EVALUATION OF THE CLINICAL ACCURACY OF A CT-BASED NAVIGATION SYSTEM FOR ACETABULAR CUP ORIENTATION USING POSTOPERATIVE CT IMAGES AND A VOLUME REGISTRATION TECHNIQUE

INTRODUCTION
In total hip arthroplasty (THA), correct orientation of the acetabular cup is critical to prevent postoperative complications including dislocation, accelerated wear and loosening. Computer navigation has been introduced to eliminate malorientation of the cup. CT-based systems are thought to be three-dimensionally the most accurate compared to imageless systems and fluoroscopic navigation systems. There are some studies showing the accuracy of guiding the cup orientation with CT-based navigation in vitro, however, it is very difficult to evaluate the clinical accuracy of the system on cup placement even using postoperative CT images due to the difficulties in matching the reference of the pelvis between the images used for navigation and the postoperative images. Therefore, we developed a method to match these references using a volume registration technique to evaluate the clinical accuracy of CT-based navigation. The purpose of the study is to investigate the differences in measurements on cup orientation between a CT-based navigation system and postoperative CT images.

MATERIALS AND METHODS
From September 2004 to April 2006, 76 hips of 64 patients were performed THA using a CT-based navigation system. And 55 of these hips (47 patients) were objects of our study, which performed THA by single surgeon via posterolateral approach and which had postoperative CT images. All hips were verified no loosening of pelvic marker pins or registration failure by checking the recovery point intraoperatively. The patients included 44 women and 3 men. The mean age was 57 (27-91). Diagnosis was osteoarthritis in 48 hips, 43 of them were secondary to hip dysplasia, avascular necrosis of the femoral head in 5, rheumatoid arthritis in 2. Using the CT-based system, the data of preoperative pelvic CT obtained with a helical scanner (HiSpeed Advantage, GE Medical Systems, Milwaukee, WI) were transferred as DICOM files to a desktop computer. Then the operator planned the appropriate position of the acetabular component, such as abduction, anteverision angle and depth. All THAs were performed by one surgeon using the same acetabular component (TRIAD, Stryker Orthopaedics, Mahwah, NJ) via posterolateral approach, and at the end of navigation we checked loosening of pelvic marker pins. After postoperative CT images were performed, these postoperative and preoperative DICOM files were imported to 3D viewer software (Virtual Place, Medical Image Laboratory, Tokyo, Japan) and the position of the pelvis in the two sets of images (navigation and postoperative CT) were matched by a volume registration technique. Then we measured postoperative acetabular component position in the coronal and axial view by the image processing software (Scion image) using multiple plane reconstructed views of the CT images of the pelvis (Fig. 1), and were compared with those measured by the navigation system immediately after the fixation of the acetabular component intraoperatively.

RESULTS
Mean error of cup orientation measurements in navigation was 0.9° (-3.0-5.8, SD2.0) for abduction and 0.2° (-2.8-4.8, SD1.9) for anteverision, when it was compared to the postoperative CT measurements (Fig. 2). Between abduction and anteverision, there were no great differences in the error and dispersion.

DISCUSSION
THA with CT-based navigation surgery have been reported to provide more accurate cup placement 1-3. However orientation of components is seriously influenced by pelvic references 4, and it is very difficult to match two different images with the same reference points such as anterior superior iliac spine, pubic tubercle and so on. We cleared this problem by using the volume registration technique. And when we found the marker pin loosening intraoperatively, we replaced pins and retried registration. In this way, we were able to improve the precision of measurement of cup orientations clinically. The similar level of abduction and anteverision error might show that the two references of pelvis matched quietly by the volume registration technique. In conclusion, we had the quite accuracy of the cup orientations by the volume registration technique and strict clinical evaluations.

REFERENCES

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