

# Howse II cemented titanium metal-backed acetabular cups

## Poor 10-year results in 107 hips

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**ABSTRACT** We report a retrospective clinical and radiographic review of 107 consecutive primary total hip replacements, using the cemented Howse II prosthesis. The review concentrates on the long-term performance of the acetabular cup, which was designed with a cylindrical titanium metal backing and a polyethylene liner. In all the hips in the series, this cup was used with a modular titanium straight femoral stem and a 32-mm diameter titanium head.

At a mean follow-up of 9.8 (7–11) years, 28 hips had already been revised and 10 others were recognized as clinical or radiographic failures. The indication for revision in 26 of the hips was aseptic loosening and the mean time to revision was 7.2 (3.7–10.9) years

This metal-backed cup has only 42% survival at 10 years, which seems to be related to certain of its design features. These include an inadequate thickness of polyethylene sterilized by gamma irradiation in air, a lack of mechanical bonding between the liner and its metal shell, and the high wear rate from the use of a 32-mm titanium femoral head.

The use of metal backing for cemented acetabular cups was first reported in 1971 (Harris 1971). The original components were designed with modular replaceable liners in anticipation of predicted polyethylene wear, especially in young patients. It was planned that this feature would allow exchange of the liner when wear had occurred, without necessitating revision of the cemented metallic shell if this remained well fixed.

Early studies using the cemented metal-backed acetabular components showed encouraging short-term clinical results with loosening rates of only around 7% (Harris and White 1982, Harris 1984, Mattingly et al. 1985). Such cups became widely accepted and were implanted extensively in the 1980s. However, a few clinical reports with intermediate to long-term follow-up (Harris and Penenberg 1987, Ritter et al. 1990) and anecdotal evidence from various centers showed a dramatic rise in failure rates. As a result, the popularity of metal-backed cups fell sharply. Despite their previous widespread use, there is a paucity of published long-term results concerning metal-backed cups (Markel et al. 1995, Ritter 1995, Ziegler and Lachiewicz 1996, Chen et al. 1998, Sochart and Hardinge 1998, Garrelick et al. 1999) and the exact mechanism of failure remains unclear.

We evaluated the long-term results of total hip replacements performed in our center, using the Howse II cemented metal-backed cup (Johnson & Johnson, Hants, UK) and suggest a mechanism of failure of this particular design of the acetabular component.

### Patients and methods

Between 1987 and 1990, 107 Howse II total hip replacements were implanted in 102 patients (Table).

The Howse II total hip replacement featured a titanium metal-backed acetabular cup with an

## Demographic and surgical data

<i>Demographic data</i>	
Number <sup>a</sup>	102 (107)
Age, mean (range)	68 (33–92)
Gender: male/female	34/68
<i>Diagnosis <sup>a</sup></i>	
Primary osteoarthritis	81 (85)
Rheumatoid arthritis	15 (16)
Posttraumatic arthritis	2 (2)
Avascular necrosis	1 (1)
Failed Internal fixation	1 (1)
DDH	1 (1)
<i>Surgical data</i>	
Approach: direct lateral/posterior	92/15
Cup sizes: small/medium/large	31/42/34

<sup>a</sup> Number of patients (hips)

ultra-high molecular weight polyethylene liner, articulating with a 32-mm diameter modular titanium head on a titanium alloy straight stem. The prosthesis was available in 3 cup sizes, 3 head lengths and 5 sizes of stem. The titanium alloy metal backing was cylindrical in cross-section with a hemisphere at its apex. Its surface was textured to improve cement fixation (Figure 1). The cylindrical polyethylene liner was machined and sterilized by gamma irradiation in air. It was not mechanically bonded to the metal backing, but was designed to be not replaceable. The liner also had small projections through the metal shell to act as cement spacers, thus preventing the cup from bottoming out during insertion and to ensure a minimum cement mantle of 2 mm.

Two senior consultants, or trainees under their supervision, performed all the operations, using either a direct lateral (86%) or posterior (14%) approach. The acetabulum was prepared with powered sequential hemispherical reamers and multiple 8 mm partial thickness drill holes were made before cement insertion by digital packing. Cup size was selected to give complete bone containment. The small cup was used in 31 hips, medium in 42, and the large in 34. All operations were carried out in laminar flow ventilation and patients received systemic antibiotics preoperatively.

Postoperatively, patients were mobilized on crutches for 6 weeks after a short period of bed rest. Thereafter, they progressed to use of a walking stick and later to unaided mobilization. Clinical and radiographic review were undertaken at 6



Figure 1. Howse II metal-backed acetabular component showing the characteristics of the cup: titanium metal backing with textured outer surface, small projections of the polyethylene liner acting as cement spacers.

weeks, 6 months, 1 year and 2 years postoperatively. Patients who were clinically asymptomatic and had no radiographic evidence of loosening were discharged after 2 years.

Surviving patients were subsequently reviewed clinically and radiographically in specially-arranged clinics. Those patients who were unable or unfit to attend were interviewed by telephone. General practitioners or relatives of the dead patients were contacted to inquire about any problems with the index arthroplasty.

Clinical evaluation was performed, using a standard Harris (1969) Hip Score. Most recent standard anteroposterior pelvic radiographs were compared with the earliest postoperative film for evidence of migration of the acetabular component, using the technique described by Massin et al. (1989). The vertical distance between the center of the cup and the line joining the two teardrops was measured, together with the horizontal distance between the center of the cup and the vertical line through the teardrop. The angle of cup inclination was also determined, using the inter-teardrop line as the reference point. The acetabular component was considered to have migrated, if these distances varied more than 5 mm, or the angle of inclination changed by more than 5 degrees. The mean postoperative cup inclination angle was 47 (41–55) degrees.

### Statistics

Statistical analysis was performed to determine any association of age, diagnosis, cup size or cup

Figure 2. Radiograph of the hip of a 56-year-old patient with osteoarthritis.



A. Immediately after surgery, showing good position of the cup and a well-fixed stem.



B. 9 years after surgery, showing gross migration of the cup and eccentric wear of the polyethylene.

inclination angle with failure. The Kaplan-Meier method was used to calculate survival of the cup with revisions and all failures (revisions + radiographic loosening) as end points. The Log rank test was used to assess the statistical significance after stratifying the data as follows: age (< 65 vs. > 65), diagnosis (OA vs. RA), cup size (small, medium or large), and cup inclination angle (< 45° vs. > 45°). Multivariate analysis, based on the Cox proportional hazards model, was used to identify independent predictors of implant survival. A *p*-value of 0.05 was considered as significant.

## Results

At the time of final assessment, 40 patients (43 hips) had died from unrelated causes with no history of any hip symptoms or revision surgery. Another 16 patients (17 hips) were unfit to attend for review, but telephone interview confirmed that their total hips were asymptomatic. 2 patients (2 hips) were lost to follow-up. Of the remaining 44 patients (45 hips), 28 hips had been revised, leaving 16 patients (17 hips) available for clinical and radiographic analysis. The mean follow-up was

9.8 (7–11) years. The mean Harris hip score at final review was 73 (28–100) points. 10 cups had migrated radiologically, 5 of which were found to require revision, but the patients either declined surgery or were unfit for this procedure. 6 of these failed hips remained asymptomatic with mild, if any, pain at all. Only 7 cups remained well fixed.

Of those revised, 26 were for aseptic loosening and the other 2 for infection. Mean time to revision was 7.2 (3.7–10.9) years. 10 patients required revision of the acetabular cup alone. 16 hips required exchange of both components either due to stem loosening or extensive proximal femoral osteolysis.

The commonest radiographic appearance of cup failure was superolateral wear of the polyethylene, tilting of the acetabular component into a more open position and occasionally contact between the femoral head and the metal backing of the cup (Figure 2).

At revision, most acetabular components were found to have failed both at the cement-cup and cement-bone interface. 4 of the cups showed complete wear of the polyethylene liner resulting in metal-on-metal contact and one had broken through the area of thinnest polyethylene result-

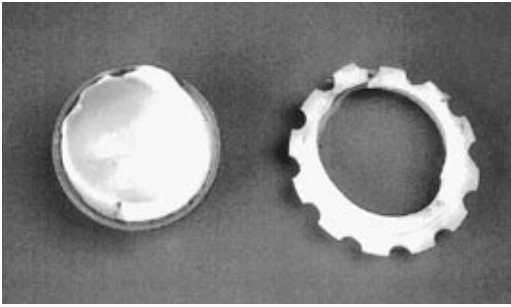


Figure 3. The retrieved cup from the hip in Figure 2, showing catastrophic wear of the polyethylene liner with complete dissociation of the rim of the cup.

ing in complete dissociation of the liner (Figure 3). The rest had marked polyethylene wear in the superolateral and weight-bearing zones. We found varying amounts of periprosthetic tissue metallosis, especially when associated with burnishing of the external surface of the cup.

#### Survivorship analysis

With all revisions as end point, the cumulative survival at 10 years was 59% (95% CI: 45% and 74%) (Figure 4A). The results of univariate analysis showed the cup size to be a significant indicator of implant survival ( $p = 0.04$ ), with the large cups surviving longer. However, using stepwise Cox Hazard modeling, none of the factors, viz. age, diagnosis of OA or RA, cup size and cup inclina-

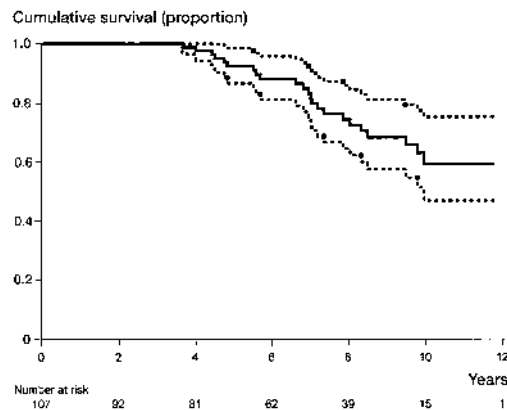
tion angle, were found to have a statistically significant effect on implant survival.

With all failures as end point (all revisions + radiologic loosening), the cumulative survival was 42% at 10 years (95% CI: 27% and 56%) (Figure 4B). With stratification, only the medium cup size was found to be a significant indicator for survival ( $p = 0.01$ ), with larger cups surviving longer than the medium sized ones. Using the stepwise Cox Hazard modeling, age ( $p = 0.03$ ) and medium cup size ( $p = 0.02$ ) were found to be independently useful predictors of implant survival, but diagnosis and cup inclination angle were not.

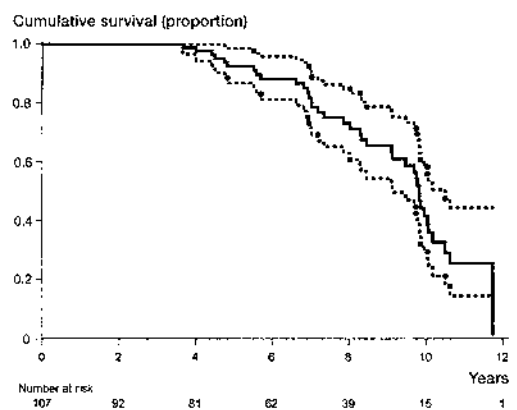
#### Discussion

In our series, the Howse II metal-backed acetabulum had a survival rate of only 42% at 10 years. Harris and White (1982) reported a 6% incidence of aseptic loosening in 51 patients at an average follow-up of 6.5 years. However, in a further follow-up evaluation at an average of 11 years (Harris and Penenberg 1987) in the same group of patients, the revision rate had risen to 19% with an additional 21% showing radiographic evidence of loosening. Ritter et al. (1990) reported their study comparing cemented Miami Orthopaedic Surgical Consultant (MOSC) metal-backed cups (Biomet, Warsaw, Indiana) with cemented MOSC all-polyethylene

Figure 4. Kaplan-Meier survivorship analysis with 95% confidence intervals.



A. Survivorship of the cup (%), using all revisions as the end point.



B. Survivorship of the cup (%), using all failures (revisions + radiologic loosening) as the end point.

components. A 28-mm titanium head was used in both these groups. At a mean follow-up of 5.2 years, the rates of complete radiolucency (39% vs. 23%), loosening (4% vs. 2%) and revision (6% vs. 2%) were found to be significantly higher in the metal-backed cup group. At a subsequent mean follow-up of 9.4 years, the failure rate had increased to 20% in the metal-backed group as compared to 9% in the all-polyethylene group. (Ritter 1995). In the same cohort of patients, Cates et al. (1993) found a 37% higher polyethylene wear rate among the metal-backed cups. On the basis of the data, these authors recommended that the use of cemented metal-backed cups should be abandoned. Using the Mallory-Head metal-backed acetabular component (Biomet, Warsaw, Indiana) with a 28-mm titanium head, Mulliken et al. (1996) reported a loosening rate of 27% at a mean follow-up of 4.8 years. The results with the Spectron metal-backed cup (Smith & Nephew Richards, Memphis TN), using the 32-mm Co-Cr head, have also been poor with Chen et al. (1998) reporting a failure rate of 41% at a mean follow-up of 10 years. More recently, with the same acetabular component, Garellick et al. (1999) have reported poor results with a revision rate of 11% at 10 years.

However, not all the reported results of metal-backed cups have been poor, particularly when these are used with smaller 22 mm heads. In a study comparing 60 metal-backed cups with 55 all-polyethylene components, Markel et al. (1995) showed no statistical difference in the rate of polyethylene wear or loosening at a mean follow-up of 7 years. There were no cup revisions and none of the cups were definitely loose. These authors later switched to the routine use of 28 mm heads and suggested that because of the resultant reduction in polyethylene thickness, the use of metal-backed cups should be abandoned. At a mean follow-up of 12 years, Sochart and Hardinge (1998) reported no revisions in a series of 67 metal-backed Wrightington FC acetabular components (Howmedica, London UK) articulating with 22 mm femoral heads. Using the Triad prosthesis with a 28 mm Co-Cr femoral head (Johnson & Johnson, New Brunswick, NJ), Ziegler and Lachiewicz (1996) reported no statistical difference in the failure rates between 48 metal-backed and 22 all-polyethylene cups at a mean follow-up of 9 years.

The performance of metal-backed cups is probably design-specific. However, the mechanism of failure remains poorly understood. Experimental studies using two-dimensional finite element analysis (Carter et al. 1982, Bartel et al. 1983, Crownschild et al. 1983) suggested significant reductions in stresses in the cement, the polyethylene and the subchondral bone when a 2-mm thick metal backing was added to cemented acetabular components. However, three-dimensional finite element studies seemed to suggest increased peak stresses in the polyethylene as well as the cement with the addition of metal backing (Dalstra and Huiskes, 1991). The high failure rate of the Howse II metal-backed cup may be ascribed to a variety of design features. These include inadequate thickness of the polyethylene liner that is sterilized by gamma irradiation in air, lack of mechanical bonding between the liner and metal backing and the use of a 32-mm titanium alloy femoral head.

Depending on size, the thickness of polyethylene in the Howse II cup at the presumed load-bearing area ranged from 8–13 mm. However, due to its cylindrical configuration, the polyethylene thickness at the equator ranged from only 4–5.5 mm. It has been shown that a polyethylene thickness of less than 6 mm results in increased stresses in the polyethylene and high wear rates (Bartel et al. 1986). In addition, a relatively vertical position of the cup may result in load being borne by the thinnest part of the polyethylene, accelerating the normal wear process. A similar mechanism of failure has been found with cementless cups incorporating cylindrical polyethylene liners with inadequate polyethylene thickness at the equator (Berry et al. 1994, Bono et al. 1994, Perez et al. 1998).

In the Howse II metal-backed cup, we observed a clear lack of mechanical bonding between the polyethylene liner and the outer metal shell. On sectioning an unused acetabular component, there was a definite gap between the liner and the metal shell allowing movement between the two (Figure 5). Cementing of the cup may reduce, but not completely eliminate this motion between the convex external surface of the polyethylene liner and the concave inner surface of the metal backing, leading to 'back-side' wear. Once the acetabular component begins to loosen, the generated metal wear



Figure 5. Cross-section of the Howse II metal-backed cup, showing a definite gap between the polyethylene liner and the metal backing.

particles from the shell may enter the articulation, abrading the femoral head and thus aggravating the wear of the polyethylene liner (McKellop et al. 1995). Titanium alloy femoral heads are known to be more susceptible to this 3rd body abrasion, contributing to the increased wear of the polyethylene (Davidson 1993, Williams 1994). 32-mm heads frequently necessitate a reduction in the polyethylene thickness and at the same time increase the rate of volumetric wear due to an increase in the contact area and the sliding distance (Livermore et al. 1990, Kabo et al. 1993). Sterilization by gamma irradiation in air has been shown to accelerate ageing of the polyethylene (Sutula et al. 1995) and this may also have contributed to the high failure of the Howse II cups.

An additional problem may have been the positioning of a cylindrical acetabular component in a socket prepared by using hemispherical reamers, making it difficult to provide an adequate and consistent cement mantle around the cup. Moreover, the small 2 mm spacers projecting through the titanium shell were of an insufficient size to prevent the apex of the metal shell bottoming-out against bone.

In conclusion, the Howse II cemented titanium metal-backed cups have a high rate of failure associated with a number of design problems. As the cumulative survival of the cup at 10 years was only

42%, we felt it was important that other surgeons were made aware of this high failure rate. We recommend that in institutions using this acetabular component, the surviving patients be recalled for clinical and radiologic review, particularly as radiographic loosening can progress markedly without clinical symptoms.

No competing interests declared.

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