INTRODUCTION: Computer-Assisted Navigation System (CANS) in total hip arthroplasty (THA) has the potential to improve the accuracy of implant placement. Correct acetabular cup position in a safe zone can assure implant stability and surgical outcome. With CANS, placement of the acetabular implants is dependent on accurate determination of the anterior frontal plane of the pelvis, which is used for describing the orientation of the implant. The objective of this study was to determine the accuracy of CANS, using an imageless technique with manual palpation of the bony landmarks. Computed Tomography (CT) was used in a randomized clinical trial to compare the achieved implant alignment with CANS to a traditional manual method.

METHODS:

Participants and the Surgery: Following Institutional Review Board approval, 50 hips (46 patients: 26 female and 20 male; 63.3±12.4 years, 173.9±12.0 cm, and 84.6±11.6 kg) were randomized into two groups where the acetabular cup was aligned in 25 with a traditional mechanical alignment guide (MAG) and the other 25 with the aid of CANS (Stryker® Corporation, Kalamazoo, MI). The targeted orientation of the acetabular cup was 40-45° for inclination and 17-23° for anteversion in both methods. Navigation could not be relied on in three patients due to pelvic orientation with significant flexion or extension. Two of the hips had CT scans images that were not reliable leaving 21 hips in CANS group and 24 hips in MAG group for analysis.

CT Examination: For all patients, CT scans were obtained in the supine position 2 days post surgery using a protocol of 1.25 mm contiguous axial slices of the entire pelvis with following parameters: 140Kv, 270mA, and 1.0 scan time.

3D Pelvis-Prosthesis Model and Anatomical Landmarks: A 3D model of the pelvis together with the prosthesis was created for each hip from the CT scans using Mimics (Materialise Software, Ann Arbor, MI, USA) software (Fig. 1). Anatomical landmarks were then identified on the bilateral Anterior Superior Iliac Spines (ASISs, shown black in Fig. 1) and bilateral Pubic Tubercles (PTs, shown green). Multiple points (a minimum of 11 points; shown red) were selected along the prosthetic acetabular rim to define the acetabular plane (Fig. 1).

Coordinate Systems: A coordinate system was established for identification of prosthesis orientation (Fig. 1). It took the origin as the midpoint between the ASISs, with a pelvic plane defined by two ASISs and PTs. The X-axis then laid in this pelvic plane pointing superiorly, with the Y-axis pointing to the right ASIS and the Z-axis pointing ventrally perpendicular to the pelvic plane.

Acetabular Component Orientation: The acetabular plane was defined by fitting a plane to the digitized points on the prosthetic acetabular rim using a least-square-error algorithm. The orientation of the acetabular cup, i.e., anteversion and inclination, was then determined from this acetabular plane in the above coordinate system.

Data Analysis: The orientation of the acetabular component obtained from both MAG and CANS groups was compared with the target zones. The difference between the actual acetabular cup orientation, the difference from the target zone and the variation in position were then compared between the groups.

Statistical Analysis: The two groups were compared on the basis of the percentage of cases in each group falling within the target zones using chi-square analysis. A p-value smaller than 0.05 was considered significant.

RESULTS: There were no dislocations or significant complications in either group.

Inclination: The mean and standard deviation inclination recorded at surgery with the CANS group was 42.1±1.5°. With 3D CT/Model analysis, the inclination values for the CANS group were 43.1±2.9° and for the MAG group were 45.3±5.3° with a larger variation. 76% of CANS group were in the 40-45° target zone compared to 29% of the MAG group, with statistical significance (p = 0.002). The range of variation of the inclination for the CANS group was 12°, compared to 24° for that of the MAG group.

Anteversion: For anteversion, the average value recorded at surgery for the CANS group was 21.5±2.4°. From the 3D CT/Model analysis, the average value for the CANS group was 26.0±4.8° and for the MAG cases was 27.9±10.4°. In the CANS group, 33% of the cases were within the 17-23° zone, which was significantly more than the 8.3% of the MAG cases (p = 0.036). The range of variation of the anteversion for the CANS cases was 15°, compared to 36° for that of the MAG cases.

Pelvic Measurement and Orientation: During the post-operative CT scan, the patients were laying supine in the CT scanner. Using the CT table as a reference, the frontal plane of the pelvis was found to have a mean 8.2°±8.7° of flexion (pelvis tilted posteriorly), varying from 5.9° of extension to 31.1° of flexion.

DISCUSSION AND CONCLUSION: This study assumed that the acetabular cup orientation calculated from a 3D pelvis-prosthesis model established from CT scans was the true anatomical orientation achieved by the surgery, based on our previous validation study. In the current study, the use of an imageless navigation technique in THA resulted in significantly more accurate placement with less variation than manual techniques, particularly with inclination. Variations in pelvic flexion-extension posture may have a marked effect on the apparent anteversion of the acetabular cup. Further development of computer assisted navigation incorporating the patient’s pelvic posture and joint mechanics may lead to more reproducible restoration of optimal range of motion and stability in total hip replacements.

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