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Original article

Computed tomography evaluation of hip geometry restoration after total hip resurfacing

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ABSTRACT

Background: Anatomic reconstruction of the hip is among the main requirements for hip arthroplasty to be successful. Resurfacing arthroplasty may improve replication of the native joint geometry but has been evaluated only using standard radiographs. We therefore performed a computed tomography (CT) study to assess restoration of hip geometry after total hip resurfacing (HR), comparatively with the non-operated side.
Hypothesis: HR does not change native extra-medullary hip geometry by more than 5 mm and/or 5°.
Patients and methods: CT was used to evaluate unilateral HR in 75 patients with a mean age of 52.2 years (range, 22–67 years). The normal non-operated side served as the control in each patient. Mean follow-up was 2.5 years (range, 1.9–3.1 years). The primary evaluation criteria were femoral offset (FO) and femoral neck anteversion (FNA) and the secondary criteria were cup inclination angle, cup anteversion angle, and lower-limb length.
Results: FO showed a non-significant decrease (mean, −2.2 mm; range, −4.5 to +3.7 mm). FNA was preserved, with a difference of less than 2° at last follow-up versus the preoperative value. Cup measurements showed a mean anteversion angle of 24.8° (0.9–48.6) and mean inclination angle of 44.1° (32.1–56.3); corresponding values for the native acetabulum were 38.9° (20.5–54.8) and 24.8° (4.8–33.6). The residual lower-limb length discrepancy was less than 1 mm (mean, −0.04 mm [−1.2 to +1.6 mm]). The mean angle between the femoral implant and the femoral neck axis was 5.4° of valgus.
Discussion: Our results show that HR accurately restored the native extra-medullary hip geometry.
Level of evidence: III, prospective diagnostic case-control study.

1. Introduction

Accurate biomechanical reconstruction of the hip is essential for total hip arthroplasty (THA) to be successful [1], as geometric parameters correlate with joint and muscle function [2]. Thus, failure to replicate the native geometry can cause a limp or instability of the hip [3]. The many methods suggested to restore hip geometry include preoperative planning (using tracing paper or dedicated computer software), navigation, and the use of modular prostheses (e.g., lateralized femoral stems and/or modular necks) [4–6]. In theory, hip resurfacing (HR) almost automatically restores the native hip anatomy [6]: in contrast to THA, HR preserves the femoral neck and therefore does not induce lateralization of the femur, lengthening of the limb, or changes in the centre of rotation of the femoral head [7]. Although restoration of hip anatomy after HR has been evaluated, only standard radiographs have been used to measure the geometric parameters [6]. Standard radiographs lack precision and cannot provide information about anteversion [2].

We therefore conducted a prospective study using computed tomography (CT) to assess hip geometry after HR comparatively to the non-operated normal side. We hypothesised that HR restored native extra-medullary hip geometry with less than 5 mm and/or 5° difference versus the non-operated side.

2. Patients and methods

2.1. Patients

A prospective non-randomised study of patients managed by a single surgeon was performed. Inclusion criteria were as follows:

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Fig. 1. Measurement on computed tomography images of cup inclination in the coronal plane, as the angle subtended by the transverse cup axis and the inter-teardrop line.

adult who underwent unilateral HR during the first half of 2010, normal contralateral hip (no degenerative disease or surgery), preoperative limb length discrepancy absent or less than 1 cm, absence of post-traumatic lesions of the spine and pelvis, absence of negative-angle hip dysplasia, and normal kidney function. In all patients, the prosthesis used was the Conserve® Plus Total Resurfacing Hip System (Wright Medical Technology, Arlington, TN, USA), with an acetabular component shaped as a truncated hemisphere and a coverage angle of 170°. All patients signed an informed consent document before study inclusion.

There were 75 patients –46 males (61.3%) and 29 females (38.7%)–with a mean age of 52.2 years (range, 22–67), a mean body weight of 80.1 ± 17 kg (95% confidence interval [95% CI], 67–92), and a mean body mass index of 26.2 ± 4.6 kg/m^2 (95% CI, 23–28). Among them, 32 (42.7%) had HR on the left side. The reasons for HR were primary hip osteoarthritis, n = 34 (45%); osteoarthritis complicating femoro-acetabular impingement, n = 23 (31%), osteoarthritis complicating hip dysplasia, n = 10 (13%); osteoarthritis complicating acetabular protrusion, n = 3 (4%), avascular necrosis of the femoral head, n = 2 (3%); polyepiphyseal dysplasia, n = 1, osteoarthritis complicating osteochondromatosis, n = 1; and residual abnormalities after femoral epiphysiolysis, n = 1. Mean postoperative follow-up was 2.5 years (range, 1.9–3.1).

2.2. Operative technique

All HR procedures were performed under laminar flow, by a single surgeon (JG), after preoperative planning aimed at replicating the native geometry of the hip (centre of rotation, femoral offset [FO], and lower-limb length [LLL] [8]). A postero-lateral approach was used and the femur was treated first [8]. The acetabular cup was press-fit in the anatomic position, i.e., parallel to the transverse ligament and to the acetabulum cleared of any osteophytes. This position was sought regardless of the reason for HR. An anterior overhang of 1 mm was maintained to eliminate all risk of cup impingement on the psoas muscle. The femoral instrumentation allowed changes in femoral component position in all three planes. The femoral component was implanted in the neutral position, in the sagittal plane of the neck and in slight valgus relative to the coronal plane. The absence of notching of the femoral neck was checked. Mean sizes were 57.3 mm (52–66) for the cup and 51.4 mm (46–60) for the femoral component.

2.3. Assessment methods

FO and FNA were the primary evaluation criteria. The secondary evaluation criteria were the inclination angles of the cup and bony acetabulum, the anteversion angles of the cup and bony acetabulum, and LLL.

Helical CT with metal artefact suppression was performed. Images were acquired from the uppermost point of the iliac crests to the lesser trochanters; slices through the femoral condyles were obtained also. CT findings were analysed relative to the anterior pelvic plane (APP, Lewinnek reference plane) [9]. Cup inclination in the coronal plane was measured between the transverse axis of the cup and the inter-teardrop line (Fig. 1). The native neck-shaft angle (CC'D) was measured on the normal contralateral hip between the axis of the neck (CC') and the axis of the shaft (C'D). The stem-shaft angle of the implant (C'C"D) was measured between the axis of the shaft (C'D) and the axis of the femoral stem (C'C") (Fig. 2a and b). FO on the operated and non-operated sides was determined as described by McGrory et al. [10]. On the normal non-operated side, version and inclination of the acetabulum were recorded (Fig. 3a). Prosthetic cup anteversion was assessed as the angle between the transverse cup axis and the sagittal plane, in the axial plane (Fig. 3b). Femoral neck version was measured relative to the posterior bicondylar plane of the femur. The head-neck ratio was computed as the femoral-head diameter divided by the femoral-neck diameter, measured in the plane through the middle of the femoral head. LLL discrepancy was assessed by determining the length of the perpendicular segments joining the line through the middles of the lesser trochanters to the CT teardrop on each side, in the coronal plane. This distance was measured on both sides to assess any LLL changes induced by HR.

All measurements were taken by an independent observer, who had no role in the surgical procedures and who used image-processing software (OSIRIX, OsiriXFoundation, Geneva, Switzerland) to obtain three-dimensional multi-planar reconstruction (MPR). This image reconstruction software has 0.3-mm precision and good reproducibility with an interclass correlation coefficient > 0.9 [11].

At last follow-up, the following clinical data were recorded: Oxford hip score [12], Merle d'Aubigné-Postel (MAP) score [13], Harris Hip Score (HHS) [14], Devane activity score [15], and UCLA activity score [16].