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Full title: An 18-year Comparison of Hybrid Total Hip Replacement and Birmingham Hip Resurfacing in Active Young Patients

Short title: A comparison of Birmingham hip resurfacing and hybrid total hip replacement

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Abstract

Aim

To compare the long-term clinical and radiological results of metal-on-polyethylene hybrid total hip replacement (THA) with metal-on-metal Birmingham hip resurfacing (BHR) in young, active patients.

Patients & Methods

From the first consecutive 63 hips in young, active patients who underwent BHR by the senior author, 54 (51 patients) were matched to patients who had undergone THA with regard to age, gender, body mass index and pre-operative levels of activity. Radiologically, all hips were assessed for migration and osteolysis, THAs for polyethylene wear and BHRs for a pedestal sign. Patient reported outcomes, mortality and revision rates were compared.

Results

The mean follow-up of the patients with a hybrid THR was 19.9 years and for those with a BHR, 17.6 years. 13 patients with a hybrid THR and 5 with a BHR had died. The revision rate of the hybrid THRs was 14/54 and of the BHRs 6/54. Log rank comparison of Kaplan-Meier survival estimates demonstrated a significantly lower mortality in the BHR group (p=0.039; Hazard Ratio=0.37 (95% CI=0.15,0.95)) but a non-significant difference in revision rates (p=0.067; Hazard Ratio=0.43 (95% CI=0.18,1.06)). The BHRs recorded superior OHS (p=0.03), UCLA (p=0.0096), and EuroQol visual analogue scores (p=0.03). Significantly more BHRs had run, played sport and undertaken heavy manual labour in the month preceding follow up.

Conclusion

After 18 years, patients with BHRs reported superior patient reported outcome measures and remained more active with a lower mortality rate but no significant difference in revision rates. Both groups demonstrated progressive radiological changes at long-term follow-up.

Introduction

Hip resurfacing (BHR) was proposed as an alternative to THR in the young active population. It was introduced in the 1990s to address the problem of poor implant survival in this population group with hip replacements of the time[1].

The incidence of hip resurfacing peaked in 2006 with an implantation rate of 10.8% of all UK hip replacements. Current latest registry data indicates that this has now fallen to 0.7%[2]. This has largely been due to complications related to metal on metal bearings and pseudo-tumour formation[3].

However registry data shows that its' 13-year survival is amongst the lowest revised (10.1%) in males >55-years[2]. Originating centres report survival of 94.1-95.8% at 15-years with good to excellent results[4,5]. Individual non-designer centres report 13-year survival of 88.8-92.4%[6,7]. Registry data reports BHR survival of 89.9% at 13-years[2] and 90.4% at 15-years[8].

This report represents the 18-year follow up of this patient group. This study compares the long-term outcome of 54 BHRs from a single surgeon series (GCB), with a matched group of hybrid THAs. We have previously reported early[9], 5-year[10] and 10-year[11] results of these cohorts in which BHR was functionally superior both in terms of hip OHS and activity levels.

The aim of this study was to see if the superiority of the BHR persists with longer-term follow-up.

Patients and Methods

Matching

The BHRs were matched with hybrid THRs for gender, age at surgery (>5 years), BMI (>5 kg/m^2) and their pre-operative level of activity before it was limited by symptoms. Activity was graded using the University of California, Los Angeles (UCLA) activity score[12]. We matched patients within 2 points on the scale. The mean age of the patients with a BHR at initial arthroplasty was 49.8 years (18 to 67), their mean BMI was 25.7 kg/m^2 (19.7 to 35.1) and their mean pre-operative UCLA activity score was 9.0 points (6 to 10). The mean age of the patients with a hybrid THR was 50.4 years (21 to 66), their mean BMI 27.0 kg/m^2 (18.5 to 37.0) and their mean pre-operative UCLA activity score was 8.9 points (6 to 10).

Patients

From August 1999 to April 2001, 63 hips were resurfaced using the BHR (previously Midland Medical Technologies, Birmingham, United Kingdom, now Smith & Nephew, Memphis, Tennessee). This comprised a cemented femoral component and an uncemented hemispherical flanged hydroxyapatite- and porous-coated acetabular cup. In no cases did the senior author decide at operation that a case was unsuitable for resurfacing and perform a THR instead. Of the 63 hips, 2 were revised for fracture of the femoral neck within 6 weeks of implantation and 1 for avascular necrosis after 1 year. There were 6 patients (6 hips) who could not be contacted, leaving 54 surviving BHRs in 51 patients (11 women, 13 hips and 40 men, 41 hips).

From January 1996 to April 2001, 54 hips in 53 patients (13 women, 13 hips and 40 men, 41 hips) underwent a hybrid THA with a cemented CPT femoral component (Zimmer, Warsaw, Indiana) and an uncemented acetabular cup and a polyethylene liner. The acetabular components were 29 Harris-Galante II (Zimmer), 16 ABG II (Stryker Orthopedics, Mahwah, New Jersey), 7 Zweymuller (PLUS Orthopedics, Rotkreuz, Switzerland), 1 PFC (DePuy International, Leeds, United Kingdom) and 1 Hedrocel (Implex Corp, Allendale, New Jersey). A 28 mm modular metal femoral head was used in 45 hips and a ceramic head in 9.

Surgery

The operations were predominantly for primary osteoarthritis[9-11]. All were performed through the posterior approach, which was extensile in the BHRs. No hybrid THRs had required further surgery following their primary procedure before recruitment to the study. All patients were allowed to fully weight bear immediately post-operatively. Patients with BHRs commenced high-impact activity after three months but those with hybrid THRs were advised to avoid heavy manual work and high impact sport.

Follow-up

All patients were invited to attend outpatient clinics, where they completed a questionnaire recording complications of their hip arthroplasty, the UCLA activity score[12], the Oxford hip score (OHS)[13], and the EuroQol[14] quality of life score. The UCLA activity score was used, as previously, with modifications for the British population[9-11]. The OHS was ranked from 12 (asymptomatic) to 60 (severe) to allow comparison with previous scores[9-11]. The EuroQol EQ-5D scores were derived from the questionnaire validated for the United Kingdom (UK TTO value set)[14].

Patients were asked to classify their running, sporting activity and heavy manual work within the last 4 weeks into the following categories: no trouble at all, very little trouble, moderate trouble, extreme trouble, tried but impossible and not attempted. They were asked to record their satisfaction with the surgery as delighted, pleased, satisfied, a little disappointed and very disappointed. These measures of activity and satisfaction are not validated.

The medical notes were checked to ensure that no complications or re-operations had been missed. The early complications have been reported previously[9-11].

Anteroposterior (AP) and lateral radiographs of each hip were taken and compared with the previous ones. Changes around the femoral and acetabular components of the hybrid THRs were described on the AP radiographs using the zones of DeLee and Charnley[15] and Gruen, McNeice and Amstutz[16] and on the lateral radiographs using the additional zones of Johnston et al[17]. Linear polyethylene wear was measured by the method of Dorr and Wan[18]. Radiological changes around the femoral component of the BHRs were recorded according to the pedestal sign classification (Table 1)[9-11]. Changes around the acetabular component in the BHRs were recorded as for the hybrid THRs.

Statistical analysis

The distribution of the data was assessed using the Kolmogorov-Smirnov test. The period of follow up was normally distributed and is therefore described with the mean and standard deviation. The rest of the data was not normally distributed and therefore non-parametric tests were used. The Mann-Whitney U test was used to compare postoperative UCLA activity score, OHS, EQ-VAS, and EQ-5D. The Chi squared test was used to assess categorical data; responses to the questionnaire on participation in running, sport, heavy manual labour and overall satisfaction with the surgery. OHS was the primary outcome measure using a minimum clinically important difference of 5 points[19]. The Wilcoxon ranked-pairs test was used for paired comparisons of OHS and UCLA activity scores with the previous studies[9-11] within each group. As the data was non-parametric it was described with the median and inter-quartile ranges. Survival analysis for revision and mortality outcomes was performed using Kaplan-Meier estimates and rates were compared between groups with a log-rank (Mantel-Cox) test. Hazard ratios and 95% confidence intervals (CI) were calculated. OA p-value of <0.05 was considered significant.

Results

Mean follow-up was 17.6 years (Standard Deviation (SD)=0.53) and 19.9 years (SD=) for BHRs and THRs respectively. Of the BHRs, 5 patients had died, 6 had been revised, 4 refused follow up but remained unrevised and 3 were lost to follow-up, leaving 35/54 non-revised BHRs available for review. Of the hybrid THRs, 14 had been revised, 13 patients had died and 1 was lost to follow-up, leaving 26/54 non-revised THRs available for review. (Figure 1). The medical records of the patients who had died or were lost to follow-up indicated satisfactory clinical performance at last review.

Functional Outcome Scores

The median OHS for BHRs was 13 (IQR 12-18) (p=0.03) and for hybrid THRs was 21 (IQR 13-27) at latest follow up. Superior OHS has been maintained at all time points that these cohorts have been compared (Figure 2)[9-11]. The median UCLA activity score was 8 (IQR 6-10) and 6 (5-7) (p=0.01) for BHRs and THAs respectively. There was no significant change in either since last follow up[11]. During the 4 weeks before review, more patients with a BHR ran (p=0.007), participated in sport (p=0.01) and carried out heavy manual work (p=0.002) than patients with a THA (Table 3). Satisfaction was higher in the BHR group with 91% (32/35) being either delighted or pleased compared with 56% (15/26) of the hybrid THR group (p=0.002) (Table 4).

Revisions

14/54 (28%) hybrid THRs have been revised, 13 for osteolysis and 1 for recurrent dislocation. The osteolysis involved the femur only in zone 7 in 1 case, the acetabulum only in 7 cases (zone 2 only (4), zone 2 and zone 1 (1), zone 2 and zone 3 (2)). Both the femur and acetabulum were involved in 6 cases, all in zone 7 on the femur and zone 2 in the acetabulum. An identical revision procedure was performed in these patients. To avoid further polyethelene wear, the bearing surfaces were changed to ceramic-on-ceramic. As ceramic liners were not available for the original acetabular shells, the shell was exchanged for a Trident component (Stryker Orthopaedics). Similarly, as neither a ceramic head nor appropriate trunnion adapter was available for the CPT stem, this was revised to an Exeter (Stryker Orthopaedics) cement-in-cement revision component, as the cement mantle was uniformly good in all cases. Areas of osteolysis in the proximal femur at zones 1 and 7 and in the acetabulum were bone-grafted.

The previous study[11] identified 8 THRs with pain, wear and osteolysis at 10 years with the intention of revision. All cases had acetabular osteolysis. Since then, 5 of these have undergone revision surgery. The final 3 remain under observation and have not progressed in terms of wear.

At 18 years of follow up, there were 13 subjects remaining at risk in the BHR group and 19 in the THR group. Kaplan-Meier estimates revealed survivorship for the outcome of revision to be 88% (95% CI 75.9,94.6) in the BHR cohort and 74% (95% CI 59.4,84.0) in the THR cohort (Figure 4). Log-rank test revealed that these differences approached but were not significant (p=0.067). The hazard ratio of revision in the BHR cohort was 0.43 (95% CI 0.18,1.06) when compared to the THR cohort.

Table 2 records hybrid THR revisions according to the acetabular component and type of head. The Harris-Galante components account for the highest failure rate when compared to previous follow up[11].

Potential Revisions

Of 35 remaining BHRs, 4 reported pain with activity. Their OHSs were 6, 35, 40 and 48. Their pedestal signs at 10-years were 2, 3, 2 and 2, which have not progressed. There was no evidence of infection in any case and all have been investigated with either ultrasound scan or MRI with no evidence of pseudo-tumour. 11/35 in total of the BHRs have been investigated with MRI with no evidence of pseudo-tumour.

Mortality

At 18 years of follow up, Kaplan-Meier estimates revealed survivorship for the outcome of mortality to be 90% (95% CI 77.8,95.8) in the BHR cohort and 71% (95% CI 54.8,82.9) in the THR cohort (Figure 5). Log-rank test revealed that these differences were significant (p=0.039). The hazard ratio of mortality in the BHR cohort was 0.37 (95% CI 0.15,0.95) when compared to the THR cohort.

Radiological Outcomes

7 BHRs were unable to attend for radiographs but completed a postal questionnaire. Their current OHSs were 12, 12, 12, 13, 16, 17 and 18. Of these patients, all had undergone radiological examination at 7,7, 8, 8, 11, 12

and 35 months before completing the questionnaires, which were used for comparison, these were at a mean of 14.5 years since implantation. Mean time to radiographic evaluation of the complete cohort was 15.3 years (Table 5).

The pedestal sign which had previously been assessed at last follow up[11] had not progressed in 33/35 cases (Figure 3).

7 hybrid THAs were unable to attend for radiographs assessment but completed a postal questionnaire. Their OHSs were 21, 21, 22, 25, 26, 32 and 42. All had radiographs at 20, 23, 26, 31, 54, 60 and 69 months before completing the questionnaires respectively (mean 15.1 years). Mean radiological follow up for the entire cohort was 16.2 years (range 12-20).

24/26 of the remaining hybrid THAs demonstrated progressive linear wear (mean 1.7mm, 0-2.6). There was evidence of periarticular osteolysis in 15 in association with polyethylene wear, 13 had lysis in Gruen zones 1 or 7. Lucent lines around the femoral component were noted in these cases but all corresponded with the areas of lysis in zones 1 or 7. There were no cases with lucent lines distal to these proximal zones. In 4 there was also periacetabular osteolysis with 2 further having isolated acetabular osteolysis. Lucent lines were seen around the acetabular component in 16 of the remaining hybrid hips. No component had migrated. Stem subsidence remained stable since last review[11].

Discussion

Our study demonstrates superior patient reported outcomes and activity levels in those patients who underwent BHR rather than THA. At mean clinical follow up of 18 years in both groups median OHS and UCLA activity score were significantly higher. Significantly more of those with a BHR ran, played sport and undertook heavy manual work in the month preceding their latest follow up. Despite a trend toward better survival in the BHR group, this did not reach statistical significance. Radiological changes remained static in both groups.

Registries report revision rates of BHRs at 6.9%[8] and 9%[20] at 10-years, 9.9% at 12-years[2] and 9.6% at 15-years[8]. Designing centres report revision rates of 5.9% at 14-years[5] and 4.2% at fifteen-years[4]. 10-year independent centre revision ranges from 5-13%[21-23]. Our results display a similar rate of revision of 11% at 16-years.

Metal-on-polyethylene hybrid THAs have a 13-year registry revision rate of 11.05% in males less than 55 years[2]. We report a higher revision rate of 27% in our cohort at 16 years. This may be explained by several factors; recruitment was performed before highly-cross-linked polyethylene which may improve survival[24], air irradiation of polyethylene liners used, young age at implantation and low revision threshold by the senior author due to the general progression of osteolysis experienced with these components[25]. Our cohort included older generation uncemented acetabular components, which have reported high revision rates at 15 years[25]. The majority of patients, although demonstrating a degree of progressive radiological change, remain symptom free and remain under observation.

Comparative studies of BHR and THA are report largely short and medium time periods only. Several report quality of life or improved functional outcomes associated with resurfacings[1,11,26-32], others however report no difference in scores but did not assess activity levels[33-35]. Costa et al[35] report no difference in either Oxford or Harris Hip scores at 12 months in their prospective randomised study of 126 patients. Our study reports outcomes at 16 years that is longer than these studies and includes data on activity specific functions. Superior function in this cohort has been maintained at 5[10], 10[11] and 16 years.

Haddad et al[36] report their series of young patients at 12 years who had either undergone BHR or cementless THA with a metal-on-highly cross-linked polyethylene bearing surface using a 32mm head. They report similar results of higher functional outcomes in patients who received a BHR despite similar patient aspirations and consider they have experienced a ceiling effect. Their wear and osteolysis rates are significantly lower but this may well be related to the better polyethylene and acetabular components used in their series. In our series, the introduction of ceramic head in 9 of the hybrid THAs in our series did not seem protective of cup failure, however numbers were too low to provide statistical significance. There are contemporary hybrid THRs that have shown improved survivorship in the early to medium term in comparison to the implants used in this study[37,38].

In this series, BHR revisions were due to femoral component failure and THA by acetabular component failure. There were no CPT stem failures and this proves to be a reliable implant in younger patients[39]. Despite early failures suggesting the BHRs would show progressive radiographic changes with the risk of subsequent failure, this has not occurred. Since last review[11] only 1 further BHR failure has occurred and the remainder are functioning well without significant radiographic progression. No pseudo-tumours have been identified which is an identified risk in this implant group[3].

Strengths of this study are that although recruitment was retrospective, the data analysed have been collected prospectively. The groups are well matched and this has not been distorted by loss to follow up. Follow up is longer than any currently published series of this type. The limitations of this study are that it is not randomised and subject to selection bias. Patients with a BHR had no activity restrictions, whereas those with a THA did, although 37%, disregarded the restrictions suggested[9]. In the young, active population hip scoring systems may have a ceiling effect[40]. Many of our patients achieved the maximum possible score. The use of other qualitative questions in our study has concurred with the significant difference in OHS.

MoM bearings pose concerns with potential for deleterious effects in relation to the bearing couple and increased revision rates[3,20,41] but we have shown that this is not reflected in a significant difference in mortality or revision rates in this cohort. Improved functional outcomes in the BHR group suggest this is an option still worth considering in appropriately selected patients and the lack of a significant difference in revision and mortality is reassuring but this must be considered in the context of the selection bias that is likely to have occurred in this and other studies.

THA survival in the under 50s has been reported as low as 60% in registry data[42]. At 15 years we have demonstrated that BHRs remain more active and superior in function to the hybrid THRs with no increase in revision or mortality rates. Hip resurfacing remains a valid option for younger male, active patients with end stage osteoarthritis.

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Tables

Table 1. Classification of radiological appearance of femoral component after resurfacing

Classification type	Radiological Appearance
0	No change
1	Pedestal sign but no migration
a	Sclerotic line confined to curved tip of stem
b	Sclerotic line confined to distal 1cm of shaft of stem
c	Sclerotic line +/- symmetrical lucent lines, extending proximally beyond distal 1 cm of shaft
2	Migration, usually into varus with asymmetrical lucent lines
3	Displaced fracture

Table 2. Distribution of components and revision rates at a mean follow-up of 19.9 years in the hybrid total hip replacement group

Acetabular component	Head type	Number	Deceased	Revised
Harris-Galante	Metal	26	5	9
Harris-Galante	Ceramic	3	0	2
Zweymuller	Metal	7	3	1
ABG	Metal	10	3	1
ABG	Ceramic	6	0	1
PFC	Metal	1	1	1
Hydrocel	Metal	1	0	0

Table 3. Participation in activities in the previous four weeks (number of hips)

Activity	Group	Trouble					
		None	Very Little	Moderate	Extreme	Impossible	Not attempted
Running	Hybrid	1	1	0	0	5	20
	BHR	8	4	0	1	4	18
Sports	Hybrid	5	2	1	0	4	15
	BHR	14	7	2	0	2	10
Heavy manual labour	Hybrid	1	3	1	0	6	16
	BHR	13	3	5	0	1	13

Table 4. Patient satisfaction with the prostheses (number of hips, %)

Group	Delighted	Pleased	Satisfied	Disappointed	
				A Little	A Lot
Hybrid	14(52)	1(4)	5(18)	6(22)	1(4)
BHR	26(74)	6(17)	0 (0)	2(6)	1(3)

Table 5. Radiological appearances and revisions for patients with Birmingham hip resurfacing.

Status	Five years (%)	Nine years (%)	Fifteen years (%)
Loss to follow up or death	1	6	9
Declined radiographs	1	3	4
Radiological appearance			
Type 0	16 (30.8)	4 (8.9)	8 (19.5)
Type 1a	6 (11.5)	4 (8.9)	6 (14.6)
Type 1b	16 (30.8)	8 (17.8)	5 (12.2)
Type 1c	9 (17.3)	19 (42.2)	11 (26.8)
Type 2	5 (9.6)	5 (11.1)	4 (9.8)
Type 3/Revised	0	5 (11.1)	7 (17.1)

Figure Legends

Figure 1. Oxford Hip Scores of both cohorts at different time points of review.

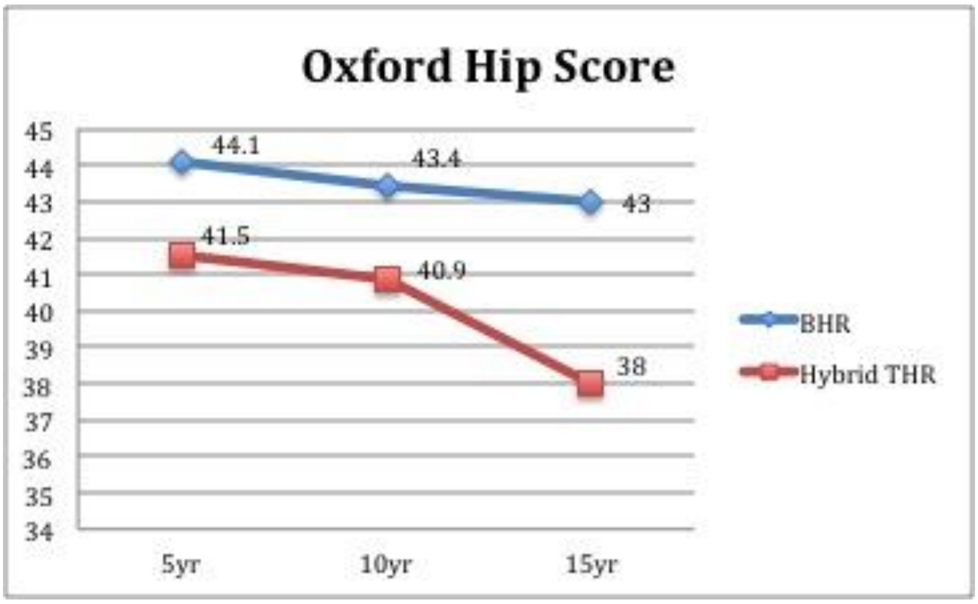

Figure 2. Kaplan-Meier estimate for revision of the construct (95% Confidence intervals)

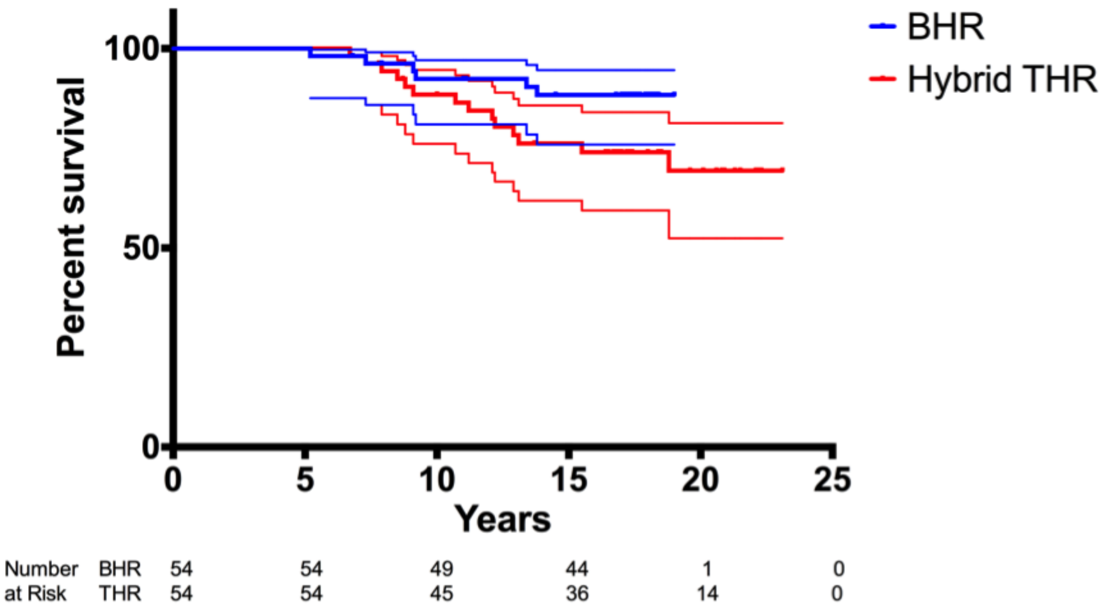

Figure 3. Kaplan-Meier curve for patient survival (95% Confidence intervals)

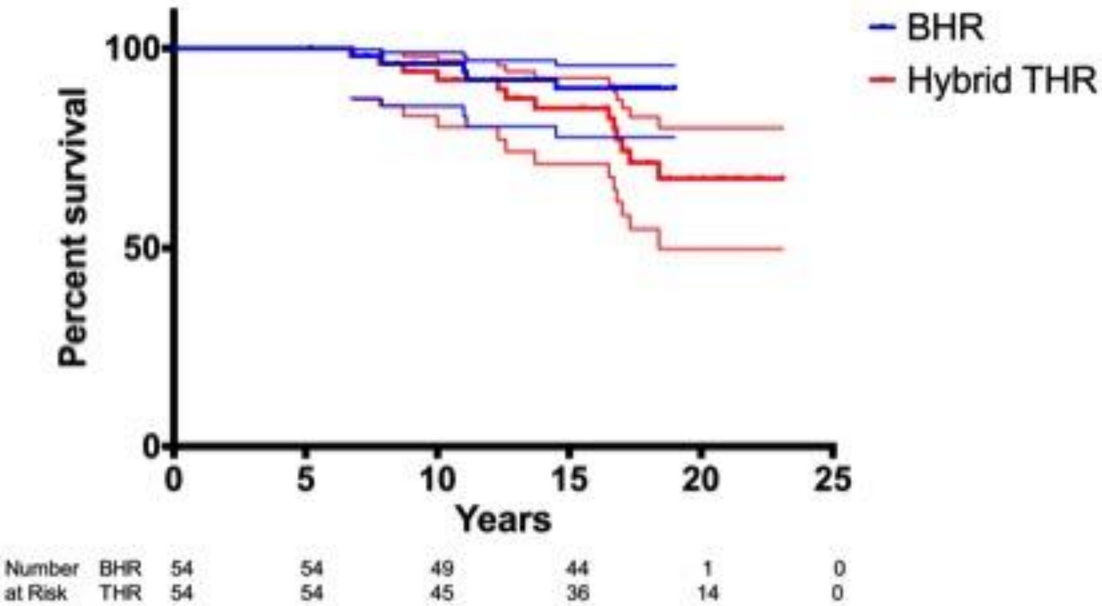

Figure 4. Typical changes around BHR femoral component that have remained stable since last review.