Combined anteversion of the THA implanted with image-free cup navigation and without stem navigation

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Introduction: Implant positioning is one of the critical factors influencing the postoperative outcome in total hip arthroplasty (THA). Malpositioning of the implant may lead to increased risk of postoperative complications such as dislocation, restricted range of motion (ROM), polyethylene wear, and loosening. Recently, combined anteversion (CA), the sum of anteversion of the cup and antetorsion of the stem, has been proposed as a parameter of overall rotational positioning in THA procedure. Yoshimine and Widmer attempted optimization of the implant positioning with computer simulation based on the combined alignment parameter of the cup and the stem. They have proposed the formulas to define the "safe zone" for achievement of essential range of motion while avoiding prosthetic impingement.

In our clinical practice, we have been using an image-free THA navigation system (Orthopilot^{TM}; B/BRAUN-Aesculap, Germany) to ensure accurate and reproducible acetabular cup orientation and leg length symmetry. Significance of this system in our clinical experience has been confirmed and reported. However, this system was not equipped with the stem nagivation to evaluate and control antetorsion of the stem. Consequently, antetorsion of the stem has been determined arbitrarily by the surgeon without the instrument to control the alignment. Therefore, CA value in our procedure can be variable.

The purpose of the study was to evaluate the CA in our series of navigated THA and examine the hypothesis that the CA value is not consistent without the systemic control of stem antetorsion.

Methods: From November 2005 to December 2010, 207 THAs were performed with the CT-free navigation system. Among these cases, following groups of patients were excluded from the analysis because the prosthetic alignment was intentionally set outside the "optimal" range; Patients with severe posterior pelvic tilt necessitating intentionally decreased cup anteversion, and patients with femoral neck deformity combined with abnormal femoral antetorsion leading to individual adjustment of prosthetic placement. Consequently, 79 THAs were evaluated in this study. All patients underwent post-operative CT from the pelvis to the posterior femoral condyles to measure the cup and stem position and alignment. THAs were performed following the same procedure using the OrthoPilot^{TM} image-free navigation system. All hips were implanted with cementless cup (Plasma cup B^{TM}, B/Braun-Aesculap, Germany) and cementless stem (Bicontact^{TM}, B/Braun-Aesculap, Germany). This stem is designed to have a flat square cross section enabling some allowance for rotational adjustment.

For the cup positioning, inclination and anteversion angles were targeted at 40°~45° and 15°~20° respectively using the navigation. The stem antetorsion was adjusted under manual control. In the calculation of the angles of the prosthetic alignment, anatomical angles obtained from CT measurement were converted to the angle of radiological definition. Parameters adopted for the analysis were as follow; radiographic cup inclination (RI), radiographic cup antevesion (AV), and stem antetorsion (AT). AT was defined as the angle formed between the proximal femoral stem axis and the line connecting the bilateral posterior femoral condyler margin on the axial plane. The CA was determined by summing the AV and AT values. Furthermore, we applied these parameters to the mathematical formula of Widmer (Widmer's CA =AV + 0.7AT) and compare the resultant values with the target value of their formula (37.3°). In the assessment of the appropriateness of the overall alignment, the calculated Widmer's CA values of 37° ± 10° was regarded as a satisfactory range.

Results: In the postoperative course, no dislocation and major complications were encountered in this series. In the measurement of the cup alignment, the measured RI and AV averaged 40.5° ± 4.1°(range: 30.4° to 49.2°) and 20.6° ± 4.6°(range: 8.7° to 32°) respectively. In the assessment of the cup positioning based on the Lewinneck's "safe zone" criteria, 74 cases (93.7%) were settled in this range. By contrast, distributions of the AT and CA values were scattered as shown by large SD value. The measured AT and CA values averaged 23.6° ± 11.2° (range: 2° to 45°) (Fig.1), and 44.4° ± 11.2° (range: 23.0° to 65°) respectively (Fig.2). Additionally, the average Widmer's CA value was 37.2° ± 8.2° (range: 21.6° to 55.1°). In the assessment of each hip, the Widmer's CA of 61 THAs (77.2%) were within the satisfactory range (37° ± 10°) while the remaining 18 THAs (23.8%) fell into less optimal category (Fig.3).

Discussion: Jolles et al. listed multiple predisposing factors for dislocation after THA procedure. Regarding the significance of CA, they reported that the dislocation rate increased by 6.9 times when the CA value was outside the range of 40° to 60°. During this study period, AT was determined and adjusted intraoperatively based on the surgeon's decision. Consequently, resultant CA (AV + AT) was in the risky range (< 40° or > 60°) in 34 hips (43%). In the calculation of Widmer's CA that is less influenced by deviated AT value, the rate of outlying CA was less (23.8%).

Considering the overall results, our current navigated THA procedure affords reasonably high consistency in achieving the optimal prosthetic alignment. However, introduction of a measure to control stem antetrosion to the navigation system seems to be desirable to further improve its accuracy.