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ORIGINAL ARTICLE

Total hip arthroplasty offset measurement: Is C T scan the most accurate option?

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Summary
Background: Femoral offset is difficult to precisely evaluate with conventional X-ray techniques. Femoral offset characterizes the balance between body weight and the resistance provided by the abductor muscles. Total hip arthroplasties should respect this balance.
Hypothesis: Computed tomodensitometry (CT-scan) is more accurate than conventional X-ray to evaluate femoral offset.
Materials and methods: Sixty-one patients who received unilateral total hip arthroplasties were prospectively included in the study. Femoral offset was measured by three-dimensional CT-scan reconstruction using the ''Hip Plan'' (Symbios™) software. Offset was also determined with conventional X-ray and results were compared. This software can be used to measure leg length by frontal telemetry. It was developed for preoperative-planning of cementless femoral stem implants with modular necks of various lengths and angles. All pre- and postoperative measurements were made according to the same protocol.
Results: Femoral offset values in this study were very similar to anatomical values found in the literature. They were significantly higher than values obtained by conventional X-ray by an average of 8%. Implantation of hip replacements resulted in a significant increase in offset (1.88 ± 4.71 mm) with a slight variation in leg length. Pre- and postoperative leg length increased slightly in the operated leg by an average of 1.66 ± 5.63 mm. Seventeen percent of these femurs had high offset associated with small or average sized proximal medullary canals. This preoperative planning software made it possible to identify these difficulties and to adapt implant components using modular long 8° varus necks to restore high offset. In most

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of these cases, only small femoral stems could be implanted because of the small size of the intramedullary femoral canal. These individual differences were identified with 3D CT-scan reconstruction and included in the preoperative planning. Moreover, leg length could also be evaluated with this method and included in the preplanning.
Discussion: Compared to conventional X-ray, measurements obtained with this preoperative planning method using 3D CT-scan reconstruction are easy to obtain and not dependent upon test conditions because the frame is placed on the femoral axis. Measurements are not influenced by position inconsistencies or if the hip is fixed in external rotation. The significant number of cases with above average offset confirms the importance of obtaining these measurements and the necessity of adapting the strategy in these cases by using lateralized stems, or, as in our series, modular necks to adjust femoral offset and neck angle.
Level of evidence: Level III diagnostic prospective study.

Introduction

Femoral offset is a variable defined to describe the balance between the weight of the body and the resistance provided by the abductor muscles of the hip. Offset is the perpendicular distance from the center of hip rotation and the line of action of the abductor muscles [1]. Because this distance cannot be observed in daily clinical practice, a fixed radiographic value is used, which defines femoral offset as the perpendicular distance between the femoral metaphyseal axis (or the center line of the femoral canal) and the center of rotation of the femoral head [1].

Calculating femoral offset with frontal plane radiographic studies is limited by the precision of the radiographic technique, which is dependent upon many variables: 1) first, the patient's position, the position of the X-ray tube the distance between the tube and the plate, which determines the enlargement coefficient; 2) the image must be obtained along the femoral axis while an osteoarthritic neck is often fixed in external rotation. With computed tomodensitometry (CT-scan) other planes of reference can be visualised such as the axial plane, which can be used to measure anteversion according to Suh et al. [2] and Olivecrona et al. [3]. With computer assisted 3D CT-scan reconstruction, measurements can be obtained by maximizing the view of the femoral cervical axis [4].

For Charles et al. [5] offset calculated by frontal plane radiograph is an individual constant, which must be integrated into preoperative planning, and failure to restore offset may oblige the surgeon to lengthen the operated leg to sufficiently restore soft tissue tension and prevent postoperative implant instability. Finally, it is difficult to compare pre- and postoperative results with this technique because of imprecise reproduction.

For Charles et al. the choice of component size and component implantation affects functional results and Total Hip Arthroplasty (THA) longetivity [5]. Preoperative planning should give the surgeon the opportunity to choose these components and restore leg length.

With 3D CT-scan reconstruction, the spatial characteristics of the patient's anatomy can be evaluated on one hand, and angles [2,3] or lengths can be measured [6,7] on the other, because the characteristics of the CT-scan workspace are well defined. Certain characteristics useful for surgery (measurement of angles, or evaluation of distances) can be obtained with implant simulation programs thanks to the standardized DICOM format. Computer assisted planning was found to be effective for simulations for Noble et al. [7] and virtual planning for Seel et al. [8]. Sari Ali et al. [4] have shown that these tools are effective for evaluating operated and contralateral leg length with frontal telemetry, and can effectively be used to choose the center of hip rotation, confirm articular range of motion and identify impingement.

We used a program of this type called ''Hip Plan'' (Symbios™) to calculate and compare variations in pre- and postoperative femoral offset in 61 patients who underwent THA. These measurements were included in our preoperative planning for implantation of a modular neck-shaft femoral stem, making it possible to adapt to variations in femoral offset as well as to plan for the neck-shaft component separately from the metaphyseal femoral stem and the acetabular components.

The purpose of obtaining preoperative femoral offset was to be able to plan for and choose a combination of hip replacement components that would restore this offset. We also associated leg length measurement into the preoperative planning protocol.

The main aim of this study was to compare conventional radiograph and CT-scan measurements of femoral offset. The second aim was the compare the pre- and postoperative values of femoral offset as well as the variations created by THA placement using the same protocol of analysis in a group of patients operated on by the same surgeon by the posterolateral approach.

Materials and methods

Patients

Sixty-one patients with unilateral arthropathies were included in this prospective study between September 2004 and March 2007. There were 45 women and 16 men, an average of 74 years old (44—83); the body mass index (BMI) was an average of 30.5 (22—45), 32 patients had a BMI above 30. The most frequent etiology was primary osteoarthritis in 55 patients, in four cases the etiology was osteoarthritis secondary to moderate dysplasia, in one case osteoarthritis secondary to end stage osteonecrosis, and in another case sequellae from a fractured pelvis, which had not been operated on with acetabular protrusion. The same surgical technique with a posterolateral approach was used by a single surgeon (GP) and all hip arthroplasties were primary.