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ORIGINAL ARTICLE

Pelvis and total hip arthroplasty acetabular component orientations in sitting and standing positions: Measurements reproducibility with EOS imaging system versus conventional radiographies

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EOS measurements;
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Total hip arthroplasty;
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Pelvis orientation;
Anterior pelvic plane

Summary
Introduction: The literature has recently underlined the interest of pelvic and acetabular component orientation measurements in the standing and sitting position. Radiographic follow-up of total hip arthroplasty (THA) is based on standard AP and lateral X-rays. The use of EOS™ 2D imaging system reduces patient's radiation exposure compared to conventional X-rays. However, using this system, the validity and reproducibility of angular measurements, have not been studied yet for the measurement of pelvic and acetabular parameters in patients with THA.
Hypothesis: The EOS™ 2D imaging system offers similar advantages to conventional X-rays in the measurement of pelvic and acetabular orientation parameters which are commonly used.
Patients and method: Five angular parameters characterizing pelvic tilt and acetabular cup orientation were determined using the same digital measurement Imagika™ software based on two series of standard X-rays and EOS™ 2D images acquired in both standing and sitting positions. Radiographs from 50 patients with unilateral THA were measured three times by two observers. Intra- and interobserver reproducibility using each method was independently studied then paired comparison was performed.
Results: The ICC and Spearman rank correlation coefficient demonstrated an excellent EOS/conventional X-ray correlation. According to the parameters, the mean difference between these two imaging modalities ranged from 0.30° to 3.43° ($P < 0.05$). The intra- and interobserver variability ranged from ±2.97° to ±6.46° using the EOS™ imaging system and from ±4.26° to ±10.22° using conventional X-rays ($P < 0.05$).

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Discussion: The EOS™ 2D imaging system may replace conventional X-rays in the assessment and monitoring of pelvic and acetabular cup orientation in THA.
Level of evidence: Level III. Prospective diagnostic study.

Introduction

Radiographic follow-up of total hip arthroplasties (THA) is based on standard AP and lateral X-rays. Despite its better accuracy [1], CT-scan imaging cannot be routinely performed since it is a costly method, which exposes patients to more radiation. Moreover, CT-scan has to be performed in the supine position whereas the literature has demonstrated the interest of the standing and sitting positions in the measurement of AP and lateral acetabular inclination [2]. Variations in pelvic tilt and anterior pelvic plane orientation (Lewinnek plane) are topical subjects since such variations may significantly modify the prosthetic hip biomechanics [3,4]. Therefore, pelvic parameters commonly measured in spine surgery (pelvic incidence, pelvic version and sacral slope) as well as the Lewinnek plane inclination (helpful in computer-assisted surgery) appear to be relevant elements during the course of THA patients follow-up [5–8].

The EOS™ imaging system provides valuable information in these specific fields since it is capable of simultaneously capturing two orthogonal AP and lateral images thus enabling full-pelvis visualization in both standing and sitting positions [9]. It substantially reduces patient's exposure to X-ray doses compared to conventional X-rays since it combines two simultaneous frontal and lateral acquisitions in a single scan and two gaseous detectors based on the work of Georges Charpak, Nobel Prize in Physics in 1992 [10,11]. The tridimensional EOS analysis allows better understanding of postural adaptation in the standing position [12] but requires reconstruction of volumes. The EOS™ 2D imaging system reduces patient's radiation exposure during the measurement of lumbo-pelvic and acetabular parameters in THA patients.

This work evaluates the reproducibility of angular measurements of lumbo-pelvic and acetabular parameters in order to check the hypothesis according to which the efficiency of this new imaging modality (EOS™ 2D imaging system) is similar to that of the reference method (conventional X-rays) and to determine if the EOS™ 2D system may replace conventional X-rays is this specific indication.

Patients and method

Patients

Fifty patients with unilateral THA were selected since they had no limb length discrepency and no associated spine pathology. They were prospectively evaluated using a conventional X-ray system and the first generation EOS™ imaging system according to an already described protocol [2] which included AP and lateral pelvic acquisitions in the standing and sitting positions. Standard X-rays and EOS images were acquired on the same day. Conventional X-rays were numerized using a Vidar™ Twain 32 scanner and all measurements were performed by means of the Imagika™ software validated in total hip prostheses analyses [13]. Feature characteristics of the patient population are reported in Table 1.

Table 1 Patient characteristics: mean ± SD (min.–max.).

Age (years)	60.94 ± 6.1 (50–73)
Sex ratio (M/F)	24/26
Weight (kg)	79.62 ± 4.53 (70–87)
Size (m)	1.71 ± 0.04 (1.64–1.79)
BMI (kg/m^2)	27.08 ± 0.99 (24.80–29.00)

BMI: body mass index.

Studied parameters

The measured angular parameters are represented on Fig. 1:

- pelvic incidence [14] (PI) was measured between a line perpendicular to the sacral plate at its midpoint and the line joining this point to the middle of the bicoxo-femoral axis;
- the sacral slope [15] in the standing and sitting position (SS St/Sit) was defined as the angle subtented by a horizontal reference line and a line tangent to the sacral end plate;
- anterior pelvic plane inclination (Lewinnek plane [16]) in the standing and sitting position (APPI St/Sit) was defined as the angle subtented by a vertical reference line and a line tangent to the anterosuperior iliac spines and the pubic symphysis;
- the acetabular inclination angle in the frontal plane [5] in the standing and sitting position (FAIA St/Sit) was defined as the angle between the cup axis and the horizontal reference line on the AP view;
- the acetabular inclination angle in the sagittal plane [5] in both standing and sitting positions (SAIA St/Sit) was defined as the angle between the cup axis and the horizontal reference line on the lateral view.

All these anatomical parameters were measured on conventional X-rays (Fig. 2) and EOS images (Fig. 3).

Method of analysis

Measurement of angular parameters was conducted by two independent operators (JYL and MG). Three successive measurements were performed for each pelvic parameter by the operator. Measurements performed on conventional X-rays were considered the reference measurements. For