Original article

Does using a polyethylene RM press-fit cup modify the preparation of the acetabulum and acetabular offset in primary hip arthroplasty?

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A B S T R A C T

Introduction: When performing total hip arthroplasty (THA), it is important to maintain the femoral and acetabular offsets to ensure good joint stability and to restore the function of the hip abductor muscles. In our practice, we mainly use a lateraled stem and hollow out the acetabulum to the quadrilateral plate to accommodate a press-fit polyethylene cup. However, the repercussions of this preparation method, which is driven by the cup’s design, are not known. We carried out a retrospective study to assess: (1) the changes in the femoral and acetabular offset; (2) the height of the center of rotation; and (3) the repercussions on wear.

Hypothesis: We hypothesized there would be no significant differences between the preoperative and postoperative femoral and acetabular offsets.

Patients and methods: We reviewed 88 primary THA cases performed with the RM Pressfit™ cup that had a minimum of 5 years’ follow-up. A lateraled self-locking Muller-type cemented femoral stem was used in 92.0% of cases and a standard stem in 8.0%. Measurements were done on plain radiographs with MHP™ and Mesurim Pro™ software. The average follow-up was 6.5 years (5–8).

Results: On average, the acetabular offset was reduced by 2.75 mm ± 5.9 mm (range: −17.5 to +10.6 mm) (P<0.001) and the femoral offset was increased by 0.01 mm ± 5.5 mm (range: −17.8 to +11.0 mm) (P=0.99). In terms of total offset, medialization of 2.74 mm ± 7 mm (range: −17.7 to +18.2 mm) was found (P=0.001). The acetabular center of rotation was on average 4.77 mm ± 5.1 mm higher (P<0.001). The mean annual wear at the more recent follow-up (min.: 5 years) was 0.068 mm (range: 0.01 to 0.25 mm) per year. The wear was not impacted by having more than 5 mm change in offset.

Discussion: Measurements of acetabular offset revealed statistically significant medialization due to the type of implant used and the surgical technique. The anatomical technique consists of positioning the cup in subchondral bone without contacting the quadrilateral plate. This preserves bone stock, which may be useful later on if the cup is revised, particularly in younger patients. Conversely, the femoral offset did not change significantly, despite the use of lateraled stems in 92.0% of cases. We measured an annual wear rate of 0.068 mm per year, which is lower than in other published studies, possibly because our patient population was older.

Level of evidence: IV, retrospective study.

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1. Introduction

When performing total hip arthroplasty (THA), it is important to maintain the femoral and acetabular offsets to ensure good joint stability and to restore hip abductor muscle function [1–5]. When implanting the cup, it is often recommended to ream the acetabulum deeply to obtain good implant hold; however, this may modify the offset. Even a small variation in the offset can alter walking [6]. As a consequence, the patient’s original acetabular offset should be maintained [7]. The same goes for the femoral side. Altering the original offset can lead to poor outcomes [8] or even revision when the changes are too large [9].

In our practice, we use the RM Pressfit™ cup. This cup’s design requires us to over-ream the acetabulum beyond subchondral bone and into the quadrilateral plate to obtain satisfactory primary
2. Material and methods

2.1. Patients

We retrospectively reviewed the primary THA cases performed with the RM Pressfit™ cup (Mathys, Bettlach, Switzerland). All cases were also performed with a standard length, non-modular, cemented femoral stem (CCA™, Mathys, Bettlach, Switzerland) using either a standard or lateralized neck. Between February 2006 and December 2008, we performed 189 consecutive THA cases with the RM Pressfit™ cup and the CCA™ stem. The cases included in this study were chosen from the above cases when preoperative radiographs and radiographs at least 5 years’ postoperative were available (Fig. 1). Our research ethics committee approved the study on 19 June 2014 (CEIC Rhône-Alpes-Auvergne, Grenoble, IRB 5921). Nine different surgeons performed these THA cases. Fifty-four patients (61.4%) were women. According to Devane activity scale [10], 3 patients (3.4%) were level 1, 30 patients (34.1%) were level 2, 43 (48.9%) were level 3, 11 (12.5%) were level 4 and 1 (1.1%) was level 5. The THA was performed because of primary hip osteoarthritis in 78 of the 88 cases (88.6%). The other cases were performed because of post-traumatic osteoarthritis (2 cases, 2.3%), rapidly destructive hip osteoarthritis (2 cases, 2.3%), femoral head vascular necrosis (2 cases, 2.3%), femoral neck fracture (2 cases, 2.3%), inflammatory hip arthritis (1 case, 1.1%) and hip dysplasia (1 case, 1.1%).

2.2. Methods

Radiographic templates were used for the preoperative planning. An anterolateral approach (modified Hardinge) was used [11]. The acetabulum was reamed as inferiorly and medially as possible until the size of the cavity matched the periphery of the cup. We used an odd-number reamer one size larger than the desired cup size and an 800-g hammer. Since the reaming went to the quadrilateral plate, it was exposed with a bone chisel. The lower portion of the reamer was placed slightly above the obturator ring. The femoral neck was cut as planned preoperatively to achieve the desired femoral offset. The femoral canal was prepared with rasps. A high-viscosity, antibiotic-loaded cement (Palacos™ Genta, Hereaus, Hanau, Germany) was injected in a retrograde manner to fix the stem; a cement restrictor was used in all cases. Either a standard or lateralized stem configuration was chosen, based on the preoperative plan.

The cup was a monoblock cementless (press-fit) cup made of ultra-height molecular weight polyethylene (non-crosslinked) that is coated with titanium and has no metal shell (RM Pressfit™ Cup, Mathys, Bettlach, Switzerland). The straight femoral stem was made of cobalt-chrome alloy (CCA™, Mathys, Bettlach, Switzerland); this was a cementedMüller-type stem [12]. A standard neck was used in 7 cases (8.0%) and a lateralized neck in 81 cases (92.0%) (stems with more than 8 mm femoral offset). A 28-mm diameter head was used in all cases; a ceramic head was used in 29 cases (33.0%) and a metal head in 59 cases (67.0%). The head length was adjusted as needed; we used 60 short heads (68.2%) (4 mm shorter for metal head and 3.5 mm shorter for ceramic heads), 27 medium heads (30.7%) and 1 long head (1.1%) (4 mm shorter). In three patients (3.4%), autologous bone graft was placed at the bottom of the acetabulum to fill a subchondral cyst. Four cups (4.5%) required two screws as supplementary fixation.

2.3. Assessment methods

All the living patients were either reviewed in person or asked to send us anteroposterior (AP) radiographs of the pelvis that showed the entire femoral stem. The radiographs were required to have the coccyx centered, symmetric obturator rings and the femoral stem had to be straight on. Calibration was done using the size of the acetabular cup. The primary outcome measure was the restoration of the femoral and acetabular offsets. Function was assessed using the Postel-Merle d’Aubigné (PMA) score [13]. The acetabular, femoral and total offsets were measured as described by Lecerf et al. [1] using Mesurim Pro™ freeware (Académie d’Amiens, France) (Fig. 2). The height of the center of rotation was measured relative to the bi-ischial line. The position of the femoral stem was determined on AP radiographs. The stem was in varus when the tip of the stem only made contact with the lateral cortex; similarly, the stem was in valgus when the tip of the stem only made contact with the medial cortex. In all other cases, the position was considered normal. We measured the leg length difference by comparing the difference in height of the lesser trochanter; this difference was considered positive if the operated lower limb was 1 cm longer or more. Cup wear was measured using MHP™ software (université Clermont-Auvergne, France) as described by Sarry et al. [14,15]. Early postoperative weight-bearing radiographs taken in the first 3 months after surgery were compared to those at the most recent follow-up (minimum 5 years). These radiographs were also used to determine cup version (Fig. 3). The center of rotation was defined by locating the center of a circle representing the femoral head or prosthetic head.
2.4. Statistical methods

The findings were described using counts and percentages for qualitative and categorical variables and using mean ± standard deviations along with minimum and maximum values for the quantitative variables. Qualitative variables were compared using the Chi² test (or Fisher’s exact test if the counts were too low). Quantitative data were compared between groups before and after the surgery using a paired Student’s t-test with P < 0.05. Correlations between variables were calculated using the Pearson R; a value of R > 0.5 indicated a strong correlation.

3. Results

The average follow-up was 6.5 years (5–8). Preoperative and postoperative radiographs were available for 88 patients. No THA revision was performed because of instability. A leg length difference of ≥ 1 cm was found in 14 patients. The mean PMA score at the last follow-up was 15.7 ± 2.8 (range: 6 to 18).

The average difference in the acetabular offset before and after the THA procedure was −2.75 mm ± 5.9 mm (range: −17.5 to +10.6 mm), resulting in postoperative medialization (P < 0.001). The average difference in femoral offset was +0.01 mm ± 5.5 mm (range: −17.8 to +11.0 mm) (P = 0.99). This resulted in an average total offset difference of −2.74 mm ± 7.6 mm (range: −17.7 to +18.2 mm) (P = 0.001). Eighteen patients had more than 10 mm difference between the preoperative and postoperative offset; however, greater wear or larger differences in the height of the center of rotation were not observed in these patients. The correlation between the femoral offset, acetabular offset and height of center of rotation on one hand, and the variation in each of these parameters on the other are shown in Fig. 4. The average difference in the height of the acetabular center of rotation was +4.77 mm ± 5.1 mm (range: −4.3 to +18.2 mm), resulting in postoperative elevation (P < 0.001).

Sixty-seven patients (76.2%) had a neutral femoral stem position, 18 (20.4%) had a varus stem and 3 (3.4%) had a valgus stem. The femoral offset as a function of stem inclination is shown in Fig. 5. The average cup version was 16.1° ± 7.9° (range: 0° to 35.5°).
The average inclination in the frontal plane was 42.8° ± 7.0° (range: 24° to 62°), with 12 patients (13.6%) having ≥50° inclination.

The mean annual wear at the most recent follow-up (minimum: 5 years) was 0.068 mm per year (range: 0.01–0.25 mm). The annual wear rate was not correlated with the inclination, acetabular, femoral or total offsets, height of the center of rotation, Devane activity score or femoral head material (all correlation coefficients less than 0.4) (Table 1).

The cup is revised, particularly in younger patients [17]. Our technique requires over-reaming (+1 mm), which can medialize the cup by 0.5 mm; however, this does not explain the average +2.75 mm of medialization measured in our study. Conversely, this technique provides reliable primary fixation.

Our study has several limitations. It was performed at a single research site and was retrospective. However, all the available THA cases with the RM Pressfit™ cup performed at our hospital were included. This may have led to a selection bias. Since only the records of living patients were analyzed, this may have increased our selection bias. The 46% review rate is low, which may have directly influenced our results. Our study population was not homogenous; both metal and ceramic femoral heads were used, although we found no differences between these two materials. Although this may have impacted the results; we likely did not have a large enough sample size to identify it. The offset can be measured more accurately with a CT scan [1,18]; however, this is harder to obtain. Three-dimensional imaging would have been more accurate.

In this study, we compared the preoperative and postoperative implant positions on the premise that the implants must be placed in the original position. But in cases of preoperative abnormality, one wonders whether this positioning should be modified, particularly in cases of large femoral valgus and coxa profunda. The femoral offset was altered in a non-significant manner after the THA. This is consistent with the preoperative plan. In our study, 92% of the cases were done with a lateraled stem. Although this may seem like a high percentage, the average femoral offset was not altered.

Fig. 3. MHP software (université Clermont-Auvergne, France) used to measure wear.
Fig. 4. Correlation between the preoperative femoral and acetabular offsets and the height of the preoperative rotation center on the one hand and the change in the femoral, acetabular offset and the height of the center of rotation. A. Correlation between preoperative femoral offset and the change in femoral offset ($R^2 = -0.57$). B. Correlation between preoperative acetabular offset and the change in acetabular offset ($R^2 = -0.64$). C. Correlation between the height of the preoperative center of rotation and the change in height of the center of rotation ($R^2 = -0.39$).

Fig. 5. Change in the femoral offset in mm (mean ± standard deviation) as a function of the position of the femoral stem.
This is further evidence of the importance of preoperative planning. It is important not to reduce it [19], as this could result in the abductor muscles having a shorter moment arm and the patient limping. Some authors have reported the femoral offset can be better restored with cementless stems [20]. This could not be evaluated in our study, as all the THA cases were done with cemented stems. Varus or valgus femoral stem positioning did not cause a significant change in the femoral offset, even though a varus stem tends to increase the offset and a valgus stem tends to decrease it. In patients with larger femoral offset, the tendency is to attempt to reduce it; the same goes for acetabular offset. Surgeons must be particularly aware of this in patients with large anatomical variations; the effect is not as pronounced for the height of the center of rotation.

Fourteen patients (15.9%) had more than 1 cm leg length difference. This is partly due to a technical error and partly due to challenges associated with performing intraoperative soft tissue release while ensuring good implant stability. Femoral offset and leg length can be measured intraoperatively with a mechanical measurement device [21] or by computer-assisted surgery [22]. However, the former is only done with the postero-lateral approach and the latter lengthens the operative time and increases the procedure costs. There are no published methods to measure acetabular offset intraoperatively.

We found an average annual wear rate of 0.068 mm per year; this is lower than the 0.09 rate reported by Wyss et al. [23] and the 0.07 rate reported Lafon et al. [24], possibly because our population was older. The study population was heterogeneous with a metal femoral head used in 67% of cases, which may have affected the wear. A new version of this cup made of highly cross-linked polyethylene loaded with vitamin E (Vitamys™) is currently being evaluated clinically.

5. Conclusion

It is critical to maintain the offset during THA. The technique we use decreases the total offset due to a decrease in the acetabular offset. We need to consider changing the surgical technique. These findings must be considered in the context of good clinical outcomes and no medium-term complications.

Disclosure of interest

Stéphane Boisgard is an educational consultant for Zimmer-Biomet outside this study. The other authors declare that they have no competing interest.

References


