The Journal of Arthroplasty 29 (2014) 181–185

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Current Status of Modern Fully Porous Coated Metal-On-Metal Hip Resurfacing Arthroplasty

Thomas P. Gross, MD, Fei Liu, PhD

Midlands Orthopedics, P.A., Columbia, South Carolina

ARTICLE INFO

Article history:
Received 4 December 2012
Accepted 12 April 2013

Keywords:
uncemented femoral component
hip resurfacing
metal-on-metal
hip arthroplasty

ABSTRACT

Between March 2007 and July 2010, 1000 consecutive fully porous coated hip resurfacing arthroplasties (HRA) were performed by a single surgeon in 871 patients. The average length of follow-up was 3 ± 1 years. Three cases (0.3%) in three patients showed adverse wear related failures. Another 17 (1.7%) failures were identified at the time of this study. Using any failure of any component as the endpoint, the survivorship rate was 98.8% at two years and 97.4% at five years. Excluding the failed cases, all components were radiographically stable; there was only one partial femoral radiolucency seen. The clinical and radiological outcomes of this fully porous coated hip resurfacing were comparable to, if not better than, those reported by others using hybrid fixation methods at five years post-operatively.

Although the majority of metal-on-metal hip resurfacing implants currently being used worldwide utilize bone ingrowth fixation on the acetabular side, cement fixation remains the standard method of fixation on the femoral side [1,2]. The literature supporting uncemented fixation in stemmed total hip arthroplasty (THA) led us to develop an uncemented femoral resurfacing component and to test our hypothesis that bone ingrowth may also be a superior method of fixation in the femoral resurfacing component. To study the value of bone ingrowth fixation of the femoral resurfacing component, we must analyze not only clinical femoral failures but also signs of radiographic fixation. Because we suspect that different types of failures may have different causative factors, we divide femoral failures into early (less than 2 years postoperative) and late types. The most common early femoral failure mode is femoral neck fracture [3,4]. The second early mode of failure is a slow collapse of the femoral head, where the component subsides and migrates into a varus position. It is suspected that this is usually caused by osteonecrosis (ON) of the femoral head due to surgical devascularization. In retrieval studies, dead bone is typically seen [5,6]. The cause of late femoral failures is more controversial. We believe that they are chiefly due to mechanical failure of cement fixation, but others have often listed late failures as ON as well [7].

Our hypothesis is that bone ingrowth fixation of a fully porous-coated component can provide the initial fixation of the femoral hip resurfacing component. We hypothesize that use of a fully porous-coated femoral hip resurfacing component will result in a high rate of bone ingrowth and therefore clinical and radiographically stable fixation on the femoral head. Bone ingrowth will reliably occur even when a posterior hip approach is used. There will be a low rate of early femoral failures: femoral neck fractures and osteonecrosis. Bone ingrowth will be demonstrated by a lack of migration of the component and absence of radiolucencies by two years postoperatively. Normally, femoral components that have achieved bone-ingrowth fixation by the above criteria will not subsequently loosen [8]. We wanted to know if this was true for uncemented femoral resurfacing components as well.

Material and Methods

At the time of this study, the senior author had performed 2801 HRA cases. Of these, 1668 cases employed a combination of a fully porous coated Biomet Recap™ femoral component and a fully porous coated acetabular component Magnum™ (Biomet, Warsaw, IN, USA). We analyzed data prospectively collected on a consecutive series of the first 1000 metal-on-metal fully porous coated total hip resurfacing arthroplasties in 871 patients from March 2007 and July 2010 (Table 1).

The Biomet hybrid resurfacing system employing the Recap and Magnum implants has been previously described in detail [9,10]. In this report, only the undersurface of the femoral component was modified. A layer of plasma sprayed titanium was added to the grit blasted cobalt-chrome undersurface of the femoral component. In the Biomet Recap system, the same instruments are used for femoral preparation whether cement or bone ingrowth fixation is used. The instrumentation allows a 0.5 mm gap for the cemented device. The added titanium layer on the undersurface of the Recap component was designed to provide a 1 mm interference fit across the diameter

The Conflict of Interest statement associated with this article can be found at http://dx.doi.org/10.1016/j.arth.2013.04.010.

Reprint requests: Fei Liu, PhD, Midlands Orthopaedics, P.A., 1910 Blanding St., Columbia, SC 29201.

0883-5403/2901-0037$36.00/0 – see front matter © 2014 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.arth.2013.04.010

Table 1
Demographic Information of the Study Group.

Variables	Number	Percentage
# of Cases	1000	—
In women	250	25.0%
In men	750	75.0%
Deceased[a]	4	0.4%
Diagnosis		
Osteoarthritis	761	76.1%
Dysplasia	125	12.5%
Osteonecrosis	54	5.4%
Post-trauma	24	2.4%
Legg-Calvé-Perthes	13	1.3%
Others	23	2.3%
	Average	Range
Follow-up (yr)	3 ± 1	2–5
Age at surgery (yr)	52 ± 8	12–76
Weight (kg)	190 ± 38	105–318
BMI (kg/m^2)	27 ± 4	18–44
T-score	0 ± 1	−3.4 to 6.7

[a] 4 patients (4 cases) died with the causes unrelated to their hip arthroplasties.

for the uncemented device. The femoral peg is uncoated. The operations were performed through a posterior minimally invasive vascular sparing surgical approach (Table 2). Details of the surgical technique were previously reported [9]. The only significant change was that femoral fixation was uncemented in this study. Spinal anesthesia was used in 992 cases, and general anesthesia was used in eight cases.

Four patients died from causes unrelated to their hip surgery. Because their two-year follow-up information was available in our database, two of these four deceased patients were still included in this study. Three other cases (0.3%) were missing their minimal two-year follow-ups in this study. The three most common primary diagnoses were osteoarthritis in 761 (76.1%) hips, dysplasia in 125 (12.5%) hips, and osteonecrosis in 54 (5.4%) hips. The average size of the femoral component was 50 ± 4 cm (range: 40 to 60 mm), and the average size of the acetabular component was 56 ± 4 cm (range: 46 to 66 mm). All pre-operative, intra-operative, and post-operative data were prospectively collected and entered into our database for later review.

Postoperatively, all patients with good bone quality (DEXA scan bone density of $T > -1.5$) were allowed to proceed with a rapid mobilization program. Weight bearing as tolerated was allowed as soon as the effects of the spinal anesthesia wore off, either on the day of surgery or post-operative day one. Patients used crutches for one to two weeks and afterwards used a cane for one to two weeks. In the hospital, physical therapists taught patients a home program of simple hip exercises and precautions to avoid extreme hip positions. No formal therapy was employed after discharge from the hospital. At 6 weeks post-operatively, a home program of light strengthening and aerobic exercise was started. Impact activities were not allowed until six months after the surgery. In patients with weaker bone density ($T \leq -1.5$), slower progression to full weight bearing over a period of 10 weeks was recommended.

Regular follow-ups were requested at six weeks, one year, two years, and every other year thereafter post-operatively. In-office follow-ups were recommended at the six week and one year postoperative. However, because 80% of the patients came from out of the state where the senior author practices, remote follow-up was sometimes obtained through the online database, or by a telephone interview. Their x-rays and physical exam results were obtained either during the office visit or performed by their local therapists and radiology centers and mailed to us. HHS, UCLA activity score, and Visual Analog Scale (VAS) pain score were utilized to evaluate the clinical outcomes after the hip resurfacing procedure. Anteroposterior and lateral radiographs from the time of the latest follow-up evaluation were evaluated. Since 2010, metal ion tests were routinely requested for all patients who had reached at least two-years post-operatively. Institutional review board approval was obtained for this study.

Statistical differences between pre-operative and post-operative Harris hip score (HHS) and the ranges of motion were performed using two-tailed student *t*-tests. The level of significance (α) was set as 0.5. Kaplan-Meier curves were plotted to report the survivorship rate using two different end points. Uni-variable and multi-variable proportional hazard regression models were used to identify the potential risk factors for the failures in metal-on-metal fully porous coated hip resurfacing.

Table 2
Surgical Summary of the Study Group.

Variables	Average	Range
ASA score[a]	2 ± 1	1–3
Length of Incision (in)	4 ± 1	3–6
Operation Time (min)	105 ± 17	35–220
Estimated Blood Loss (mL)	196 ± 102	50–600
Size of femoral components (mm)	50 ± 4	40–60
Hospital Stay (days)	2 ± 1	1–5

[a] American Society of Anesthesiologists Scores.

Results

The average length of follow-up was 3 ± 1 year (range: 2 to 5 years). There were a total of 20 revisions (2%) (Table 3). There were eight (0.8%) early femoral failures: six (0.6%) femoral neck fractures occurred between one month and two months post-operatively and two (0.2%) cases of femoral head collapse (osteonecrosis [ON]) at ten months and twelve months post-operatively. In both ON cases, radiographs revealed subsidence and varus tilt of the femoral component with development of a radiolucent line in zone 3 and a sclerotic line in zone 1. There were no femoral failures after one year post-operatively. In all eight femoral failures, the femoral components were revised with the use of stemmed large bearing metal-on-metal prostheses that mated with the remaining acetabular components. There were nine (0.9%) acetabular failures: six (0.6%) failures of acetabular component ingrowth recognized at 2 months to 32 months postoperatively and three (0.3%) cases due to acetabular malposition resulting in adverse wear related failures, which occurred between 24 months and 44 months postoperatively. There was one patient revised to a THA elsewhere for recurrent subluxation; two cases were revised to THA — one due to intertrochanteric fracture and one due to periprosthetic femur fracture.

The *Kaplan-Meier* survivorship rate was 98.8% at the two-year follow-up, and 97.4% at the five-year follow-up when failure of any component was used as the endpoint (Fig. 1). The *Kaplan-Meier* survivorship rate was 100% at the two-year follow-up, and 99.4% at the five-year follow-up when adverse wear related failure was taken as the endpoint. When any femoral failure was taken as the endpoint, the *Kaplan-Meier* survivorship rate was 99.8% at both the two-year and five-year intervals.

Excluding the failed cases, there was only one case in which a partial radiolucency was identified around the femoral component. There were no cases of osteolysis. Therefore, there were no impending radiographic failures in addition to the known clinical failures. The average acetabular inclination angle was 39° ± 7° (range: 15° to 57°) (Table 4). In 18 cases, the acetabular inclination angle (AIA) was ≥55° (range: 56 to 59). In 46 cases, the AIA was ≥50°.

The average blood loss was 195 ± 102 cc (range: 50 to 600 cc). Cell saver was used in 117 patients with an average amount returned of 104 ± 58 cc (range: 20 to 300 cc). No blood transfusion was required for any patient. After all failures are excluded, the average post-operative HHS score was 98 ± 7 at the latest follow-up showing significant improvement compared with the average pre-operative HHS score of 57 ± 15 ($P < 0.001$) (Table 4). At the latest follow-up,

Table 3
Complication and Failure Summary of the Study Group (n = 1000).

Variables	Number	Incidence of Failures	Incidence of the Entire Group	Treatment
Modes of Failure	20	100%	2%	—
Acetabular Loosening	6	30%	0.6%	Acetabular revision: 3 Total revision: 3
Femoral Neck Fracture	6	30%	0.6%	Femoral revision
Adverse Wear	3	15%	0.3%	Acetabular revision: 2 Total revision: 1
Early Femoral Head Collapse (Osteonecrosis) (before 1 year)	2	10%	0.2%	Femoral revision
Late Femoral Loosening (after 1 year)	0	0%	0.0%	—
Intertrochanteric Fracture	1	5%	0.1%	Total revision
Subluxation	1	5%	0.1%	Total revision
Periprosthetic Femur Fracture	1	5%	0.1%	Total revision
Complications	21	100%	2.1%	—
Shift in Acetabular Component Position (stabilized)	7	33%	0.7%	Observed
Infection (cured)	3	14%	0.3%	Reoperation and antibiotics
Pulmonary Embolus	3	14%	0.3%	Anticoagulation
Isolated Hip Dislocation	2	10%	0.2%	Reduced, no further instability
DVT	2	10%	0.2%	Anticoagulation
GI bleed	2	10%	0.2%	Medical management
Suture reaction	1	5%	0.1%	Debrided
Retinal embolus with PDA[a]	1	5%	0.1%	Medical management
Psoas tendonitis	0	0%	0.0%	—
Abductor Tear	0	0%	0.0%	—

[a] PDA = patent ductus arteriosus.

361 cases had their physical exam performed at our practice; the rest of them had the exam done elsewhere. The range of motion of the study group was significantly improved after the surgery (Table 5). Cobalt and chromium results from metal ion tests were available for 483 cases. The metal ion level threshold of 10 ug/L was chosen in this study because we have never seen any adverse wear failure with a level below 15 ug/L in our experience of over 3000 metal-on-metal hip resurfacing cases. Four cases in four patients had metal ion levels ≥10 ug/L. Among them, three cases showed adverse wear related failures and were revised. All of these three cases had femoral component size ≤48 mm and AIA ≥50º. The primary diagnosis was OA in two cases and dysplasia in one case.

No intra-operative complications were observed. No femurs were notched. No intra-operative fractures occurred. In every case scheduled for uncemented resurfacing, no cases were converted to stemmed THA for any reason. All femoral components achieved an excellent tight press-fit; none were converted to cement fixation. There were 21 complications not requiring revision listed in Table 3. At the most recent follow-up, all of these patients were doing well with pain relief and high UCLA activity scores.

The uni-variable proportional regression model identified gender, femoral component size and AIA as the significant risk factors affecting the outcomes after metal-on-metal hip resurfacing arthroplasty (Table 6). A multi-variable proportional regression model including only these three factors suggested that only AIA (>50º) and gender were significant risk factors. A multi-variable proportional regression model including only femoral component size and gender could not confirm gender ($P = 0.10$) as the only risk factor over the femoral component size ($P = 0.75$). A multi-variable proportional regression model including only femoral component size and AIA showed that both femoral component size ($P = 0.002$) and AIA ($P = 0.0003$) were significant risk factors for failures after HRA. This suggested that gender and femoral component size may be correlated with each other.

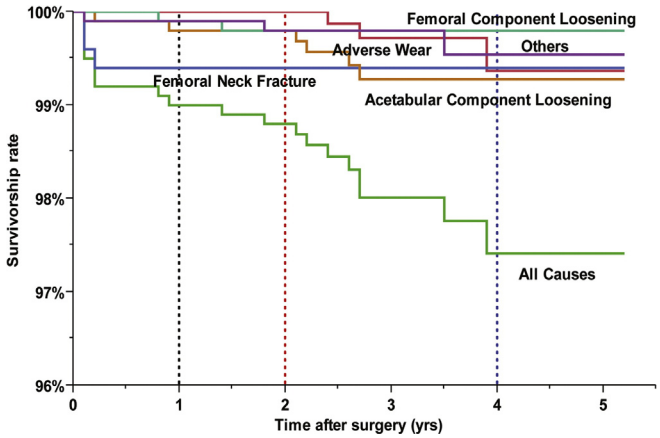

Fig. 1. *Kaplan-Meier* survivorship curves for any component revised due to different causes as the end point in the study group.

Discussion

This study demonstrates that uncemented femoral fixation in HRA is extremely predictable and reliable in the short term. There were only eight (0.8%) early femoral failures before the end of the first postoperative year and no further femoral failures after the first year in 1000 consecutive cases with 2–5 years of follow-up. There were also no additional radiographic impending failures. This seems to indicate that bone ingrowth is established in this porous femoral HRA component within the first year and is stable thereafter until 5 years. Clearly, if failure of ingrowth occurred, at least radiographic signs of migration would be visible by the two year follow-up. Extrapolation

Table 4
Follow-Up Summary of the Study Group.

Variables	Average	Range
Preoperative		
HHS score	57 ± 15	14–98
Postoperative		
Clinical Data		
HHS score	98 ± 7	31–100
UCLA Activity Score	7 ± 2	1–10
VAS Pain: Regular Days	0 ± 1	0–6
VAS Pain: Worst Days	1 ± 2	0–10
Radiographic Data		
Acetabular inclination angle (°)	39 ± 7	15–57
	Number	Percentage
Radiolucency[a]	2	0.2%
Osteolysis	0	0%

[a] One partial 1 mm radiolucency occurred in femoral zone 1; one occurred in acetabular zone 1.

Table 5
Range of Motion of the Study Group.

Range of Motion (°)	Pre-Operative		Post-Operative		
	Average	Range	Average	Range	*P*-Value
Contracture	0.6 ± 3.6	0–30	0 ± 0.5	0–10	0.001
Flexion	89 ± 17	30–130	107 ± 13	75–145	<0.001
Abduction	32 ± 17	0 to 80	58 ± 33	3–70	<0.001
Adduction	13 ± 12	−45 to 45	31 ± 7	0–60	<0.001
External Rotation	27 ± 14	−20 to 80	46 ± 12	3–80	<0.001
Internal Rotation	4 ± 17	−60 to 60	35 ± 10	0–70	<0.001

from the history of other bone ingrowth hip implants would suggest that late loosening of initially bone-ingrown implants is unlikely unless excess wear debris incites osteolysis.

One of the limitations of this study is that even though the incidence of revision surgery for adverse metal related wear was low in this series, there may be unrecognized metal wear/reaction issues for those with metal ion levels ≤10 ug/L. Also, another significant limitation of this study is that the relationship between metal ion levels and the lack of clinical complaints have not been established in this study, which may lead to the oversight of potential cases of adverse metal related wear/reaction. Both of these limitations cannot be overcome based on the currently available information. Further studies should be performed in order to thoroughly understand these two issues. Thirdly, advanced imaging (MARS MRI, CT and/or ultrasound) was not available for most cases except those with high metal ion levels, which may help identify more adverse wear related cases. However, according to the recommendation of the U.S. Food and Drug Administration (FDA), no advanced images should be mandatory without the indication of high metal ion levels or other complications.

There was also a low rate of acetabular failure (0.9%), including 6 cases of acetabular ingrowth failure and 3 cases of adverse wear caused by acetabular component malposition. Notably there were no failures due to infection and only one due to hip instability. The overall survivorship was 98.8% at 2 years and 97.4% at 5 years, which is comparable to previous publications (Table 7). Survivorship rate with use of aseptic femoral component loosening as the end point was 99.9% at 1 year and 99.8% at 5 years. Survivorship with adverse wear as an endpoint was 100% at 2 years and 99.4% at 5 years.

Our hypothesis that the use of a fully porous-coated femoral hip resurfacing component will result in a high rate of bone ingrowth and therefore clinical and radiographically stable fixation on the femoral head is confirmed. Our hypothesis that even when a posterior hip approach is used, bone ingrowth will reliably occur is confirmed. Our hypothesis that uncemented resurfacing femoral components that have achieved bone-ingrowth fixation will not subsequently loosen has received preliminary confirmation. Long-term follow-up will be required to gain more certainty about this conclusion.

During the early years after the introduction of metal-on-metal hip resurfacing, most attention was focused on early failure mechanisms such as femoral neck fracture. Recently, more attention has been directed at adverse wear response to metal bearings. The hip resurfacing community was largely taken by this phenomenon, which was not predicted by biomechanical wear studies. The causative mechanisms of small component size, acetabular component malposition, and poor implant design have been elucidated. The reported failure rate due to adverse wear varies widely, but in most large series from experienced surgeons using well-designed implants the rate is below 1% [1,16,17]. In our previous study, we analyzed 373 Corin Cormet hybrid HRAs. The failure rate at 11 years was 6.7% due to all causes. We found that the largest single cause of failure, with an incidence of 2.9%, was mechanical loosening of the cemented femoral component. In contrast, adverse wear reaction was seen in only 2 (0.5%) out of 373 hip resurfacing cases. Although strategies to avoid wear need to be implemented, we feel that adverse wear has been overemphasized as a failure mechanism. In our experience and in other midterm studies, failure of fixation of the cemented femoral component is a much more common problem. We therefore hope to focus efforts on the more common problem of femoral implant fixation.

Our data suggest that the major midterm failure mode of hybrid HRAs is actually mechanical failure of fixation of the cemented femoral component as opposed to adverse wear failure. Because we suspected that cemented fixation could be problematic, we developed an uncemented component with a full undersurface coating of titanium plasma spray and a precise set of matching cutting tools. We began using the Biomet uncemented Recap shortly after it was FDA-approved for femoral resurfacing in the United States in 2007. Because cement fixation has been established as the standard for the femoral side in England, where hip resurfacing technology was

Table 6
Univariate and Multivariate Proportional Hazard Analyses for Determining the Potential Risk Factors for Metal-On-Metal Fully Porous Coated Hip Resurfacing Arthroplasty.

Variables	Higher Risk	*P*-Value	Hazard Ratio	95% Confidence Interval	
Univariate proportional hazard analysis					
T-score(bone density index)	—	0.34	0.16	0.56	1.19
T-score(bone density index) (≤ −1.5 and > −1.5)	—	0.44	1.68	0.39	5.11
UCLA Activity Score[a]	—	0.14	—	—	—
Range of Motion	—	0.13	0.98	0.96	1
BMI	—	0.71	1.02	0.92	1.12
BMI Grouped (<29 and ≥29)	—	0.83	1.1	0.43	2.66
American Society of Anesthesiologists (ASA) score[a]	—	0.88	—	—	—
Diagnosis (OA, Dysplasia, Others)	—	0.49	2.03	0.57	5.72
Size of Cyst[a]	—	0.24	—	—	—
Age	—	0.22	1.04	0.98	1.1
Age Grouped (<55 and ≥55)	—	0.1	2.11	0.87	5.38
Weight	—	0.27	0.99	0.98	1.01
Gender (male/female)[b]	Female	0.041	3.7	1.53	9.18
Acetabular Inclination Angle (AIA)[b]	Larger	0.0005	1.12	1.05	1.17
AIA Grouped (<50° and ≥50°)[b]	≥50°	0.0006	8.09	2.64	23.45
Size of Femoral Components[b]	Smaller	0.02	0.87	0.77	0.98
Size of Femoral Components <48/≥48 mm)[b]	<48 mm	0.017	3.05	1.23	7.37
Multivariate proportional hazard analysis					
AIA Grouped (<50° and ≥50°)[b]	≥50°	0.0004	8.97	2.92	26.02
Gender (male/female)[b]	Female	0.037	5.74	1.11	27.51
Size of Femoral Components <48/≥48 mm)	<48 mm	0.58	1.49	0.4	7.3

[a] Ordinal variables.
[b] Statistical significant.

Table 7
Comparison of Previous Published Hybrid and Uncemented HRA Studies.

Study Name	Type of Implant	No. of Hips	Years Operations Performed	Follow-Up (yrs)	Age of Patients	Early Femoral Failure Rate[a]	Late Femoral Failure Rate[b]	Survival Rate	
								Total	Femoral
Back [11]	Birmingham hip Resurfacing	230	1999-2001	3 (range: 2 to 4)	52 (range: 18 to 82)	0%	0%	99%	100%
Amstutz [12]	Conserve Plus	400	1996-2000	3.5 (range: 2 to 6)	48 (range: 15 to 77)	—[c]	—[c]	94.40%	97%
Jaffe et al [13].	Hybrid Corin Cormet 2000	337	2001-2003	2.6 (range: 2 to 3)	50.1	—[d]	—[d]	92.9%	94.3%
Lilikakis [14]	Uncemented Corin Cormet 2000	70	2001-2002	2.4 (range: 24 to 38)	52 (range: 23 to 73)	0%	0%	97%	98.60%
Hull [15]	Uncemented Corin Cormet 2000	135	————————	2.9 (rang: 24 to 60)	60 (range: 34 to 77)	0%	0%	100%	100%
Current study	Uncemented Biomet Recap	1000	2007–2010	3 (range: 2 to 5)	52 (range: 12 to 76)	0.2%	0%	98%	98%

[a] Before 1 year after surgery.
[b] After 1 year post-operatively.
[c] Totally 7 (1.8%) femoral component loosening.
[d] Totally 11 (3.3%) femoral component loosening.

pioneered, many surgeons are understandably skeptical about uncemented fixation. Much critique of the concept of hip resurfacing has, in the past, been focused on the compromised blood flow to the femoral head. The observation that more than 98% of femoral components do not fail before 5 years indicates that the femoral head remains alive in most cases. However, there remains concern that the femoral head vasculature may become too compromised by the surgical exposure to allow reliable bone ingrowth into a prosthesis. It was our hypothesis that if the femoral head can remain viable enough to support a cemented component, then it will also be able to adequately incorporate into a porous femoral component. Furthermore, we hypothesized that late osteonecrosis of the femoral head rarely occurs. Late failures of the femoral component are largely due to mechanical fixation failure of the cement, but are often misdiagnosed as late osteonecrosis. We believe that this study proves that bone ingrowth and stable early fixation can be routinely achieved with an uncemented femoral component in hip resurfacing. Long-term follow-up is required to determine if our other hypotheses are correct.

Other studies have reported early success with uncemented femoral fixation. We previously reported excellent femoral fixation with a small group of uncemented femoral components at seven years [8]. However, we were not confident enough about the long-term potential of this implant, which featured a cobalt-chrome grit blasted surface and three longitudinal splines coated with hydroxylappatite, to continue its use. Lilikakis et al have reported good short-term results in 70 cases using this same implant [14]. We previously found no difference in short-term results in a comparison study between the 96 cemented and 191 uncemented Recap components used during the same time period [10].

On the other hand, numerous clinical [1,6] and basic science [18] studies have focused on improving cement techniques. It took much longer for uncemented fixation to become the technique of choice for United States surgeons on the femoral side as compared to the acetabular side of THA. Meanwhile, there were numerous attempts to improve cement techniques, before cement was largely abandoned in favor of uncemented fixation of femoral stems in the United States. We suggest that it may be more fruitful to apply the principles of implant fixation that we have already learned in stemmed THA to hip resurfacing.

From this consecutive series of 1000 uncemented HRA with 2–5 year follow-up we can conclude:

1) The fully porous BIOMET Recap component reliably achieves bone ingrowth.
2) A posterior hip approach does not impair femoral blood flow enough to prevent femoral bone ingrowth.
3) A well-fixed fully porous femoral HRA component does not exhibit any radiolucency.
4) The rate of femoral neck fracture (0.6%) is similar to that of hybrid HRA.
5) Postoperative osteonecrosis (0.2%) and femoral loosening (0%) may be less common than for cemented femoral HRA components.
6) Adverse wear failures and abnormally elevated metal ion levels (>10 ug/L) are uncommon (0.3%) with well-designed HRA components implanted by experienced surgeons.

References

1. Amstutz HC, Le Duff MJ. Eleven years of experience with metal-on-metal hybrid hip resurfacing: a review of 1000 conserve plus. J Arthroplasty 2008;23(6 Suppl 1):36.
2. Gross TP, Liu F, Webb LA. Clinical Outcome of the Metal-on-Metal Hybrid Corin Cormet 2000 Hip Resurfacing System An up to 11-Year Follow-Up Study. J Arthroplasty 2012;27(4):533.
3. Ball ST, Le Duff MJ, Amstutz HC. Early results of conversion of a failed femoral component in hip resurfacing arthroplasty. J Bone Joint Surg Am 2007;89(4):735.
4. Mont MA, Schmalzried TP. Modern metal-on-metal hip resurfacing: important observations from the first ten years. J Bone Joint Surg Am 2008;90(Suppl 3):3.
5. Beaule PE, Matar WY, Poitras P, et al. 2008 Otto Aufranc Award: component design and technique affect cement penetration in hip resurfacing. Clin Orthop Relat Res 2009;467(1):84.
6. Campbell P, Beaule PE, Ebramzadeh E, et al. The John Charnley Award: a study of implant failure in metal-on-metal surface arthroplasties. Clin Orthop Relat Res 2006;453:35.
7. Revell MP, McBryde CW, Bhatnagar S, et al. Metal-on-metal hip resurfacing in osteonecrosis of the femoral head. J Bone Joint Surg Am 2006;88(Suppl 3):98.
8. Gross TP, Liu F. Metal-on-metal hip resurfacing with an uncemented femoral component. A seven-year follow-up study. J Bone Joint Surg Am 2008;90(Suppl 3):32.
9. Gross TP, Liu F. Minimally invasive posterior approach for hip resurfacing arthroplasty. Tech Orthop 2010;25(1):39.
10. Gross TP, Liu F. Comparison of fully porous-coated and hybrid hip resurfacing: a minimum 2-year follow-up study. Orthop Clin North Am 2011;42(2):231.
11. Back DL, Dalziel R, Young D, et al. Early results of primary Birmingham hip resurfacings. An independent prospective study of the first 230 hips. J Bone Joint Surg Br 2005;87(3):324.
12. Amstutz HC, Beaule PE, Dorey FJ, et al. Metal-on-metal hybrid surface arthroplasty: two to six-year follow-up study. J Bone Joint Surg Am 2004;86-A(1):28.
13. Ramakrishnan R, Jaffe WL, Kennedy WR. Metal-on-metal hip resurfacing radiographic evaluation techniques. J Arthroplasty 2008;23(8):1099.
14. Lilikakis AK, Vowler SL, Villar RN. Hydroxyapatite-coated femoral implant in metal-on-metal resurfacing hip arthroplasty: minimum of two years follow-up. Orthop Clin North Am 2005;36(2):215.
15. Hull P, Baxter JA, Lewis C, et al. Metal-on-metal hip resurfacing with uncemented fixation of the femoral component. A minimum 2 year follow up. Hip Int 2011;21(4):457.
16. McMinn D, Treacy R, Lin K, et al. Metal on metal surface replacement of the hip. Experience of the McMinn prothesis. Clin Orthop Relat Res 1996;329(329 Suppl):S89.
17. McGrath MS, Desser DR, Ulrich SD, et al. Total hip resurfacing in patients who are sixty years of age or older. J Bone Joint Surg Am 2008;90(Suppl 3):27.
18. Bitsch RG, Loidolt T, Heisel C, et al. Cementing Techniques for Hip Resurfacing Arthroplasty: In Vitro Study of Pressure and Temperature. J Arthroplasty 2011;26(1):144.