Evaluation of imageless navigation system with computed tomography in total hip arthroplasty

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Introduction: Recently, several papers have reported the efficacy of an imageless navigation system in acetabular cup orientation during total hip arthroplasty (THA). Last year, we evaluated the accuracy of cup implantation angles, leg length, and stem antetorsion with the imageless navigation system by comparing the navigation data with postoperative radiographs. However, measuring the cup implantation angle from a radiograph is difficult because of pelvic tilt or the need for a complicated formula to calculate cup anteversion from the radiograph. In this study, we measured the cup and stem implantation angles from postoperative CT by using 3D THA planning software. The purpose of this study was to evaluate the accuracy of placement of the implant, which was measured by CT with the imageless navigation system.

Materials & Methods: CT evaluation was performed in 22 patients (22 joints) who underwent THA from January 2011 to December 2011. There were 1 male and 21 female patients. The mean age at surgery was 70.4 years (range 43–83 years). The mean BMI at surgery was 24.7kg/m^2 (18.1–33.7kg/m^2). Twenty-one patients had osteoarthrosis and 1 patient had idiopathic osteonecrosis. All surgeries were performed in the supine position with the direct anterior approach. The OrthoPilot imageless navigation system (BBraun/Aesculap) was used during surgery. A Plasmacup and either an Excia stem or a Bicontact stem was used.

Evaluation of the cup inclination angle (CIA), cup anteversion angle (CAA), and stem antetorsion angle (SAA) was carried out. The navigation indicates CIA and CAA in the anterior pelvic plane (APP) during surgery. Instead of SAA, the navigation indicates the rasp antetorsion angle during surgery. Radiographic CIA, CAA in APP, and SAA were measured with CT by using 3D THA plannning software (ZedHip, Lexi). Also, the thickness of subcutaneous tissue at the anterior superior iliac spine (ASIS) and the pubic symphysis were measured with CT. The accuracy of the imageless navigation system was evaluated by comparison of the navigation values obtained during surgery with the CT measured values. Correlations were analyzed with Pearson correlation analysis.

Results: The mean CIA was 35.8±4.7 degrees (24.8–44.3 degrees) and the CAA was 21.9±6.6 degrees (6.5–33.1 degrees) with CT evaluation. No patients showed more than 50 degrees in CIA. Navigation showed 37.4±5.2 degrees (24.9–51.1 degrees) in CIA and 17.0±7.0 degrees (1.6–32.9 degrees) in CAA during surgery. The mean absolute difference in CIA between navigation and CT was 2.5±1.8 degrees (0.1–5.8 degrees). The mean absolute difference in CAA between navigation and CT was 5.4±3.8 degrees (0.1–17.2 degrees).

The rasp antetorsion angle was 24.2±10.9 degrees (-2.7-50.4 degrees) in the navigation system. The mean SAA was 22.6±9.3 degrees (1.7-41.9 degrees) in CT. Strong correlation was found between the rasp antetorsion angle and SAA (r=0.841). The mean absolute difference between the rasp antetorsion angle and SAA was 5.2±3.0 degrees (1.1-12 degrees).

The mean thickness of subcutaneous tissue was 20.8±12.2mm (3-47.5mm) at ASIS and 39.5±10.7mm (24.9-57.2mm) at pubic symphysis Factors that have an effect on the difference between the CT and the navigation were analyzed. The thickness of subcutaneous tissue at the pubic symphysis was correlated to the difference in CAA between the navigation and CT (r=0.456).

Discussion: In this study, we demonstrated that imageless navigation shows good accuracy, especially in CIA, according to CT evaluation. There is a limitation of accuracy in the imageless navigation

system because of the registration method, that is, to palpate bony landmarks over the skin. Navigation CAA values were affected by the thickness of subcutaneous tissue. Innovation of new technology for more precise registration of bony landmarks, such as ultrasound, may help the imageless navigation system to obtain more accurate values comparable to CT-based navigation.

Imageless navigation has a definite advantage because of its easy registration method and no need for special preparation for surgery compared with CT or image-based navigation. Placing the implant close to the ideal position allows us to avoid impingement of the implant, excessive wear due to edge loading, leg length discrepancy, and limping after surgery. Therefore, imageless navigation is a useful tool for performing accurate surgery for THA.