INTRODUCTION:
The anterior frontal plane of the pelvis (AFPP), defined by the bilateral Anterior Superior Iliac Spines (ASISs) and pubic symphysis (PS), is generally used as the basis for angular measurements of cup orientation in total hip arthroplasty (THA). It is the basis for the coordinate system using computer-assisted navigation systems (CANS)\(^1\) for THA. Precise determination of the AFPP is essential to accurately determine the acetabular cup alignment in THA relying on CANS\(^2\). With computer navigation systems that are imageless, the determination of the AFPP is dependent on manual palpation and this palpation may be influenced by the thickness of patient soft tissues and the patient’s position on the operating table. Pelvic flexion-extension, which may affect the determination of the AFPP, also varies between patients and may vary between supine and lateral operating positions. The purpose of this study was to assess the variation of AFPP in relationship to the patient position and for correction of the reference plane.

METHODS:
Participants and the Surgery: The data was collected as part of a study approved by our institution’s Institutional Review Board. A total of 67 hips (61 patients: 29.1±4.6 BMI (Body Mass Index)) who received CANS-aided THA were studied (CANS: Stryker® Navigation System, Kalamazoo, MI). All operations were done by the same surgeon (RLW) through a posterior approach in the lateral position with firm anterior and posterior supports for the pelvis and trunk.

Palpating the Anatomic Landmarks (Figs. 1 and 2): The anatomic landmarks were identified by the surgeon through palpation of PS and bilateral ASIS. The palpation was done in the patient in two positions, lateral and supine. The surgery was performed in the lateral position with the patient supported by upright, padded posts to stabilize the pelvis. Following fixation of a navigation tracker with pins in the iliac crest, the initial anatomic landmarks establishing the AFPP used in surgery were obtained with the patient in the lateral position (Fig. 1A). Additional points were collected on the mid-axial line of mid-cough and over the center of the greater trochanter (Fig. 1B). Together with a point in the acetabular fossa, this mid-line formed a reference plane (REF-PL1) for the mid-line of the upper body. Following completion of the surgery, points were taken from the upright post to identify a plane perpendicular to the table and parallel to the table edge (REF-PL2, Fig. 1C). The patient was then turned supine on the table and repeat measurements made of the ASIS and PS to determine the AFPP in the supine position. Three points were then taken from the surface of the table (REF-PL3). The same pin fixation attachment and navigation tracker were used for all measurements so that all the reference planes were obtained in the same coordinate system.

AFPP Orientation (Fig. 3): For each of the three reference planes, a plane parallel to the reference surface passing through the mid-point between the bilateral ASISs was defined (shown red in the left drawing in Fig. 3). Flexion of the AFPP was defined as the PS posterior to this plane and extension as the PS anterior to it.

Data Analysis: First, the orientations of the AFPP obtained from the supine position were compared with the AFPP established in the lateral position, which was used in surgery, to determine how the patient’s position affected the establishment of the AFPP. Second, the AFPP orientations in the lateral position were compared to REF-PL1 and REF-PL2. Lastly, the AFPP orientation in the supine position was compared to REF-PL3.

Statistical Analysis: Paired t-test was used to compare the flexion-extension angles of the AFPP obtained in lateral and supine positions. Similar t-test was used to compare the AFPP orientation obtained in supine position to REF-PL3, between the AFPP orientation obtained in lateral position and REF-PL1, and between it and the REF-PL2. In addition, an two-sample t-test was performed to compare the groups on the basis of BMI. The significance level was set at 0.05.

RESULTS: The difference in AFPP angle measured in the supine and lateral positions was 0.7±4.1º, range 19.2º, with no significant difference (p = 0.144). In the lateral position, the pelvic plane was extended 6.9±2º, range 49.1º, relative to the edge of the operating table (REF-PL2), both with significant difference (both with p < 0.001). With the patient supine, the pelvic plane was flexed 3.2±7.9º, range 38.1º, relative to the surface of the table (REF-PL3), also with significant difference (p < 0.01). There was no significant difference between patients with BMI above and below 30 (p > 0.05).

DISCUSSION: With imageless navigation, the differences in angles from determining the planes in the lateral and supine position were relatively small and without statistical significance, occurred in both directions and were not affected by their BMI, suggesting that the patient position has little impact on establishment of a pelvic plane in THA. However, the 19º range of variation indicates that the technique may not be as reliable in all patients. The patient’s upper body and the operating table, which are frequently used for alignment in conventional THA, showed a wide range of variation from the pelvic plane with statistically significant differences, although the mean pelvic planes relative to operating table were small. Incorporation of individual patient pelvic tilt into computer navigated THA may, therefore be, useful.

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REFERENCES:

Fig. 1. AFPP (red triangle) in lateral position. White rectangle indicates operating table in the superior view (C), the AFPP is seen as a line. Two reference planes used in lateral position are shown in pink.

Fig. 2. The AFPP (red triangle) in supine position (white rectangular indicates operating table). The reference plane of table surface is shown in pink (REF-PL3).

Fig. 3. Orientation of AFPP (left) and the method for comparison of each pelvic plane (right, ASISs on each pelvic plane from each type are placed on an axis of a coordinate system defined for comparison).