The EOS X-Ray Imaging Acquisition System is useful to measure the implant angles after THA in standing positions

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Introduction

The safe zone of the acetabular cup for total hip arthroplasty (THA) was discussed based on the anterior-posterior (AP) X-ray films of hip joints (Lewinnek 1978). Recently, computer simulations revealed that the actual safe zone was narrower than expected (Widmer 2007). Pelvic information in a supine position is still used to determine the cup position for computer assisted orthopaedic surgery such as navigation systems. There were few data about the implant positions after THA in standing or sitting positions. The EOS X-Ray Imaging Acquisition System (EOS system) (EOS imaging Inc, Paris, France) reduces radiation exposure and allows image acquisition with the patients in a standing or sitting position. We can obtain AP and lateral X-ray images with high-quality resolution and low dose radiation exposure by the two radiographic imaging acquisition systems mounted at right angles to each other. Preliminary clinical measurements of acetabular cup angles did not show the three dimensional (3D) accuracy of this system (Lazenneca 2011). Recently, we have obtained the EOS system for the first time in Japan. We investigated 3D accuracy and usefulness of the EOS system for implant measurements after THA in standing positions.

Patients and Methods

We measured the implant angles of the 68 patients (59 females and 9 males, average age: 61y.o.) who underwent CT-based navigation assisted THA using the EOS system. The radiographic cup inclination and anatomical cup anteversion were measured based on the anterior pelvic plane (APP) coordinate. The femoral stem antetorsion was analyzed by measuring the angles between the stem neck axis and the posterior condylar axis based on the functional axis coordinate of the femur in the EOS sytstem. These data were compared with the implant angles of the same patients measured by the post-operative CT scan images and the 3D image analysis using the ZedHip software (LEXI, Japan). The APP coordinate was used to measure the acetabular cup angles, and the table top coordinate was used to measure the stem antetorsion in the CT scan analysis. We also measured the cup angles based on the patient plane (PP) which was the coordinate created when the patients stud in the EOS apparatus. The pelvic rotation in the Z-axis was corrected by rotating the pelvic X-axis to be parallel to the X-axis of the EOS apparatus in the PP.

Results

The average ± standard error (SE) angles of the cup inclination measured by the EOS system and the CT scan were 40.6 ± 0.64° and 42.9 ± 0.53°, respectively. The average ± SE angles of the cup anteversion by the EOS system and the CT scan were 22.9 ± 1.3° and 22.8 ± 1.0°, respectively. The average ± SE angles of the stem antetorsion by the EOS system and the CT scan were 28.9 ± 1.3° and 29.8 ± 1.6°, respectively. The differences (average ± SE) between the EOS system and the CT scan in the cup inclination, the cup anteversion, and the stem antetorsion were -2.3 ± 0.38°, -0.09 ± 0.82°, and -0.90 ± 0.91°, respectively. There were strong correlations in measurement values of the EOS system and the CT scan (the Spearman's correlation coefficients of the cup inclination, the cup anteversion, and the stem antetorsion were 0.6521 [$p<0.001$], 0.7154 [$p<0.001$], and 0.8645 [$p<0.001$], respectively).

The average ± SE angles of the cup inclination and anteversion based on the PP were 40.7 ± 0.67° and 22.4 ± 1.1°, respectively. The differences (average ± SE) between the APP and the PP in the cup inclination and anteversion were 0.14 ± 0.30°and -0.54 ± 1.4 °, respectively. There was a strong correlation in the cup inclination between the APP and the PP, however, the correlation coefficient was very small in the cup anteversion (the Spearman's correlation coefficients of the cup inclination and anteversion were 0.8382 [$p<0.0001$] and -0.2610 [$p=0.0316$], respectively).

Discussion

The EOS system provides acceptable clinical accuracies in measuring acetabular cup and femoral stem angles after THA in our data. The accuracy of the cup angles was accorded with that of the basic experimental data using a dry pelvis (Journé 2012). For the femoral antetorsion, the Z-axis of each coordinate was different between the EOS system and the CT image analysis, however, strong correlation was found in the stem antetorsion. The Z-axis of the femoral functional axis coordinate seemed to be close to the Z-axis of the femoral table top coordinate.

The EOS system also provided patients' 3D information in standing positions with low doze radiation exposure. The actual range of motion of hip joints for the activities of daily living (ADL) was demonstrated using the 4D analysis (Miki 2012), however, measurement errors of surface markers could not be ignored. The EOS system can provide accurate snap shots of variable postures with high resolution. Weak correlation was demonstrated in the acetabular anteversion between the APP and the PP coordinates in our study. Using the EOS system, we may establish real optimum positions of THA implants by measuring the patients after THA in several postures including standing, squatting, or sitting positions which required for Japanese ADL.

References

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