

# **ACCURACY OF COMPONENT ORIENTATION AND LEG LENGTH ADJUSTMENTS USING A REVISED VERSION IMAGE-FREE NAVIGATION IN TOTAL HIP ARTHROPLASTY**

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## **INTRODUCTION**

We have been using an imageless navigation in total hip arthroplasty (THA) since 2006. In our previous studies, we reported that the use of the initial version image-free navigation system (Orthopilot ver1.1, and Orthopilot THAplus B/BRAUN-Aesculap, Germany) could achieve satisfactory accuracy and consistency in cup positioning. However, the system of this version did not include the software to adjust the stem anteversion (AT), and thus the resultant stem AT showed a wide variation as indicated by a large SD value. Since 2011, we have used revised version navigation system (Orthopilot THApro B/BRAUN-Aesculap, Germany), which enables intra-operative assessment of stem AT. Additionally, this system is equipped with a software program enabling intraoperative leg length adjustment.

The purpose of this study was to assess the accuracy of this revised version navigation system based on the assessment of measurement discrepancy between the intraoperative navigation and postoperative CT evaluations. We hypothesized that the revised version navigation system can serve to certify the accuracy in adjustment of prosthetic alignment and leg length.

## **MATERIALS AND METHODS**

### *Study population*

This study was approved by our institutional review board and informed consent was obtained from all patients.

Sventy patients who underwent primary THA using the imageless navigation Orthopilot THApro during December 2011 and January 2015 were included in the study. Intraoperative assessments for cup and stem positioning as well as change in leg length were performed using the software included in the navigation system. There were 21 male and 49 female patients with the mean age of 65.1 years (range, 23 to 86 years). Hip pathologies in this study population included osteoarthritis in 59 patients, osteoarthritis secondary to osteonecrosis in 11 patients.

#### *Surgical procedure and intraoperative navigation*

Surgeries were performed by modified-Hardinge approach and Antero-lateral-spine approach. All THAs were implanted with a cementless cup (Plasma cup B<sup>TM</sup>, B/Braun-Aesculap, Germany), a cementless stem (Bicontact<sup>TM</sup>, B/Braun-Aesculap, Germany), a ceramic 32-mm head and a ceramic liner.

This revised version navigation system necessitates attachment of a tracker device to the trochanter major for navigation on the femoral side. Intraoperatively, the cup inclination, anteversion (AV), and stem AT and change in leg length were measured by the use of the navigation system. In the surgical planning, cup inclination and AV angles were targeted at 35-45° and 15°-25° respectively. The stem AT was basically determined by the amount of the native femoral AT angle of each individual. The resultant AT value ranged from 10° to 30°. Regarding leg length, the resultant length of the operated leg was basically targeted at equal length to the contralateral leg. For assessment of postoperative implant alignment and leg length change, all included patients underwent pre- and postoperative CT examinations for of both legs from the pelvis to the knee.

#### *Postoperative evaluation*

Postoperative cup and stem alignment as well as change in leg length were assessed using the 3D-Template system (Zed Hip, LEXI, Japan) on CT images. For evaluation of the accuracy of the navigation system, the intraoperative navigation results and the corresponding values obtained from the pre- and postoperative CT measurements were compared.

## **RESULTS**

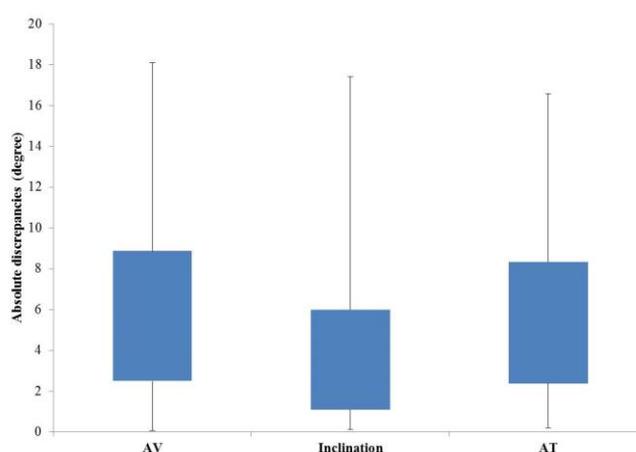
There was no complications related navigation procedure such as dislocation, deep or superficial infection and intraoperative loosening of the navigation devices during the study period. Intra-operative assessment by the navigation system indicated that the cup inclination and AV values averaged  $38.5^{\circ} \pm 2.7^{\circ}$  (range, 33° to 43°) and  $16.4^{\circ} \pm 6.0^{\circ}$  (range, 2° to 30°) respectively, while the average stem AT was  $16.0^{\circ} \pm 10.3^{\circ}$  (range, -4°

to 39°). Postoperative CT evaluation indicated that the cup inclination, AV, and stem AT values averaged  $36.1^\circ \pm 5.2^\circ$  (range,  $21.5^\circ$  to  $45.9^\circ$ ),  $20.6^\circ \pm 6.9^\circ$  (range,  $-3.7^\circ$  to  $33.2^\circ$ ), and  $21.0^\circ \pm 9.9^\circ$  (range,  $-1.1^\circ$  to  $45.8^\circ$ ) respectively. (Table 1)

The median absolute discrepancies between the intraoperative and CT measurement results in each subject were  $2.7^\circ$  for cup inclination,  $5.3^\circ$  for cup AV, and  $4.7^\circ$  for stem AT (Figure 1). Intra-operative elongation of leg length value as assessed by the navigation system averaged  $10.3 \text{ mm} \pm 4.8 \text{ mm}$  (range,  $0 \text{ mm}$  to  $22 \text{ mm}$ ), while the corresponding value measured on pre- and postoperative CT images were  $10.5 \text{ mm} \pm 5.6 \text{ mm}$  (range,  $1.9 \text{ mm}$  to  $25.8 \text{ mm}$ ). (Table 1) When the intraoperative navigation measurement and CT evaluation result in each patient were compared, the median of absolute discrepancy between the two measurements was  $2.03 \text{ mm}$  for leg length.

	Intraoperative navi value (ave.±SD)	CT value (ave.±SD)
Cup inclination	$38.5^\circ \pm 2.7$ ( $33.0^\circ$ to $43.0^\circ$ )	$36.1^\circ \pm 5.2$ ( $21.5^\circ$ to $45.9^\circ$ )
Cup anteversion	$16.4^\circ \pm 6.0$ ( $2.0^\circ$ to $30.0^\circ$ )	$20.6^\circ \pm 6.9$ ( $-3.7^\circ$ to $33.2^\circ$ )
Stem antetorsion	$16.0^\circ \pm 10.3$ ( $-4.0^\circ$ to $39.0^\circ$ )	$21.0^\circ \pm 9.9$ ( $-1.1^\circ$ to $45.8^\circ$ )
Elongation of leg quantity	$10.3 \text{ mm} \pm 4.8 \text{ mm}$ ( $0 \text{ mm}$ to $22.0 \text{ mm}$ )	$10.5 \text{ mm} \pm 5.6 \text{ mm}$ ( $1.9 \text{ mm}$ to $25.8 \text{ mm}$ )

**Table 1: Results of intraoperative navigation values and postoperative CT measurement values**



**Figure 1: Results of absolute discrepancies between the intraoperative values and CT measurement values**

## **DISCUSSION**

It has been already shown that initial-version image-free THA navigation could provide accurate cup placement for inclination and AV. The present study confirmed the accuracy of the revised version navigation system for the stem AT adjustment. In general, the values obtained from intra- and postoperative assessments for prosthetic alignment agreed well. Comparison of the intra- and postoperative measurement results in each patients showed intraoperative navigation assessment indicated slightly higher value for cup inclination (by 2° on averaged), lower value for cup AV (by 4° on averaged), and lower value for stem AT( by 5° on averaged ) as compared to the postoperative CT results.

Regarding the stem navigation, a tracker device for the femur was not required in the initial version navigation system, while a device (clamp) has to be attached to the trochanter major to navigate the femoral stem in the revised version. Although this navigation process may increases the surgical invasion, no significant differences in total surgical time and intraoperative bleeding volume were demonstrated between the two navigation systems.

The revised-version (OrthoPilot THApro) image-free navigation system could achieve accurate positioning for both acetabular and femoral components as well as leg length adjustment; however, in the assessment of prosthetic alignment, small amount of over- or underestimation for each of the parameters was detected. These discrepancies should be taken into consideration during surgery.

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#### **DISCLOSURES**

The authors have nothing to disclose or conflict of interest of this work.