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Femoral Fixation Methods in Hip Resurfacing Arthroplasty: An 11-Year Retrospective Comparison of 4013 Cases

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ABSTRACT

Background: The optimal femoral fixation method remains unclear. To evaluate the role of femoral fixation techniques in hip resurfacing, we present a comparison of 2 consecutive groups: group 1 (739 hips) with cemented femoral components; group 2 (3274 hips) with uncemented femoral components.

Methods: We retrospectively analyzed our clinical database to compare failures, reoperations, complications, clinical results, and radiographic measurements. Groups were consecutive, so cemented cases had longer follow-up. However, all patients from both groups were at least 2 years out from surgery. Two-year clinical and radiographic data were compared. Longer-term comparison data as well as Kaplan-Meier implant survivorship curves specifically focusing on femoral failure modes were analyzed.

Results: Kaplan-Meier 10-year implant survivorship using nontraumatic femoral failure as an end point was 98.9% for the cemented and 100% for the uncemented femoral component. The uncemented, group 2 cases showed a significantly lower raw failure rate (1.1% vs 4.6%), 2-year failure rate (0.8% vs 2.8%), 2-year femoral failure rate (0.4% vs 0.9%), and a lower combined rate of femoral complications and failures (0.6% vs 1.8%). In cases that did not fail, patient mean clinical scores, pain scores, and combined range of motion were all significantly better for group 2.

Conclusion: We have demonstrated that in the fully porous-coated ReCap device, uncemented femoral fixation is superior to cemented fixation at 11 years follow-up (0.0% vs 1.1% late femoral loosening) in this single-surgeon cohort. Early femoral fractures also reduced from 0.8% to 0.3%, but this may be partially or completely due to a new bone density management program. This study demonstrates better femoral implant survivorship for the uncemented device compared to the cemented femoral resurfacing component for this implant design.

Metal-on-metal (MoM) hip resurfacing arthroplasty (HRA) was introduced in the 1990s by McMinn et al and Amstutz et al [1,2] as a bone-preserving alternative to total hip arthroplasties (THA), particularly for young people who demonstrated poor implant survivorship with total hips. In patients younger than 50 years, THA still only has 83% implant survivorship at 10 years and 60% at 20 years in the Swedish register [3,4]. On the other hand, we recently published 96.5% 10-year implant survivorship in a series of 1285 patients younger than 50 years, establishing MoM HRA as a durable option for the young patient. Studies report numerous other benefits: better function in high-impact sports [5–8], more nearly normal gait [9–12], reduced thigh pain [13,14], superior stability [15–17], bone preservation [18,19], improved durability [18–20], and lower all-cause mortality [21,22].

Despite these benefits, primarily 3 factors have prevented a wider adoption of MoM HRA technology. First, failures related to large-bearing MoM THA spiked in the mid-2000s; this spike was driven largely by one brand (the DePuy ASR), which had numerous serious design flaws. The cause of the failures was poorly understood and inaccurately attributed to "metal allergy" or some intrinsic flaw of metal bearings [23]. Unfortunately, this enmity was generalized to MoM HRA as well. Second, HRA is considered technically more challenging to perform than THA, and few academic teaching centers employ staff qualified to teach this to surgeons in training [24]. Lastly, fear of metal wear became widespread, especially for small-bearing MoMs. The senior surgeon (T.P.G.) began performing MoM HRA in 1999 and has fought much criticism of

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MoM arthroplasty, particularly regarding adverse wear-related failure. However, this has only occurred at a rate of 1% by 10 years. We have had no cases of adverse wear-related failure (AWRF) or abnormal metal ion levels since 2009 after full implementation of our relative acetabular inclination limit (RAIL) guidelines [25].

Improvements in management of HRA at our practice have also led to reduction in early femoral failures from 2.0% to 0.1% [26]. Selective use of supplemental cup fixation eliminated failures of acetabular stability in dysplasia, and an improved acetabular preparation method eliminated all failures of acetabular ingrowth in HRA. Better perioperative management led HRA to become available as an outpatient procedure at our surgical center in 80% of cases and reduced the rate of infection to less than 1:3000.

To further improve HRA outcomes, we began using a fully porous-coated femoral component in 2007 instead of the industry standard of cement fixation. This was met with skepticism because the prevailing belief was that femoral heads became devascularized during the HRA procedure and therefore were not suitable for bone ingrowth technology. An early, small preliminary study by McMinn et al showed inferior fixation with a press-fit head [1], but the femoral component did not have an adequate porous bone ingrowth surface. Often large areas of dead bone and cyst are removed during HRA. Generally, these defects are segmental and are filled with bone cement. Large amounts of excess cement lead to increased thermal necrosis causing collateral damage to the remaining viable bone [27,28]. With uncemented femoral components, these defects are typically filled with acetabular reamings to prevent thermal damage [6,29–31].

We present a comparison of failures between 2 consecutive fixation groups of HRA by the same surgeon, with the same approach, and using the same implant. The first group is a hybrid-cemented Biomet system, and the latter is a fully porous-ingrowth, uncemented Biomet system. We present all failures but focus our analysis on femoral failures, particularly the mode of late femoral loosening. Logically, a change in femoral fixation method may affect femoral failures but would not be expected to influence other failure modes. Femoral failure modes include late femoral loosening, early femoral neck fracture, and early femoral head collapse. The purpose of this study is to present midterm to long-term clinical results of uncemented fixation and to compare outcomes and survivorship with the cemented alternative.

Materials and Methods

Hybrid HRA is the industry standard [32]. In this, the acetabular component is uncemented, and the femoral component is cemented. The senior surgeon used this approach from 2000 to 2007 when a fully porous-coated femoral component first became available. The surgeon had already completed their initial learning curve of nearly 400 cases when this study commenced in 2005. The control group 1 consisted of 739 consecutive hybrid HRA performed using the Biomet Magnum-ReCap resurfacing system between 11/2004 and 3/2007, excluding 17 cemented cases during the transition period; the final cemented case was 8/2008. Group 2 comprised 3410 consecutive uncemented Biomet Magnum-ReCap HRA done between 3/2007 and 12/2016. The closing date was selected to ensure a minimum of 2-year follow-up. The follow-up of group 1 was therefore up to 2 years longer. Patients were matched similarly by body mass index (BMI), T-score, and gender (Table 1). Group 2 was slightly older, on average, and had more cases of dysplasia. However, we have never selected against patients on basis of age or diagnosis. We previously described our surgical technique [33]; bone defects were filled with acetabular reamings before impaction. Intraoperative information is listed in Table 2.

Table 1
Demographics.

Variable	Group 1	Group 2	*P* Value
Date range	11/2004-8/2008	3/2007-12/2016	—
# of Cases	739	3410	—
# Deceased	14 (1.9%)	10 (0.3%)	**<.0001**
Demographics			
% Female	212 (28.7%)	913 (26.7%)	.289
Mean follow-up (y)	7.4 ± 2.7	3.9 ± 2.1	**<.0001**
Age (y)	51.2 ± 8.2	53.3 ± 8.3	**<.0001**
Body mass index	27.3 ± 4.7	27.2 ± 4.7	.601
T-score	−0.1 ± 1.1	0.0 ± 1.3	.052
Diagnoses			
Osteoarthritis	605 (81.9%)	2671 (78.3%)	**.032**
Dysplasia	63 (8.5%)	419 (12.3%)	**.003**
Rheumatoid arthritis	0 (0.0%)	9 (0.3%)	.161
Post-trauma	17 (2.3%)	52 (1.5%)	.136
Legg-Calve-Perthes disease	12 (1.6%)	46 (1.4%)	.562
Slipped capital femoral epiphysis	7 (0.9%)	16 (0.5%)	.112
Osteonecrosis	31 (4.2%)	163 (4.8%)	.497
Other	4 (0.5%)	34 (1.0%)	.238

Bolded values indicates the statistical significance.

The Biomet system is high-carbon (0.2%) cast cobalt-chromium alloy without heat treatment. Each individual component was quality tested, with surface roughness less than 0.5 mm and a radial clearance of 75 mm. The ReCap femoral component has a hemisphere undersurface on top of a cylindrical section. The cylindrical stem is 8 mm in diameter. The apex of each component is 6 mm thick, tapering to 0 at the head-neck junction. The undersurface of the cemented femoral component is grit blasted with cobalt-chromium and has a machined radial gap of 0.5 mm for cement application. The uncemented femoral component is plasma-sprayed with titanium and hydroxyapatite for enhanced bone ingrowth. Beginning in 2007, the additional Tri-Spike Magnum component became available for each size.

Femoral failures were defined as follows: early fractures occur before 6 months postoperative. They are related to low preoperative bone density and high patient BMI, and they usually occur spontaneously or with minimal trauma. Early head collapse occurs within 2 years of surgery. This failure mode is sometimes referred to as osteonecrosis, but we think it may better be characterized as a variant of femoral neck fracture (stress fracture of the femoral head). Late femoral failures are those cases where femoral migration begins after 2 years. In these cases, initial biological failure of the proximal femur was avoided, and a good clinical outcome and stable radiographic appearance is seen at 2 years. At some later point, femoral fixation is lost, and the patient becomes symptomatic. We have seen 2 cases of traumatic late femoral failures (both uncemented) due to fractures of the femoral head with major trauma, as well as numerous cases of nontraumatic loosening without major trauma. These, along with other failures, are listed in Table 3. We occasionally encounter late traumatic femoral

Table 2
Surgical Information.

Variable	Group 1	Group 2	*P* Value
Length of incision (in)	4.2 ± 1.1	4.2 ± 0.5	1.000
Operation time (min)	118.4 ± 22.8	94.3 ± 23.9	**<.0001**
Estimated blood loss (mL)	228.5 ± 114.2	166.1 ± 152.5	**<.0001**
Hospital stay (d)	2.7 ± 1.2	1.5 ± 1.1	**<.0001**
# Transfusion received	2 (0.3%)	0 (0.0%)	.003
Transfusion volume (cc)	375 ± 0.0	—	—
ASA score	1.7 ± 0.6	1.7 ± 0.6	1.000
Femoral component <48 mm	120 (16.2%)	743 (22.1%)	**.001**
Femoral component size (mm)	51.2 ± 3.9	49.8 ± 3.8	**<.0001**

Bolded values indicates the statistical significance.
ASA, American Society of Anesthesiologists.

Table 3
Failures.

Type	Group 1	Group 2	*P* Value
# Cases	739	3410	—
Acetabular failures			
Adverse wear	4 (0.5%)	3 (<0.1%)	**.006**
Acetabular component loosening	2 (0.3%)	2 (<0.1%)	.09
Failure of acetabular ingrowth	8 (1.1%)	8 (0.2%)	**.008**
Acetabular component shift	0 (0.0%)	2 (<0.1%)	.51
Femoral failures			
Head collapse	0 (0.0%)	2 (<0.1%)	.51
Early fracture	6 (0.8%)	10 (0.3%)	**.039**
Femoral component loosening	7 (0.9%)	3 (<0.1%)	**<.0001**
Other failures			
Recurrent instability	1 (0.1%)	2 (<0.1%)	.50
Early infection	2 (0.3%)	0 (0.0%)	**.002**
Late fracture	0 (0.0%)	3 (<0.1%)	.42
Unexplained pain	3 (0.4%)	4 (0.1%)	.08
Psoas tendonitis	1 (0.1%)	0 (0.0%)	**.03**
Total failures	33 (4.5%)	38 (1.1%)	**<.0001**

Bolded values indicates the statistical significance.

trochanteric and subtrochanteric fractures, which are repaired (reoperation wherein components are retained); thus, they do not represent failures or true resurfacing complications. Reoperations and complications are listed in Table 4. For the sake of brevity, we avoid detailing other failure modes, causes of reoperation, and complications because they are not central to the theme of this investigation.

Office or remote follow-up was requested of all patients postoperatively at 6 weeks, 1 and 2 years, and every other year thereafter. A clinical questionnaire, radiographic analysis, and a physical examination testing range of motion and strength were performed at each visit; for remote follow-ups, we no longer requested physical examinations after 1 year postoperative. We used our OrthoVault clinical database (Midlands Orthopaedics & Neurosurgery PA, Columbia, SC) for prospective collection and retrospective analysis of demographic, clinical, and radiographic data. We list clinical and radiographic information in Table 5. We used the information collected from patient questionnaires to calculate the following scores for clinical evaluation: Harris hip score (HHS) for functional assessment [34], University of California, Los Angeles activity score [35], and visual analog scale (VAS) pain score for normal and worst days [36]. University of California, Los Angeles activity scores measure postoperative activity level on a scale from 1 to 10, for which a 10 represents the highest level of activity; VAS pain scores rate the level of pain from 0 to 10, with 0 representing no pain and 10 representing maximum, debilitating pain. We collected supine and standing anterior-posterior pelvis and lateral radiographs and analyzed these for component position, shifting, and radiolucencies. We determined acetabular inclination angle by taking the angle between a measurement line running across the face of the acetabular component and a reference line horizontal across the inferior pubic rami [33]. All measurements were taken using InteleViewer (Intelerad, Chicago, IL).

We performed all statistical analyses using XLSTAT (Addinsoft, New York, NY). Paired, 2-tailed Student *t*-tests were carried out to find significant differences between averages. Two-sample proportion Z-tests were used to compare ratios between groups. All tests were carried out at $\alpha = 0.05$. Kaplan-Meier (KM) implant survivorship curves were generated using revision as an end point to estimate postoperative survival rates of implants. We performed both a log-rank test and a Wilcoxon test to determine whether implant survivorships between groups were statistically different.

Table 4
Complications and Reoperations.

Type	Group 1	Group 2	*P* Value
# Cases	739	3410	—
Complications			
Dislocation	7 (0.9%)	9 (0.3%)	**.006**
DVT/PE	3 (0.4%)	14 (0.4%)	.984
Femoral fracture	0 (0.0%)	2 (<0.1%)	.509
Femoral component shift	0 (0.0%)	2 (<0.1%)	.509
Hematoma	1 (0.1%)	2 (<0.1%)	.483
Intratrochanteric fracture	0 (0.0%)	1 (<0.1%)	.638
Loose femoral component	0 (0.0%)	2 (<0.1%)	.509
Urinary retention	0 (0.0%)	5 (0.1%)	.298
Spinal headache	0 (0.0%)	5 (0.1%)	.298
Other fracture	1 (0.1%)	3 (<0.1%)	.704
Other	3 (0.4%)	14 (0.4%)	.984
Reoperations			
Abductor tear	1 (0.1%)	0 (0.0%)	.032
Intratrochanteric fracture	1 (0.1%)	8 (0.2%)	.596
Early infection	2 (0.3%)	5 (0.4%)	.459
Hematoma	0 (0.0%)	3 (<0.1%)	.418
Fascia failure	2 (0.3%)	2 (<0.1%)	.093
Dislocation	0 (0.0%)	1 (<0.1%)	.638
Psoas tendonitis	2 (0.3%)	0 (0.0%)	**.002**
Other	0 (0.0%)	2 (<0.1%)	.5090
Total	27 (3.7%)	80 (2.3%)	**.042**

Bolded values indicates the statistical significance.
DVT/PE, deep vein thrombosis/pulmonary embolism.

Table 5
Clinical Outcomes.

Variable	Group 1	Group 2	*P* Value
Preoperative			
HHS	54.9 ± 12.0	58.0 ± 15.2	**<.0001**
Postoperative			
HHS	95.3 ± 8.3	98.2 ± 5.2	**<.0001**
HHS pain score[a]	41.3 ± 5.3	42.8 ± 4.0	**<.0001**
UCLA score	7.4 ± 1.7	7.5 ± 1.9	.188
VAS pain: regular	0.4 ± 0.8	0.2 ± 0.8	**<.0001**
VAS pain: worse	1.4 ± 1.7	1.3 ± 2.1	.227
Combined ROM	272.7 ± 42.0	257.3 ± 41.0	**<.0001**
Radiographic data			
AIA	39.3 ± 5.4	34.8 ± 5.6	**.0007**
Under RAIL (# hips, %)	0/18 (0.0%)	3032/3261 (93.0%)	**<.0001**
Radiolucency (# hips, %)	0 (0.0%)	0 (0.0%)	1.000
Osteolysis (# hips, %)	0 (0.0%)	0 (0.0%)	1.000

Bolded values indicates the statistical significance.
AIA, acetabular inclination angle; HHS, Harris hip score; RAIL, relative acetabular inclination limit; ROM, range of motion; UCLA, University of California, Los Angeles; VAS, visual analog scale.
[a] Higher pain score indicates less pain.

Results

For nontraumatic femoral loosening as an end point (Fig. 1), uncemented implants had 100% 10-year survivorship, while cemented femoral components achieved 99.1% ($P < .0001$). Including the 2 late femoral failures due to traumatic fractures, uncemented 10-year survivorship was still significantly greater (99.9% vs 98.9%, $P < .0001$). Failure of early femoral fracture (before 2 years postoperative) was also significantly lower for uncemented components (0.8% vs 0.3%, $P = .04$). Thus, overall 10-year femoral survivorship was higher for group 2 ($P < .0001$; Fig. 2). Uncemented implants had a significantly higher overall (all-cause) 10-year KM survivorship at 98.9% compared to group 1 at 95.1% ($P < .0001$; Fig. 3). Overall raw failures were also significantly lower for uncemented cases (Table 3); the rate of AWRF ($P = .006$), failure of acetabular ingrowth ($P = .008$), early femoral fracture ($P = .04$), femoral loosening ($P < .0001$), early infection ($P = .002$), and psoas

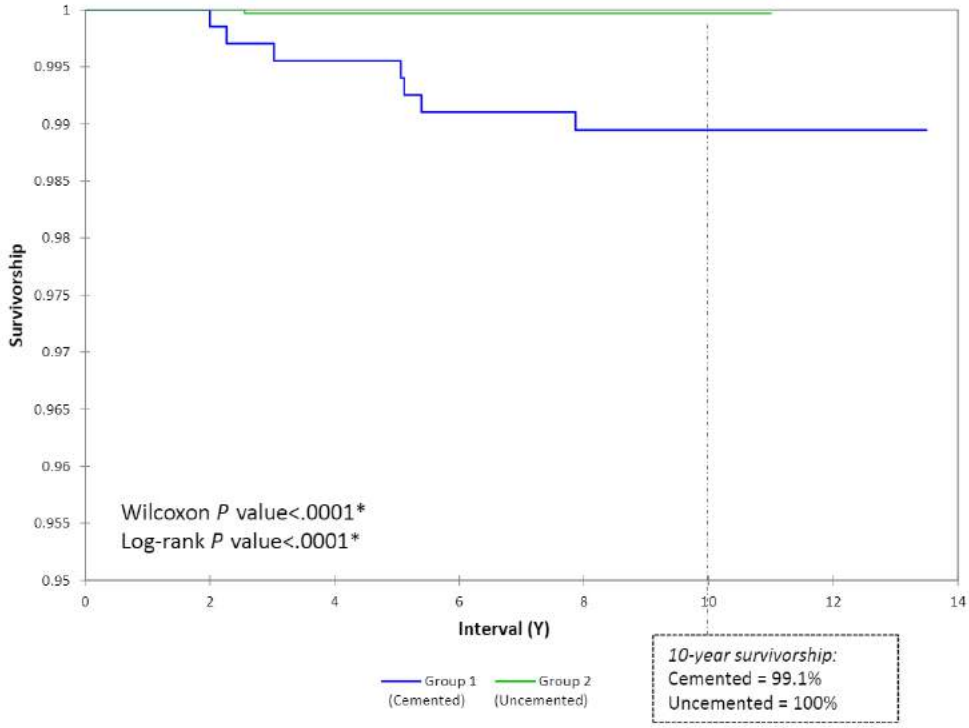

Fig. 1. Kaplan-Meier implant survivorship for cemented vs uncemented fixation (nontraumatic femoral loosening only).

tendonitis ($P = .03$) were all significantly lower for group 2. Uncemented implant survivorship is broken down by failure type in Figure 4.

Overall rate of complications and reoperations (an unfavorable surgical consequence not resulting in revision) was lower for group 2 ($P = .042$). There were significantly fewer dislocations in group 2 ($P = .006$) and fewer instances of psoas tendonitis ($P = .002$). Rate of femoral complications—including femoral fracture not requiring revision, femoral component shift, and femoral component loosening—was similar between both groups ($P = .509$).

HHS clinical score, which comprises pain, function, and mobility, was significantly higher for group 2, both preoperatively

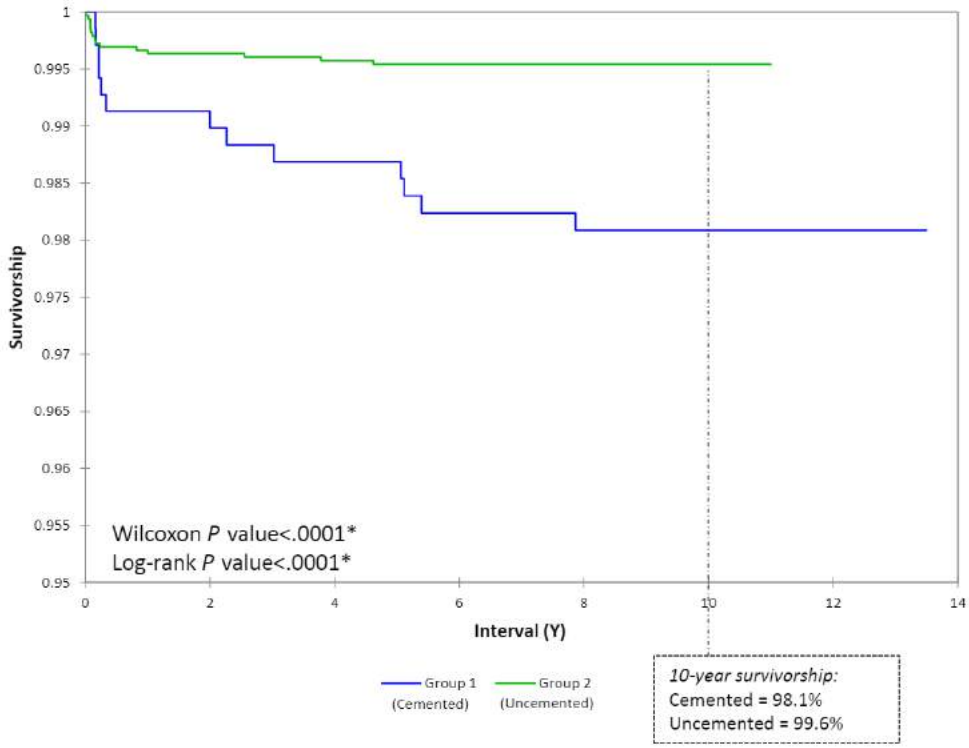

Fig. 2. Kaplan-Meier survivorship for cemented vs uncemented fixation (femoral failures only).

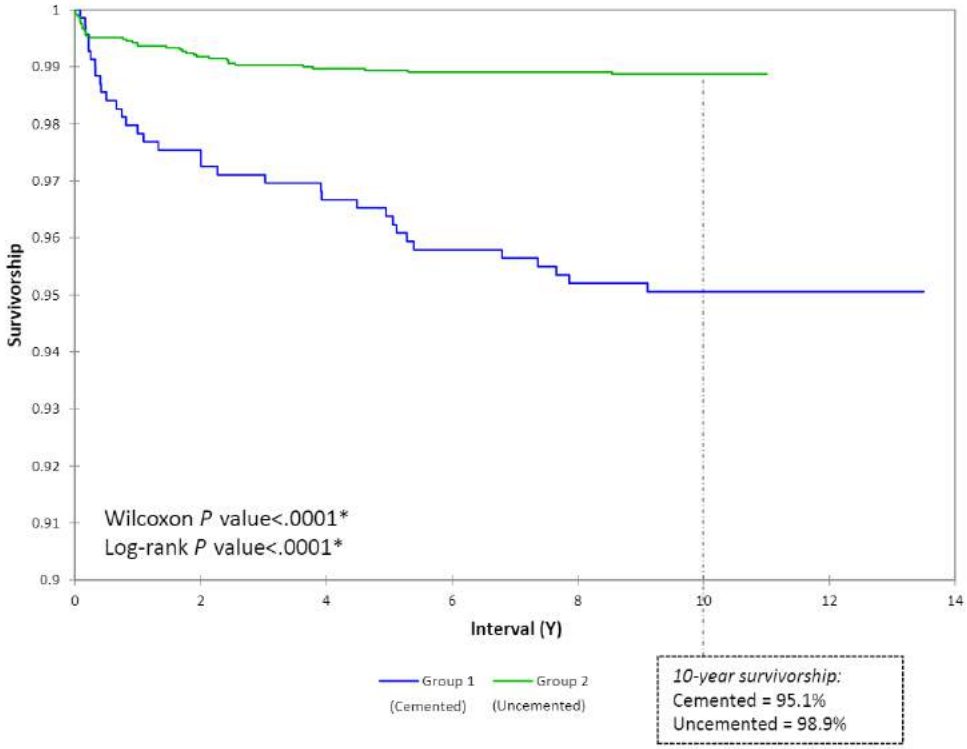

Fig. 3. Kaplan-Meier implant survivorship for cemented vs uncemented fixation (all failures).

and postoperatively ($P < .0001$). Correspondingly, postoperative HHS pain score was also significantly greater for group 2 ($P < .0001$). While VAS worst pain score was similar between the 2 groups, VAS regular pain score was significantly better for group 2 ($P < .0001$). Additionally, range of motion was significantly greater for group 2 ($P < .0001$).

After switching to an uncemented femoral fixation technique, mean operation duration significantly decreased ($P < .0001$). Average estimated blood loss fell significantly ($P < .0001$), and mean postoperative hospital stay decreased by 1 day ($P < .0001$). Mean incision length remained the same between both groups ($P = 1.000$), and rate of transfusion was similar ($P = .003$).

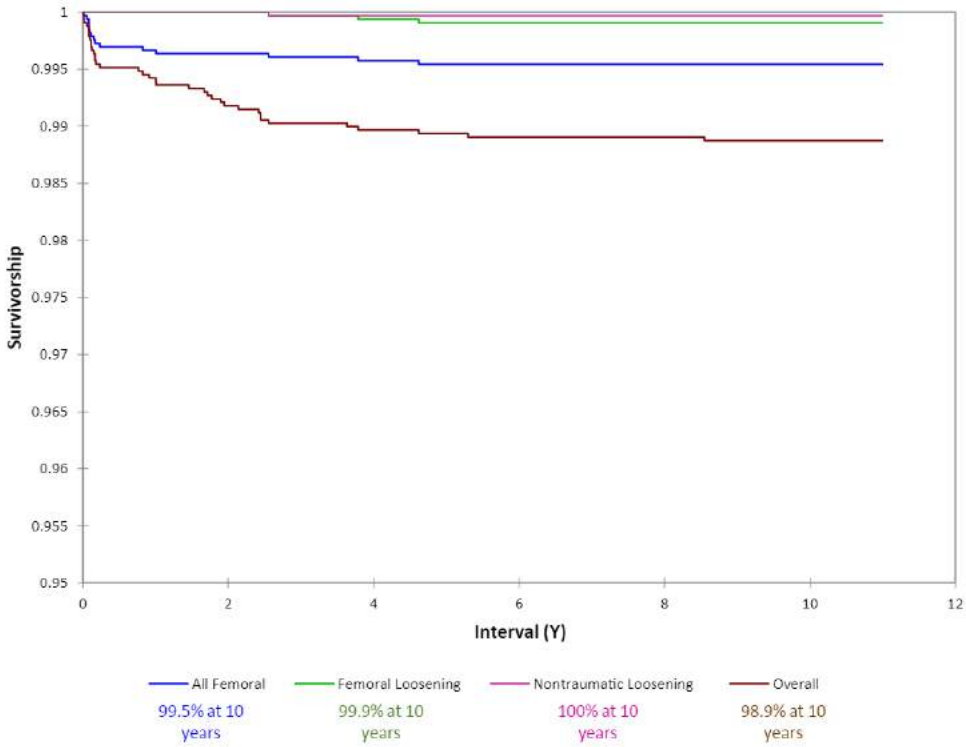

Fig. 4. Kaplan-Meier implant survivorship by failure type (uncemented fixation only).

Table 6
Literature Comparison.

Study	Procedure	Prosthesis/Fixation	Date Range	Patient Cohort		Average FU (y)	Survivorship		
				Hips	Female		FU	Rate (All)	Rate (Femoral)
Wagner and Wagner [45]	HRA	Uncemented Wagner	1991-1994	35	—	1.7	1.7	85.7%	88.6%
McMinn et al [1]	HRA	Uncemented Corin and McMinn	1991-1992	70	—	4.2	4.2	87.1%	91.4%
McMinn et al [1]	HRA	Hydroxyapatite uncemented Corin and McMinn	1992	6	—	3.3	3.3	100%	100%
Lilikakis et al [39]	HRA	Uncemented Corin Cormet	2001-2002	70	41.4%	2.4	2.4	97.1%	98.6%
Berstock et al [46]	HRA	Hybrid Corin Cormet	2000-2006	30	37%	2	2	100.0%	100%
Berstock et al [46]	HRA	Uncemented Corin Cormet	2000-2006	30	42%	2	2	100.0%	100%
Hull et al [31]	HRA	Uncemented Corin Cormet	2000-2006	135	34.8%	2.9	2.9	100.0%	100%
Australian 2018 Registry [48]	THA	Cementless, assorted	2003-2017	200,398	45%	—	2	97.4%	—
							10	95.0%	—
Present study (hybrid)	HRA	Biomet hybrid	2004-2008	739	25%	7.4	2	97.3%	99.0%
							10	95.1%	98.1%
Present study (uncemented)	HRA	Biomet fully porous-coated	2007-2016	3410	18%	3.9	2	99.2%	99.6%
							10	98.9%	99.5%

FU, follow-up; HRA, hip resurfacing arthroplasty.

Discussion and Conclusions

The current standard for MoM HRA fixation is cementation of the femoral component [37]. Several recent studies demonstrated promising clinical outcomes with use of fully porous-ingrown femoral components [38,39]. However, these studies were limited in size and follow-up length. These current midterm to long-term data (>10 years) support our hypothesis that switching from cemented femoral components to porous-coated, uncemented femoral components reduces the rate of late femoral loosening; this trade in fixation increased HRA 10-year femoral implant survivorship at our practice by 1.4%. The early femoral fracture rate and mean clinical scores also improved, but we suspect this may be due to other factors.

After implementing porous-ingrowth, uncemented fixation, all-cause failure rate also decreased significantly. In previous publications, we demonstrated that the reduction in AWRF was a result of implementing relative acetabular inclination limit guidelines for acetabular placement [25]; the reduction in acetabular failure of ingrowth was likely due to a "wedge-fit" acetabular preparation technique and using supplemental acetabular fixation (Tri-Spike Magnum) in selected dysplasia cases (unpublished work). The complete elimination of early infection is likely a result of gradually improving prevention strategies which are beyond the scope of this article (unpublished work). Psoas tendonitis likely no longer occurs because we now avoid cup overhang in the anterior-inferior acetabulum where the psoas can become irritated by the edge of the component (unproven author observation).

Two femoral failure modes have decreased after changing to uncemented fixation. Almost certainly the elimination of late, nontraumatic loosening can be ascribed to changing fixation method. There were 2 late traumatic loosenings in group 2 and 1 in group 1 ($P = .51$); we do not believe these are related to fixation. Even still, overall femoral loosening rate is lower for uncemented cases. Early femoral neck fractures were also significantly less common in the uncemented group. Although this could be due to avoiding the adverse thermal effect of cement on the proximal femur, we think it is more likely due to our perioperative bone management program that we gradually instituted between 2008 and 2010. We have previously demonstrated that patients with low bone density and high BMI are at greater risk of early femoral failure (but not late femoral loosening) [26]. We have also shown that a combination of immediate (but gradual) weight-bearing and a 6-month course of oral antiresorptive medication significantly reduces the incidence of this complication.

This study contains several limitations worth mentioning. Possibly the most notable is the natural shortcoming arising from the employment of nonconcurrent groups. In the present study, group 1 cases were completed between 2004 and 2008, whereas group 2 were done later between 2007 and 2016. Greater surgeon experience correlates to lower rates of failure [16,40]; thus, it is reasonable to argue that these improvements are a result of enhanced technical skills. However, the primary surgeon had already surpassed their initial learning curve before group 1 cases began, and similar femoral surgical technique was employed. Furthermore, one might make a strong case that because group 2 surgeries were performed later, the same failures from group 1 may not have had enough time for detection. However, all group 2 cases had a minimum 2-year follow-up, allowing adequate time for early symptoms of failure to develop. All cases of early femoral fracture occurred before 2 years; these failures were significantly higher for group 1. Additionally, the KM curves show a marked disparity in rate of failure at 2 years between the 2 fixation methods. This valid 2-year comparison, and the 98.9% implant survivorship at 10 years for group 2, certainly convinces us to employ exclusively uncemented devices. Another notable limitation is that this is a single-surgeon cohort; thus, difficulty in reproducing these results may arise, particularly among less-experienced HRA surgeons. Smith et al [40] demonstrated that surgeons who perform less than 5 HRA procedures per year achieve lower implant survivorship with HRA than with THA at 5 years. The primary surgeon performs between 400 and 500 primary HRAs each year. We encourage other experienced hip resurfacing surgeons to share their outcomes with uncemented fixation. Lastly, the cemented group was younger, on average, than the uncemented group, with fewer cases of dysplasia. However, we have never practiced patient selection by age or diagnosis. Furthermore, we have previously demonstrated that results do not vary among age-groups at our practice [41]. Also, studies have shown inferior results in cases of dysplasia [11,42–44]; thus, we argue that this could only potentially hinder results for the uncemented group, which are still statistically superior despite this.

There are other notable publications on uncemented HRA (Table 6). Wagner and Wagner [45] introduced a cementless MoM resurfacing device in 1991; both components comprised a layer of titanium alloy backing and a Metasul articulation. At 1.7 years, the rate of femoral component survivorship was 88.6%. Around the same time, McMinn et al [1] reported on uncemented Corin and McMinn HRA devices, with a femoral component survivorship of 91.4% at 4.2 years. Large technical strides and improvements in

survivorship have been made since then. Lilikakis et al [39] reported 97.1% implant survivorship for all failures and 98.6% for femoral failures at 2.4 years using the uncemented Corin Cormet HRA system. Berstock et al [46] reported 100% implant survivorship for both the uncemented and hybrid cemented Corin Cormet system at 2 years postoperative; Hull et al [31] similarly reported 100% implant survivorship for the uncemented Corin Cormet at 2.9 years postoperative with a larger sample size (139 hips compared to 30 Berstock cases). Our implant survivorship for cemented HRA is comparable to other reports [46,47]; while our 2-year uncemented implant survivorship is comparable or slightly improved, our sample size is the largest existing single-surgeon uncemented cohort, and our follow-up interval is the longest available, to the best of our knowledge.

This report presents the longest-term follow-up data and largest single-surgeon cohort available on uncemented femoral components in modern HRA, to our knowledge. These data demonstrate that uncemented femoral fixation showed improvement over the results with cemented fixation in HRA with the ReCap device by reducing the nontraumatic late femoral loosening rate from 1.1% to 0%. Early femoral neck fractures also reduced significantly from 0.8% to 0.3%, but this may be due to a change in our early postoperative bone management program. These uncemented cases showed excellent stability, radiological results, and clinical performance even beyond 10 years postoperative. Based on these notable outcomes, we recommend that other HRA surgeons consider uncemented devices as an alternative fixation method to traditional bone cement.

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