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# Incidence and Natural Course of Initial Polar Gaps in Birmingham Hip Resurfacing Cups

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**Abstract:** The purpose of this study was to retrospectively investigate the incidence of initial polar gaps and their effect on clinical results in Birmingham Hip Resurfacing cups. A total of 151 hips in 134 patients who underwent hip resurfacing at a mean age of 50 years were examined. The mean follow-up period was 7 years. A polar gap was identified in 47 hips (31%) with a mean width of 2.1 mm. Gaps of 2 mm or more were identified in 21 hips, 6 of which showed reductions in cup inclination during the initial 3 months. After 3 months, no progressive cup migration was observed. There was no cup revision. All gaps were filled with bone within 2 years of surgery. The initial polar gaps had no significant influence on the stability of hydroxyapatite-coated Porocast cobalt-chromium hemispherical monoblock cups (Midland Medical Technologies Ltd, Birmingham, UK), although gaps of 2 mm or more had a higher risk of early migration.
**Keywords:** gap, cobalt-chromium monoblock cup, hip resurfacing arthroplasty, hydroxyapatite coating, bone ongrowth.


The current standard acetabular component design for metal-on-metal hip resurfacing is a cementless monoblock cup made of a cobalt-chromium alloy. Secure initial fixation of the monoblock cup using the press-fit technique is required for hip resurfacing because additional dome screw fixation cannot be applied. The press-fit technique uses underreaming of the acetabular cavity with a hemispherical cup design, or same-size reaming with a rim enlarged cup design. This press-fit technique increases the peripheral contact of the cup before full seating into the cavity, and this may result in gap formation between the acetabular floor and the cup, if the impact force is not sufficient.

The incidence of such polar gaps is reported to be 16% to 39% in titanium modular cups fixed using the 1- to 3-mm press-fit technique [1-4]. Most studies have reported that the initial polar gaps had no significant influence on clinical results with titanium alloy cups.

Long et al [5] reported that the Durom cup (Zimmer, Warsaw, Ind), a metal-on-metal monoblock cobalt-chromium alloy cup, showed unexpectedly high rates of aseptic loosening related to gap formation. They noted that the flare design and uncoated cup rim may prevent the fixation surface from contacting throughout the prepared acetabular bone, whereas the plasma spray titanium coating on the cobalt-chromium alloy might not promote bone formation in the gaps. This suggests that large initial polar gaps reflect low bone contact in the cup for osseointegration, which might increase the rates of aseptic loosening. However, there have been few reports regarding the incidence and size of initial polar gaps in metal-on-metal monoblock cobalt-chromium alloy cups with different designs or their effects on clinical results. The higher stiffness of cobalt-chromium alloy acetabular cups may increase the impact force until full seating due to reduced cup deformation, which may increase the incidence and size of initial polar gaps. It is inherently difficult to confirm acetabular cup seating because there are no dome holes.

The purpose of this study was to retrospectively investigate the incidence and size of initial polar gaps and their effect on clinical results when hydroxyapatite (HA)-coated Porocast cobalt-chromium monoblock hemispherical cups (Midland Medical Technologies Ltd, Birmingham, UK) were used in metal-on-metal hip resurfacing arthroplasty.

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## Patients and Methods

Institutional review board approval was obtained for this retrospective study. From February 1998 to December 2007, 141 patients (160 hips) underwent hip resurfacing arthroplasty using HA-coated Porocast cobalt-chromium hemispheric monoblock cups (Birmingham Hip Resurfacing [BHR] prosthesis; Midland Medical Technologies Ltd). Of the 141 patients, 2 (2 hips) were lost to follow-up and 5 (7 hips) died of unrelated causes. Thus, 134 patients (151 hips) were available for inclusion in the present study, after a mean follow-up duration of 7 years (range, 2-11 years). Patient demographics are listed in Table 1.

The acetabular components of the BHR prosthesis are manufactured by casting of a high-carbon cobalt-chromium alloy. The cup is hemispherical with 2 fins pointing toward to the pubis and ischium for rotational stability [6]. The backside of the cup has a 1-mm porous-like textured rough surface (Porocast) with HA coating to promote bone ongrowth. The cup has a wall thickness of 3 or 4 mm, and cup sizes are available in Japan in increments of 2 mm. In this series, the median diameter of the acetabular cups was 52 mm (44-62 mm).

All procedures were performed through a posterolateral approach with the patient in the lateral position. The acetabulum was reamed progressively with a hemispherical reamer to obtain an interference fit between the anterior and the posterior columns. The same-size hemispherical provisional cup with dome holes and slits was used to check the cavity for complete seating. If the provisional cup could not be seated on the floor, reaming was repeated with the same reamer to remove the rim bump until full seating was achieved. Acetabular cups with a 1-mm larger diameter were impacted into the acetabulum using the press-fit technique. After press-fit fixation, the quality of cup fixation was confirmed with synchronized movement of the pelvis and the cup inserter by applying weight with one hand. In all cases, the initial stability of the acetabular component was assessed as satisfactory during surgery. All patients were allowed full weight bearing immediately after surgery.

Clinical and radiographic follow-up was performed immediately after surgery, at 3 weeks, 3 and 6 months, and 1 year after surgery and then annually thereafter. Clinical assessments were performed preoperatively and at the most recent follow-up using the Merle d'Aubigne and Postel Hip Score System [7]. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [8] self-assessment questionnaire was administered at the most recent follow-up. The Merle d'Aubigne and Postel Hip Score System consists of a total score of 6 points each for pain, range of movement, and gait function. The WOMAC consists of a total score and 3 subscales for pain, stiffness, and physical function. Ranges of subscale scores are 0 to 20, 0 to 8, and 0 to 68, respectively. The score obtained using WOMAC for an asymptomatic patient is 0, and the worst score is 96.

Anteroposterior radiographs were taken in a supine position with bilateral hip joints in the internal-rotation position, with the beam center on the pubic tubercle. Radiographs were digitized to tagged image file format files at a resolution of 300 dots/in. Measurements on the radiographs were corrected for magnification and were based on the known diameter of the cup equator. The presence of a gap was assessed on radiographs taken immediately after surgery. Gap width was measured on the radial line passing through the center of acetabular components. *Gap size* was defined as the maximum width of each gap (Fig. 1). *Cup inclination angle* was defined as the angle between a line across the face of the acetabular component and the interteardrop line.

**Table 1.** Demographic Characteristics of the 134 Patients (151 Hips)

| Variables | |
|---|---|
| Age (y), mean (range) | 49.1 (19-85) |
| Height (cm), mean (range) | 160.9 (138-184) |
| Weight (kg), mean (range) | 60.7 (35-96) |
| Body mass index (kg/m$^2$), mean (range) | 23.4 (16.8-33.2) |
| Sex (patients), M:F | 61:73 |
| Diagnosis, patients (hips) | |
| Osteoarthritis | 92 (104) |
| Osteonecrosis | 32 (37) |
| Other | |
| Rheumatoid arthritis | 3 (3) |
| Ankylosing spondylitis | 1 (1) |
| Traumatic osteoarthritis | 5 (5) |
| Traumatic osteonecrosis | 1 (1) |

Abbreviations: M, male; F, female.

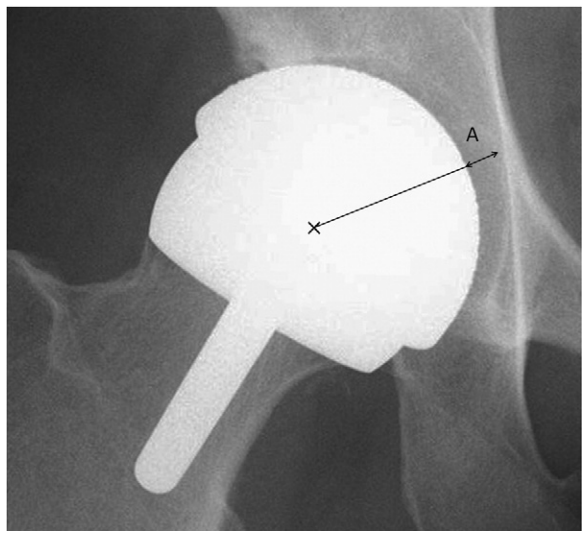


**Fig. 1.** Gap size was defined as the maximum width of each gap. Gap size was measured between the acetabular cup and the acetabular floor, along a line running across the center of the acetabular component (A; bidirectional black arrow).