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Mortality rates at 10 years after metal-on-metal hip resurfacing compared with total hip replacement in England: retrospective cohort analysis of hospital episode statistics

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Abstract

Objectives To compare 10 year mortality rates among patients undergoing metal-on-metal hip resurfacing and total hip replacement in England.

Design Retrospective cohort study.

Setting English hospital episode statistics database linked to mortality records from the Office for National Statistics.

Population All adults who underwent primary elective hip replacement for osteoarthritis from April 1999 to March 2012. The exposure of interest was prosthesis type: cemented total hip replacement, uncemented total hip replacement, and metal-on-metal hip resurfacing. Confounding variables included age, sex, Charlson comorbidity index, rurality, area deprivation, surgical volume, and year of operation.

Main outcome measures All cause mortality. Propensity score matching was used to minimise confounding by indication. Kaplan-Meier plots estimated the probability of survival up to 10 years after surgery. Multilevel Cox regression modelling, stratified on matched sets, described the association between prosthesis type and time to death, accounting for variation across hospital trusts.

Results 7437 patients undergoing metal-on-metal hip resurfacing were matched to 22 311 undergoing cemented total hip replacement; 8101 patients undergoing metal-on-metal hip resurfacing were matched to 24 303 undergoing uncemented total hip replacement. 10 year rates of cumulative mortality were 271 (3.6%) for metal-on-metal hip resurfacing versus 1363 (6.1%) for cemented total hip replacement, and 239 (3.0%) for metal-on-metal hip resurfacing versus 999 (4.1%) for uncemented total hip replacement. Patients undergoing metal-on-metal hip resurfacing had an increased survival probability (hazard ratio 0.51 (95% confidence interval 0.45 to 0.59) for cemented hip replacement; 0.55 (0.47 to 0.65) for uncemented hip replacement). There was no evidence for an interaction with age or sex.

Conclusions Patients with hip osteoarthritis undergoing metal-on-metal hip resurfacing have reduced mortality in the long term compared with those undergoing cemented or uncemented total hip replacement. This difference persisted after extensive adjustment for confounding factors available in our data. The study results can be applied to matched populations, which exclude patients who are very old and have had complex total hip replacements. Although residual confounding is possible, the observed effect size is large. These findings require validation in external cohorts and randomised clinical trials.

Introduction

Total hip replacement was introduced in the 1960s and has developed into one of the most successful treatments in modern medicine.[1] [2] Historically, the operation involves replacing

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Extra material supplied by the author (see http://www.bmj.com/content/347/bmj.f6549?tab=related#webextra)

Web appendix: Supplementary material the arthritic joint surfaces with a hard metal head and a softer polyethylene cup, both of which are cemented for secure fixation to bone. In comparison to their longevity in patients older than 65 years, cemented metal and polyethylene prostheses are associated with high rates of early failure in more active patients; particularly men under the age of 55 years.[3] [4] Implant failure is commonly due to early wear and localised osteolysis.[5] Metal-on-metal hip resurfacing was introduced in the 1990s with the hope that wear rates would be lower for the harder bearing surfaces, that larger head sizes would reduce the rate of dislocation, and that subsequent revision surgery would benefit from bone preservation of the femoral neck.[6] [7]

Functional outcomes after metal-on-metal hip resurfacing in the medium term were good[8] [9] and encouraged more widespread use, reaching a peak in 2006 when it constituted 10% of all primary total hip replacements in England and Wales.[10] Subsequent reports of neck of femur fractures,[11] local pseudotumour formation in response to metal wear particles,[12] and the systemic accumulation of high levels of cobalt and chromium ions raised concerns over the long term safety of these devices.[9] [13] [14] Unacceptably high early failure rates led to the withdrawal of the Articular Surface Replacement component,[15] and have been reported in women and anyone receiving a small femoral head component (<50 mm).[16] [17] Although several groups have published findings supporting metal-on-metal hip resurfacing when performed by experienced centres on young men with appropriate anatomy,[17][18][19] several influential commentaries reacted by calling for an abolition of the prosthesis.[20] [21]

Understanding the effect that different types of primary total hip replacements—especially metal-on-metal hip resurfacing—have on long term mortality is an essential part of treating patients with debilitating osteoarthritis. The establishment of national databases has allowed the analysis of population based mortality in the long term. McMinn and colleagues recently examined the National Joint Registry database of England and Wales and found a significantly decreased risk of death in patients undergoing uncemented total hip replacement compared with cemented total hip replacement.[22] The greatest survival advantage was observed in patients undergoing a metal-on-metal Birmingham hip resurfacing component. The global effect of this finding was limited by the potential influence of unknown confounding factors, as well as the exclusion of all metal-on-metal hip resurfacings that were not Birmingham hip resurfacings of defined dimensions performed on men only.

We obtained data from the English hospital episode statistics database, which is linked to mortality records between 1999 and 2012 from the Office for National Statistics. This study aimed to account for confounding by indication, using propensity score matching to allow meaningful comparison of 10 year rates of all cause mortality in patients undergoing metal-on-metal hip resurfacing, cemented total hip replacement, and uncemented total hip replacement.

Methods

Study design, setting, and source of data

We conducted a nationwide retrospective cohort study. Data were obtained from the hospital episode statistics database, which holds information on patients admitted to English hospitals in the United Kingdom's health service. Each record in the database relates to one finished consultant episode, describing the time an individual spends under the care of one NHS consultant. Procedures performed in private hospitals are excluded. The information held includes age, sex, area of usual residence, diagnosis or reason for admission to hospital, and procedure undertaken. Further information is available online (www.hesonline.nhs.uk). Hospital episode statistics data were then linked to mortality records from the Office for National Statistics, which provided information about the date and cause of death.

Participants

We extracted anonymised records for all patients over 18 years of age who underwent primary hip replacement between April 1999 and March 2012. Patients were included if they had primary total hip replacement (cemented or uncemented) or primary hip resurfacing. We excluded patients who had revision surgery, total hip replacement of unspecified fixation, hybrid prosthetic hip replacement, and total prosthetic replacement of the femur head. The following exclusions were made to remove potential case mix issues: diagnostic codes indicating fracture or cancer of the hip bones; other injuries due to trauma, such as transport accidents and falls; non-elective admissions; and a diagnosis other than primary hip osteoarthritis.

Primary outcome and exposure

The outcome of interest was date of death (all cause mortality). Patients were followed for up to 10 years from the date of operation. Secondary outcomes included the most common underlying causes of death using codes from ICD-10 (international classification of diseases, 10th revision). Causes of death included malignant neoplasms (C00-C97); ischaemic heart diseases (I20-I25); cerebrovascular diseases (I60-I69); diseases of arteries, arterioles, and capillaries (I70-I79); pneumonia (J12-J18); and bronchitis, emphysema, and other chronic obstructive pulmonary disease (J40-J44). The exposure of interest was prosthesis type (cemented and uncemented total hip replacement, and metal-on-metal hip resurfacing). Episodes involving these procedures were identified using a combination of OPCS4 codes in the procedure fields (codes from the Office of Population Censuses and Surveys that contain information about a patient's operations) and ICD-10 codes from the diagnostic fields (that contain information about a patient's illness or condition; web appendix).

Potential confounders

Confounding variables at the patient level included age, sex, year of operation, and degree of comorbidity classified for each patient by using the Charlson comorbidity index. We used data from across all diagnostic fields to create a weighted score and an ordinal variable (none (0), mild (1), moderate (2), severe (≥3)).[23] The annual volume of hip replacement operations and operations for metal-on-metal hip resurfacings in an NHS hospital trust was derived for each financial year of hospital episode statistics, and categorised into five equal groups based on annual volume over the follow-up period. An NHS hospital trust, known as an acute trust, provides secondary health services within the English NHS. We treated the Royal Orthopaedic Hospital NHS Trust in Birmingham as a separate category owing to the high volume of metal-on-metal hip resurfacings performed. Ecological variables were linked to the lower level, super output area where the patient lived. Super output areas are small areas of England that have a consistent population size with a minimum population of 1000 people and mean of 1500 people. Ecological variables included rurality (categorised as urban population ≥10 000; town and fringe; and village or isolated) and the Index of Multiple Deprivation 2004 as a measure of social deprivation.

Statistical methods

In randomised controlled trials, each person has an equal probability of being in a treatment or control group. Observational study designs are limited by an inherent imbalance of both known and unknown confounders, which makes some patients more likely to undergo metal-on-metal hip resurfacing than total hip replacement. Because the type of surgery given was not randomly allocated in our study, we accounted for confounding by indication by using propensity score matching methods. These methods for the assessment of causality in epidemiological studies has been previously described.[24] The propensity score represents the probability that a patient received the intervention (that is, metal-on-metal hip resurfacing). We fitted two separate logistic equations where the outcomes were metal-on-metal hip resurfacing versus cemented or uncemented total hip replacement. Age, sex, Charlson comorbidity, rurality, Index of Multiple Deprivation, volume of total hip replacement, volume of metal-on-metal hip resurfacing, and year of operation were introduced as potential confounders of all cause mortality in the long term.

With propensity scores using a 0.02 standard deviations calliper, we matched each patient undergoing metal-on-metal hip resurfacing to three comparable controls undergoing total hip replacement.[25] This is the standard method for minimising confounding by indication, which not only provides participants with balanced baseline characteristics in both surgical groups, but also eliminates patients undergoing metal-on-metal hip resurfacing with no comparable controls.[26]

We included patients undergoing metal-on-metal hip resurfacing and controls in a Cox regression survival model to describe the association between prosthesis type and time to death from any cause. The model is stratified on matched sets to allow for the correlation between matched pairs of patients undergoing metal-on-metal hip resurfacing and controls. We tested for evidence of interactions of prosthesis type with age, sex, and comorbidity. Because clustering exists within the data (patients nested within hospital trusts), we fitted a multilevel survival model by extending the Cox regression model to include a frailty term with a Gaussian distribution.[27] This inclusion allowed adjustment for evidence of unexplained variation across hospital trusts. The proportional hazards assumption was assessed using Shoenfelds residuals. We used Kaplan-Meier plots to estimate the probability of survival up to 10 years after surgery in patients undergoing metal-on-metal hip resurfacing and controls. To assess the potential effect of unmeasured confounders, we conducted a Rosenbaum bounds sensitivity analysis.[28] This analysis estimates the magnitude of hidden residual bias that would have to be present to explain the associations actually observed. Stata version 12.1 was used for all statistical analyses.

Results

Data were available for 263 915 patients undergoing primary cemented total hip replacements, 121 144 undergoing uncemented total hip replacement, and 18 599 undergoing metal-on-metal hip resurfacing. Patients were followed for a median (interquartile range) of 6.1 (3.1-9.0) years (cemented total hip replacement), 3.4 (1.6-5.9) years (uncemented total hip replacement) and 5.5 (3.7-7.3) years (metal-on-metal hip resurfacing). Patients undergoing metal-on-metal hip resurfacing were younger (mean age 53.8 years) than those undergoing total hip replacement (uncemented, 65.2 years; cemented, 71.2 years). The majority of metal-on-metal hip resurfacings where performed on men (68.3% *v* 36.9% and 44.1% for cemented and uncemented total hip replacements, respectively). Patients undergoing metal-on-metal hip resurfacing were more likely to be from affluent areas, whereas total hip replacement had no association with area deprivation. Patients undergoing metal-on-metal hip resurfacing had fewer comorbidities at the time of surgery than those undergoing total hip replacements. Metal-on-metal hip resurfacings were more likely than total hip replacements to be performed in high volume hospital trusts.

Logistic regression models using propensity score matching achieved a c statistic (corresponding to the area under the receiver operating characteristics curve) of 0.97 and 0.93 for metal-on-metal hip resurfacing versus cemented and uncemented total hip replacement, respectively. This indicated substantial imbalance with respect to measured confounding factors by type of surgical procedure before propensity score matching was applied. The surgical groups became balanced on known confounders after propensity score matching—particularly for older age groups undergoing total hip replacements (table 1⇓ and 2⇓). Mortality rates in the matched populations for metal-on-metal hip resurfacing compared with uncemented total hip replacement were 24 (0.3%) versus 145 (0.6%) at one year, and 239 (3.0%) versus 999 (4.1%) at 10 years. Corresponding rates between metal-on-metal hip resurfacing and cemented total hip replacement were 22 (0.3%) versus 154 (0.7%) at one year, and 271 (3.6%) versus 1363 (6.1%) at 10 years.

The figure⇓ shows Kaplan-Meier survival curves according to the type of operation and length of follow-up. At 10 year follow-up, patients undergoing metal-on-metal hip resurfacing had a strong survival advantage compared with those undergoing total hip replacements (hazard ratio 0.51 (95% confidence interval 0.45 to 0.59) for cemented hip replacements; 0.55 (0.47 to 0.65) for uncemented hip replacements). Significant differences in survival were observed as early as 90 days after surgery for the comparison between metal-on-metal hip resurfacing and cemented total hip replacement. There was no evidence for an interaction with age, sex, or comorbidity.

A secondary analysis investigated the underlying cause of death. The most common causes of death were malignant cancers and ischaemic heart disease, together accounting for about 60% of all deaths. Other common causes were cerebrovascular disease, aortic aneurysm, pneumonia, and bronchitis, although these causes combined only accounted for a further 10% of all deaths. Compared with cemented and uncemented total hip replacement, metal-on-metal hip resurfacing had reduced risk of death from cancer (hazard ratio 0.58 (95% confidence interval 0.47 to 0.72) and 0.63 (0.49 to 0.80), respectively) and ischaemic heart disease (0.54 (0.38 to 0.75) and 0.56 (0.38 to 0.84), respectively). The numbers of deaths from other causes were much smaller, which limited power. No significant association was observed in relation to aortic aneurysm for metal-on-metal hip resurfacing versus cemented or uncemented total hip replacement (1.07 (0.45 to 2.50) and 0.42 (0.14 to 1.25), respectively). The effect size of metal-on-metal hip resurfacing was stronger for pneumonia (0.47 (0.16 to 1.39) and 0.21 (0.05 to 0.93)) and bronchitis (0.19 (0.06 to 0.62) and 0.11 (0.03 to 0.45)) compared with cemented and uncemented total hip replacement, respectively.

We used a sensitivity analysis with Rosenbaum bounds to assess the potential effect of unmeasured confounders. When applied to the analysis of metal-on-metal hip resurfacing versus cemented total hip replacement, Rosenbaum bounds suggested a γ value of 1.7. This means that for any unmeasured confounder to explain a higher rate of death, the confounder would need to produce a two times increase in the odds of undergoing cemented total hip replacement over metal-on-metal hip resurfacing. When comparing metal-on-metal hip resurfacing with uncemented total hip replacement, Rosenbaum bounds analysis suggested a γ of 1.4.

Discussion

We found a survival advantage for patients undergoing metal-on-metal hip resurfacing compared with both cemented and uncemented total hip replacement. This advantage persisted after removing potential case mix issues and after accounting for confounding by indication using propensity score matching methods. Owing to the observational nature of the study, there remains the potential for residual confounders—such as health and lifestyle effects—that could attenuate the observed association.

Meaning of the study's findings

An additional way of measuring the impact of treatment is the number needed to treat. This is the number of patients who would need to be treated with hip resurfacing rather than total hip replacement in order to prevent one adverse event (death at 10 years after surgery). The number of patients needed to treat with metal-on-metal hip resurfacing compared with cemented total hip replacement to prevent one excess death at 10 years was 34. The equivalent number for metal-on-metal hip resurfacing compared with uncemented total hip replacement was 55. The number of patients needed to treat with metal-on-metal hip resurfacing compared with cemented total hip replacement to prevent one excess death at 10 years was 34. The equivalent number for metal-on-metal hip resurfacing compared with uncemented total hip replacement was 55. Over 71 000 primary hip arthroplasties took place in the UK in 2011-12, of which only 2% were resurfacing procedures; a marked decrease from 10% of 59 000 in 2006.[10] Our findings suggest that this reduction could lead to an increase in future mortality, and encourage continued prospective investigation of the relative merits of metal-on-metal hip resurfacing.[30] Any survival advantage in the long term needs to be carefully balanced against the potential for harm. Metal-on-metal hip resurfacing has been reportedly associated with local soft tissue reaction,[12] femoral neck fracture,[11] elevated systemic ion levels,[9] [13] [14] and early failure in women who need small hip components.[16][17]

Strengths and weaknesses in relation to other studies

A similar survival advantage for men who underwent Birmingham hip resurfacing was described in 2012 using data from the UK National Joint Registry.[22] Mortality hazards were 1.64 (95% confidence interval 1.33 to 2.02) times higher for cemented total hip replacement (number needed to treat of one in 23), and 1.47 (1.19 to 1.82) times higher for uncemented total hip replacement compared with this brand of metal-on-metal hip resurfacing. These findings were not only limited to men but also excluded other types of metal-on-metal hip resurfacing, together constituting about 40% of all resurfacings in 2005-10. Although the study applied flexible parametric modelling (Royston-Parmer) to adjust for confounding factors, this methodology was criticised for not dealing with potential confounding by indication (preselection bias) as well as for relying on American Society of Anesthesiologists (ASA) grading as an accurate predictor of future mortality risk.[31] Patients who went on to have a revision procedure were also excluded, potentially distorting the true long term mortality after the first procedure. Investigation of cancer after metal-on-metal hip resurfacing, using data from the National Joint Registry, also found that patients who underwent resurfacing procedures had a lower risk of death than patients receiving other bearing surfaces.[32]

We used the hospital episode statistics database, which provided a large, nationally representative dataset of all elective NHS admissions for primary total hip replacement and metal-on-metal hip resurfacing across England. The data are linked to national mortality records, ensuring accurate determination of the primary outcome measure. To overcome the effect of confounding by indication, we used propensity score matching on known measurable confounders, including age, sex, the Charlson comorbidity index, socioeconomic status, surgical volume, and time of the operation. Our study results apply to the matched population, which was a sample of younger and relatively healthy patients undergoing total hip replacement. We excluded patients who were older and who had complex total hip replacements after matching. To minimise bias due to confounding by indication, propensity score matching therefore runs the risk of limiting the generalisability of the findings to younger and healthier patients. This potential weakness reduced the mean age from 71.2 to 59.4 years in patients undergoing cemented total hip replacement, and from 65.2 to 57.7 years in patients undergoing uncemented total hip replacement, after matching (tables 1 and 2). Although data from patients at extremes of age and associated comorbidities were excluded by the matching process, about 50% of patients undergoing a cemented total hip replacement and 40% undergoing an uncemented total hip replacement remained over 60 years of age. In addition, we failed to find a significant interaction between mortality and age alone.

It was difficult to assess generalisability. Metal-on-metal hip resurfacing was developed for young and active patients who were likely to have several hip replacement procedures of increasing complexity during their lifetimes. Guidance from the National Institute for Health and Care Excellence[33] stated that metal-on-metal hip resurfacing "is recommended as an option for people with advanced hip disease who would otherwise receive a conventional primary total hip replacement (THR) and are likely to live longer than the device is likely to last." The inclusion of a higher proportion of younger patients in both total hip replacement groups arguably allows a clinically relevant comparison of their outcomes against similar patients undergoing metal-on-metal hip resurfacing.

The potential for residual confounding—despite propensity score matching—remains for two main reasons. The scope of known, measured confounders is limited; for example, age is not a reliable indicator of a patient's level of activity and Charlson comorbidity index does not fully assess risk factors predictive of future disease. In addition, there is a potential confounding effect of surgeon experience beyond the measurable "hospital trust surgical volume," whereby specialist hip surgeons performing high volume surgery are more likely to perform metal-on-metal hip resurfacing. Secondly, there are likely to be important unknown confounders that are not patient specific. These confounders could include inequalities in healthcare provision such that metal-on-metal hip resurfacings are more likely to be performed in specialist surgical centres. For these reasons, an important strength of the study is the Rosenbaum bounds sensitivity analyses, allowing us to estimate the likelihood that an unknown or immeasurable confounder could explain the observed differences in long term mortality. A γ value of 1.7 when comparing metal-on-metal hip resurfacing with total hip replacement suggests that it is unlikely that unaccounted confounding remains. Although we cannot fully exclude confounding by indication, our analyses suggest that such confounding would have to be due to an unmeasured confounder with a very large effect size or a cumulative effect of several unmeasured confounders relating to health and lifestyle. Regarding the comparison between metal-on-metal hip resurfacing and uncemented total hip replacement, an unmeasured confounder would need an effect size as small as 1.4 to attenuate the observed association with mortality and so bias our results.

In addition to equalising potential follow-up time in the operative groups, adjustment for time of operation allowed us to control for changing trends in mortality over time and trends in the usage of the different types of operation. The use of a multilevel model enabled us to further account for unexplained variation and clustering across hospital trust sites. A limitation is that routine hospital admissions data are collected for administrative rather than research purposes, and concerns have been raised over the completeness and accuracy of such data. Lastly, hospital episode statistics data underestimates the total number of procedures performed by excluding a minority of privately funded operations, but this is unlikely to bias the observed results.

Unanswered questions and future research

It is currently unclear why there is a survival advantage after metal-on-metal hip resurfacing compared with after total hip replacement. Potential contributing factors could be broadly grouped into patient selection (discussed above), perioperative care of patients, operative techniques, and bearing surfaces.

Metal-on-metal hip resurfacing constituted a minority (<7%) of primary hip arthroplasty, and the most commonly used brand was the Birmingham hip resurfacing component (>60% in 2012). Compared with the more widespread use of total hip replacement, this difference could represent a discriminatory concentration of specialist skills in a small number of regional centres that could translate into a higher or more consistent standard of care. Early revision rates of metal-on-metal hip resurfacing could also affect long term survival by increasing the frequency of patient-hospital encounters.[16] [17] This trend is likely to continue after regulatory advice that patients with metal-on-metal bearings need annual monitoring for ion levels and local tissue reaction.[34]

Metal-on-metal hip resurfacing only requires preparation of the head of the femur.[8] But in total hip replacement, the femoral canal is mechanically reamed, rasped, cleaned and, if cemented, pressurised during polymethylmethacrylate (PMMA) cement insertion. These steps are associated with bone cement implantation syndrome, which is loosely characterised by hypoxia, hypotension, increased pulmonary vascular resistance, and cardiac dysrhythmias.[35] The proposed pathophysiology of bone cement implantation syndrome includes polymethylmethacrylate toxicity, release of bone marrow emboli, and vasoactive inflammatory mediators. Embolic release could have more of an effect than polymethylmethacrylate toxicity, which alone cannot explain the survival advantage of metal-on-metal hip resurfacing over uncemented total hip replacement. Transoesophageal echocardiography has detected emboli throughout the preparation of the femoral canal, not just during cement pressurisation.[36] Bone cement implantation syndrome might offer one explanation for the increase in relative risk of death from cardiopulmonary causes after cemented and uncemented total hip replacement versus metal-on-metal hip resurfacing. However, currently there is only limited evidence that metal-on-metal hip resurfacing releases fewer emboli than total hip replacement.[37] Furthermore, no correlation has been shown between the extent of emboli and clinical sequelae—perhaps partly because bone cement implantation syndrome is a poorly defined disorder that is rarely fatal and thus risks under reporting.

The observed survival advantage after metal-on-metal hip resurfacing seems at odds with accumulating descriptions of local and systemic effects of metal wear debris. Metal bearings are more resistant to mechanical wear than polyethylene bearings, but overall they release a greater number of smaller wear particles that can drive chronic inflammation and “pseudotumour” formation.[12] [38] [39] Systemically, high levels of cobalt and chromium ions have been found after metal-on-metal hip resurfacing.[9] [40] They continue throughout the life of the prosthesis, penetrate solid organs, and are further elevated in patients with loosening implants.[13] [14] Although both ions are known to be genotoxic,[41] so far epidemiological studies have failed to show an increase in cancer related mortality after hip arthroplasty.[32] [42] [43] Smith and colleagues recently observed lower rates of cancer in patients over a seven year period after metal-on-metal hip resurfacing than in the general population, but failed to account for confounding by indication.[32] We observed an increased risk in cancer related deaths after cemented and uncemented total hip replacement compared with metal-on-metal hip resurfacing. It is still possible that metal-on-metal hip resurfacing will result in an increased mortality beyond the 10 year period of our study. Long latency periods are associated with occupational exposure to other metal ions—for example, nickel[44]—and the reported increase in the incidence of melanoma and prostatic cancer in one meta-analysis only became apparent beyond 10 years after hip arthroplasty.[42]

Conclusion

In our study, patients undergoing metal-on-metal hip resurfacing had a long term survival advantage compared with those undergoing cemented and uncemented total hip replacement. These findings were robust to adjustment for known and measured confounders. The observed survival advantage requires confirmation in randomised controlled trials or external cohorts with more detailed data on potential confounders, and should be balanced against known complications for an informed decision on surgical management of patients with symptomatic hip osteoarthritis.

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What is already known on this topic

Total hip replacement is a highly successful treatment for symptomatic hip osteoarthritis

An alternative procedure for younger and more active patients is metal-on-metal hip resurfacing

Information is scarce on the mortality risks of both these procedures in the long term

What this study adds

Patients undergoing metal-on-metal hip resurfacing had a survival advantage over those undergoing cemented or uncemented total hip replacement; this effect persisted after removing potential case mix issues and accounting for confounding by indication using propensity score matching methods

Owing to the observational nature of this study, residual unmeasured confounders, such as health and lifestyle effects, could attenuate the observed association

The survival advantage requires confirmation in randomised controlled trials, or external cohorts with more detailed data on potential confounders

interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

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Data sharing: No additional data available.

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Tables

Table 1| **Baseline characteristics of patients: metal-on-metal hip resurfacing versus cemented total hip replacement**

	Before matching (whole study cohort)		After propensity score matching*	
	MoMR (n=18 599)	Cemented THR (n=263 916)	MoMR (n=7437)	Cemented THR (n=22 311)
Deaths at 10 year follow-up	433 (2.3)	49 589 (18.8)	271 (3.6)	1363 (6.1)
Duration of follow-up (years; median (IQR))	5.5 (3.7-7.3)	6.1 (3.1-9.0)	7.2 (5.1-9.0)	5.7 (3.6-7.7)
Age at operation				
Mean (SD)	53.8 (8.5)	71.2 (9.5)	57.3 (8.3)	59.4 (8.5)
<50 years	5341 (28.7)	5626 (2.1)	1152 (15.5)	2737 (12.3)
50-60 years	8508 (45.8)	23 091 (8.8)	2726 (36.7)	8442 (37.8)
60-70 years	4387 (23.6)	75 745 (28.7)	3210 (43.2)	10 217 (45.8)
70-80 years	341 (1.8)	109 391 (41.5)	333 (4.5)	873 (3.9)
>80 years	16 (0.1)	49 904 (18.9)	16 (0.2)	42 (0.2)
Sex				
Male	12 699 (68.3)	97 448 (36.9)	4356 (58.6)	12 852 (57.6)
Female	5899 (31.7)	166 392 (63.1)	3081 (41.4)	9459 (42.4)
IMD 2004 deprivation score				
Group 1 (most deprived)	3251 (17.8)	52 258 (20.0)	1469 (19.8)	4352 (19.5)
Group 2	3489 (19.1)	51 777 (19.9)	1384 (18.6)	4262 (19.1)
Group 3	3455 (18.9)	52 649 (20.2)	1442 (19.4)	4244 (19.0)
Group 4	3766 (20.7)	52 749 (20.2)	1507 (20.3)	4519 (20.3)
Group 5 (least deprived)	4276 (23.4)	51 315 (19.7)	1635 (22.0)	4934 (22.1)
Rurality				
Urban	13 682 (74.1)	189 931 (72.2)	5577 (75.0)	16 582 (74.3)
Town or fringe	1885 (10.2)	33 384 (12.7)	782 (10.5)	2374 (10.6)
Village or hamlet	2906 (15.7)	39 792 (15.1)	1078 (14.5)	3355 (15.0)
Charlson comorbidity				
None	16 852 (90.6)	220 004 (83.4)	6630 (89.1)	19 666 (88.1)
Mild	1584 (8.5)	35 349 (13.4)	716 (9.6)	2339 (10.5)
Moderate	129 (0.7)	6539 (2.5)	72 (1.0)	245 (1.1)
Severe	34 (0.2)	2023 (0.8)	19 (0.3)	61 (0.3)
Volume of THR procedures per year				
0-163 (group with fewest procedures)	3340 (18.0)	53 184 (20.2)	1315 (17.7)	4046 (18.1)
164-222	3283 (17.7)	52 616 (19.9)	1347 (18.1)	3953 (17.7)
223-287	3308 (17.8)	50 674 (19.2)	1374 (18.5)	4320 (19.4)
288-444	3659 (19.7)	52 393 (19.9)	1447 (19.5)	4643 (20.8)
445-1106 (group with most procedures)	5009 (26.9)	55 048 (20.9)	1954 (26.3)	5349 (24.0)
Volume of MoMR procedures per year (quintiles)				
1-3 (group with fewest procedures)	711 (3.8)	142 544 (54.0)	659 (8.9)	2021 (9.1)
4-7	1282 (6.9)	28 132 (10.7)	702 (9.4)	2418 (10.8)
8-15	2863 (15.4)	28 806 (10.9)	1314 (17.7)	4090 (18.3)
16-30	4186 (22.5)	31 655 (12.0)	1859 (25.0)	5549 (24.9)
31-181 (group with most procedures)	7442 (40.0)	29 344 (11.1)	2176 (29.3)	7112 (31.9)
Outlier (Royal Orthopaedic Hospital NHS Trust)	2115 (11.4)	3434 (1.3)	727 (9.8)	1121 (5.0)
Financial year of operation				

Table 1 (continued)

	Before matching (whole study cohort)		After propensity score matching*	
	MoMR (n=18 599)	**Cemented THR (n=263 916)**	**MoMR (n=7437)**	**Cemented THR (n=22 311)**
1999	262 (1.4)	22 356 (8.5)	249 (3.3)	426 (1.9)
2000	404 (2.2)	21 695 (8.2)	368 (4.9)	565 (2.5)
2001	593 (3.2)	22 070 (8.4)	528 (7.1)	853 (3.8)
2002	921 (5.0)	23 885 (9.1)	779 (10.5)	1377 (6.2)
2003	1315 (7.1)	25 297 (9.6)	1059 (14.2)	1963 (8.8)
2004	2037 (11.0)	22 960 (8.7)	1127 (15.2)	2781 (12.5)
2005	2587 (13.9)	21 914 (8.3)	1033 (13.9)	2996 (13.4)
2006	2682 (14.4)	19 258 (7.3)	667 (9.0)	2730 (12.2)
2007	2660 (14.3)	18 830 (7.1)	560 (7.5)	2746 (12.3)
2008	2020 (10.9)	16 797 (6.4)	445 (6.0)	2218 (9.9)
2009	1581 (8.5)	15 678 (5.9)	272 (3.7)	1665 (7.5)
2010	979 (5.3)	16 169 (6.1)	204 (2.7)	1185 (5.3)
2011	558 (3.0)	17 006 (6.4)	146 (2.0)	806 (3.6)

MoMR=metal-on-metal hip resurfacing; THR=total hip replacement; SD=standard deviation; IQR=interquartile range; IMD=Index of Multiple Deprivation. Data are number (%) of patients or procedures, unless stated otherwise.

*Matching 1:3 datasets.

Table 2| **Baseline characteristics of patients: metal-on-metal hip resurfacing versus uncemented total hip replacement**

	Before matching (whole study cohort)		After propensity score matching*	
	MoMR (n=18 599)	**Uncemented THR (n=121 144)**	**MoMR (n=8101)**	**Uncemented THR (n=24 303)**
Deaths at 10 year follow-up	433 (2.3)	8038 (6.6)	239 (3.0)	999 (4.1)
Duration of follow-up (years; median (IQR))	5.5 (3.7-7.3)	3.4 (1.6-5.9)	5.8 (3.7-8.0)	4.6 (2.9-6.5)
Age at operation				
Mean (SD)	53.8 (8.5)	65.2 (10.4)	57.2 (8.1)	57.7 (8.9)
<50 years	5341 (28.7)	8340 (6.9)	1198 (14.8)	4172 (17.2)
50-60 years	8508 (45.8)	24 952 (20.6)	3212 (39.6)	9758 (40.2)
60-70 years	4387 (23.6)	45 640 (37.7)	3342 (41.3)	9291 (38.2)
70-80 years	341 (1.8)	32 613 (26.9)	333 (4.1)	1036 (4.3)
>80 years	16 (0.1)	9509 (7.9)	16 (0.2)	46 (0.2)
Sex				
Male	12 699 (68.3)	53 331 (44.1)	4467 (55.1)	14 236 (58.6)
Female	5899 (31.7)	67 671 (55.9)	3634 (44.9)	10 067 (41.4)
IMD 2004 deprivation score				
Group 1 (most deprived)	3251 (17.8)	23 511 (19.7)	1615 (19.9)	4602 (18.9)
Group 2	3489 (19.1)	23 953 (20.1)	1574 (19.4)	4784 (19.7)
Group 3	3455 (18.9)	24 095 (20.2)	1592 (19.7)	4728 (19.5)
Group 4	3766 (20.7)	23 624 (19.8)	1607 (19.8)	4853 (20.0)
Group 5 (least deprived)	4276 (23.4)	24 117 (20.2)	1713 (21.1)	5336 (22.0)
Rurality				
Urban	13 682 (74.1)	87 644 (72.6)	6080 (75.1)	18 053 (74.3)
Town or fringe	1885 (10.2)	14 370 (11.9)	836 (10.3)	2569 (10.6)
Village or hamlet	2906 (15.7)	18 701 (15.5)	1185 (14.6)	3681 (15.1)
Charlson comorbidity				
None	16 852 (90.6)	100 099 (82.6)	7158 (88.4)	21 397 (88.0)
Mild	1584 (8.5)	17 344 (14.3)	844 (10.4)	2589 (10.7)
Moderate	129 (0.7)	2810 (2.3)	78 (1.0)	239 (1.0)
Severe	34 (0.2)	891 (0.7)	21 (0.3)	78 (0.3)
Volume of THR procedures per year				
0-163 (group with fewest procedures)	3340 (18.0)	24 268 (20.0)	1467 (18.1)	4448 (18.3)
164-222	3283 (17.7)	24 809 (20.5)	1486 (18.3)	4421 (18.2)
223-287	3308 (17.8)	26 654 (22.0)	1556 (19.2)	4762 (19.6)
288-444	3659 (19.7)	23 705 (19.6)	1458 (18.0)	4719 (19.4)
445-1106 (group with most procedures)	5009 (26.9)	21 708 (17.9)	2134 (26.3)	5953 (24.5)
Volume of MoMR procedures per year				
1-3 (group with fewest procedures)	711 (3.8)	122 917 (47.7)	701 (8.7)	2094 (8.6)
4-7	1282 (6.9)	15 962 (13.2)	1067 (13.2)	2868 (11.8)
8-15	2863 (15.4)	16 249 (13.4)	1801 (22.2)	5045 (20.8)
16-30	4186 (22.5)	14 733 (12.2)	2002 (24.7)	5881 (24.2)
31-181 (group with most procedures)	7442 (40.0)	14 266 (11.8)	1981 (24.5)	7067 (29.1)
Outlier (Royal Orthopaedic Hospital NHS Trust)	2115 (11.4)	2179 (1.8)	549 (6.8)	1348 (5.5)
Financial year of operation				
1999	262 (1.4)	2886 (2.4)	235 (2.9)	332 (1.4)
2000	404 (2.2)	2963 (2.4)	286 (3.5)	358 (1.5)

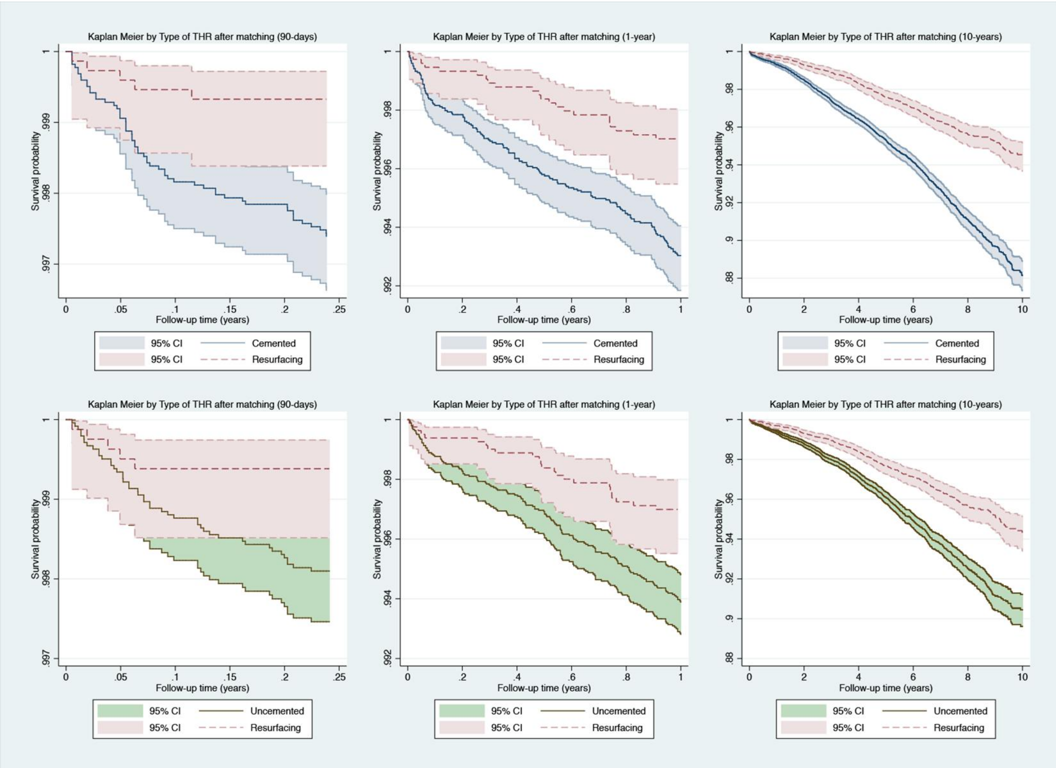
Table 2 (continued)

	Before matching (whole study cohort)		After propensity score matching*	
	MoMR (n=18 599)	Uncemented THR (n=121 144)	MoMR (n=8101)	Uncemented THR (n=24 303)
2001	593 (3.2)	3084 (2.5)	419 (5.2)	585 (2.4)
2002	921 (5.0)	3932 (3.2)	533 (6.6)	826 (3.4)
2003	1315 (7.1)	4950 (4.1)	625 (7.7)	1215 (5.0)
2004	2037 (11.0)	6563 (5.4)	909 (11.2)	1998 (8.2)
2005	2587 (13.9)	7965 (6.6)	958 (11.8)	2673 (11.0)
2006	2682 (14.4)	9997 (8.3)	947 (11.7)	3183 (13.1)
2007	2660 (14.3)	12 761 (10.5)	901 (11.1)	3639 (15.0)
2008	2020 (10.9)	14 765 (12.2)	821 (10.1)	3429 (14.1)
2009	1581 (8.5)	16 156 (13.3)	699 (8.6)	2985 (12.3)
2010	979 (5.3)	17 525 (14.5)	468 (5.8)	1898 (7.8)
2011	558 (3.0)	17 597 (14.5)	300 (3.7)	1182 (4.9)

MoMR=metal-on-metal hip resurfacing; THR=total hip replacement; SD=standard deviation; IQR=interquartile range; IMD=Index of Multiple Deprivation. Data are number (%) of patients or procedures, unless stated otherwise.

*Matching 1:3 datasets.

Figure



Kaplan Meier survival curves by type of operation after matching. THR=total hip replacement; cemented or uncemented=type of total hip replacement; resurfacing=metal-on-metal hip resurfacing. Numbers at risk are available in the web appendix