Injury, Int. J. Care Injured 46 (2015) 666–670

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Radiographic landmark for humeral head rotation: A new radiographic landmark for humeral fracture fixation☆

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ARTICLE INFO

Article history:
Accepted 19 October 2014

Keywords:
Rotational profile
Humeral head
Radiographic
Crest of lesser tuberosity

ABSTRACT

Background: There is no definite radiographic landmark in plain radiographs for proximal humeral rotation, which is an important parameter for avoiding rotational malalignment during fracture fixation. Here, we used radiographic images of cadaveric humeri to determine whether the landmark of the crest of lesser tuberosity (CoLT) in plain radiographs could be used to determine humeral rotation.

Methods: Twenty adult cadaveric humeri were collected and seven consecutive radiographic anteroposterior views (45°, 30°, 15° internal rotation; neutral rotation; and 15°, 30°, 45° external rotation) were obtained for each specimen.

Results: The proportional distance (PD) of the CoLT landmark relative to the humeral head was measured and analysed. The mean PDs of the CoLT landmark were 10.2%, 17.9%, 25.6%, 35.9%, 53.4%, and 62.9% of the diameter of the humeral head, corresponding to 45°, 30°, and 15° external rotation, neutral rotation, and 15° and 30° internal rotation, respectively. We found significant differences in the mean PDs with humeral rotation.

Conclusion: The projection of the CoLT in plain radiographs can be used as an important landmark to assess humeral head rotation and will be a useful landmark for rotational control of fracture fixation.

Introduction

Rotational malalignment is a complication that may occur during percutaneous plating or intramedullary nailing [1–4], although there is a high threshold for rotational deformity of the upper arm compared with the lower extremity. Intraoperative assessment of humeral rotation may help surgeons obtain the correct rotational alignment [3]. Several anatomic landmarks of the proximal humerus can be used as references for humeral head rotation, such as the bicipital groove, the crest of the greater tuberosity, and the margins of the greater and lesser tuberosities [5–8]. However, no report has examined which radiographic landmark surgeons could use practically in the clinical setting to assess humeral head rotation [9]. So far, no clear reference line in standard radiographs has been proposed that surgeons can use to avoid rotational malalignment when treating humerus fractures. Furthermore, there is lack of a unified standard definition of what constitutes a neutral humeral position in plain radiography because radiographic parameters of the humerus currently used in clinics are based on an anteroposterior (AP) view with neutral humeral rotation [10,11].

We conducted this cadaveric study to find a clinically relevant radiographic reference landmark that can be used during the treatment of humeral shaft fractures. The purpose was to investigate the hypothesis that the landmark of the lesser tuberosity projection in plain radiographs and its relative distance to the lateral–medial diameter of the humeral head can be used to assess humeral rotation, thus providing a well-defined radiographic landmark for reducing the risk of rotational malalignment in the treatment of humerus fractures.

☆ This cadaveric study is waived for IRB approval from Asan Medical Centre.

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http://dx.doi.org/10.1016/j.injury.2014.10.059
0020–1383/

Materials and methods

Sample

We collected 20 frozen cadaveric humeri for this study, 14 males and 6 females. The average age was 65 years (range: 50–80 years old). Plain radiographs were taken to confirm the absence of any radiologically visible pathological conditions such as previous fractures, tumorous conditions, or advanced arthritic changes that could change the anatomy of the proximal humerus.

Radiographic examination

Bones were placed in a horizontal position in a custom-made frame with a goniometer. The distal part of the humerus was carefully controlled by transepicondylar K-wire in order to penetrate the humerus along the transepicondylar line from the centre of the medial epicondyle to the lateral epicondyle [12]. The humeral rotation to the desired position was set according to the angle of the K-wire relative to the horizontal plane to simulate the clinical situation (Fig. 1). A neutral position of the humerus in the AP view (X-ray beams perpendicular to the humerus) was defined as the K-wire in the horizontal position. This study consisted of a series of radiographs, taken as AP views of the humerus at different rotational angles. Images were obtained at 15° intervals as the humerus was rotated from 45° internal to 45° external rotation. Thus, seven different AP images were obtained for each cadaveric humerus. We calculated the proportional distances (PDs) of the crest of the lesser tuberosity (CoLT) landmark in different positions.

Radiographic measurement

The radiographic images were subsequently imported into Picture Archiving and Communication Systems software (PACS, version 2.1.0.963). The tangent points of these three lines were the most lateral (Line L) and most medial (Line M) margins of the humeral head and the most lateral prominent radiodense curve of the CoLT (Line P) (Fig. 2). Three tangent lines—L, M, and P—were drawn parallel to the longitudinal axis of the humeral shaft using the PACS software. The radiodense curve is the projection of the interface between the CoLT and the bicipital groove, which was a conspicuous radiographic landmark of the humeral head in the AP view and could be easily identified. Next, we used the PACS software to directly measure the distances between the three tangent lines. The L–P distance was from the most lateral margin to the CoLT landmark, whereas the L–M distance was from the most lateral margin to the most medial margin. The L–M distance was defined as the lateral–medial diameter of the humeral head. The PD of the CoLT landmark was quantified as the L–P distance divided by the L–M distance, which was calculated and expressed as a percentage (Fig. 2). Three attending orthopaedic surgeons used the uniform method to independently measure the images. The mean of the three measurements was used for further analysis.

Statistical analysis

We statistically analysed the PD changes using repeated-measure analysis of variance (RANOVA), followed by a post hoc paired Student's *t*-test. We set the level of significance at 0.05 and required a statistical power of 0.80 or greater. Intrarater and interrater reliabilities and side-to-side variability were also assessed.

Results

When the humerus was in the neutral position, the average PD of the CoLT landmark, expressed as a percentage of the diameter of the humeral head, was 35.9% (range: 32.3–40.1%). With an increase in the external rotational angle, the CoLT landmark moved closer to the lateral margin of the humeral head. Conversely, with an increase in the internal rotational

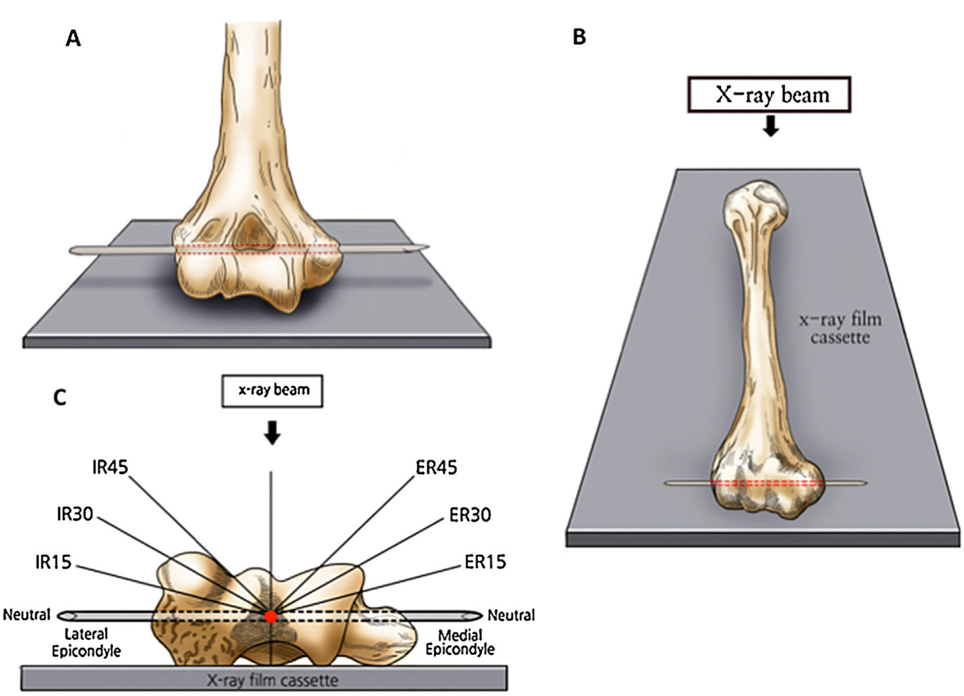

Fig. 1. (A) A K-wire was used to penetrate the humerus along the transepicondylar line from the centre of the medial epicondyle to the lateral epicondyle. (B) Bones were positioned in a custom-made frame with a goniometer. (C) The humeral rotation to the desired position was set according to the angle of the K-wire relative to the horizontal plane. Films were shot at 15° intervals as the humerus was rotated from 45° external to 45° internal rotation. The X-ray beam was perpendicular to the horizontal plane.