Original Article

Cross table lateral radiography for measurement of acetabular cup version

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Background: Appropriate orientation of the acetabular cup is an important factor for long-term results of total hip arthroplasty. For measurement of cup version cross-table lateral radiography is frequently used, but the reliability has been questioned. We compared cross table lateral radiography with computed tomography in patients that had undergone primary total hip arthroplasty.

Methods: The study was prospectively done in 117 patients (117 hips). At 3 months after total hip replacement the acetabular version was measured by cross table lateral radiography and compared to measurements by computed tomography.

Results: By cross table lateral radiography acetabular anteversion was on mean 13.9° with a standard deviation of 10.1° as compared to 17.8°±12.6° by computed tomography. Mean difference was –3.8 with a distribution of measurements of ±13 degrees for 95% of the cases.

Conclusions: Our study shows that cross table radiography provides acceptable information for clinical use, but has limited use for precise analysis of acetabular cup version.

Keywords: Accuracy; acetabular component; measurement; precision; total hip; version angle

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Introduction

Anteversion of the acetabular component is an important factor for long-term results of total hip arthroplasty (THA). It is generally accepted that the acetabular component should be placed with an anteversion of 15°±10°, and inaccurate placement can cause impingement, dislocation and accelerated wear (1-5). Computed tomography (CT) is considered the most accurate method for measurement of cup anteversion (6), but in clinical practice conventional radiology is most commonly used because it is easier to implement, has low emissions, and low cost (7). While the inclination of the acetabulum easily can be measured from standardized anteroposterior (AP) views, the calculation of anteversion is more difficult. Therefore, acetabular anteversion has been measured from cross-table lateral radiographs (8). However, the accuracy of conventional radiography to measure the acetabular component anteversion after THA is controversial (6), and in this study we sought to determine the accuracy of cross-table lateral radiography as compared to CT for measuring anteversion of the acetabular component.

Methods

The study was approved by the Regional Ethics Committee of South East Norway and performed in accordance with the ethical standards of the Declaration of Helsinki. After informed consent to participate, 71 women and 46 men (117 hips) aged 48 to 81 (mean 66) years were prospectively enrolled in the study. They all underwent cementless THA and consecutively were recruited into the study. We

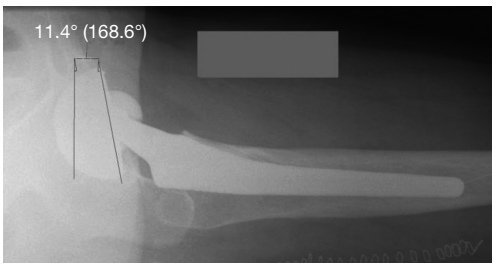

Figure 1 Acetabular anteversion of 11.4 degrees measured by cross table lateral radiography.

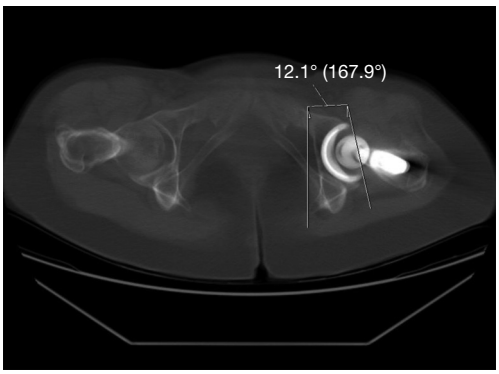

Figure 2 Acetabular anteversion of 12.1 degrees measured by computed tomography.

used a porous coated hemispherical press fit cup, and we aimed to obtain acetabular anteversion of 10° to 30° using a cup positioner with an alignment connector and frame provided with the implant. This is designed to obtain 20° of anteversion if the alignment rod is in line with the longitudinal axis of the patient.

At 3 months postoperatively, and after informed consent, the acetabular component version was measured by cross table lateral radiography. It was carried out with the patient in a supine and neutral position. The contralateral was flexed 45 degrees and placed on a small stand to keep the position. The direction of the radiation beam was parallel to the examination table with 45° to the long axis of the body, and the X-ray film was perpendicular to the examination table. The acetabular component version was determined as the angle in degrees between a line drawn along the angle of the rim of the cup and a line perpendicular to the horizontal plane (*Figure 1*).This was compared with the version measured by CT (General Electric LightSpeed Pro 16 Milwaukee, Wi, USA). Single scans, 10 mm of thickness, were made through the centre of the femoral head, and the

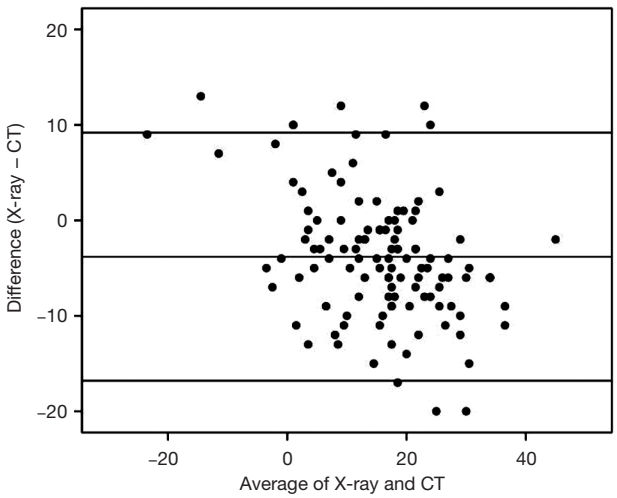

Figure 3 Bland Altman plot: Bland-Altman plot for X-ray and CT measurements with mean difference of −3.8 (95% limits of agreement −16.8 to 9.2). CT, computed tomography.

angle between a line connecting the lateral anterior and posterior margins of the acetabular component and the coronal plane defined as the plane perpendicular to a line connecting two identical points on either side of the pelvis was measured (*Figure 2*). The same specialist in radiology made all assessments.

X-ray and CT measurements were described with mean, standard deviation (SD) and 95% confidence interval (CI). The agreement of measurements from X-ray and CT were analyzed by calculating the intraclass correlation coefficient (ICC). It is a measure of the proportion of variance that is attributed to the individual patients when they are all rated by the same rater. An ICC of 1 indicates a perfect agreement. A Bland-Altman plot with the mean of differences between measurements from X-ray and CT and the limits of 95% agreement (mean ± 1.96SD) was also conducted.

Results

The X-ray (mean 13.9, SD 10.1, 95% CI: 12.1–15.8) and CT (mean 17.8, SD 12.6, 95% CI: 15.4–20.1) measurements were obtained as described. The ICC was 0.789 (95% CI: 0.587–0.880). Mean difference (X-ray – CT) was −3.8 with −16.8 and 9.2 as 95% limits of agreement (Bland Altman plot *Figure 3*). It was a tendency to reversed difference between X-ray and CT measurements with increased average measurement, i.e., higher X-ray measurements

compared with CT for lower average measurements and lower X-ray measurements compared with CT for higher average measurements. This was statistically assessed with a regression analysis of the data in the Bland Altman plot and a significant slope coefficient of –0.242 (95% CI: –0.345 to 0.139), P<0.001 was found.

Discussion

In this study we measured the acetabular cup anteversion on a lateral view radiograph and compared with CT scans. The results suggest that lateral view radiographs provide values that are on average four degrees lower than on CT scans, and that this bias may increase with higher values for acetabular component anteversion.

Different techniques for measurement of cup anteversion from plain AP views have been described, but with different conclusions concerning validity (9). There are various reasons for this. Anteversion has been defined in relation to different planes and landmarks, the tecniques require difficult trigonometric calculations and divergence of the X-ray beam as well as uncontrolled rotation of the pelvis are all factors that may affect the measurements (10). In a study by Nho *et al.* (11) radiographic anteversion calculated from plain AP radiographs was compared with anteversion measured on the CT, and it was concluded that the methods of Lewinnek *et al.* (1), Hassan *et al.* (12), Liaw *et al.* (13) and Woo *et al.* (14) were accurate, whereas the methods of Widmer (15) and Ackland *et al.* (16) were not.

The accuracy of cup anteversion on lateral view radiographs depends on the patient positioning whereas properly performed CT measurements are more independent of patient positioning (6). In our study the anteversion was measured in relation to the horizontal plane, and we assumed that the patient positioning was parallel to this plane using a standardized positioning protocol. However, a standardized pelvic tilting and rotation during imaging may be difficult, and a tilted pelvis changes the radiographic projection and distorts the measurement. Computed tomography decreases the effects of positioning of pelvic tilt, and we used CT as reference standard. But it should be emphasized that there is no gold standard for validation of radiographic or CT-based values *in vivo*. Our calculations were performed by one reviewer, but Ghelman *et al.* (6) demonstrated a strong intraobserver and interobserver reliability in the measurement of both conventional radiographs and CT scans for the assessment of acetabular version. We therefore assume that the use of a single reviewer should not adversely affect our observations.

While plain AP pelvic radiographs easily can be obtained, their accurate interpretation is subject to error (9,17,18). Both the direction of the central beam and tilt of the pelvis could influence the calculation of anteversion and cause significant errors (10). Centering of the X-ray beam over the hip versus the pubic symphysis, could theoretically reduce the sources of error with lateral view radiographs. However, Nishino *et al.* (19) compared acetabular component anteversion measured on lateral view and AP radiographs, and they found a difference of 2.8°±4.1° and –0.57°±3.1°, respectively as compared to CT scans. Nunley *et al.* (20) found a strong correlation between anteversion determined from lateral view radiographs and CT scans. Acetabular anteversion averaged 26.1° on lateral view imaging and 28.8° on CT scans. However, variation exceeded 10° for 20% of the patients. Ghelman *et al.* (6) found that measurements of anteversion on lateral view radiographs correlated (ICC =0.69) with those on CT (ICC =0.69). But the radiographs averaged 8.7° more anteversion than the CT measurements. Our results are on average between these observations. We found that lateral view measurements was on average 3.8 degrees lower than CT measurements with a distribution of measurements of ±13 degrees for 95% of the cases. This indicate that lateral view radiographs provides acceptable assessment for clinical use, but this imaging has limited use for precise analysis of acetabular component anteversion in THA.

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Footnote

Conflicts of Interest: The authors have no conflict of interest to declare.

Ethical Statement: This study was approved by the institutional ethic review board and informed consent was obtained from all patients.

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