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ORIGINAL PAPER

Bousquet dual mobility socket for patient under fifty years old. More than twenty year follow-up of one hundred and thirty one hips

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Abstract
Purpose The aim of this study was to analyze dual mobility cup survival rate on young patients under 50 years old at more than 20 years of follow up.
Methods One hundred thirty seven hips with a first generation of dual mobility Bousquet cup (Serf) were included. The mean age at the time of the surgery was 41 years and the mean follow-up was 21.9 years.
Results Twenty year follow-up cup survival rate was 77%. No dislocation occurred, 44 hips were revised (including 21 cup aseptic loosenings isolated, 15 Intra Prosthetic Dislocations), seven hips were lost to follow-up, 11 patients died, and 75 hips were still in situ.
Conclusion First generation dual mobility cup survival on young patient was comparable with literature results. The main complications, cup aseptic loosening and intra prosthetic dislocation, were wear-related. With improvements of the defects of first generation dual mobility, we might expect an even better survival rate with contemporary DM cups.

Keywords Cement less · Dislocation · Dual mobility · Young patients · Instability · Total hip arthroplasty

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Introduction

Although more total hip arthroplasty (THA) procedures are performed in older adults than in younger adults, the latter group places greater demands on their implant in terms of wear and range of motion. The high activity level of patients under 50 years of age increases the potential for implant wear. Thus, this specific population is more likely to experience the consequences of wear: osteolysis, aseptic loosening, instability, etc. According to published data, the THA failure rate in younger patients is highly variable, ranging between 0 and 67% after five to 15 years of follow-up [1–15].

The dual mobility concept was developed by Professor Gilles Bousquet in 1974. His goals were to limit the risk of post-operative prosthetic instability and to restore the post-operative range of motion (ROM) so that it matches the physiological ROM as closely as possible. Over the years, dual mobility cups have been shown to have an undeniable advantage for reducing the risk of dislocation [16, 17]. They are now routinely used in patients above 60 years of age who are undergoing surgical revision with very good results [18].

We have a historical THA cohort consisting of the first cases of dual mobility cup implantation. Dual mobility cups were used in every THA case by the Saint-Etienne team between 1974 and 1999, independent of patient age. The aim of this study was to analyse the survival rate of a dual mobility cup in patients less than 50 years of age after more than 20 years of follow-up.

Material and methods

Patients

This was a retrospective study of a single centre, homogeneous, continuous cohort of 137 THA with dual mobility cup in 114

patients. Patients were included if they were 50 years of age or less and had undergone a THA procedure with a dual mobility cup in the orthopaedic surgery unit of the Saint Etienne University Hospital in France between January 1985 and December 1995. The THA procedures were performed for the following reasons (most to least frequent): hip dysplasia (27%), post-traumatic hip osteoarthritis (OA) (24%), avascular necrosis of the femoral head (23%), sequelae of slipped capital femoral epiphysis (12%), sequelae of osteochondritis (9%), primary hip osteoarthritis (4%), neurogenic osteoma (1%). At the last follow up, seven patients (6.14%) were lost and 11 patients died (9.66%) (with their prosthesis in place). The average patient age at the time of the THA procedure was 41 years (18–50 years). There were 66 men and 48 women. The average follow-up was 21.9 years (40–371 months).

Materials

The acetabular cup was a first-generation Bousquet dual mobility cup (NOVAE 1®, Serf, Decine, France) (Fig. 1). This cup was made of forged stainless steel (316 L), had a spherical cylinder shape with cut-out and had a porous alumina coating on its outer surface. It was a cementless cup. Primary stability of the tripod cup was obtained through a press-fit effect, two impacted anchoring pegs and a superior fixation screw. It included a classical retaining polyethylene (UHMWPE: 4.5 millions g /mol) liner, sterilized in air. The femoral heads were made of cobalt-chrome or stainless steel. They were either 22.2 mm (93%) or 28 mm (7%) in diameter.

Two femoral stem models were used. PF® (Serf), which is a conical, screwed stainless steel stem with an alumina (Al2O3) coating; the one-piece stem and head (22.2 mm) were made of stainless steel with a conical, wide (16-mm diameter) and smooth neck. PROFIL® (Serf), which is a conical, screwed titanium (Ti6Al4V) stem with an alumina coating; the stem and neck were made of anodized. The neck was conical, wide (13-mm diameter) and rough (non-polished titanium). The head was separate and secured through a Morse taper (Fig. 2).

Methods

All patients came to our surgery unit every two years for clinical and radiological follow-up. They underwent clinical evaluation at follow up with Devane, Harris hip score (HHS) and the Postel-Merle d'Aubigne (PMA) scores. The results were considered excellent when the HHS was between 90 and 100, good when between 80 and 89, average when between 70 and 79 and poor when below 70.

Radiological outcomes were based on an analysis of AP and lateral X-rays of the pelvis taken immediately after surgery and at the longest follow-up. The post-operative X-rays were also used to look for various complications (radiolucent lines, osteolysis, migration) and to measure cup inclination and assess DeLee and Charnley [19], Gruen [20] and Brooker [21] scores.

Statistical analysis

Data was collected in a secure Excel spreadsheet (Microsoft Corp., Redmond, WA, USA). Statistical tests were carried out with 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 actuarial methods [22] and 95% confidence intervals. Failure was defined as surgical revision of the implants (unipolar or bipolar) for any reason.

Fig. 1 The original Bousquet dual mobility tripod cup (Novae 1®): anterior view with polyethylene liner

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

Results

Clinical outcomes

At the longest follow-up, 84% of patients had good or excellent clinical results. The functional scores had improved from the pre-operative condition to the last follow-up: HHS went from 48.30 to 85.1 and PMA went from 11.5 to 17.1. Devane score stayed around 3. No thigh pain was noted.

Radiological outcomes

There was one case of femoral loosening and it was associated with acetabular loosening. A granuloma at the calcar (Gruen's zone 7) was found in 17% of cases. Other than the one case of femoral loosening, there were no cases of extensive osteolysis at the femur.

There was a significant number of peri-acetabular radiolucent lines and osteolysis: 30% at the longest follow-up, mostly in zone I (9%) and zone III (21%) of De Lee and Charnley. No radiolucent line was found in the other zone. Aseptic loosening of the cup occurred in 14% of patients (19 cases). The average Brooker score was 1.3 (SD 0.5) for the 137 hips.

Implant survival

Of the 137 THA included, 44 underwent surgical revision because of failure.

There were 19 cases (13.9%) of isolated aseptic loosening. Only the acetabular component was changed in these patients. For all cup revision cases, we used a dual mobility cup with tripodal fixation (Novae E®, Serf) with bone graft if necessary.

There were 15 revisions (10.9%) for intraprosthetic dislocation (IPD) (Fig. 3). This complication is specific to dual mobility cups, mainly of first generation—the prosthetic head separates from the polyethylene liner. In these cases, the IPD was due to wear of the liner's retention collar, resulting in loss of the liner's retaining ability [22]. None of these separation cases were due to trauma. All were treated surgically. In ten of the 15 cases, only the bearing (femoral head and liner) was changed because the implants were not loosened or damaged. In the five other cases, both the cup and bearing were changed because the metal shell had been damaged due to contact with the neck or femoral head. No acute lymphocytic vasculitis associated lesions (ALVAL) was observed. Six patients had significant wear of the PE liner but not the retaining collar. There was no IPD or aseptic loosening in these patients but they experienced hip pain with audible snapping, and eccentration of the femoral head on X-rays. In four of these patients, only the head and liner were revised. In the two other patients, the cup was changed in order to implant the latest generation model (Sunfit® or Novae E®, Serf). One patient (0.79%) had aseptic loosening of the acetabular cup and

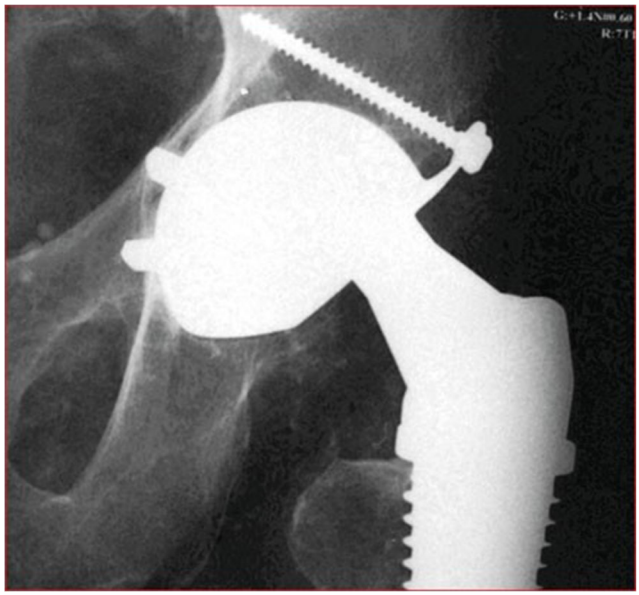

Fig. 3 X-ray showing intraprosthetic dislocation

femoral stem; both components were revised. There were two cases (1.46%) of femoral aseptic loosening in the left femur. This complication can be attributed to the stem's design. In very rare cases, the stem can unscrew itself during forced external rotation of the femur before the stem is fully integrated into bone. One femoral stem fracture (0.79%) occurred that required a new femoral stem and appropriate fracture fixation hardware. One infection (0.79%) occurred early on that required lavage but no implant change. No recurrence of the infection occurred after one year of follow-up in this patient.

There were no cases of early or late THA dislocation.

Survival at the last follow-up (more than 20 years) was 77% (95% CI 74.4–82%) with revision for any reason as the end point ($P < 0.05$). Survival of the dual mobility cup for isolated aseptic loosening was 82.4% (95% CI 78.7–86%) ($P < 0.05$) (Fig. 4).

Discussion

Because of the high demands of their work and recreational activities, patients under the age of 50 make up a specific patient population. The aim of our study was to evaluate the survival of the original Bousquet dual mobility cup after at least 20 years of follow-up in this active population who have a high risk of component wear and dislocation.

Polyethylene wear particles and osteolysis are the primary factors limiting the lifespan of THA with a polyethylene interface [23]. In our study, radiolucent lines and osteolysis were found mainly in the peri-acetabular region (30% of patients and 14% acetabular aseptic loosening) and the calcar (17% of patients, one case of femoral aseptic loosening). In addition, six cases (4%) had significant polyethylene wear that required

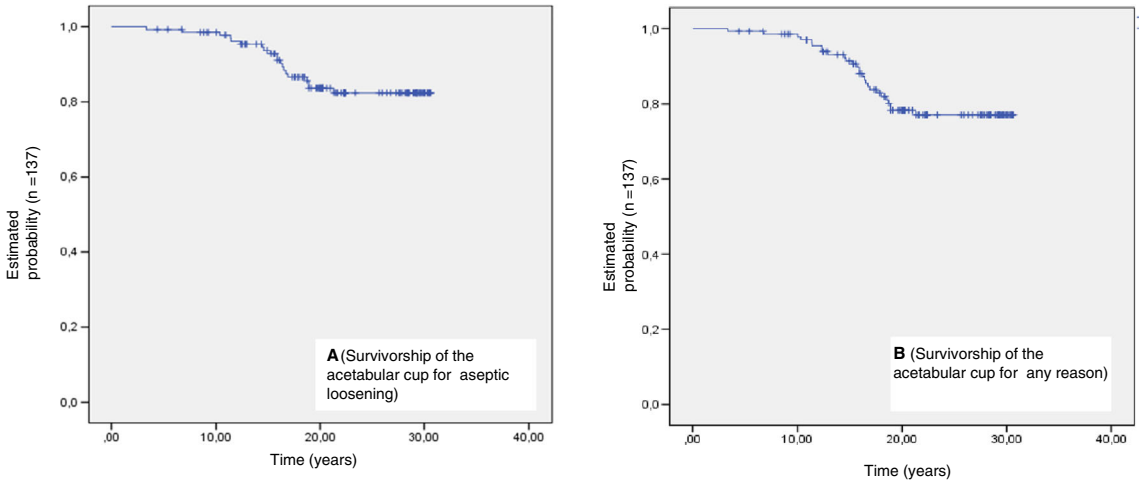

Fig. 4 Survival of the acetabular cup with aseptic loosening of the acetabular cup as the end point (curve A) and survival of the acetabular cup with all revision causes included (curve B)

surgical revision. These results are comparable with those of other published THA studies with early generation polyethylene liners in younger patients (Table 1).

Although the loosening rate (15%) appears to be higher in our study than in other studies of cementless metal-back sockets and polyethylene liners, the follow-up was longer in our study [24]. If we compare our findings to cases of cementless THA with fixed polyethylene liners and more than 20 years follow-up, the results in terms of wear are similar. This suggests that dual mobility cups are the source of polyethylene wear debris, but this wear is not greater than the wear found in standard polyethylene bearings. Use of newer types of polyethylene, namely cross-linked polyethylene (XLPE®), appears to reduce wear debris [14, 25]. Also, improvements in surface coating technology have reduced the rate of acetabular aseptic loosening. The plasma-sprayed alumina coating in the original Bousquet cup has been abandoned in favour of a bilayer hydroxyapatite-titanium coating that results in better osseointegration [26].

Our study found an 11% IPD rate. IPD is due to loss of the retention mechanism of the polyethylene liner because of wear in the liner's retaining collar [22, 27]. Firstly, poor tribology at the neck–collar interface, as explained by Noyer et al. [28] contributes to this wear. In our study, the femoral neck was roughened and thick. The friction of the insert on a rough neck will then cause wear of the collar. This explains the high rate of IPD. A study of 437 hips in which a Bousquet cup was paired with a femoral neck with thin polished neck (Charnley-Kerboull) found an IPD rate of only 0.7% after 16.5 years of follow-up [29]. Changes made to the femoral neck area helped to eliminate this complication, or at least delay its appearance. Secondly, a blocking of high mobility, as explained by Fabry et al. [30], can lead to greater solicitation of small mobility and increase the liner's retaining collar wear.

It appears that hard-on-hard bearings such as ceramic-on-ceramic or metal-on-metal provide better implant survival [6, 7, 31]. Nevertheless, there is no published data on this type of bearing in younger patients after more than 20 years of follow-up. As a consequence, we cannot make formal comparisons. Although the results seem promising, these bearings have their own drawbacks: breakage and squeaking for ceramic, ion release with allergy and toxicity for metal-on metal bearing [32].

The loosening and osteolysis rate with cementless implants is lower than the rates found with cemented cups in other studies [3, 12]. This is confirmed by the Callaghan study comparing the outcomes of cemented or hybrid THA in which the superiority of cementless implants in younger subjects was demonstrated but not for Kerboull which give good results [33, 34].

According to the literature, the challenge of THA in young patients is based on three primary long-term objectives: good fixation, minimal wear, and maximum stability. The Bousquet dual mobility cup fully meets the stability objective. The absence of joint dislocation episodes in our study confirms the good short-term and long-term stability of the dual mobility cup. This is a key finding: young active patients require maximum hip ROM during their work and recreational activities, making them at-risk patients for dislocation. The overall dislocation rate is estimated to be 4% in all patients who have undergone THA, but it appears higher in patients under 50 years of age. In their study, Archibeck et al. [1] found five patients (5%) requiring surgical revision because of chronic instability.

Conclusion

The survival of first-generation dual mobility THA in patients less than 50 years of age is tempered by the large number of

Table 1 Comparison of radiological osteolysis and aseptic loosening rates following THA in patients less than 50 years of age

Authors	n	Mean follow-up (years)	Components fixation	Bearing couple	Acetabular radiolucent line	Femoral radiolucent line	Acetabular aseptic loosening	Femoral aseptic loosening
Berger et al. [2]	79	9	cementless	metal-polyethylene	7.4%		0%	
Callaghan et al. [3]	93	20	cemented	metal-polyethylene			19%	5%
Sporer et al. [13]	45	8	hybrid	metal-polyethylene	49%	100%	0%	18%
Smith et al. [12]	47	20	cemented	metal-polyethylene	55%	11%	32%	6%
Kerboull et al. [33]	287	15	cemented	metal-polyethylene	13.6%	5.6%	3.5%	2.4%
Duffy et al. [4]	84	10	cementless	metal-polyethylene	18%		7%	
Kim et al. [7]	70	7	cementless	metal-metal	1.4%	3%	0%	0%
Archibeck et al. [1]	100	9	cementless	metal-polyethylene	29%	47%	2%	0%
Murphy et al. [11]	194	9	cementless	ceramic-ceramic	0%	0%	0%	0%
Hwang et al. [6]	78	12	cementless	metal-metal	5.1%	22%	2.6%	0%
Kim et al. [8]	108	28	cementless	metal-polyethylene	85%	45%	66%	90%
Kim et al. [25]	130	8	cementless	ceramic-polyethylene (XLPE)	0%	0%	0%	0%
Stambough et al. [14]	75	10	cementless	metal-polyethylene (XLPE)	0%	0%	1%	3%
Kim et al. [31]	334	9	cementless	ceramic-ceramic	0%	0%	0%	0%
Schmolders et al. [24]	111	13	cementless	ceramic-polyethylene	21%	35%	5.3%	0%
Our series	137	22	cementless	metal-polyethylene (dual mobility)	30%	14%	14%	2%

XLPE cross-linked polyethylene

IPD and aseptic loosening cases. This poor outcome can be explained by flaws in the design of first-generation dual mobility cups (single-layer alumina coating that did not allow osseointegration, low-quality polyethylene material, and unfavourable neck configuration) that have been addressed in newer models.

Our historical cohort confirms the excellent stability of the dual mobility cup, which when combined with newer implant designs, can be advantageous in a population of young athletic patients who have high mobility demands. The dual mobility cup provides the largest ROM of all implants while eliminating the risk of large ceramic head breaking. On-going studies in patients under 50 years of age who have undergone THA with a newer version of the dual mobility cup will help to further define these promising results in younger subjects.

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