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ORIGINAL PAPER

Results of primary total hip replacement with first generation Bousquet dual mobility socket with more than twenty five years follow up. About a series of two hundred and twelve hips

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Abstract
Purpose The aim of our study was to evaluate long-term survival and dislocation rate of this concept.
Methods It was a retrospective study, on 212 hips using a Bousquet dual mobility Novae® tripodal socket (SERF). Mean follow-up was 25.3 years (95 to 372 months). Mean age at the time of the surgery was 53 years.
Results Pre-operative mean Harris and PMA scores were respectively 54.14 and 11.2. Their respective last follow-up counterparts were 83.6 and 16.9; 25 year follow-up cup survival rate was 90.6%. No dislocation occurred, 45 hips were revised (including 17 cup aseptic loosenings, ten intra prosthetic dislocations, nine liner changes, seven stem failures, two sepsis).
Conclusion Dual mobility socket global long term survival rate was comparable to similar cemented or uncemented series. The absence of dislocations proved the interest of dual mobility concept in hip stability. Implant improvements might widen DM socket indication.

Keywords Dislocation · Dual mobility · Instability · Total hip arthroplasty

Introduction

The dual mobility concept developed by Gilles Bousquet in 1974 is based on two principles [1]. The first is Charnley's low friction arthroplasty principle, namely that a smaller head will prevent multi-directional wear [2]. The second is the McKee-Farrar principle that a large head increases the joint's range of motion and reduces the dislocation risk by increasing the jump distance [3]. As a result, dual mobility cups help to restore the physiological joint range of motion and prevent postoperative dislocation, while also limiting wear stresses.

Although the follow-up of metal-on-polyethylene (MoP) bearings has been described through studies with Charnley total hip arthroplasty (THA) implants [4, 5] and PCA implants [6, 7], there is no comparable study with dual mobility cups reporting more than 25 years' of follow-up.

The team at the Saint-Etienne universitary hospital France helped to pioneer this system and has used dual mobility cups during THA procedures since 1974. As a consequence, we have a historical cohort with the longest known follow-up of Bousquet's original dual mobility cup [8, 9].

The purpose of this study was to analyse the functional outcomes, survival rate, dislocation rate and intra-prosthetic dislocation (IPD) rate after more than 25 years' follow-up of a cohort of primary THA cases performed with first generation dual mobility cups.

Material and methods

Patients

This was a retrospective, single-centre study of an historical cohort of 212 continuous THA cases performed with dual mobility cups in 174 patients. The cohort consisted of all the French patients who underwent primary THA with a first generation dual mobility cup at the Saint Etienne University Hospital between 1 October 1985 and 31 December 1990.

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These THA procedures were performed for the following reasons (listed most to least frequent): primary hip osteoarthritis (OA) (74%), avascular necrosis of the femoral head (12%), hip dysplasia (11%), inflammatory arthritis and post-traumatic hip OA (3%). Patients were excluded if they were from a foreign country (irregular follow-up) or had undergone THA because of a femoral neck fracture or conversion from hip fusion. The latter are complex cases that have different survival than a general, more representative THA population.

The average follow-up was 25.3 years (95–372 months). Of the 174 patients included (212 THA cases), 12 patients were lost to follow-up (6.89%) and 76 died of unrelated causes with their implant still in place. The mean patient age at the time of the THA procedure was 53 years (19–88 years) and the mean BMI was 25.96 (17.51–46.29). There were 104 men and 70 women.

Material

All patients in this cohort received the same prosthesis. The acetabular cup was a first-generation Bousquet dual mobility cup (NOVAE®, Serf, Decine, France) (Fig. 1). The cup was made of stainless steel (316 L) and its outer surface had a porous alumina coating. Primary stability of this tripod cup is obtained through a press-fit effect, two impacted anchoring pegs and one superior fixation screw.

The femoral component (PF®, Serf) was an alumina-coated stainless steel conical, screwed stem; the modular one-piece head-neck component was also made of stainless steel (316 L). The femoral neck of this stem is wide, and roughened. All femoral heads had a 22.2 mm diameter. The cup had a retaining polyethylene (UHMWPE) mobile insert.

All patients were operated using the Moore posterolateral approach. The standard surgical recovery protocol consisted of getting the patient to stand up on the first post-operative day.

Fig. 1 Original Bousquet dual mobility tripod cup (Novae®) with polyethylene insert

Methods

All patients came to our surgery unit every two years for clinical and radiological follow-up. Clinical outcomes consisted of the Harris hip score (HHS), the Postel-Merle d'Aubigne (PMA) score and the Devane activity score pre-operatively and at the last follow-up. Radiological outcomes were based on an analysis of AP and lateral X-rays of the pelvis taken immediately after the surgery and at the longest follow-up (Fig. 2). The analysis consisted of measuring acetabular cup inclination and calculating the DeLee and Charnley [10], ARA [11] and Brooker [12] scores. The final X-rays were also used to look for radiolucent lines, osteolysis and migration.

Statistical analysis

Data was collected in a secure Excel spreadsheet (Microsoft Corp., Redmond, WA, USA). Statistical tests were carried out with the SPSS Statistics software (SPSS Inc., Chicago, IL, USA). The significance threshold was set at $P < 0.05$. A survival analysis at the last follow-up was performed using Kaplan Meier survival curves and 95% confidence intervals.

Results

Clinical outcomes

The mean HSS and PMA scores were significantly improved ($P < 0.001$): from 51.1 (26–83) to 83.6 (76–100) and from 11.2 (5–14) to 16.9 (13–18), respectively, between the pre- and post-operative period. At the last follow-up, the average Devane score was 3 (30% of patient had a score of 4 and 22% a score of 5).

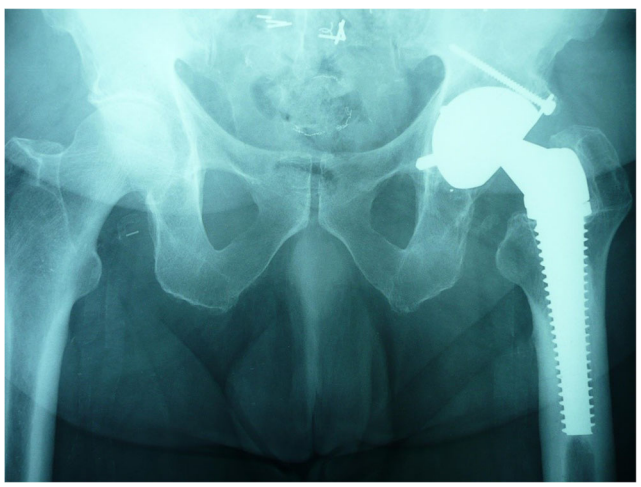

Fig. 2 X-ray of a THA case with a Bousquet dual mobility cup and screwed femoral stem

Radiological outcomes

The mean cup inclination was 45° ± 6° (36–60). Considering acetabular osteolysis, 17 patients had radiological evidence of aseptic loosening (8%), 12% of patients had osteolysis without loosening in Delee–Charnley zone 1 and 5% in zone 3.

Considering femoral osteolysis, there were no instances of loosening on the femoral side. Nevertheless, 30% of patients had osteolysis in Gruen zone 7 and 10% had osteolysis in Gruen zone 1. No radiolucent line was found in other Gruen zone. No stress shielding was observed.

The mean Brooker score was 1.20 ± 0.55 at the last follow-up.

Failures

At the last follow-up, 45 THA (21.22%) cases had been revised surgically because of failure:

There were 17 cases (8.02%) of isolated aseptic loosening. Only the acetabular component was changed in these patients.

There were ten revisions for IPD (4.71%). This complication, first described by Lecuire et al. in 2004 [13], is specific to dual mobility cups—the prosthetic head separates from the polyethylene insert because wear of the insert's retention collar results in loss of its retaining ability (Fig. 3). The insert was changed in all cases; in one patient, the cup was also changed because the metal shell had been damaged due to contact with the neck or femoral head with a metal on metal bearing.

Significant polyethylene wear led to the insert being changed in nine cases. Clinically, these patients experienced hip pain, limped and heard audible snapping; out-of-round of the femoral head was detected on X-rays. The cup was changed in two of these nine cases (4.24%) to implant the latest generation cup.

Seven patients (3.30%) had a periprosthetic fracture around the femoral stem. They were treated either with internal fixation or by changing the femoral stem; the cup was not changed.

Two infections (0.94%) occurred early on that required lavage but not an implant change. The infections had not recurred at the last follow-up.

Fig. 3 Picture of an insert showing wear of the retention collar that led to intra-prosthetic dislocation

There were no cases of early or late THA dislocation, and no reports of iliopsoas impingement.

Cup survival rate

Survival at the last follow-up (more than 25 years) was 90.6% with revision for all revisions causes (aseptic loosening, IPD and insert polyethylene wear) as the end point (Fig. 4). Survival of the dual mobility cup for aseptic loosening and IPD was 91.5%. Survival of the dual mobility cup for isolated aseptic loosening was 92%.

Discussion

This study's 25+ years of follow-up makes it the longest reported follow-up ever with a Bousquet-style dual mobility cup. In this historical cohort, the cup survival rate at 25 years was good (90%). The absence of reported dislocations confirms this design's ability to reduce the risk of dislocation.

We compared the survival rate of dual mobility cups in our study with that of other published studies (Table 1). When compared to standard cups with a MoP and ceramic on metal bearing and similar follow-up, dual mobility cups appear to have slightly better survival [15–17]. One of the drawbacks of dual mobility cups is polyethylene wear [19]. As the insert is movable in the cup, the outer wear of the liner is homogenous. For the inner wear of the liner, the behaviour is the same as Charnley's THA. When the wear is localized to the retentive rim, an IPD may appear. Nevertheless, our study shows that with good distribution of mechanical stresses and the use of a small head in order to abide by Charnley's low friction arthroplasty principle, the wear is not any higher than in long-term studies of the Charnley prosthesis, which is still considered the gold standard for MoP bearings [2]. This reinforces published findings about wear volume. With an estimated wear rate of 50 mm^3/year, the volumetric wear of the dual mobility cup is comparable to standard MoP bearings (30–80 mm^3/year at 15 to 21 year follow up) [20–22].

As described by Callaghan et al. [4], this study demonstrates the long-term superiority of cementless implants for THA. In addition, using two fixation methods (press-fit and tripod) appears to improve the survival of acetabular cups. The fixation provided by the tripod system is highly secure and allows biological fixation to go to term. Although there were instances of peri-acetabular osteolysis, no cup migration occurred.

The mean patient age at the time of primary THA in this study was relatively young (53 years). Given that younger patients are more active, this population segment has a higher risk of dislocation and wear and is more likely to experience the consequences of wear [14, 18, 23]. Our findings show that using a dual mobility cup not only reduces the dislocation risk,

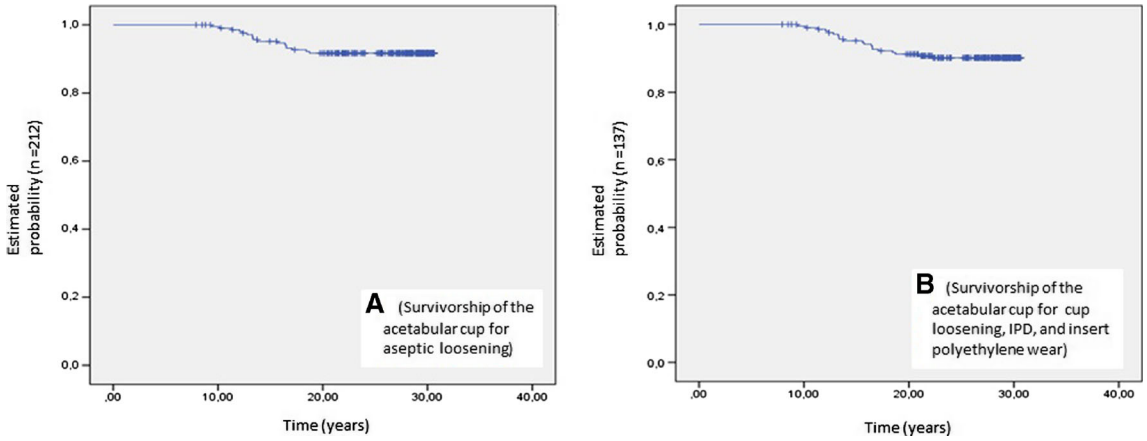

Fig. 4 Survival of the acetabular cup with aseptic loosening of the acetabular cup as the end point (curve A) and survival of the acetabular cup with all revision causes included (aseptic loosening, IPD and insert polyethylene wear) (curve B)

but also restores the maximum range of motion that younger patients need to carry out their work and recreational activities, without necessarily inducing additional wear [24].

IPD is a complication specific to dual mobility cups that occurs when the insert's retention collar becomes overly worn or has a bad design [25]. This complication occurred in 4.72% of cases in our study. It can be attributed to use of a first generation polyethylene insert that was less dense and had a small retention collar, and to use of a wide, roughened femoral neck. When a first-generation dual mobility cup was paired with a Charnley-like stem with a thin polished neck by Lautridou et al. [26], the IPD rate was only 0.7 to 0% with a third generation [3]. Current results with contemporary generation inserts that are made of higher density polyethylene, have a larger retention collar, a head with chrome cobalt alloy and more optimal neck configuration (thin with mirror-polished surface) have helped to eliminate this complication, or at least delay its appearance.

Our study reports the outcomes with a first-generation dual mobility cup. The early results with third-generation dual mobility cups that have additional macrostructures and a bilayer titanium–hydroxyapatite coating instead of a single-layer alumina coating seem promising [27].

Conclusion

This historical cohort confirms the excellent stability of dual mobility cups. The long-term survival (25+ years) of THA cases performed with a first-generation dual mobility cup is

Table 1 Long follow-up THA series comparison. Only series with more than 15 years of mean follow-up were included. (CoC ceramic on ceramic, *C/PE* ceramic on polyethylene)

Series	*n*	Mean follow-up (y)	Cup	Fixation	Stem	Cup survivorship - any reason	Cup survivorship - aseptic loosening
Aldinger et al. (2009) [14]	154	17	Mecron 67% Weill 27% cemented 4%	Cementless	CLS	Mecron 38% Weill 68%	–
Kim et al. (2014) [6]	88	28.4	PCA	Cementless	PCA	66%	90%
Yoon et al. (2008) [15]	157	17.2	Biolox CoC CST C/PE	Cementless	Autophor	81% 74.4%	–
Grant et al. (2004) [16]	116	17.5	Lord	Cementless	Lord	65%	–
Bojescul et al. (2003) [7]	100	15.6	PCA	Cementless	PCA	83%	–
Della Valle et al. (2009) [17]	204	20	Harris-Galante I	Cementless	151 HG I 39 cemented 14 Gustilo-Kyle	86%	96%
Philippot et al. (2008) [9]	438	17	Bousquet DM cup (Novae)	Cementless	Screwed Profil/PF Corail	93.3%	–
Wroblewski et al. (1986) [18]	116	17	High density polyethylene socket	Cemented or cementless	Charnley	–	78%
Berry et al. (2002) [5]	2000	25	Charnley	Cemented	Charnley	87%	–
Callaghan et al. (2004) [4]	330	30	Charnley	Cemented	Charnley	–	84%
Our series	212	25	Bousquet DM cup (Novae)	Cementless	Screwed PF	90.60%	92%

comparable to long-term studies of standard implants with MoP bearings. The appearance over time of polyethylene wear particles and osteolysis suggests that the main complications of the dual mobility design are related to insert wear. The cases of aseptic dislocation and IPD observed seem to be symptoms of prosthetic flaws: first-generation polyethylene with insufficient retention collar, neck–insert interface that has poor tribology and single layer alumina coating on the cup that does not allow osteointegration. Improvements in the implant's materials and design, based on retrieval analysis, may actually expand the indications for dual mobility cups, which are typically limited to patients above 65 years of age.

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