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Acetabular and Femoral Anteversions in Standing Position are Outside the Proposed Safe Zone After Total Hip Arthroplasty

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ABSTRACT

Background: Although most hip dislocations occur in either standing or sitting position, the safe zone for implant position is defined for the supine position. Our goal was to determine preoperative and postoperative pelvis and hip orientations and whether the safe zone defined in supine position can be used to assess standing radiographs.

Methods: Preoperative and postoperative three-dimensional EOS images were assessed in 66 total hip arthroplasty patients. None of the patients had dislocation within the follow-up period (12–36 months). The acetabular anteversion (both anterior pelvic plane [APP] and patient functional plane) and the femoral anteversion were measured. The sacral slope, pelvic version, pelvic inclination, and pelvic incidence were also measured.

Results: Acetabular anteversion increased postoperatively in both APP and patient functional plane ($P < .001$). Femoral neck anteversion decreased postoperatively ($P = .0942$). Sacral slope was 42.4° (-25.9° to 24°) preoperatively compared with 40.3° (-4.1° to 64.2°) postoperatively ($P = .013$). Pelvic version changed from 15.2° (-10.4° to 43.8°) to 17.2° (-6° to 46.7° ; $P = 0.008$). Pelvic inclination was 1.12° (-25.9° to 24°) before total hip arthroplasty and -1.2° (-40.7° to 23.4°) postoperatively ($P = .005$).

Conclusion: The acetabular and femoral implant orientations in standing position reside out of the safe zone in most patients. The APP is not vertical in standing position in most patients due to anterior or posterior pelvic tilt. The proposed safe zone in supine position may not be a useful measure in the assessment of standing radiographs of patients with significant anterior or posterior pelvic tilt.

Level of Evidence: Level IV, therapeutic case series study.

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Dislocation is the most common early complication after total hip arthroplasty (THA) [1–5]. The reported rate in the literature varies between 0.5% and 11% [1–3,5–10]. Hip instability after THA is multifactorial in nature. Surgeons' skill in placing the implant in optimal position, surgical approach, patient factors, and implant design features have been associated with this complication

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Study approval was obtained from the Pitié-Salpêtrière Hospital review board.

Study was performed at the Pitié-Salpêtrière Hospital, Paris, France.

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[1,10–12]. Optimal implant orientation and position has been shown to be the important factor in hip stability [3,13–16]. The concept of a safe zone, described by Lewinnek et al [17], is commonly referenced to assess acetabular implant orientation in supine position. It is recommended that the acetabular implant be placed in about $40^\circ \pm 10^\circ$ of abduction and $15^\circ \pm 10^\circ$ of anteversion [3,13,15,16]. Surgeons attempt to place the femoral stem in about 10° – 15° of anteversion [3,13,15,16]. Although most dislocations occur in either standing or sitting position, the initial description was based on radiological definitions of anteversion in supine position with a relatively small sample size considering the low rate of hip dislocation. This results in error in measurement when there is unexpected coronal or sagittal pelvic version [18–21]. Also, the proposed safe zone in supine position is used to assess standing radiographs postoperatively for both routine follow-up and also patients with hip dislocation.

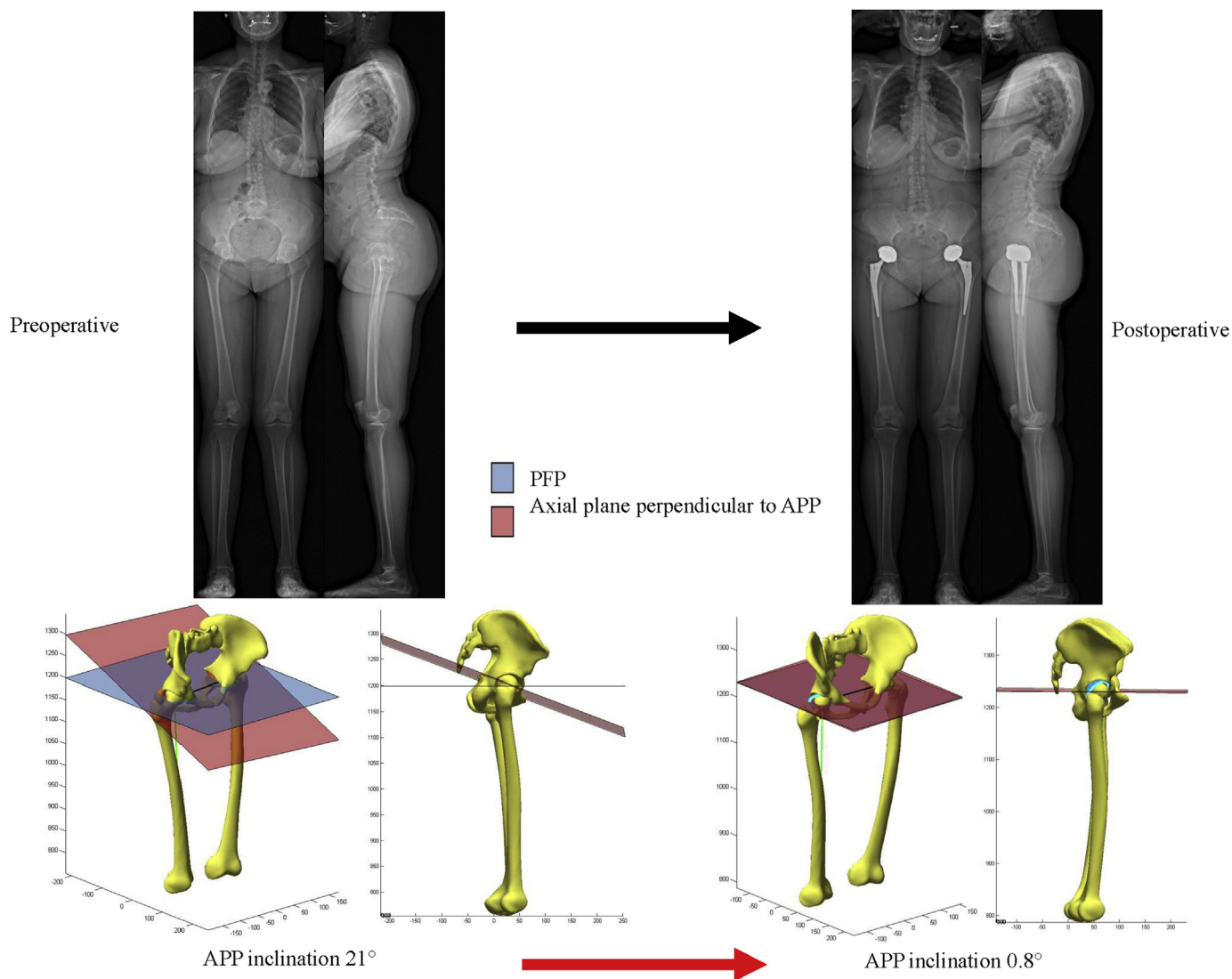


Fig. 1. The preoperative and postoperative APP and PFP. In this patient, surgery substantially decreased APP angle. APP, anterior pelvic plane; PFP, patient functional plane.

The anterior pelvic plane (APP) has been used as the referential plane for these measurements, especially when THA is performed using the navigation technique. However, imaging in supine position and use of the APP ignore the spinopelvic junction as one of the most important variables in determining the anteversion of the acetabular and femoral implants in functional positions from the equation. Thus, the radiographic assessment of THA patients, especially those who sustain dislocation, is not conducted properly. The concept of the patient functional plane (PFP), as the horizontal plane passing through the center of both femoral heads, was developed to describe the orientation of the cup in standing position projected onto this plane for calculation of femoral anteversion.

This study aimed to evaluate the following:

1. How does THA affect acetabular anteversion in APP and PFP, and what percentage of patients reside in the range currently considered the safe zone?
2. How does THA affect femoral neck anteversion, and what percentage of patients reside in the range currently considered the safe zone?
3. How does THA affect sacral slope, pelvic version, pelvic incidence, and pelvic inclination?

Materials and Methods

Study Design and Setting

This was a nonrandomized, retrospective study (preliminary feasibility) of consecutive patients who were assessed with EOS imaging (EOS imaging SA, Paris, France) and met our inclusion and exclusion criteria. Study approval was obtained from the institutional review board. Patients had the surgery in the Department of Orthopaedic and Trauma Surgery, Pitié-Salpêtrière Hospital, between January 2013 and January 2015. All patients underwent assessment with EOS imaging in standing position before primary THA. Each patient stood comfortably in the EOS machine according to a previously described protocol [22,23]. The biplanar acquisition was used to perform stereoradiographic 3-dimensional (3D) modeling of each lower extremity using specialized software (sterEOS 3D, EOS imaging SA, Paris, France) according to a previously described method [19]. Two experienced observers performed the 3D modeling with this software independently. The sterEOS software then made the 3D model and performed the measurements.

All surgeries were performed through anterolateral approach using the conventional technique. The orientation of the

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