracture fragments in ankle fractures is essential, as this is the leading argument for internal fixation. The purpose of this study is to assess diagnostic accuracy of measurements on plain lateral radiographs.
Methods: Quantification of three-dimensional computed tomography (Q-3D-CT) was used as a reference standard for true articular involvement (mm^2) of posterior malleolar fractures. One-hundred Orthopaedic Trauma surgeons were willing to review 31 trimalleolar ankle fractures to estimate size of posterior malleolus and answer: (1) what is the involved articular surface of the posterior malleolar fracture as a percentage of the tibial plafond? and (2) would you fix the posterior malleolus?
Results: The average posterior malleolar fragment involved 13.5% (SD 10.8) of the tibial plafond articular surface, as quantified using Q-3D-CT. The average involvement of articular surface of the posterior malleolar fragment, as estimated by 100 observers on plain radiographs was 24.4% (SD 10.0). The factor 1.8 overestimation of articular involvement was statistically significant ($p < 0.001$). Diagnostic accuracy of measurements on plain lateral radiographs was 22%. Interobserver agreement (ICC) was 0.61. Agreement on operative fixation, showed an ICC of 0.54 (Haraguchi type I = 0.76, Haraguchi type II = 0.40, Haraguchi type III = 0.25).
Conclusions: Diagnostic accuracy of measurements on plain lateral radiographs to assess articular involvement of posterior malleolar fractures is poor. There is a tendency to misjudge posteromedial involvement (Haraguchi type II).

Introduction

Both size of a posterior malleolar fracture that requires fixation, as well as the reliability of measurements on plain lateral radiographs are subject of ongoing debate. Several studies suggest that posterior malleolar fractures involving 25–33% of the tibial plafond require fixation [1–5]. If the size of the posterior fragment is important in decision-making it seems foolish to rely on questionable diagnostics: it has been stated before that reliability of plain radiographs is poor compared to measurements on

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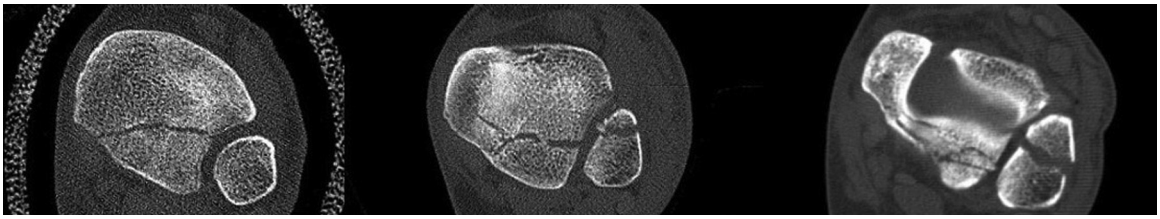

Fig. 1. On the left a Haraguchi Type I fracture of the posterior malleolus, with a triangular fragment, comprising only the posterolateral corner. In the middle a Haraguchi type II fracture, with extension of the fracture into the posteromedial corner. Sometimes there is extension into the medial malleolus fracture. Mostly Type II fractures consist of two fragments: posterolateral and posteromedial (posterior colliculus of medial malleolus). On the right a Haraguchi type III fracture is seen, with small shell-shaped fragments at the posterior rim.

two-dimensional Computed Tomography (CT) [6]. However Ferries' study was limited by a 2D-CT reference standard, rather than quantification using three-dimensional (3D)-CT [7–9]. Moreover, a recent study concluded that plain radiographs allowed for accurate assessment of the size of the posterolateral fragment in terms of interobserver reliability by eight experienced orthopaedic trauma surgeons, as compared to their standard: interpretation of the senior author and experienced musculoskeletal radiologist in a consensus agreement [3]. In order to minimalise subjectivity, we aimed to compare plain lateral radiographs to a 3D-CT reference standard. Previous research shows that quantification of 3D-CT modelling (Q-3D-CT) is a reliable technique to calculate articular surface areas [10–12].

It has been suggested that morphology of the posterior malleolar fragment might be even more important than fracture size [5,13]. Haraguchi and colleagues classified posterior malleolar fractures into three types, based on pathoanatomy of posterior malleolar fragments (Fig. 1) [14]. To the posterolateral fragments usually the posterior syndesmotic ligaments are attached. To the posteromedial fragments the deep deltoid ligament can be attached, which has significant implications for stability [15–17]. Weber and colleagues have described the Haraguchi type II fractures (including the posterior colliculus of the medial malleolus as having impacted fragments posteromedially that interfere with spontaneous anatomic reduction. We hypothesise that especially these types of posterior involvement are frequently missed on plain lateral radiographs.

The purpose of the present study is to find the diagnostic accuracy of measuring articular involvement of posterior fragments in ankle fractures on plain radiographs in a web-based collaborative [18,19] using Q-3D-CT as a reference standard. A second goal is to assess the reliability of lateral radiographs on decision making, whether or not to fix the posterior fragment. We expect that surgeons overestimate true articular involvement on plain radiographs (because of discrepancy of the orientation of the fracture plane and the obliquity of the roentgen beam); but hope that the inter-observer agreement is good to excellent, since estimating fragment size on plain lateral radiographs has been the standard of care for decades.

Methods

Subjects

A retrospective search for plain radiographs plus preoperative CT-scans of patients with ankle fractures (OTA type 44) involving the posterior malleolar fragment was performed in a Level III Trauma Center (St. Lucas Andreas, Amsterdam) treated between 2005 and 2012. This resulted in a total of 57 patients. After exclusion of 12 tibial pilon fractures (OTA type 43) in a consensus meeting, and 14 because of poor image quality, 31 ankle fractures were included and evaluated using Q-3D-CT-modelling technique as previously described [7–9].

Q-3D-CT modelling technique as a reference standard

We used quantitative three-dimensional CT modelling (Q-3D-CT) techniques as previously validated and reported for upper extremity articular anatomy [7–9], and pathoanatomy of distal radius, coronoid, radial head and distal humeral fractures [10,11,20]. Reliability of Q-3D-CT to determine articular involvement of posterior malleolar fractures as a percentage of the tibial plafond to establish a reference standard has been validated (ICC 0.993), in a separate study.[12] A video to illustrate the methodology in detail is available at http://www.traumaplatform.org. The DICOM files were exported for further processing into MATLAB 8.0(Natick, Massachusetts, USA). The created images and additional data were then loaded into Rhinoceros 4.0 (Seattle, Washington, USA). A wire model was constructed (Fig. 2) to be used

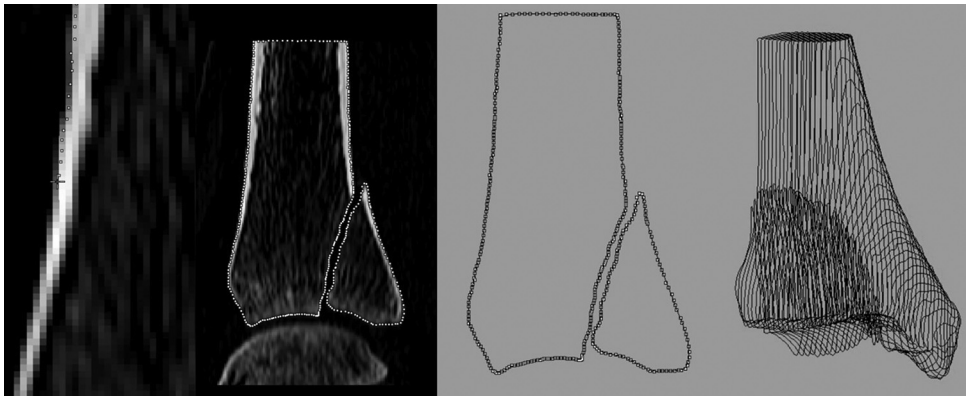

Fig. 2. On the left the cortex of the bone is marked on sagittal CT slices. On the right the wire model is seen after combining multiple slices.