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ORIGINAL STUDY

Are there differences in Hip Biomechanics after hybrid and cementless resurfacing arthroplasty?

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There is a paucity of information regarding the clinical performance of the fully cementless metal-on-metal hip resurfacing designs. We compared the biomechanical reconstruction between the two hips of a group of patients treated with a hybrid resurfacing design on one side and a new, fully cementless version of the same resurfacing design on the other side.

We retrospectively identified 20 patients with a hybrid hip resurfacing on one side and a fully cementless device on the contralateral side. The cemented femoral components were implanted with a target angle stem to shaft angle of 140° while the cementless femoral components were implanted with the aim to replicate the natural neck to shaft angle.

No significant differences were observed post-operatively in femoral offset or leg length despite implantation with a larger metaphyseal stem to femoral shaft angle in the hybrid group.

Both hybrid and cementless designs provide similar biomechanical reconstructions.

Keywords : Hip resurfacing ; hybrid ; cementless ; biomechanics

INTRODUCTION

In modern metal-on-metal hip resurfacing arthroplasty (HRA), the most common prosthetic design is hybrid, consisting of a cementless acetabular component and a cemented femoral component. While certain hybrid designs have shown excellent long-term survivorship in selected patient populations *(3,6,17,21)*, there have been concerns that the cement used for fixation of the femoral component can cause thermal necrosis of the bone at the time of implantation *(8,11,13)*. Aseptic failures of the femoral component typically account for 27% to 45% of the causes for revision in hybrid hip resurfacing designs *(2,6,7)* and the presence of bone cement creating an additional interface between bone and the femoral component could be one factor contributing to these failures. As an alternative to hybrid designs, HRA can be performed with a cementless femoral component, much like stemmed-type total hip arthroplasty has been effectively performed in the past 15 years *(12,16,19,20,22)*. There is currently a paucity

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of publications related to the use of completely cementless designs and their effectiveness *(9,15)*. In addition, the quality of the biomechanical reconstruction associated with the use of hybrid designs has been shown *(5,10,18)* but the use of a cementless component in HRA may lead to an alteration of the hip biomechanics because of the absence of a cement mantle and the need for the surgeon to implant the femoral component with a tight fit on the reamed femoral head.

The purpose of this study was to compare selected biomechanical parameters (Femoral offset, leg length, and metaphyseal stem to femoral shaft angle) between hips in a group of patients with bilateral disease who were treated with both hybrid and fully cementless versions of the same hip resurfacing design.

Table I. — Demographic characters of the study group

	Mean	Range
Age at the time of 1st surgery (years)	50.1	23 to 61
Height (m)	1.78	1.60 to 1.86
Weight (Kg)	84.7	59 to 107
Body Mass index	26.6	23 to 31

MATERIALS AND METHODS

From the senior author's database, we retrospectively selected (Table I) all patients (19 men and 1 woman) who had undergone HRA using the Conserve®Plus hip resurfacing system (Wright Medical Technology, Inc., Arlington, TN), with a hybrid design on one hip and a fully cementless design (introduced in 2010) on the contralateral hip (Fig. 1).

Both components were made of the same cobalt chromium molybdenum alloy and the design of the outer shell of the two femoral components was identical, including tolerances for sphericity and clearance with the acetabular component. Both components used a chamfered cylinder design interface with the reamed femoral head. However, the inside walls of the hybrid design featured grooves destined to enhance cement adhesion and defined a straight cylinder with a 170° chamfer. In contrast, the side walls of the cementless design featured a 3° tapered cylinder capped with the same 170° chamfer, and had three tapered ridges to prevent rotation around the metaphyseal stem (shorter in the cementless version) and a titanium plasma spray porous (80-150 micrometers) surface to enhance fixation with the bone. The hybrid design was implanted as early as 1996 under off-label use and subsequently approved by the FDA in 2009 following a multicenter IDE that started in 2000. The cementless design was implanted under off-label use and awaits FDA approval.

Indications for surgery included idiopathic osteoarthritis in eighteen patients, developmental dysplasia in one and osteonecrosis of the femoral head in one. The details of the surgical technique used for implantation of the hybrid design were previously reported *(1)*. The differences associated with the implantation of the cementless component begin after the cylindrical reaming. A tapered reamer is then utilized prior to removing the dome with a different cut-off guide and the tapered stem hole is prepared. With the hybrid design, the aim was to create a stem to femoral shaft angle of 140° in the frontal plane, but because there is often superior flattening or erosion of the head in the osteoarthritic hip, the senior author chose to implant the cementless femoral components at an angle matching the native neck to shaft angle of the femur, to ensure perfect apposition of the reamed bone with the porous coating of the component and avoid potential notching of the femoral neck laterally. Pin centering was adjusted accordingly. Only the final ream was performed with the tapered reamer. A trial prosthesis with a cut out was used to visualize bone–prosthesis apposition. The femoral component was impacted in place and rotational stability vigorously tested. Photographic documentation of the femoral head before femoral component insertion was obtained for all hips. There were 5 hips with large femoral head defect (> 1cm) in the hybrid group versus none in the cementless group ($p=0.0253$). Three hips in the cementless group had small (< 1cm) femoral head defects which were paste-grafted with reamed bone from the acetabulum. The postoperative weight bearing protocol was the same in both hybrid and cementless groups (one month on crutches with partial weight bearing).

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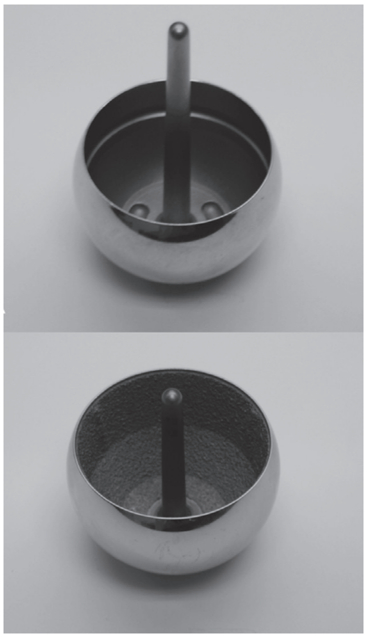

Fig. 1.A. — Top: Hybrid design featuring a longer metaphyseal stem (which can be cemented in case of large femoral head defects), and recesses inside the component for interlocking with bone cement. Bottom: Cementless design featuring a shorter metaphyseal stem (used for component alignment only) and a titanium plasma spray placed directly in contact with the reamed bone.*

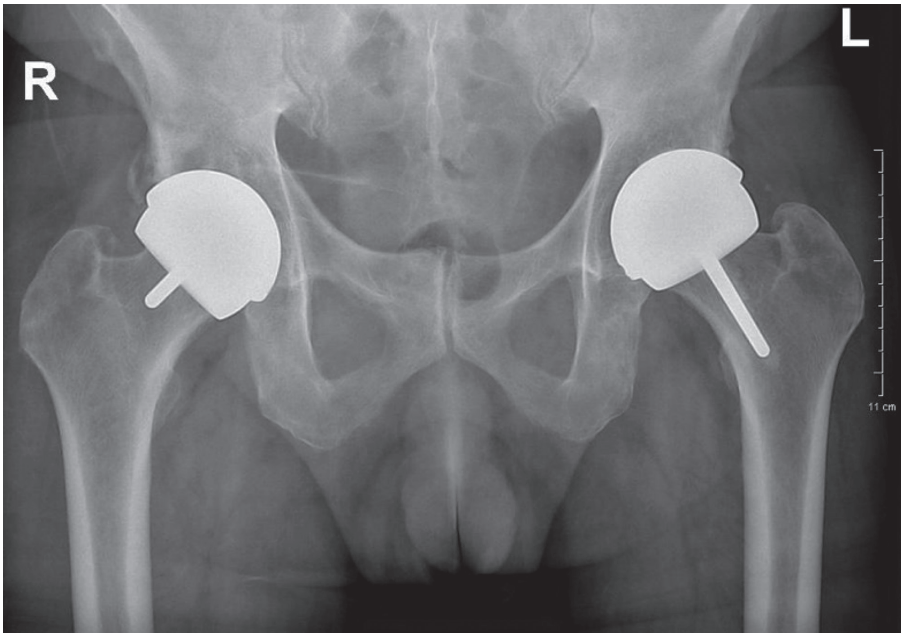

Fig. 1.B. — Anteroposterior radiograph showing the hybrid design (left hip) and the cementless design (right hip) in a 61 year-old patient.

*Femoral components used in this study

All patients had the hybrid resurfacing performed before their second hip was treated with the cementless component, except one patient who underwent a one-stage bilateral procedure. The mean time between surgeries was 85.2 months (range 0 to 160). The patients were followed at three months and then on an annual basis. Anteroposterior radiographs were taken with the patient supine and hips in internal rotation. From the radiographs, femoral offset, leg length, and femoral stem to shaft angle were measured using in combination the femoral component application of Einzel-Bild-Roentgen-Analyse software (EBRA-FCA; University of Innsbruck, Innsbruck, Austria) *(4)* and Image J 1.41 image processing and analysis software (National Institutes of Health) (Fig. 2). All measurements were normalized to the distance between teardrops which was calculated from post-operative radiographs, based on the known outside diameter of one acetabular component.

Radiographic measurements between hips were assessed with independent student's t-tests. Differences between pre-operative and post-operative radiographic measurements were evaluated with paired Student's t-tests. Alpha level was set at 0.05.

RESULTS

The mean stem to femoral shaft angle in the hybrid group was 139.7° (range, 131° to 153°). The mean stem to femoral shaft angle in the cementless group was 133.3° (range, 120° to 149°). This difference was significant (p=0.0128).

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Mean femoral offset and mean leg length were comparable between the two groups both pre-operatively and post-operatively (Table II). The differences in femoral offset and leg length between pre-and post-operative values were not statistically significant in the hybrid group (p= 0.1899 and p=0.0712, respectively). However, the small differences observed in the cementless group between pre- and post-operative measurement were statistically significant for both femoral offset (p=0.0016) and leg length (p=0.0015).

Table II.

Pre-operative measurements		
	Femoral offset (mm)	Leg length (mm)
Hybrid design	35.2 (10.8-49.2)	38.6 (24.4-53)
Cementless design	39.4 (25.2-52.1)	41.4 (28.7-53.7)
p value	0.0932	0.2482
Post-operative measurements		
	Femoral offset (mm)	Leg length (mm)
Hybrid design	37.2 (28.8-47.6)	36.3 (24.4-52.9)
Cementless design	35.6 (23.6-51.3)	37.7 (22.8-52.4)
p value	0.3854	0.6233

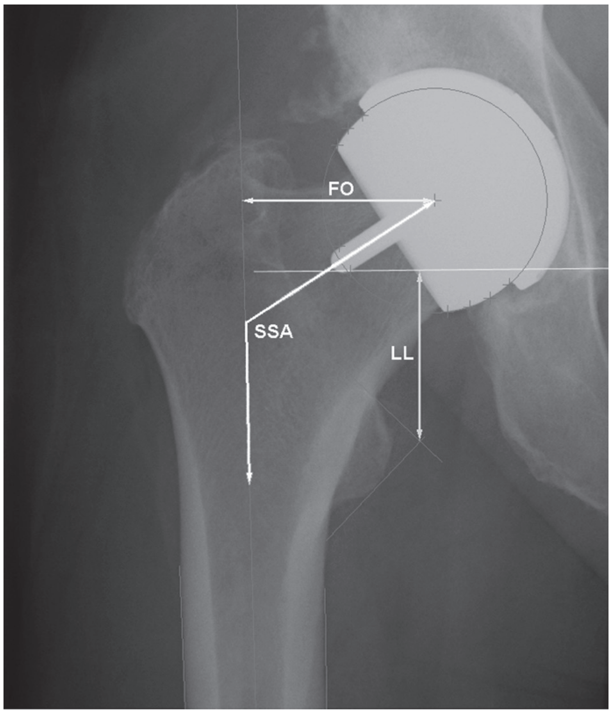

Fig. 2. — For the measurement of the femoral offset, the central axis of the femoral shaft and the center of the head were determined using EBRA – FCA (grey lines). The femoral offset (FO) was measured using Image J software as the shortest distance in millimeters between the center of the head and the central femoral shaft axis. This distance was normalized to the distance between teardrops calculated from the known diameter of the acetabular component on a post-operative x-ray.
Leg length (LL) was measured as the shortest distance in millimeters between the inter-teardrop line and the apex of the lesser trochanter determined by the intersection of EBRA-FCA construction lines set for a 45° angle with the central axis of the femur. This distance was normalized as described above.
The femoral stem shaft angle (SSA) was measured using the central axis of the femoral shaft and the axis of the metaphyseal stem of the femoral component.

DISCUSSION

Hybrid metal-on-metal hip HRA has been available for over 15 years but very little is known about the new generation of hip resurfacing devices that use a cementless, porous coated femoral component. We sought to determine whether the biomechanical reconstruction of the hip joint differed between the standard of care in resurfacing and these new devices.

There are several limitations in our study. First, all but one of our patients had their first hip resurfacing performed with the hybrid design and the second surgery done several years later with the cementless femoral component. Patients who have undergone a successful arthroplasty on one hip tend to seek treatment of the contralateral joint much earlier in the development of the disease (as confirmed by the presence of larger femoral defects in the hips resurfaced with the hybrid design in our series) and this may have limited the ability of some patients to internally rotate their hips into the position needed for a well-standardized anteroposterior pelvis radiograph. This could explain why the mean pre-operative femoral offset tended to be slightly larger in the cementless group (delta 4.2 mm, p=0.0932). However, we are confident that the post-operative radiographs showed both hips internally rotated in a symmetrical position and ensured a fair comparison of the biomechanical reconstruction provided by the two designs (Table II). Also, the larger prevalence of femoral head defects greater than 1cm in the hybrid group

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did not impair in any way the ability for the surgeon to preserve femoral neck length because none of these defects affected the entirety of the dome and chamfered area of the reamed femoral head.

We found that the stem to femoral shaft angle was lower in the cementless group and this was no surprise as the senior author deliberately modified the target angle to facilitate the reaming of the femoral head and ensure complete apposition of the bone to the porous coating inside the femoral component. However, neither femoral offset nor leg length differed significantly between the two groups post-operatively. The reconstruction with both hybrid and cementless designs may lead to small reductions of femoral offset and leg length compared with the native hips and the absence of reduction in femoral offset on the hybrid side would owe to the inability for some patients to be properly positioned for the pre-operative x-ray, as explained in the limitations of the study. However, it is important to note that these pre- to post-operative differences ranged in magnitude from 2 to 4 mm on average and are unlikely to represent perceivable or clinically meaningful modifications of the hip biomechanics. Our results for the hybrid design confirm those of Herman et al. who found no difference in femoral offset or leg length between the reconstructed hip and the contralateral, unoperated hip *(10)*, or those of Silva et al. and Leclercq et al. who found minimal differences in femoral offset and leg length between reconstructed hips and pre-operative measurements of the same hips *(14,18)*. These results are also consistent with those of Brown et al. who found both post-operative femoral offset and leg length to be very close to the pre-operative values while the discrepancies were substantially larger in reconstructions performed with total hip arthroplasty *(5)*.

In conclusion, both hybrid and cementless designs provide similar biomechanical reconstructions comparable to the morphology of the native hip and this is achieved independently from the orientation of the femoral component in the frontal plane. Further data with longer follow-up are needed to determine whether the all cementless hip resurfacing designs perform as well or better over time than the now well-established hybrid designs.

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