Title:
Ceramic bearings are associated with a significantly reduced revision rate in Primary Hip Arthroplasty: a study using the NJR dataset

Keywords:

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ABSTRACT

Background

Prosthetic joint infections (PJI) is a devastating complication after total hip arthroplasties (THA) with both significant morbidity and sometimes mortality, posing a significant health economic burden. Studies, both clinical and in-vitro have suggested possible reduction in PJI with the use of ceramic bearing in THA. We investigated the role of ceramic-on-ceramic (CoC), ceramic-on-polyethylene (CoP) or metal-on-polyethylene (MoP) bearing surface in reducing the risk of revision surgery after primary THA.

Methodology

We conducted a retrospective study of data collected from National Joint Registry (NJR) for England, Wales, Northern Ireland and the Isle of Man between 2002 and 2016. All adult patients who underwent THA using an uncemented acetabular component with CoC, CoP or MoP bearing surfaces were included (ie fully cementless and hybrid THA). A competing risk regression model to investigate predictors of each revision outcome, such as infection, dislocation, aseptic revision and all cause revision was used. Time-to-event was determined by the duration of implantation since primary surgery with competing risks being death or revision for another indication. The results were adjusted for age, gender, ASA grade, BMI, indication for surgery, intraoperative complications and implant data.

Results

456,457 THA (228,786 MoP, 128,403 CoC and 99,268 CoP) were identified. In a multivariable model, the adjusted risk of revision for PJI was lower with CoC (Risk Ratio (RR) 0.748, $p<0.001$) and CoP (RR 0.775, $p<0.001$) in comparison to MoP joint replacement. Additionally there was also a significant reduction in the risk of all cause revision for CoC (RR 0.918, $p=0.002$) and CoP (RR 0.806, $p<0.001$), bearings as compared with MoP. The protective effect of ceramic bearing was predominantly seen after two years of implantation with a significant ($p<0.0001$) reduction of revision because of infection in both CoC (by 42.8%) and CoP (by 41.3%) group. This effect was also seen for late dislocations (>2 years) with a significant ($p<0.001$) reduction in revision for dislocation by 40.9% for CoC. In addition aseptic revision beyond two years reduced by 18.1% and 24.8% for CoC and CoP ($p<0.001$), respectively. Overall all cause revision rate beyond two years reduced by 21.6% for CoC and 27.1% for CoP ($p<0.001$).

Conclusion

Within the limits of registry analysis, this study has demonstrated an association between the use of ceramic as part of the bearing, with lower rates of revision for all causes, and revision for infection and aseptic loosening. This finding supports the use of ceramic bearings in THA.

INTRODUCTION

Ceramic bearings have been in use for over forty years[1 2] with proven lower wear rates when compared with cobalt-chrome (CoCr) metal and polyethylene (PE)[3 4 5 6]. Potential reasons for this include their excellent tribological properties and good biomechanics. [18,23] Additionally less osteolysis with decreased wear has been observed in a number of clinical studies[3-10] and taper corrosion is seen less in ceramic femoral head-neck junctions compared to metal heads[7 10]. Based on this evidence, it would be expected that joint replacements with ceramic bearings would have lower long-term revision rates. However, cost still remains a barrier to their widespread use[7] . There are also residual concerns regarding head fractures, despite a revision risk of only 0.01% due to this complication, [3,19,23] and squeaking which can be a frustrating complaint in CoC THA[11 12]. Less understood is the role of ceramic bearings in preventing infection after joint replacement.

Evidence from registry data suggests that using a replacement joint with a CoC bearing surface may help reduce infection when compared to MoP bearing surfaces[13-15]. Lenguerrand et al[13] looked at the risk factors associated with revision for prosthetic joint infection after hip replacement in the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man (NJR) and found that use of a ceramic on ceramic rather than metal on polyethylene bearing was associated with a decreased risk of revision for prosthetic joint infection.

In-vitro studies seem to corroborate the results of the clinical studies and have looked at the potential mechanism of this effect. Bacterial adherence and subsequent biofilm formation on implant surfaces are involved in the origin and maintenance of implant-related infections[16], because the presence of biofilm hinders the microbiological diagnosis and eradication of the detached micro-organism. This is considered the key phenomenon in the pathogenesis of these infections[17]. Reduced bacterial adhesion has been noted in ceramics used for arthroplasties[18 19]. This would lead to lower bacterial biofilm formation on ceramic bearing surfaces when compared to metal and polyethylene[20-23].

However, two meta-analyses looking at the effect of bearing surface on risk of periprosthetic joint infection in total hip arthroplasty concluded that there was no evidence that bearing choice influences the risk of PJI[24 25]. The more recent of these studies also looked at recently published registry data and recommended that future research, including basic science studies and large, adequately controlled registry studies, may be helpful in determining whether implant materials play a role in determining the risk of PJI following arthroplasty surgery[24].

The aim of this study was to explore the NJR data to estimate differences in revision rates for infection and for all causes between different bearing surfaces, following primary THA. We also wanted to find out if the risk for revision was period specific (<3 mth, 3-6 month, 6-24 months and > 2 years) after surgery and whether there was an effect of surgeon preference. The null hypothesis was that use of a CoC or CoP bearing surface was not associated with a significant increase in the rate of revision when compared to a MoP bearing surface.

Patients and Methods

Approval for this observational study was granted by the NJR research committee (reference number). The focus of this study was on the impact of the bearing surface on revision rate, so we restricted our analysis to uncemented acetabular fixation only. From the NJR database, we identified all adult patients (>=18 years) who underwent primary total hip arthroplasty using an uncemented acetabular component and a bearing surface of either metal-on-polyethylene (MoP), ceramic-on-polyethylene (CoP) or ceramic-on-ceramic (CoC) implanted between 2002 and December 2016. We excluded resurfacing arthroplasty, all metal-on-metal (MoM) joint replacements and cemented acetabular components.

The NJR collect national data from England, Wales, Northern Ireland and the Isle of Man on all primary and revision arthroplasty procedures. Data are derived from proformas completed by the responsible surgeon or their deputy at the time of primary and revision arthroplasty. Available variables include patient demographics (age, gender, American Association of Anaesthesiologists grade (ASA) and Body Mass Index (BMI)), indication for primary surgery, surgical factors including intraoperative complications and implant data pertaining to the primary procedure. Indication for revision is recorded by the revising surgeon. We studied four revision end points: revision for periprosthetic infection, dislocation, aseptic revision (revision for any cause other than infection) and revision for all causes. Date of death is established by the NJR through linkage to the Office of National Statistics as part of the national audit program. Each primary procedure was followed up for a minimum of 12 months to determine revision and survival status.

Statistical Methods

Between group demographic characteristics were compared using Chi-square (categorical data) and one-way ANOVA (continuous data). Unless otherwise stated, numbers in parentheses represent 95% confidence intervals. The entire cohort was classified into 4 equal groups based upon the date of implantation. This corresponded to "early" (February 2002 to January 2010), "mid – early" (January 2010 to October 2012), "mid – recent" (October 2012 to January 2015) and "recent" (January 2015 to December 2016) follow-up time periods from implantation.

We determined the crude incidence rate for revision for infection, dislocation, aseptic revision, and all cause revision for the overall cohort and broken down by bearing group and for each exposure. We used a competing risks regression model to investigate predictors of each revision outcome using available covariates for the entire time-period of observations. Both death and revision for another cause were considered competing risks for the revision outcome being studied (e.g. in the case of revision for dislocation, both death and revision due to infection represent competing risks). Accordingly, for each revision outcome, every case was assigned to one of three survival statuses – 1) revised, 2) alive with primary arthroplasty in vivo, 3) either (i) dead or (ii) alive but having been revised for another revision outcome (competing risk).

To examine period-specific differences in revision rates at several post-operative time periods, we repeated the regression analyses after splitting each observation into at-risk time periods according to the duration spent within each time-period of observation and re-assigned the patient's survival status according to the outcome for the case in the given time period. Follow-up time periods examined were <3 months, 3 to 6 months, 6 months to 2 years and >2 years for revision for infection and <6 months, 6 months to 2 years and >2 years for the remaining revision outcomes.

Statistical analysis was performed using the time-series and survival analysis features available in STATA version 15 (StataCorp. 2017. *Stata Statistical Software: Release 15*. TX). The statistical approach was hypothesis generating rather than formal hypothesis testing, therefore a p value of <0.05 was deemed significant for findings warranting further investigation, without adjustment for multiple comparisons.

Sample Size

Taking CoC as the reference category and CoP as the category with the lowest hazard ratio, assuming an infection rate of around 0.9% in the CoP group and 0.7% in the CoC group and setting α = 5% and power at 90% suggests a minimal sample size of 41,701 for the smallest surface bearing category.

Sensitivity Analyses

In order to further investigate and corroborate the findings of the above model, we performed several sensitivity analyses.

Firstly, we examined the effect of stepwise elimination of non-significant variables on the predictor of interest (bearing surface) in our primary competing risks analysis for revision for infection.

Secondly, in order reduce the effect of bias towards the preferential use of ceramic bearings in younger, fitter patients, we attempted to examine outcomes of high-volume consultants who routinely demonstrated a preference for using a ceramic femoral head vs. those who routinely used a metal femoral head prosthesis. Consultant practice may change over time and so for every year, we looked at each consultant's practice and categorised consultants into the following groups: "Ceramic head preference" (>=90% ceramic head use and >20 cases performed in the given year), "Metal head preference" (>=90% metal head use and >20 cases performed in the given year) and "Other" (all other). We excluded cases of metal head use for consultants with ceramic head preference and vice-versa (approximately 4,000 cases (<1% of entire cohort)) from this analysis. Thus, the entire cohort was classified into three groups – 1) Ceramic head used and performed by consultants with ceramic head preference, 2) Metal head used and performed by consultants with metal head preference and 3) Cases for all other consultants (including high and low volume) with no strong preference (<90%) towards either bearing surface. We then repeated the competing risks regression model using consultant head preference as the principal variable of interest for all time periods and by follow-up period.

Thirdly, to further attempt to mitigate residual confounding due to poor matching of age and fitness between the MoP, CoP and CoC groups, we performed an analysis limiting the cohort to patietns aged 60 to 69 years and ASA grade 2 examining the outcome of revision for infection across all time periods.

Finally, apparent effectiveness of ceramic bearings in reducing revision rate in early cohorts may have been biased, for example, by the use of non-UHMWPE acetabular liner use in MoP articulations thus we performed regressions for annual NJR cohorts between 2003 and 2016 to examine the effect of bearing surface each year.

RESULTS

456,457 primary arthroplasties were performed during the study period. Baseline demographics and frequency of revisions are presented in Table 1. There were significant differences in both patient and surgical characteristics when comparing the three bearing groups (all $p < 0.05$). In particular, patients receiving a ceramic bearing were significantly more likely to be younger, fitter (higher proportion of ASA grade 1), of male gender, to receive a larger head diameter and to receive a cementless femoral stem. Osteoarthritis was the most common indication for primary surgery across all bearing groups (90%). Dislocation was the most common cause for revision and was recorded in 0.5% of cases overall.

Overall incidence rate for all cause revision was 4.049 (3.970 to 4.129) per 1,000 person years meaning that for every 1,000 patients followed up for 12 months, approximately 4 patients would undergo revision during this period. Incidence rate for revision for infection, dislocation and all aseptic causes were 0.644 (0.613 to 0.676), 0.898 (0.861 to 0.937) and 3.405 (3.333 to 3.478) per 1,000 person-years respectively. The Incidence rate of revision for infection and dislocation were higher in the MoP group compared to CoP and CoC; revision for infection – MoP 0.675 (0.631 to 0.722), CoC 0.588 (0.536 to 0.645), CoP 0.655 (0.585 to 0.733), revision for dislocation – MoP 1.067 (1.011 to 1.126), CoC 0.602 (0.550 to 0.660), CoP 0.936 (0.852 to 1.029), revision for aseptic causes – MoP 3.454 (3.352 to 3.559), CoC 3.551 (3.420 to 3.687), CoP 3.029 (2.874 to 3.193), revision for all causes – MoP 4.129 (4.017 to 4.244), CoC 4.139 (3.997 to 4.286), CoP 3.684 (3.512 to 3.864) per 1,000 person-years. Incidence rates for all four revision outcomes are reported by bearing surface for each patient and surgical factor and shown in table 2 (appendix).

Considering all time periods adjusting for available co-variates, the use of a ceramic bearing was associated with a significant reduction in the risk of all four revision outcomes (Figure 1, Table 3) when compared to MoP (the reference group for all analyses). This effect was strongest with respect to risk of revision for infection where the use of a CoC or CoP bearing was associated with a risk ratio of 0.748 (0.649 to 0.862) and 0.775 (0.675 to 0.890) respectively.

Revision for Infection

Univariable analysis reveals that the incidence rate of revision for infection (Table 2) is lower for CoC and CoP when compared to MoP for all age groups under consideration (<60, 60-69, 70-80 and >80 years). Patient factors associated with a significantly increased risk of revision for infection included younger age, male gender, higher BMI, increasing co-morbidity (ASA grade) and a primary pathology other than osteoarthritis or trauma (Table 3). Cementless stem fixation and the use of a posterior surgical approach were both associated with a significantly reduced risk of infection.

Period specific analysis (Table 4) showed the protective effect of the use of a CoP or CoC bearing in preventing infection to be strongest and significant only after 2 years of implantation. High BMI and increased ASA grade had strong effects on revision risk in the early post-operative period (less than 6 months) however the effect of these characteristics were not significant after 2 years. Femoral component head size was a significant predictor of early revision although the numbers in the <28mm group were small (<0.4% of the overall cohort) and the effect was lost after 6 months.

Revision for Dislocation

Adjusting for other covariates, CoC bearings were associated with a significantly reduced risk of dislocation. High BMI (BMI >= 30), ASA grade, posterior surgical approach, cementless stem fixation, intra-operative complication and a primary indication for pathology other than osteoarthritis were all significant risk factors for revision for dislocation. Larger femoral head size was strongly protective against dislocation with a head size ≥32mm more than halving the risk relative to a 28mm head. Risk of revision for dislocation was significantly higher in earlier NJR cohorts, for reasons difficult to explain.

Period specific effects were seen for several patient and surgical factors with CoC bearings and cemented fixation being significantly protective but only after 2 years implantation (Table 4). . Older patients (>80 years) were at significantly higher risk of dislocation in the early post-operative period (<6 months) but had a significantly lower risk of dislocation beyond 2 years where the highest risk for dislocation was seen in the 60-69 years group. Male gender was associated with significantly increased risk of early dislocation but protective beyond 2 years of implantation. Increased BMI, posterior approach and a smaller head size were significantly associated with increased dislocation risk in all follow-up periods.

Aseptic Revision

Considering all time periods collectively, statistically significant ($p<0.001$, Table 4) lower risk was associated with the use of a CoP bearing in comparison to MoP. Younger age, male gender, higher BMI and ASA grade, a primary indication other than osteoarthritis, intra-operative complication and earlier NJR cohorts were associated with significantly higher risk of revision for aseptic cause. Posterior approach, cemented fixation and a larger femoral head size were associated with significantly lower risk of aseptic revision.

Period specific analysis showed both CoC and CoP bearings to be associated with significantly reduced risk of aseptic revision beyond 2 years of implantation. Younger age was protective in the early post-operative period but associated with significantly increased risk of aseptic revision beyond 6 months. Intraoperative complication, cementless fixation and a smaller head size (28mm vs 32mm) were significant predictors of increased risk of aseptic revision across all time periods.

All Cause Revision

For all cause revision, CoC and CoP bearings were associated with statistically significant ($p<0.001$, Table 4) lower risk of revision compared to MoP after 2 years implantation. High BMI (≥30kg/m2), higher ASA grade and an intra-operative complication represented significant early risk factors for revision however these effects were not significant beyond 2 years. Younger age was protective for early revision but a significant risk factor for revision beyond 6 months follow-up. Male gender and surgery for trauma were associated with increased revision risk across all time periods.

A larger femoral head size was associated with significantly lower risk of revision across all time periods however beyond 6 months, there was no significant advantage gained from a head size of greater than 32mm.

Sensitivity Analysis

In the first sensitivity analysis, coefficients and significance for the effect of bearing surface were stable after step-wise elimination of non-significant variables in competing risk regression analysis for the outcome of revision for infection (considering all time periods) (table 5).

In the second sensitivity analysis, demographics and outcomes were compared based upon ceramic or metal femoral head use and consultant preference (table 6). Whilst the differences were less pronounced than when grouping based on bearing surface, significant differences remained in baseline demographics with the ceramic head preference group remaining significantly younger, fitter (higher proportion were ASA 1) and more likely to be male. Adjusting for all available co-variates, for all four revision outcomes, the use of a ceramic head was associated with a significantly lower risk of revision beyond 2 years in comparison to a metal head (table 7 & 8). This effect was strongest for revision for infection where ceramic head use was associated with half the risk ($p=0.0005$).

In a discrete analysis of patients aged 60 to 69 and ASA grade 2, a ceramic bearing surface remained a significant predictor of revision for infection after 2 years – almost halfing the risk ($p = 0.01$) (table 9).

Regressions performed for yearly NJR cohorts showed that across the majority of the years and for the four revision outcomes, the risk ratio was in favour of a ceramic bearing for all time periods and revision after 2 years. However, this was statistically significant in less than half of the years studied (table 10 & 11) and it may be that yearly analyses are statistically underpowered.

DISCUSSION

Infection after joint replacement is a devastating complication which frequently requires further (revision) surgery, prolongs recovery and leads to poor outcomes. Such infections are a significant burden to healthcare services and are likely to result in undue personal suffering for the patients concerned. We have used the NJR data on more than 450,000 primary hip replacements to explore the role of ceramic bearings in reducing the risk of revision for infection and also dislocation, aseptic loosening and all causes. This is perhaps one of the largest studies of its kind and has controlled for confounding variables like method of fixation of acetabular component, age, gender, BMI, comorbidities, surgeon preference and change in surgeon practice. We have been able to show that the use of a ceramic bearing has a significant protective effect in all revision outcomes at various time periods but especially after two years of implantation. This effect was strongest with respect to risk of revision for infection where the use of a CoC or CoP bearing was associated with a reduction of revision burden by 25.2% and 22.5% respectively as compared with MoP (Table 3) in a multivariate model adjusting for all available factors.

The mechanism by which ceramic materials reduce infection has been a matter of several invitro studies and perhaps is related to the adhesive and absorptive properties of the ceramic bearing. Ceramics can be polished to lower surface roughness and are hydrophilic with excellent wettability; surface properties such as roughness and hydrophobicity are known to influence the formation of biofilms,[26 27] and it is for this reason that it has been suggested that ceramic bearing surfaces may potentially confer a degree of protection against biofilm formation. Significant reduction ($p<0.01$) in colony forming units have been noted in sonification studies looking at bacterial counts from biofilms in ceramic (230 CFU/ml) as compared to polyethylene (6250 CFU/ml) and metal bearing (5,870 CFU/ml)[19]. Bioceramics reduced bacterial adhesion and subsequent biofilm formation more effectively in comparison with metal and polymer surfaces, especially in the first 24 hours[18]. It has been proposed that ceramic bearing surfaces have an isolectric point at lower pHs and adsorbed a larger amount of proteins in comparison with metal surfaces[23]. This correlated with bacteria biofilm growth and ceramic surfaces were also less colonised by Staphylococcus aureus in comparison to metal surfaces ($p<0.005$).

Clinical studies seem to come to similar conclusions. The Australian Registry (AOANJRR) analysed 177,237 primary THAs with 3 different bearing surfaces, of which 95,129 were MoXP (metal-on-highly cross-linked polyethylene), 24, 269 were CoXP (ceramic-on-highly cross-linked polyethylene) and 57,839 were CoC (ceramic-on-ceramic)[14]. The CoXP and MoXP groups showed higher revision rates for infection than the CoC group[14]. However, the lower revision rates were evident in patients 70 years and younger. A different study using data from the New Zealand Joint Registry looked at 97,889 THAs over a 15-year period[15]. Of these 54,409 (64%) were MoP (metal-on-polyethylene), 16,503 (19%) were CoP, 9051 (11%) were CoC and 4931 (6%) were MoM (metal-on-metal)[15]. The rate of early PJIs (<6 months) was independent of the bearing surface, however they noted that over the entire study period CoC hips were associated with a significantly lower risk of revision for deep infection when compared with CoP, MoP, and MoM. However, due to lack of data for American Society of Anaesthesiologists class (ASA, data collection started in 2005) and BMI (data collection started in 2010) they concluded that their results should be interpreted with caution[15]. Similarly, a study using data from the Emilia-Romagna region Registry for Orthopaedic Prosthetic Implants (RIPO) since 2003 found that the bearing surface influenced the rate of PJI[28]. Of

39,206 cementless THAs the CoC bearings had a lower rate of PJIs than MoM. Kurtz et al looked at 315,784 medicare patients (>65 years old) between 2005 and 2014 found that there were significantly lower rates of infection in the CoC and CoPE groups compared to the metal-on-polyethylene (MoPE) group[29]. Additionally they found that the CoPE group had lower rates of dislocation and mortality.

In a recent meta-analysis by Hexter et al[24], data were pooled from 11 RCTs and six observational, which included some registry studies and showed no significant difference between the three bearing combinations in terms of risk of PJI [MoP 0.85% (1353/158 430); CoP 0.38% (67/17 489); and CoC 0.53% (94/17 459)]. However, this study does not include the recent publications from the AOANJRR[14], RIPO[28] and the Medicare[29] series as discussed above. Another meta-analysis of 974 THAs, which included five RCTs comparing clinical and radiological outcomes of CoC and MoP, showed decreased revision rates, osteolysis, radiolucent lines, aseptic loosening and dislocation in the CoC group[25]. There was no significant difference in deep infection rates, post-operative hip function and hetertrophic ossification (HO). However an increase in intraoperative implant fracture and squeaking was identified in the CoC group. The same authors also performed a meta-analysis comparing CoC with CoP hip replacements and in 9 RCTs involving 1575 patients found no significant differences with respect to revision, osteolysis and radiolucent lines, loosening, dislocation, and deep infection between the CoC and CoP bearing surfaces[30].

In our analysis of the NJR data of 456,457 patients we have noted that there are clear patient related trends in the risk of revision for infection. The univariate analysis has shown the protective effect of ceramic bearing on revision for infection in all age groups (Table 2) in contrast to the AOANJRR[14]. In the multivariate model younger (<60 years) males seem to have a higher risk of revision because of infection particularly after three months of surgery, with the effect being compounded in the presence of higher BMI. Similarly posterior approach has a protective influence on infection rate. With the use of antibiotic loaded cement[31], one would expect a lower infection rate for cemented fixation, but paradoxically it seems the three month and >2 year risk of revision for infection is significantly higher with cemented fixation. Despite this increase, of note is the significant reduction in all cause revision rate by 20.4% associated with cemented stems as compared to cementless (Table 3). Lenguerrand et al[13] in their exploration of the NJR data looking at the risk factors associated with revision for PJI have also reported similar association with demographics and approach; however they found a higher early (<3 months) revision rate for PJI for cementless implants as compared to cemented hip replacements, while the 3-24 month risk was lower or similar. In contrast to our dataset which includes patients who had their primary surgery between February 2002 and December 2016, Lenguerrand et al's series[13] included patients operated between April 2003 and December 2013. Moreover in our analyses we have focussed on the effect of bearing surfaces while mitigating potential confounding variables like the influence of cemented cups by excluding them in the dataset. Thus the cemented THRs in Lenguerrand's cohort will include a cemented cup in addition to a cemented stem and therefore a higher antibiotic delivery typically added to the cement [31] which might partly account for the differences noted between the studies.

The protective effect of ceramic bearing was predominantly seen after two years of implantation (Table 4) with a significant ($p<0.0001$) reduction of revision because of infection in both CoC (by 42.8%) and CoP (by 41.3%) group. This effect was also seen for late dislocations (>2 years) with a significant ($p<0.001$) reduction in revision for dislocation by 40.9% for CoC, perhaps related to late polyethylene wear in other bearing combinations.

Similarly aseptic revision beyond two years reduced by 18.1% for CoC and by 24.8% for CoP ($p<0.001$). Overall all cause revision rate beyond two years reduced by 21.6% for CoC and 27.1% for CoP ($p<0.001$). The data suggests that adding ceramic bearing either on both acetabular and femoral side or even on femoral side has a protective effect on revision. Intuitively one would expect the ceramic bearings to be use for younger, fitter patients and indeed there would be a surgeon bias depending on the preference which may change over time. We have done a sensitivity analyses to account for these (Table 7) and ceramic head remained a significant factor in reducing revision for infection (27.7% reduction), aseptic revision (17.5%) and all cause revision (19.2%). The regression by time period figures (Table 8) also reflected the finding of the overall cohort.

Our study has limitations inherent to any National Joint Registry study. It relies on the data that has been entered at the time of surgery which may lead to some inaccuracies and there may be a degree of under reporting of revisions performed for infection as microbiological data is not available. Some revisions for aseptic loosening may be actually low grade infections. We do not have information on patients who had superficial infections or those who had a DAIR procedure (debridement, antibiotics and implant retention) although they may have been entered as single stage revision. Another possible limitation would have been selection bias but we have tried to account for that by doing a sensitivity analyses. All registry studies have intrinsic bias due to the potential effect of unknown variables and a prospective experimental study is perhaps the definitive way proving this; although this would require a large multicentred study with a minimum sample size of 41,701 for one bearing surface, as estimated in our power analyses. Moreover combining data can loose some of the subtelties within brand and surgeons should always consider all the evidence for the implants they are using in the registry report.

In conclusion, in this study looking at 456,457 primary hip replacement recorded in the NJR we have noted that a ceramic bearing was associated with a significant reduction in the risk of all four revision outcomes when compared to MoP. This effect was strongest with respect to risk of revision for infection where, in a multivariate analyses accounting for all confounding variables, the use of a CoC or CoP bearing was associated with a reduction of revision burden by 25.2% and 22.5% respectively as compared with MoP. Additionally, in the multivariate model there was a significant reduction in all cause revision by 8.2% for CoC and 19.4% for CoP as compared to MoP bearing. The protective effect of ceramic bearing (CoC and CoP) on infection was observed for all age groups with a reduction in the incidence rate of revision for infection as compared to MoP. The effect was most pronounced after two years of implantation with a significant reduction in revision for infection and all cause in both the CoC and CoP group as compared with MoP. This data will be helpful for surgeons to decide on their bearing choice with potentially huge cost savings for the health service and additionally will inform future prospective work required to validate the findings.

TABLE & FIGURE LEGEND

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