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ORIGINAL STUDY

Birmingham hip resurfacing and the ASR at a minimum of 10 years : a prospective cohort study

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We performed a prospective cohort study to assess whether the Birmingham Hip Resurfacing (BHR) and ASR are compliant with NICE guideline recommendations at 10 years. This is the first study in the literature to directly compare these two implants with respect to their NICE-compliance rates.

Only ASR and BHR implants were included in the analysis. Patients were prospectively reviewed at 6 months, 2 years, 5 years and 10 years. Outcome measures included the following : revision, re-revision, cause for revision, time to revision, length of stay (LOS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores at each review.

Three hundred and ninety-two hip resurfacings were performed on 364 patients. For the ASR, 26/119 implants were revised giving a 78.2% 10-year survival rate. The BHR had a 95.7% 10-year survival rate, in keeping with NICE recommendations. The ASR had a significantly higher all-cause revision rate when compared to the BHR at 10 years ($p<0.05$).

BHR is a NICE-compliant implant at 10 years . The ASR fell short of NICE 10-year recommended revision rates in just under 2 years. We suggest that the BHR still has a role in hip osteoarthritis hip in high-demand males.

Keywords : Hip ; resurfacing ; metal-on-metal ; revision arthroplasty.

The Authors declare that there is no conflict of interest.

INTRODUCTION

Metal on metal hip resurfacing (MoMHR) has instigated many controversies over the past decade in relation to high rates of early failure. Recent evidence in the literature has since shown that specific implant types are highly predictive of functional and radiographic outcomes. Certain implant types such as the Birmingham Hip Resurfacing (BHR) (Smith & Nephew, Birmingham, UK) have been shown to be a very reliable and successful implant at long-term follow-up. NICE (‚National Institute for Healthcare and Excellence') guidance is very clear regarding the usage of implants for the treatment of hip osteoarthritis. All implants must have a 10-year survivorship of at least 95% *(8)*. We performed a prospective cohort study to assess whether the BHR is NICE-compliant for patients of all ages at 10 years. We compared the performance of this implant

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insertion, the Articular Surface Replacement (ASR) (DePuy Orthopaedics Inc, Warsaw, Indiana). This is the first study in the literature to directly compare these two implants with respect to their NICE-compliance rates.

PATIENTS AND METHODS

We performed a prospective cohort study to assess the outcomes of the two commonest total hip resurfacing implants in our institution : the Articular Surface Replacement (ASR) and Birmingham Hip Resurfacing (BHR). Patients who underwent total hip resurfacing between the dates of February 1st 2005 and October 31st 2007 were included. Only ASR and BHR were included in the analysis. Implant choice was dictated by the operating surgeons preference. A minimum of 10-year follow-up was required for inclusion in this study on review. All other hip resurfacing systems were excluded.

A dedicated arthroplasty clinical nurse specialist (CNS) collected clinical, functional, biochemical and radiographic data for the two patient cohorts and prospectively recorded this in our institutions arthroplasty database. Patients were prospectively reviewed in the dedicated arthroplasty clinic at intervals of 6 months, 2 years, 5 years and 10 years. Dependent variables recorded for each cohort were as follows : patient age, BMI, gender, ASA grade, operative time, approach used, surgeon, implant used, head size, blood loss and operative time (mins). Outcome measures recorded for each cohort included the following : revision, re-revision, cause for revision, time to revision, length of stay (LOS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores at each review.

Statistical analysis was performed initially with univariate analysis. The relationship between the independent predictors described above and all dependent variables was assessed. Significant predictors of revision were identified. These variables were then controlled for by using multivariate analysis to eliminate confounding factors in our initial univariate analysis. Kaplan-Meier survival graphs were used to compare the two implants as per current NICE guidelines using all-cause revision as the failure event. The software used to complete the analysis was STATAã(Stata/IC 13.1 for Mac (64-bit Intel)). The specific tests used included the following : Chi-square test and Fisher's Exact test for categorical dependent and independent variables. Simple logistic regression was used for interval independent variables with a categorical dependent variable. The Kruskal-Wallis rank test was used to assess the categorical independent variables effect on interval dependent variables. Multivariate analyses using factorial logistic regression were performed to control for confounding variables when numerous predictors of outcome were identified. The nature of the variables in question determined the appropriate statistical analytical test to be used as described. A p-value of less than 0.05 was taken to be statistically significant.

RESULTS

Three hundred and ninety-two hip resurfacings were performed on 364 patients. Overall, there were 119 ASR and 273 BHR implants inserted between February 2005 and October 2007. Twelve surgeons performed all procedures varying in experience from 1 procedure performed by the least experienced surgeon to 155 procedures performed by the most experienced surgeon. There were 4 "high-volume" surgeons, (defined as performing greater than 40 resurfacings within the 2 year period). In total, 72% of the patients were male. The ASR group had a male preponderance of 81% while the BHR group had a male preponderance of 68%. Mean age of the entire group was 55 years. The BHR cohort had a higher mean age when compared to the ASR (57.6 years vs 52 years respectively).

Revision

Thirty-eight implants were revised in total at 10 years resulting in a 90.4% overall survivorship at 10 years for all hip resurfacings. For the ASR, 26/119 implants were revised giving a 78.2% 10-year survival rate for the ASR cohort. The BHR in contrast had a 95.7% 10-year survival rate as only 12/261 implants were revised. The mean time to revision overall was 46 months (1-120). For the

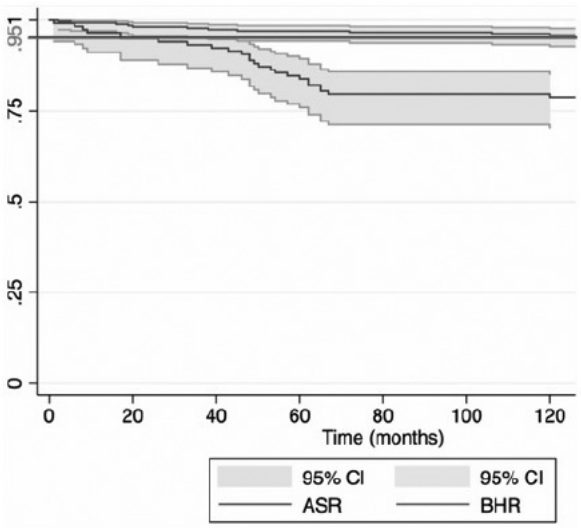

Figure 1. — Kaplan-Meier Survival Curves.

ASR, mean time to revision was 43 months (1-120). For the BHR, the mean time to revision was longer at 51 months (2-120). Kaplan-Meier survival curves were generated to compare the failure patterns over time of these two implants using all-cause revision as the failure event (Figure 1). As demonstrated by the 0.95 reference line on the Y-axis, the BHR revision rate at 10 years is in accordance with acceptable rates as dictated by the NICE guidelines published in 2014 [1]. The ASR however, falls short of this recommendation in under 2 years.

In order of decreasing frequency, the commonest cause for revision in the BHR cohort was periprosthetic fracture (n=4), periprosthetic infection (n=3) and aseptic loosening (n=2). There was one revision for 'adverse reaction to metal debris' (ARMD), dislocation and pain due to unknown cause respectively. In the ASR cohort, The commonest reason for revision was ARMD (n=6) followed by aseptic loosening (n=5), periprosthetic fracture (n=3), infection (n=2) and dislocation (n=2). Notably in the ASR cohort, 8 patients were revised for 'pain' without an obviously attributable cause. Painful micromotion was the suspected cause in these cases. There were 2 re-revisions in the ASR group and 3 re-revisions in the BHR group. Two were re-revised for infection, 2 for pain and 1 for instability.

Univariate analysis confirmed that three variables were associated with significantly higher revision rates. Implant-specific analysis confirmed that the ASR had a significantly higher all-cause revision rate when compared to the BHR at 10 years ($p<0.001$). We also confirmed that hip resurfacings performed through the posterior approach had a significantly higher all-cause 10 -year revision rate when compared to those performed through the anterolateral or the direct anterior approach ($p<0.001$). The third variable predictive of outcome was the performing surgeon ($p<0.01$).

In order to account for any confounding in our statistical analysis, we performed a multivariate analysis assessing the effect of surgical approach and surgeon on revision rates. We found that when the operating surgeon was controlled for, the surgical approach had no impact on revision rates in this cohort ($p=0.8$). However, when the surgical approach was controlled for, the operating surgeon still had a significant predictive effect on revision rates ($p<0.01$). Even after multivariate analysis, both the implant type ($p<0.01$) and surgeon performing ($p=0.011$) were predictive of outcomes.

Assessing surgeon experience, we identified 4 "high-volume" surgeons performing over 40 resurfacings in the 2 years period. The highest volume was 149 BHRs and 6 ASRs performed by a single surgeon, all through the anterolateral approach with a 1.9% revision rate. The next highest performed 49 BHRs through the posterior approach with a 6.1% revision rate. The next surgeon performed 18 BHRs and 23 ASRs through the posterior approach with a 26.8% revision rate. The final "high-volume" surgeon performed 38 BHRs and 2 ASRs through the anterolateral approach with a 0% revision rate. The highest volume surgeon had one of the lowest revision rates in this cohort. We also noted a trend of increasing revision rates with reducing levels of experience (Figure 2).

Of note, age, gender, BMI and femoral head size had no predictive effect on the revision rates for both cohorts. Overall, women had a 12.8% revision rate compared to an 8.4% revision rate in men. This finding was not statistically significant. For femoral heads less than 46mm in size, the revision rate was 25% for both implants. The revision rate for head

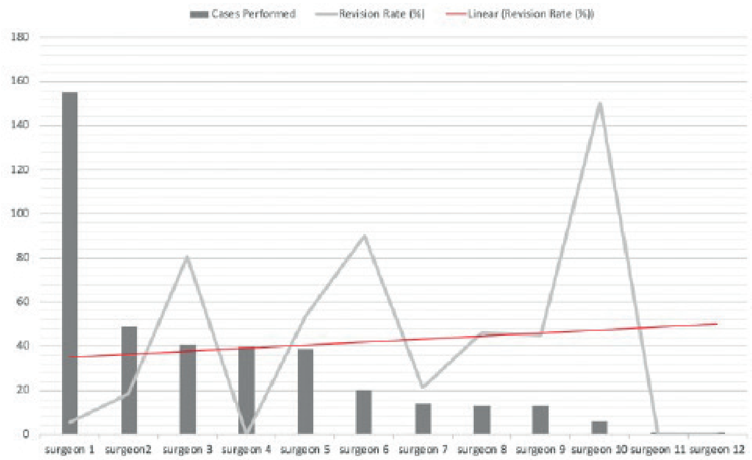

Figure 2. — Surgeon-specific Workload and Revision Rate.

sizes 46mm and above was 22.3%. This was not a significant finding. For all patients less than 50 years of age, the revision rate was 16.3% for all-causes at 10 years. For patients aged 50 and above, the revision rate was 7.3% at 10 years. Again, this was not statistically significant.

12-year revision rates

Subgroup analysis of our 2 cohorts revealed that there were 69 BHRs that had 12-year follow-up results at the time of review. We noted a very low revision rate in this cohort also. Only 1 BHR in this group was revised at 12 years giving a 1.4% all-cause revision rate for these implants. The indication was periprosthetic fracture in this instance. Only 2 ASR implants had follow-up of 12 years, neither of these 2 were revised.

Secondary outcomes

Functional outcomes assessed by the WOMAC scoring system confirmed the predictors of poor functional outcome. At 2 years postop, the ASR was associated with significantly poorer WOMAC scores (p=0.041). By 5 and 10 years however, this observation was no longer evident and there was no difference in the WOMAC scores between the 2 implants. BMI had a significant effect on the WOMAC scores at 5 years with obese patients performing worse (p=0.034). This effect was insignificant at 10 years.

Blood loss was measured for each case in millilitres. It was found that the only significant predictor of an increased blood loss was high BMI (p=0.001). Of all the patients with a BMI of 30 or above, 15% lost at least 500ml of blood or more.

Length of stay was significantly higher in female patients, patients who underwent a BHR, and patients who underwent the anterolateral approach (p<0.001). No other significant findings were recorded in our cohort study.

DISCUSSION

Early outcomes for MoMHR's demonstrate the poor performance in the ASR when compared to the BHR *(11)*. Data from the UK NJR has confirmed that the ASR has a statistically higher revision rate when compared to the BHR *(3)*. It is widely accepted now that the ASR is an inferior implant, even when compared to other MoMHR's with similar design features. Part of the reason for the high global uptake and subsequent failure of this implant was due to the accelerated introduction of the ASR to market which did not follow the normal guidelines for introduction of new orthopaedic implants *(9)*. We confirm a 78.2% survivorship rate at 10 years for our ASR implants, in keeping with the poor results reported internationally.

Regarding the BHR, reports have been variable and much research is needed to define the outcomes of this implant. Implant-specific analysis reports that the all-cause revision rate for the BHR in the Finnish arthroplasty registry at 10 years was 91% *(11)*. Seppänen et al. published results in 2016 claiming that the 8-year all-cause revision rates for the BHR were 93% *(10)*. The most recent NICE guidelines have recommended that an implants all-cause revision rate at 10 years should be at least 95% *(8)*. We see here that the BHR has numerous reports of suboptimal survivorship in the literature. There is also some controversy in the literature regarding this BHR survivorship as per NICE guidance. Our findings seem to strengthen the evidence base around this implant.

Despite the negative results surrounding many of the MoMHR's in the literature, there are still many documented benefits associated with hip resurfacing. Kendal et al. assessed all-cause mortality rates in the UK NJR at 10 years and found that the MoMHR's had a significantly reduced mortality at 10 years when compared to cemented or uncemented THR *(4)*. This study controlled for confounding variables and concluded that a significantly lower mortality rate is associated with MoMHR's. The BHR is noted to be particularly useful in the young, high-demand male population in whom conventional THA can often have inferior outcomes. Matharu et al. reported a 100% 14-year survival rate for the BHR in male patients under the age of 55 when aseptic revision was the endpoint *(6)*. These results are impressive and imply that the BHR may still have a role in future hip osteoarthritis management for the young active male.

We present a prospective cohort study of the 2 most popular MoMHR implants with a minimum follow-up of 10 years. As discussed, our survivorship rates at 10 years were 95.7% for the BHR and 78.2% for the ASR. Our BHR results fulfil the recommended criteria as dictated by NICE. Data from other registries, for young patients undergoing MoMHR, has confirmed NICE-compliant survivorship at 10 and 12 years in patients under 50 years of age *(2)*. Other studies show good results in cohorts of patients less than 45 years of age *(12)*. Limiting observations to a specific age runs the risk of compromising the generalisability of results. Our study does not limit analysis to a specific age group and still it shows a NICE-compliant survivorship across all ages in the BHR cohort.

Moroni et al. performed an observational study assessing the BHR survivorship at 10 years and found very good rates of survivorship at 96%. These results were observed in an independent centre affirming that non-designer surgeons can achieve the same long term results as designer surgeons *(7,1)*. In contrast to Moroni's observational study, we performed a comparative prospective cohort study to compare our BHR results to the other most frequently used implant in the MoMHR range. Similar to Moroni's observations we confirm that it is possible for non-designer surgeons using a multitude of approaches and techniques to attain very high survivorship rates with the BHR implant. Our study therefore contributes to the current controversy in the literature around NICE-compliance with the BHR. We find that the BHR is a NICE-compliant implant and there is still a role for its usage in a highly selected patient cohort.

We had very few revisions for dislocation in both cohorts. The commonest reason for revision in the ASR cohort was ARMD (n=6), whereas in the BHR it was periprosthetic fracture (n=4). It is known that adverse local tissue reactions (ALTRs) develop at different locations depending on the approach used. Madanat et al. described how ALTRs develop more posteriorly when the posterior approach is utilised for inserting the MoMHR *(5)*. If the anterolateral approach is used, ALTRs develop more anteriorly. We found also, that the surgeon performing the procedure was more predictive of outcomes than the approach used. The highest volume surgeon had among the lowest revision rate (1.9%), performing almost half of all resurfacings.

The limitations of our study include a 5.2% loss to follow-up rate. Twenty patients were lost to follow-up at the time of review. Eighteen patients opted to be managed in other institutions and 2 patients were deceased at the time of review. Specific parameters that were not included in our analysis were metal ion levels and acetabular cup abduction angles. These may have proven to be factors predictive of revision but would not have altered the 10-year all-cause revision rates described in the results above.

CONCLUSION

We demonstrate in our prospective cohort study that the BHR is a NICE-compliant implant at 10 years for all ages regarding all-cause revision rates. The ASR performed predictably poorly, falling short of NICE 10-year recommended revision rates in just under 2 years. We propose that the BHR still has a role in the management of hip osteoarthritis for high-demand males. We also report superior outcomes with high-volume surgeons who are more experienced with this procedure.

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