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THA Using Metal-on-Metal Articulation in Active Patients Younger Than 50 Years

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Abstract The main concern of patients with longer life expectancies and of patients who are younger and more active is the longevity of their total hip arthroplasty. We retrospectively reviewed 83 cementless total hip arthroplasties in 73 patients implanted with metal-on-metal articulation. All patients were younger than 50 years old (average age, 41 years) at the time of the index procedure, and 80% of the patients had an activity level graded 4 or 5 when measured with the system of Devane et al. A 28-mm Metasul articulation was used with three different cementless titanium acetabular components. At the most recent followup (average, 7.3 years), the average Merle d'Aubigné-Postel score improved from a preoperative 11.1 points to 17.4 points. We observed no radiographic evidence of component loosening. Ten acetabular components had lucency limited to one zone. The 10-year survivorship with the end point of revision (ie, exchange of at least one prosthetic or bearing component) was 100% (95% confidence interval, 90%–100%). Metasul bearings with cementless acetabular components remain promising in this high-risk younger patient population. However, additional followup strategies are recommended to determine any possible long-term deleterious effects associated with the dissemination of metallic ions.
Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

One author (CD) certifies that he has received payments or benefits from a commercial entity (Zimmer-GmbH, Winterthur, Switzerland) related to this work.
Each author certifies that his or her institution has approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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Introduction

As a result of the general increase in longevity in the older population and the expansion of surgical indications, primary THA is a growing procedure worldwide. Improvements in manufacturing processes have led to the near elimination of catastrophic component fracture resulting from corrosive and noncorrosive fatigue. Consequently, from the overall successful outcome of primary THA, a dramatic reduction in the conservative application of these surgical procedures has resulted in a growing application of THA in younger and more active individuals. The rate of THA performed in "younger" patients, as reported in various national registries, ranges from less than 4% in patients younger than 45 years old up to 15% in patients younger than 55 years old [2, 5, 15, 26, 44, 50].

The primary concern of patients with longer life expectancies and of patients who are younger and more active is the longevity of their THA. Annual reports of the Swedish Hip Arthroplasty Registry [15, 36] consistently document among patient-related risk factors young age (ie, younger than 50 years) substantially reduces the survival of all types of primary THAs. The Maurice E. Müller Research Center in Orthopaedic Surgery at the University of Bern reported the risk of aseptic stem loosening

increases by 1.8% for each year of age reduction at the time of index surgery [43].

High activity level is highlighted worldwide as the major factor affecting prosthetic reconstruction durability as a result of conventional polyethylene (PE) wear. Even in a center of excellence, cemented fixation of the THA using low friction arthroplasty (LFA), considered worldwide as a gold standard, cannot achieve a long-lasting outcome. In patients younger than 50, the best results have been reported with the Kerboull cemented hip, providing 85.4% ± 5% survival at 20 years [30]. At worst, in patients younger than 40 years of age, the Wrightington survival was 76% at 20 years and none of the cups with a wear rate greater than 0.2 mm per year survived 25 years [54]. However, activity level varies considerably between patients of the same age class (body mass index, type of work, sports, leisure activities) [10, 51]. Moreover, younger candidates for THA are not normally active as a result of the etiology of their disease (eg, juvenile arthritis, avascular necrosis, or developmental dysplasia of the hip) [47]. Obviously, cemented fixation of low-friction torque metal-on-PE THA in younger active patients does not achieve the goal of longevity.

We hypothesized cementless fixation and hard-on-hard bearings could improve THA survival in a highly active patient population.

Materials and Methods

We retrospectively reviewed data from 73 patients (83 hips) from three orthopaedic centers on all THAs performed in active patients younger than 50 years old between 1995 and 2004. All patients had a cementless primary THA with 28-mm metal-on-metal (MoM) bearings. To reduce patient-related bias (eg, bone quality, functional needs) and surgery-related technical difficulties (eg, anatomic deformity, previous surgery), we excluded patients with high dysplasia (greater than Crowe II), rheumatoid arthritis, and juvenile arthritic hips, and those with a low activity level. Among the 73 patients, there were 58 male and 15 female patients (gender ratio 4:1) with an average age at surgery of 40.7 years (range, 23–49 years). Twenty-eight patients were graded Charnley A, 42 Charnley B (10 bilateral), and three Charnley C. One patient with a Merle d'Aubigné-Postel score [38] of 17 points after the first postoperative year was lost to followup. For the 82 hips with available information at the latest followup (minimum, 2 years; average, 7.3 years; range, 2–10.4 years), using the classification of Devane et al. [16] preoperative activity level was Grade 3 in 15 patients, Grade 4 in 31 patients, and Grade 5 in 27. The preoperative surgical diagnoses included aseptic necrosis in 35 hips (42%), secondary arthritis in 29 hips (dysplasia Crowe I and II, 23; posttrauma, four; Legg-Calvé-Perthes disease, two), and osteoarthritis in 19 hips. Previous surgery was noted in 12 hips (14.5%): five fracture internal fixations (four of the femoral neck and one acetabulum), three core decompressions, two shelf procedures, one femoral osteotomy, and one Chiari pelvic osteotomy. By surgical site location, the patient contribution to the study was 40 in Lille (Center A) by three surgeons, 24 in Longjumeau (Center B), and 19 in Strasbourg (Center C) by one surgeon in each of these two last centers.

The first author and all coauthors were the five operating surgeons (CD in Center A; HM, PL in Center B; and FB, PC in Center C). Sixty-four THAs were performed through a posterolateral approach (in Centers A and B), whereas 19 were operated on through a transgluteal approach (Center C). In all cases, a Zweymüller-Alloclassic-SL femoral component was implanted without cement (Zimmer, Winterthur, Switzerland). The MoM bearings were composed of forged, high-carbide cobalt-chromium alloy Protasul-21 WF (ISO 5832–12, Metasul™; Zimmer). All acetabular components were titanium metal-backed components from the same manufacturer (Zimmer) and implanted without cement. However, the acetabular components were of two different profiles: 59 were hemispheric press-fit cups (40 of the Armor® design with titanium mesh and one or two additional screws in Center B, and 19 of the press-fit hydroxyapatite® design without screws in Center C) and 24 were conical threaded rings (Alloclassic-CSF® in Center A) (Fig. 1). All PE liners for the three designs were made in GUR 1020 resin sterilized by gamma radiation in nitrogen (ex-Chirulen®; Ticona, Oberhausen, Germany). The capture mechanism was of the "snap-fit fastened" type for all three designs, with antirotation devices by additional two thin bottom spikes for the press-fit HA cup or by pegs engaging in metallic shell rim grooves (two for the Armor cup and four for the CSF threaded cup).

Each author clinically and radiographically reviewed their own patients. Clinical results were graded according to the Merle d'Aubigné-Postel scoring system with a maximum of 18 points [38]. Radiographic results for the femoral component were described according to Gruen [23] and for the acetabular component according to DeLee and Charnley [14] on anteroposterior radiographs. Femoral component stability and osseointegration were assessed according to the method described by Engh et al. [19] (calcar atrophy, spot welds, stress shielding, and pedestal). Wear was measured according to the method described by Livermore et al. [34].

Survivorship analysis was conducted according to the Dobbs life table with 95% confidence intervals calculated with the Wilson quadratic method as recommended by Dorey and Korn [17].

Fig. 1A–C Three acetabular components used in the study were (**A**) the Armor-Allofit press-fit acetabular component with titanium fiber-mesh and adjuvant screws; (**B**) the Alloclassic-CSF grit-blasted threaded acetabular component; and (**C**) the press-fit hydroxyapatite acetabular component with hydroxyapatite coating.

Results

The 10-year survivorship for the end point of THA component revision for any cause was 100% (95% confidence interval [CI], 89.6%–100%). These data indicated our hypothesis about the beneficial effect of cementless THA implant fixation and hard-on-hard metallic bearings remained thus far valid (Table 1).

The mean Merle d'Aubigné-Postel score increased from a preoperative 11.1 points (range, 6–15 points) to a postoperative 17.4 points (range, 14–18 points). Osseointegration was confirmed by radiographic evidence of periprosthetic spot welds in 51 hips and calcar atrophy in 53 hips. For both acetabular and femoral component profiles, there was no radiographic evidence of osteolysis or loosening in any observed hips. Nevertheless, 10 cases had radiographic evidence of nonprogressive acetabular component lucency limited to only one zone. Bearing wear was undetectable. Seventy THAs (83%) were graded A (Fig. 2), 11 THAs (14%) were graded B, two THAs were graded C (each had a reoperation, see subsequently), and none were graded D.

We reoperated on two Grade C THAs for unexplained pain. In one patient (one hip), lateral pain was judged to be from trochanteric bursitis. Transosseous nodes about the trochanteric posterior margin were identified and resected 9 years after the index THA resulting in relief of pain. In the other patient (one hip), groin pain from impingement between the cup rim and the psoas tendon was surgically relieved 5.7 years after the index THA by tendon release. In these two hips with a secondary surgical procedure, we observed no visual evidence of macroscopic metallosis. For the end point of hip reoperation for any cause, the 10-year survivorship was 96.4% (95% CI, 83.2%–99.3%).

Complications included one intraoperative nondisplaced, incomplete fracture of the greater trochanter, which was detected on postoperative immediate radiographic control. The patient was treated with protected weightbearing with no adverse postoperative effect on the outcome. There were no deep infections but two early superficial infections. We treated one late dislocation from a violent fall 7.6 years post-THA surgery with closed reduction; the patient had no recurrence or further adverse

Table 1. Dobbs life table and 95% confidence intervals for the end point 'THA component revision for any cause' (n = 83 hips)

Interval (years)	Examined	Withdrawn	Dead	Revision	Number of hips	Number of hips at risk	Superior interval	Inferior interval	Survival rate
0–1	83	0	0	0	83	83	100%	95.58%	100%
1–2	82	1	0	0	83	82.5	100%	95.55%	100%
2–3	80	2	0	0	82	81	100%	95.47%	100%
3–4	74	6	0	0	80	77	100%	95.25%	100%
4–5	67	7	0	0	74	70.5	100%	94.83%	100%
5–6	61	6	0	0	67	64	100%	94.34%	100%
6–7	58	3	0	0	61	59.5	100%	93.94%	100%
7–8	53	5	0	0	58	56	100%	93.58%	100%
8–9	42	11	1	0	54	48	100%	92.59%	100%
9–10	24	18	0	0	42	33	100%	89.57%	100%
10–11	8	14	0	0	24	17	100%	81.57%	100%

Fig. 2 This 8.4-year postoperative followup radiograph shows a primary Alloclassic-SL femoral component and CSF-threaded acetabular component with 28-mm Metasul bearings. The patient is an active (Grade 5 of Devane et al. [16]) truck driver who was 46 years old at the time of the index surgery.

events. One patient who was 45 years old at the time of the index surgery died 8 years postoperatively of complications related to severe alcohol addiction.

Discussion

A report from the Swedish Hip Registry confirmed the deleterious effect of young age on THA longevity using any end point [36]. In its last electronic issue, the probability of revision for second-generation cemented implants in patients younger than 50 years was approximately 14% and 20% at 10 and 13 years, respectively [15]. Our survival rate of 0% at 10 years with cementless MoM articulating THA components suggests improvement in THA outcome in the young and active patient population.

Nevertheless, no definitive conclusions about outcomes in the younger patient can be drawn before at least a minimum 10-year followup, and the minimum 2-year and mean 7.3-year followup of this study is too short to draw definite conclusions. Our study was also retrospective and used three cup designs. Although we did not separately analyze the three cup designs, none were revised for aseptic loosening and the few complications were not specifically associated with a particular design.

Femoral component fixation in younger, more active patients continues to be debated. Ten-year survival rates greater than 90% have been achieved in patients younger than 50 years either with Charnley or Charnley-Kerboull cemented femoral components using the first-generation cementing technique [24, 29, 30, 49, 59] and with other cemented femoral components using the second-generation technique [53]. However, in the younger, more active THA population, continued optimum outcomes beyond 10 years have not been achieved with the so-called gold standard Charnley LFA. In patients younger than 50 years, the LFA survival rate has been reported as 86% at 15 years [47], 74.3% at 20 years in Wroblewski et al. [59], and 60% at 30 years in the Johnston Iowa series [29]. The results deteriorate even more in patients younger than 40 years (76% survival at 20 years) mainly as a result of excessive

PE wear with an average annual rate of 0.11 and 0.12 mm [22, 54].

For the same patient population, modern cementless femoral components in use since the late 1980s also showed promising results with 10-year survival rates regularly greater than 95% with hydroxyapatite-coated [6, 52], porous-coated [32], or grit-blasted [1, 55] implants. In a multicenter study of 1419 primary THAs in active patients younger than 50 years of age, the 10-year survival rate was greater than 97% for the cemented Charnley-Kerboull (polished steel alloy) and for five cementless stems [13]. At an equivalent 10-year followup, there is still no clear advantage of one technique for femoral component fixation in the young and active patient population, but there is no longer an advantage for cementing as it was repeatedly stated over the last two decades. Although our results are at a mean followup of 7.3 years (minimum 2 years), we report 100% survival of all cementless femoral components implanted for this study.

On the acetabular side, comparative analyses of the large database of the Research Center in Orthopaedic Surgery of the University of Bern reported 10-year survivorship of uncemented press-fit (96.9%) and threaded (96.7%) titanium acetabular component designs [42]. Interestingly, the hazard ratio in the incidence of radiographic signs of loosening, adjusted for age and gender, was nearly twofold better for threaded titanium cups (0.16) than for press-fit titanium acetabular components (0.29), with cemented conventional PE acetabular components being defined as the reference level (1.00). This observation was also confirmed in the Finnish Arthroplasty Register, in which the risk of revision for aseptic loosening in patients younger than 55 years of age operated on for primary osteoarthritis was three times higher for all-PE cemented acetabular components than for press-fit porous-coated uncemented acetabular components [20]. A similar conclusion was drawn from the meta-analysis of the international literature conducted by Migaud et al. [40]. We observed similar radiographic evidence of stable acetabular component fixation in a younger, more active patient population.

In the younger, more active patient population, the introduction of cementless acetabular component fixation seemed promising. However, the intuitive advantages with the early design of cementless acetabular components may have been offset by an increased rate of conventional modular PE liner revisions resulting from deficient locking mechanisms, thin PE, and subsequent PE wear [21, 42]. These facts are confirmed by US investigations on patients younger than 50 years of age using the Harris-Galante I press-fit cup (HG I; Zimmer, Warsaw, IN). In two series, efficient primary fixation with adjuvant screws and osseointegration into the titanium fiber-mesh led to survival of 98% or higher at 10 years, but overall results were marred by periprosthetic osteolysis (observed in 20% and 23% of hips) and substantial PE wear (average annual rate 0.15 and 0.19 mm, respectively), and the 10-year survival rate of 80.7% in the Mayo Clinic series [7, 18]. However, McAuley et al. [37] reported on a cohort of patients 50 years and younger. The survival rate for six different porous-coated acetabular components was 89.88% (± 3.86%) and 60% (± 9.8%) at 10 and 15 years, respectively, which was mainly the result of thin conventional PE liners [37]. Despite the in vitro superior tribology of alumina-on-alumina articulating surfaces [10], we turned our interest to the MoM combination. Twenty-eight millimeter, forged, high-carbide ([C], 0.2%–0.25%) CoCr alloy femoral articulations were introduced in France in 1994 at the senior author's (CD) institution (Metasul; Zimmer, ex-Centerpulse, Winterthur, Switzerland) [9]. The component was CE-marked in 1995 and FDA-cleared in 1998. In the general population, cementless fixation of Metasul-layered acetabular components was achieved with various component configurations [11, 35, 45]. Other MoM combinations, with low carbon CoCr alloys, demonstrated poor wear properties [46]. This has been the case with the low-carbon ([C], 0.05–0.08) Sikomet SM21 (Sikov, Medizintechnik, Austria) in which disappointing results of survival rates of 93% at 6 years and 91% at 7 years were reported [33, 41]. In patients younger than 50 years old, provided osseointegration of the acetabular component is achieved, our results of Metasul MoM THA survival remains similar to other independent reports at 5 years (100%) and at 7 years (100%) [31, 39]. These data indicated satisfactory midterm results can be obtained in younger and more active patients with high-carbon Metasul 28-mm articular bearing surfaces across a variety of cementless shell profiles, including microporous threaded cups [12, 48].

Metallic wear particles are markedly smaller than PE wear particles and can easily disseminate in the whole body before urinary excretion [10, 28]. Therefore, MoM bearing surfaces are associated with the potential risk of systemic dissemination of metallic ions. This is particularly true for young, active patients who could be exposed to higher levels of ions for longer periods of time. Measured systemic metal levels can be used to monitor MoM hip arthroplasties, but the methodology is demanding and controversy remains with respect to analytic techniques, units, and acceptable range level [27]. More interestingly, blood or serum cobalt and chromium ion levels are not markedly affected by patient activity [11, 25]. Additionally, carcinogenic concern is loosing argumentative consistency as epidemiologic data are reported in the Nordic population [56]. However, temporary increases in hematopoietic cancers were observed [57]. In addition, Type IV hypersensitivity reactions have been described

around failed MoM THAs that were unknown with non-metallic bearing surfaces [8, 58]. Better knowledge of the exact frequency and clinical consequences of these observations deserves ongoing extensive research. In the authors' opinion and according to the current knowledge, the use of all types of MoM bearings either in conventional THA or with surface replacement arthroplasty must be weighed against these potential risks, particularly in younger individuals. Renal insufficiency and patients with allergic disposition are certainly not recommended candidates [3]. For women of reproductive age, transplacental transfer of metallic ions remains controversial [4, 60]. However, from our experience, standard cementless THAs with 28-mm MoM articulating surfaces have the advantages of a variety of known standard surgical techniques, are proven regarding component design and fixation methodology, remove conventional PE from the bearing profiles, and eliminate the adverse issues encountered with early results of hip resurfacing products (femoral neck fracture).

Improving longevity and long-term outcome of THA in younger and more active patients remains a challenge. So far, the cementless grit-blasted titanium Alloclassic-SL straight taper was well adapted to the standard femoral configuration selected according to the inclusion criteria. No difference in fixation quality to the host bone could be observed among the three types of cementless acetabular components, despite the fact two were not hydroxyapatite-coated and one was a threaded ring. From our experience, the Metasul bearing surface remains promising as an option in the young and more active patient population. Additional followup is necessary to determine any possible long-term deleterious effects associated with metallic ion chronic dissemination.

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