Accuracy Of Acetabular Cup Placement Using A Smartphone As An Intraoperative Measurement Tool: in Vitro Assessment Using Model Bone

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Introduction: In consideration of optimizing total hip arthroplasty (THA) procedure, accuracy of cup placement is one of the critical factors influencing the postoperative outcome. However, process of intraoperative estimation of the cup alignment is mostly relied on surgeon’s perception with limited accuracy. In order to attain reproducible prosthetic placement, a concept of computer-assisted navigation has been proposed and improved accuracy of implant placement with the use of this system has been reported. However, potential limitation of computer navigation THA is a cost issue, which interfere with the wide spread of this system. With the intent of applying the concept of intraoperative navigation to the clinical practice with improved availability, in 2012, Peters1) first proposed the technique to utilize a free smartphone application of Angle, Sumude Apps and Camera Protractor Lite, YJ Soft intraoperatively in adjustment and determination of the acetabular cup placement. He reported excellent clinical results showing that all examined cups (n: 50) could be aligned inside of the Lewinnek’s safe zone2). However, reproducibility and accuracy of this method has not been examined and thus its efficacy has not been well validated. The purpose or this study was to examine the accuracy of this new technique by assessing the orientation of the cup positioned with a smartphone using the Orthopilot image free navigation system (OrthopilotTM; B/BRAUN-Aesculap, Tuttingen, Germany) in model bone. Additionally, intra-and inter-tester reliabilities were assessed. We hypothesized that the use of the smartphone technique can afford acceptable accuracy and reliability regardless of the surgeon’s experience.

Methods: Fifteen orthopedic surgeons (7 residents and 8 senior staff surgeons) participated in this study. The plastic model pelvis was used, and the model bone was fixed to the testing table in a lateral position.

(Cup placement using the smartphone system) Acetabular cup was placed using the application (Angle, Sumude Apps) for inclination, and the iPad with the application (Camera Protractor Lite, YJ Soft) for anteversion (Fig.1.2). Both applications were downloaded to the iPhone and iPad from the Apple application store (App Store). The target angles of the cup alignment were 40° for inclination and 15° for anteversion.

(Assessment of cup placement using the navigation system) The Orthopilot image-free navigation system was used to measure the resultant anteversion and inclination of the acetabular component placed with the use of the smartphone. In accordance with the standardized procedure of this navigation system, a tracker pin was inserted and fixed to the iliac crest in the model bone, and the bilateral antero-superior iliac spines and the upper margin of the symphysis were located and registered (Fig.1). In this navigation system, the triangular plane made by these three anatomical landmarks is defined as the reference plane (anterior pelvic plane) in the analysis of cup alignment.3,4) (Comparison of the smart phone/iPad and navigation assessment results) The Orthopilot navigation system indicates the acetabular cup orientation by radiographic anteversion (RA) and inclination (RI) angles in relation to the anterior pelvic plane. In order to compare the smartphone/iPad results (operative inclination: OI and operative anteversion: OA) with the navigation results indicated by radiological values, the OI and OA values were converted to RI and RA values using a formula proposed by Murray5).

In this experiment, we adopted two sets of cup alignment; OI/OA of 40°/15°, and 38°/19° that correspond to RI/RA of 40°/15° as calculated by Murray’s formula. Each of the study participants (15 surgeons) placed the cup with the smartphone method aiming at the two sets of alignment as described above three times. During the cup placement using the smartphone method, cup alignment was simultaneously assessed using the navigation system (Fig.3).

(Statistical analysis) Differences between the smartphone results and the navigation results were assessed using the t test. Reliability of the measurement was assessed by the likelihood ratio analysis based on the linear mixed model.

Results: When the intended angle was set at 40°/15° for OI/OA values, the resultant values assessed by the navigation system were 39.4° ± 1.0° for inclination and 14.4° ± 2.3° respectively. When the results obtained from the senior staff surgeons and the orthopaedic residents were compared, the measured inclination angles were 39.4° ± 1.4° and 39.4° ± 0.5° in the staff and resident groups while anteversion angles were14.2° ± 2.8° and 14.7° ± 1.7° in each of the two groups with no significant
intergroup difference (P=0.99 for inclination and P=0.71 for anteversion). When the intended angle was set at 38°/19° for OI/OA values, the resultant values assessed by the navigation system were 37.6° ± 1.1° for inclination and 16.2° ± 2.1° for anteversion. When the results obtained from the two surgeons groups were compared, the measured values for inclination and anteversion were 37.6° ± 1.0° and 15.8° ± 2.2° in the staff group and 37.6° ± 1.2°, 16.8° ± 2.0° in the resident group respectively with no significant intergroup difference (P=0.98 for inclination and P=0.37 for anteversion). Finally, scatter plots were showing that all examined (n:90 times) could be aligned inside of the Lewinnek’s safe zone (Fig.4). Reliability analysis showed that intratester reliability was high, while variability among the different testers was significant both in the staff and resident groups regardless of the surgical experience.

**Discussion:** Peters reported that accuracy of acetabular cup orientation can be improved by the smartphone technique as compared to the conventional THA procedures. However, Meermans6) pointed out the flaw of the methodology employed in the Peter’s study, claiming that the operative angle indicated by the smartphone was comparatively analyzed with postoperative radiographic angle. In the present study, the operative inclination and anteversion angles as assessed by the smartphone were converted to the radiological angles using the Murray’s formula, and thus a fair comparison of the values obtained from the two systems was feasible. However, only one model bone was used in this study, which impaired the quality of the reliability assessment. Further analysis using multiple model bones (or cadavers) seems required to critically evaluate the accuracy of the smartphone method in intraoperative adjustment of cup orientation.

**Significance:** Application of smartphone technology to intraoperative assessment of prosthetic orientation in THA may help attain accurate and reliable cup positioning regardless of the surgeon’s experience.

**Acknowledgments:** non

**References:**
4. Fukunishi S et al. Orthopedics 2008;31
Fig.1 Figure is showing smartphone to measure cup inclination and a tracker pin was inserter and fixed in the model bone corresponding to image free navigation system.
Fig. 2 Figure is showing iPad to measure cup anteversion.
Fig. 4 The scatter plots were showing cup inclination and anteversion angle, all 90 examinations were resulted inside of the Lewinnek's safe zone.
Fig. 3 The navigation monitor displayed radiographic inclination and anteversion.

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