Nine years follow-up of 100 ceramic-on-ceramic total hip arthroplasty

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Abstract The aim of this study was to evaluate the first 100 cementless ceramic-on-ceramic total hip arthroplasty (THA) performed at our institution with more than nine years of follow-up. Clinical evaluation was performed using Harris hip score. Radiological evaluation was performed by two surgeons. Four patients were lost to follow-up. Harris hip score significantly improved at latest follow-up. Radiological analysis showed calcar osteolysis for 75 patients and one cup loosening. One patient required a revision five years postoperatively for cup loosening. Based on these results and the routine use of a navigation system to optimise positioning of the implants, we advocate the use of uncemented hydroxyapatite coated ceramic-on-ceramic THA in young and active patients in our current practice.

Introduction

Total hip arthroplasty (THA) has revolutionised the treatment of coxarthrosis [1]. One initial bearing surface

was a 22-mm metal head diameter articulated in a polyethylene inlay (low friction arthroplasty theory) [1], and all prosthetic components were cemented. Although this type of prosthesis still remains the “gold standard”, many studies have highlighted the rule of polyethylene debris in generating aseptic loosening and osteolysis [2]. Alumina ceramic-on-ceramic bearing surfaces were proposed and developed as an alternative bearing by Pierre Boutin in France during the 1970s. [3]. Such an alternative bearing is expected to improve long-term outcome by reducing the wear. Since 1972, use of the ceramic-on-ceramic (COC) bearing has increased. Many improvements have been made and biomechanical and tribological properties of alumina ceramics are now better known. The third generation of ceramic alumina is currently in use [4, 5], and the risk of fracture is now extremely rare [6]. In addition, wear seems to be undetectable. However, the stiffness of this material and the current use of non cemented acetabular shells raise concerns about the potential for failure of the fixation of the acetabular component because of high stress transmission to the bone-cup interface [7]. Few European orthopaedic teams have routinely used ceramic-on-ceramic bearings for more than 20 years [8], while the majority has adopted this bearing more recently.

For these reasons, limited data are available regarding long-term follow-up for ceramic-on-ceramic cementless THA. Moreover, most of the available studies concerning ceramic bearings involve a variety of implant designs and fixation methods.

The aim of this study was to analyse the first 100 ceramic-on-ceramic cementless THA performed at our institution using a single design of implant at nine years mean follow-up.

Level of evidence: Level IV, retrospective study. See guidelines online for a complete description of level of evidence

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Materials and methods

We retrospectively analysed a continuous series of the first 100 ceramic-on-ceramic cementless THA performed on 92 patients at our institution between October 1999 and December 2000. This series included 59 males and 33 females. Forty-eight arthroplasties were performed on the left hip and 52 on the right.

The mean age at the time of the surgery was 52.3 years (range, 20–73 years). The mean body mass index was 26 (average 16.9–44.5). Forty-five patients (45 THA), were overweight or obese (body mass index over 25 kg/m²).

The most common indication for THA was primary osteoarthritis (60 hips). Other indications included osteonecrosis (16 hips), developmental dysplasia of the hip (13 hips), post traumatic arthritis (five hips), inflammatory arthritis (four hips), femoral neck fracture (one hip) and THA after hip fusion (one hip). Eleven hips had at least one previous surgical procedure before the index arthroplasty: previous THA (four hips), pelvic osteotomy (three hips), open reduction and internal fixation of an acetabular fracture (two hips), osteosynthesis after femoral neck fracture (one hip), and arthrodesis (one hip).

The index total hip replacements were performed under the supervision of two senior orthopedic surgeons (JPC, JBH) at our institution. A posterior approach was used in 35 cases, and a Hardinge antero lateral approach in 65 cases, at the surgeon's discretion.

The single design of uncemented implants used consists of a hydroxyapatite plasma sprayed press fit hemispherical acetabular titanium shell (Horizon®, Amplitude®, Porte du grand Lyon, France), with a third generation ceramic liner (BioloX forte, Ceramtec®) (Fig. 1a) in a design such that the liner fits the shell using a morse taper.

A single design of uncemented femoral component was also used and was made of titanium and fully hydroxyapatite coated with a 10/12 morse taper (Integrale®, Amplitude®, Porte du Grand Lyon, Neyron, France) (Fig. 1b).

All hips had a 28-mm alumina head. A standard neck length was used in 72 cases, a short neck in 16 cases and a long neck in 12 cases.

Patients were allowed immediate full weight bearing after the replacements.

All patients were clinically and radiographically evaluated preoperatively and postoperatively at three months, six months and every year after surgery.

Clinical evaluation was performed using Postel Merle d'Aubigné hip score and Harris hip score.

Radiographical assessment was performed using standard anteroposterior and lateral radiographs of the involved joint. X-rays were reviewed by two independent senior surgeons to assess the position of the prosthesis and to look for wear, osteolysis and signs of implant loosening. Wear

Fig. 1 a Acetabular implant. b Stem implant

measurement was done manually by duoradiographic measurement as described by Charnley [9].

Femoral components were assessed for subsidence and the femur was divided into seven zones as described by Gruen et al. [10] to assess radiolucent lines and osteolysis. *Definite loosening* was defined as subsidence of the femoral component or changes into varus or valgus alignment, *probable loosening* was defined as the presence of a continuous radiolucent line along the entire component, and *possible loosening* was defined as the presence of a radiolucent line occupying more than 50% but less than 100% around the femoral component.

Acetabular components were evaluated in each of the three zones defined by DeLee and Charnley to evaluate the location of radiolucent lines [11]. *Definite loosening* was

defined as migration of the component, *probable loosening* as the presence of a circumferential radiolucent line around the entire component and *possible loosening* as the presence of a radiolucent line around 50–99% of the component.

Statistical analysis was performed using Stat View 5.0. Changes from the preoperative clinical status to the latest clinical follow-up were evaluated using the Wilcoxon signed-rank test. A Kaplan-Meier survivorship analysis [12] was performed for the entire cohort, with revision for any reason or cup and/or stem radiographic loosening as the end point, and only for cup radiographic loosening or revision as the end point.

Results

At latest follow-up, seven patients had died of unrelated causes. Four patients were lost to follow-up two years after the index procedure. All of them were known to have had a well functioning THA at last review. There were 81 patients (89 THAs) available for the study at a minimum follow-up of 72 months (mean, 106.6 months; range 72–125 months).

The mean preoperative Harris hip score and Postel Merle d'Aubigné score, respectively, improved from 41.2 (range, 20–60) to 96.1 (range, 58–100) at latest follow-up ($P<.05$), and from 7.9 (range, 3–13) to 17.2 (range, 11–18) at latest follow-up ($P<.05$).

No wear was measured on the ceramic liner.

There was no evidence of cup migration in any patient. One patient had a revision of an acetabular component for aseptic loosening. This was done five years after the index surgery. The stem was not changed. At latest follow-up, one patient had a radiographic acetabular *probable loosening* (Fig. 2) associated with thigh pain at the last follow-up (THA performed after acetabular fracture). A cup revision at the time of the study was pending for this patient. In ten cases (12.6%), a radiolucent line was observed on the immediate postoper-

Fig. 2 Aseptic loosening of the acetabulum at nine years of follow-up

Fig. 3 Calcar osteolysis at nine years of follow-up

ative X-ray, but disappeared at latest follow-up. No migration of the femoral or acetabular implants was observed. A mild to moderate calcar osteolysis was observed in 72 cases (92%) (Fig. 3). Stress shielding was reported in two cases (2.5%).

Intraoperative complications included calcar crack in three cases, treated with a cerclage wiring. A cup liner fracture was also observed in one case, at the time of the impaction. A new cup liner was immediately substituted.

Five patients had early dislocations within the first three months and one patient had dislocation eight months after the operation. All were evaluated by computer tomography and no abnormal orientation was reported. The mean cup abduction was 43° (range 38° – 56°) and the mean cup anteversion was 19° (range 11° – 36°). All of them were treated by closed reduction under anaesthesia, and remained stable at the latest follow-up without any reoperation. Five patients reported squeaking complications. No ceramic

Fig. 4 Survivorship with revision for any reason of either component as an end point

Fig. 5 Survivorship of the acetabular implant with revision for aseptic loosening or clinical loosening as an end point

head fracture was reported. Two patients had a deep venous thrombosis without pulmonary embolism, while three had deep haematoma without reoperation.

Two deep infections were also reported. One infection occurred one month after the surgery, and was treated by early surgical debridement and intravenous antibiotic therapy without removal of the prosthesis. The second case occurred after one year and was treated by two-stage revision surgery and intravenous antibiotic therapy.

Survivorship with revision for any reason of either cup or femoral component as an end point was 95.8% at nine years (Fig. 4).

Survival rate at nine years was 100% for the femoral implant, considering radiographic or clinical loosening as an end point. It was 97.7% for the acetabular implant considering the same end point (Fig. 5).

Discussion

Total hip arthroplasty for young and active patients remains a challenging situation for the orthopaedic surgeon, i.e. because of the long life expectancy and a high level of activity, longevity of the implants is an issue. In addition,

the likelihood of a revision, preserving bone stock by limiting osteolysis is another issue.

In our study, THA were implanted in young and active patients at a mean age of 52.3 years. In view of its tribological properties, ceramic-on-ceramic bearing is attractive for implant longevity, reduced wear and limitation of bone osteolysis.

To date, limited data is available regarding medium- to long-term follow-up of ceramic-on-ceramic uncemented total hip arthroplasty [5, 7, 13–19] (Table 1). The longest follow-up reported with ceramic-on-ceramic bearing is 18.5 years [5], including different designs of implants: cemented, uncemented and hybrid implants.

Despite technical improvement in cementation, cemented THA in young and active patients has a high rate of failure [20, 21]. The use of porous cementless THA has also been associated with high failure rates [22].

In our study, we report the use of a single design of fully hydroxyapatite coated uncemented implant, with a 28-mm head diameter. Our experience of the use of ceramic-on-ceramic cementless THA began in 1999, and to date more than 1,200 such implants have been implanted. In order to provide the greatest follow-up, we have limited our study to the first 100 THA performed at our institution using ceramic-on-ceramic bearings with the subscribed uncemented implants. In this series, cementless fully hydroxyapatite coated implants with ceramic and ceramic bearings provided very encouraging results at medium follow-up. This study is in line with previous reports with shorter or similar follow-up [13, 15, 18, 19].

However, this study has some limitations. The main limitation is the design of the study, as it is retrospective, without any control group; however, all the patients have been reviewed and only four were lost to follow-up (4%). The X-ray analysis was performed by two senior surgeons without the use of any software. There were numerous surgeons involved in the study. This may explain the incidence of complications such as instability related to variable experience of the surgeons.

Table 1 Previous publication of ceramic-on-ceramic bearing total hip arthroplasty (THA)

Study	Number of cases	Follow-up (y)	Head diameter (mm)	Fixation
Hamadouche et al. [5]	118	18.5	32	Cemented, hybrid, cementless
Bizot et al. [7]	71	6–11	32	Hybrid
D'Antonio et al. [13]	109	4	28–32	Cementless
Yoo et al. [14]	93	5	28	Cementless
Murphy et al. [15]	194	2–9	28–32	Cementless
Sugano et al. [16]	59	6	28	Cementless
Lusty et al. [17]	301	5	28–32	Cementless
Kim et al. [18]	93	11.1	28	Cementless
Our study	100	9	28	Cementless

Improvement of HHS and PMA scores are comparable with others studies [5, 7, 13–18]. Radiographic analysis reveals that most of the radiolucent lines that were visible on early postoperative X-rays disappeared at the latest follow-up as bone ingrowth occurred.

Calcar remodelling was reported in 92%. For all cases, it was only moderate. This could be explained by the effective by-pass of the constraint lines of the calcar by the stem. This phenomenon has been reported as an internal stress shielding [23]. For Engh et al. [23], such a design is proof of correct stem fixation. However, an excess of calcar remodelling is a sign of varus migration of the stem, related to an excess of constraints. We didn't find any migration of the stem in this study.

In this series, we did not observe any osteolysis around the stem. Those results confirm that the association of ceramic-on-ceramic bearing with uncemented hydroxyapatite fully-coated implant reduces the incidence of osteolysis compared with cemented THA with metal on polyethylene bearings [24, 25].

The dislocation rate reported in this series (6%) is higher than commonly reported rates of instability for primary THA [5, 15]. Many factors can be considered to explain such a high rate. Among them the number of surgeons involved, as eight different surgeons took part. Our institution is an academic centre, and the experience of the surgeon is highly variable. In addition, a 28-mm head diameter was used in all cases as no greater diameters were available in 1999 and 2000 at our institution. In 2002, 32- or 36-mm heads became available and the use of larger diameter heads lead to a decrease in the dislocation rate. In addition, the routine use of a computer navigation system since 2005 has contributed to dramatically improve THA stability.

All patients with dislocation were successfully managed by closed reduction and none of them required a reoperation. These hips remained stable at latest follow-up.

No case of ceramic head fracture was observed in this study, but one case of acetabular liner fracture was observed intraoperatively at the time of impaction. A technical error explained this intraoperative complication as an incompletely seated insert had been impacted. This problem has already been reported in the literature [26].

There were five cases of squeaking. Incidence of squeaking is highly variable, ranging from less than 1% to more than 20% [17, 27]. In our experience, none of these patients required a revision for squeaking. It has been proven that this problem is multifactorial and can be reproduced in vitro with the interposition of a third body such as metal particles [27]. None of these five patients had experienced a dislocating event to explain this phenomenon. Further investigations with CT scan to assess orientation of the implants are currently ongoing at our institution.

Based on these results and based on the routine use of a navigation system to optimise positioning of the implants at our institution since 2005, we advocate the use of uncemented hydroxyapatite coated ceramic-on-ceramic THA in young and active patients in our clinical practice.

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