



**Cost-effectiveness of total hip arthroplasty versus resurfacing arthroplasty: economic evaluation alongside a clinical trial**

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-001162
Article Type:	Research
Date Submitted by the Author:	29-Mar-2012
Complete List of Authors:	Edlin, Richard; University of Auckland, Health Systems, School of Population Health Tubeuf, Sandy; University of Leeds, Academic Unit of Health Economics Achten, Juul; University of Warwick, Division of Health Sciences Parsons, Nicholas; University of Warwick, Division of Health Sciences Costa, Matthew; University of Warwick, Warwick Clinical Trials Unit
<b>Primary Subject Heading</b>:	Health economics
Secondary Subject Heading:	Surgery
Keywords:	Hip < ORTHOPAEDIC & TRAUMA SURGERY, Adult orthopaedics < ORTHOPAEDIC & TRAUMA SURGERY, Orthopaedic & trauma surgery < SURGERY

SCHOLARONE™  
Manuscripts

1  
2  
3 **Objectives:** To report on the relative cost-effectiveness of total hip arthroplasty and  
4 resurfacing arthroplasty (replacement of articular surface of femoral head only) in patients  
5 with severe arthritis suitable for hip joint resurfacing arthroplasty.  
6  
7

8 **Design:** Cost-effectiveness analysis (cost per QALY) on an intention to treat basis of a single-  
9 centre, single-blind randomised controlled trial of 126 adult patients within 12 months of  
10 treatment. Missing data was assessed using multiple imputations with differences in  
11 baseline quality of life and gender adjusted using regression techniques.  
12  
13

14 **Setting:** A large teaching hospital trust in the UK  
15

16 **Participants:** 126 adult patients with severe arthritis of the hip joint suitable for a  
17 resurfacing arthroplasty of the hip.  
18  
19

20 **Results:** Data was received for 126 patients, 4 of whom did not provide any resource use  
21 data. For the remainder, data was imputed for costs or quality of life in at least one time  
22 point (baseline, 3 months, 6 months, 1 year) for 18 patients. Patients in the resurfacing arm  
23 had higher quality of life at 12 months (0.795 vs. 0.727) and received 0.033 more QALYs  
24 within the first 12 months post operation. At an additional cost of £410, resurfacing  
25 arthroplasty offers benefits at £12,374 per QALY within the first 12 months of treatment.  
26 When covariates are considered, the health economic case is stronger in men than women.  
27  
28  
29

30 **Conclusions:** Resurfacing arthroplasty appears to offer very short term efficiency benefits  
31 over total hip arthroplasty within a selected patient group. This conclusion should be tested  
32 over a longer period through longer series following up resurfacing arthroplasty and through  
33 decision analytic modelling.  
34  
35

36 **Trial registration:** Current controlled Trials ISRCTN33354155. UKCRN 4093.  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**Funding statement**

The work described in this manuscript has been funded through the Research for Patient Benefit scheme of the NIHR, grant number PB-PG-0706-10080. This manuscript presents independent research commissioned by the National Institute of Health Research. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.:

For peer review only

## Introduction

Hip arthroplasty is acknowledged to be a highly effective and cost-effective procedure for treating patients with severe arthritis of the hip joint, with 87% of patients reporting an improvement in their general health following surgery.<sup>1</sup> The total health gain is expected to be substantial given the effectiveness of treatment; EQ-5D based quality of life improvements following surgery are estimated to be 0.409, within the 45,000 cases measured in the UK Patient Reported Outcomes programme<sup>2</sup>. 97% of UK hip replacements are still working (unrevised) at 5 years<sup>3</sup> and 83% of all primary hip arthroplasty (all age, all implant types) are unrevised at 17 years post surgery in Sweden<sup>4</sup>. If the initial quality of life gains are maintained, each unrevised surgery represents over five discounted QALYs gained and a benefit of over one hundred thousand pounds at the £20,000 per QALY threshold used by NICE. Compared to these gains, the costs of hip arthroplasty surgery appear modest. As a result, most analyses considering health economics have concentrated on questions of which type of prosthesis to use, and many cost-effectiveness analyses have involved analysis of newer, more expensive operations against older, established comparators.<sup>5-7</sup> Resurfacing arthroplasty of the hip is a newer alternative form of arthroplasty designed for younger, active patients with severe arthritis of the hip.

Hip resurfacing arthroplasty involves the insertion of an acetabular component and the 'capping' of the femoral neck, rather than its removal and replacement with a femoral component in a standard total hip arthroplasty. Of the 70,000 hip arthroplasty operations conducted in England and Wales every year<sup>3</sup>, approximately 6% are hip resurfacings. The equivalent figure amongst men aged under 55 is 33%. As resurfacing preserves the bone of the proximal femur, it may be expected to provide better clinical outcomes on revision of this component than available with a standard hip arthroplasty. Despite advances in their construction, there are still questions about the durability of modern resurfacing implants and there have been few explicit economic evaluations comparing resurfacing arthroplasties against total hip arthroplasties.<sup>8-9</sup> Few RCTs have been conducted to assess the outcomes of hip resurfacing, and those that exist provide little detail about the economic costs and benefits within the initial year following surgery. This paper reports the first within-trial economic evaluation of resurfacing arthroplasty versus total hip arthroplasty.

## Methods

### Interventions and sample

This evaluation reports on the efficiency of resurfacing arthroplasty versus total hip arthroplasty. Patients were deemed eligible for the trial if they were aged over 18 years of age, were medically fit for an operation, and were deemed suitable to receive a resurfacing arthroplasty. Patients were only excluded from the study if there was evidence that the patient would be unable to adhere to trial procedures or complete questionnaires. Patients were randomised on a 1:1 basis between THA and RSA, with each patient operated on according to the preferred technique of the operating surgeon. Other perioperative interventions, such as prophylactic antibiotics and thrombo-prophylaxis were the same for all patients and the same standardised rehabilitation plan was employed for both trial arms. Further details on recruitment and randomisation procedures are reported elsewhere.<sup>10</sup>

### Perspective

The aim of the economic study is to determine the intervention that would maximise health outcomes within the limited NHS budget in this period, and so a cost-effectiveness (cost-utility) analysis with an NHS and Personal Social Services (PSS) perspective is adopted. This paper considers the within-trial period (as intention to treat) of the first 12 months follow up. It considers only resources used within the NHS setting including any aids and adaptations required. The base year for all costs figures was 2009/10, with figures from other years converted using the HCHS Pay and Prices Index (for adults, excluding capital).<sup>11</sup> For current costs, figures are deflated assuming an estimated inflation rate of 1.9% to 2010 from this index for both 2009/10 and 2010/11. As the analysis uses a one year time horizon, discounting for the future cost and health outcome is not necessary in this analysis. The currency used was the pound sterling (£).

### Quality of life

Responses from the EQ-5D were obtained from patients at baseline, 3 months, 6 months and 12 months as secondary outcomes of the trial<sup>10</sup>; results from other outcomes are reported in greater depth elsewhere.<sup>12</sup> The standard tariff values<sup>13</sup> were applied to these responses at each time point to provide EQ-5D quality of life values. Quality-adjusted life-years (QALYs) were calculated as an “area under the curve” and form the main outcome measure of the study.

### Resource use and valuation

The costs of THA and RSA treatments were considered across six broad categories – the costs of the initial operation, of inpatient care post-discharge, of outpatient care, of primary/community care, and of medications, and aids/adaptations required whilst in the community.

The current Healthcare Resource Group v.4 (HRG4) reference costs do not include a single category for primary replacements (as appeared in previous versions). Identified HRG4 frequencies for primary hip replacements are available<sup>14</sup> and these are used to calculate average costs, average length of stay, and average cost per excess bed day. Using these figures, the average cost of the initial hospitalisation is calculated for each patient by using the mean cost and LOS figures and adjusting for each patient's length of stay (as a number of bed days from the mean). In this way, a person admitted for the average length of stay would be assigned the average cost of treatment, with those staying shorter and longer periods assigned lower and higher costs, respectively.

These initial cost figures were calculated for both THA and RSA groups, and used as costs for the initial operation in the THA group. For the RSA group, the operative costs for THA are adjusted for differences in the expected implant/operative costs. All RSA patients received a Cormet resurfacing (Corin Group, Cirencester, UK), whilst THA patients received their surgeon's preference of prosthesis. For THA, prosthesis type was identified from patient records with three types of bearing surface (ceramic femoral head on ceramic socket, metal-on-metal and metal-on-polyethylene) accounting for 95% of cases. The University Hospitals Coventry and Warwickshire NHS Trust Finance Department provided implant costs for both the resurfacing implant and representative cost figures for the three types of prosthesis used. The expected difference in implant costs between RSA and THA patients was added to the operative costs for RSA patients and adjusted for inflation.

Patient-reported data on resource usage were collected alongside other outcomes at 3 months, 6 months and 12 months. For the 3 month data, the recall period was since discharge from hospital. For the other cases, it was since the last questionnaire was due to be completed. The questionnaires included sections on further inpatient care following the initial operation (speciality and length of stay/day case), outpatient care, primary and community care, aids and adaptations provided by the NHS/social services, and medication (pain relief and other NHS medication). Medicines usage was estimated based on mean dosage when used and average usage within the three budgetary periods (discharge to 3 months, 3-6 months, 6-12 months). In order to convert resource usage figures into costs, unit cost figures were assigned from NHS Reference costs<sup>15</sup>, PSSRU unit costs<sup>11</sup>, NHS Electronic

1  
2  
3 Drug Tariff<sup>16</sup>, and relevant RCTs in the relevant year. Individual resource items and unit prices,  
4 including for aids and adaptations, are available in Tables provided as a Web Extra. Where resource  
5 usage data is analysed between trials, t-tests are used to calculate for significance in expected usage.  
6  
7

8  
9 Data on personal costs (private treatments, out of pocket expenditures and time off work) were also  
10 collected but are not reported in the present analysis. Productivity data may be of some relevance  
11 given the age of participants but is outside the scope of the perspective used here.  
12  
13

### 14 15 16 Cost-effectiveness

17  
18 Using the methods identified above, total costs and QALY figures were calculated for all patients  
19 where response data was available. For those cases in which either resource usage or quality of life  
20 data was unavailable, these figures cannot be calculated. In these cases, we used multiple  
21 imputation via chained equations<sup>17</sup> to complete missing data using STATA 11 (StataCorp 2009, TX,  
22 USA).<sup>18 19</sup> Missing cost data was predicted in terms of QALYs, treatment received, length of stay  
23 (LOS), age, gender, height, weight, and baseline clinical scores (Oxford Hip, Harris Hip); missing QALY  
24 data was predicted in terms of this same list (excluding QALYs), plus each of the cost items; missing  
25 LOS was predicted using the same list as for QALYs, with QALYs included. In order to remove  
26 implausible data, missing cost data was constrained to be positive and length of stay was  
27 constrained to be at least 3 days post-imputation. A total of 500 imputations were used to inform  
28 each item of missing data.  
29  
30  
31  
32  
33  
34  
35  
36

37  
38 For the cost-effectiveness analysis, we identified the differences between costs and QALYs between  
39 the two arms, dividing the former by the latter to compute an incremental cost-effectiveness ratio  
40 (ICER). When compared against the marginal trade-off for the NHS as a whole – the cost-  
41 effectiveness threshold – the ICER gives an indication of whether spending additional money on hip  
42 arthroplasty appears efficient. This analysis is used as our base case.  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

### Scenarios/univariate sensitivity analyses

Key uncertainties in the scenarios considered were explored using univariate sensitivity analyses. The results for complete cost and quality of life data (i.e. those with no missing data) were provided to identify the impact of missing data on the analysis, as is a strict per-protocol analysis of the data to reflect any sensitivity to protocol violations. As patients might also recover function within the first three months (rather than continuously to three months), a quicker initial recovery was explored in QALY calculations, where each patient's quality of life was assumed to reach its observed 3 month level at 6 weeks post-operatively. (When imputing for missing data, this was performed alongside the main imputation, using the same predictors as when imputing for the base case QALY measure.) The cost assumptions in the analysis were modified by assessing the impact of assuming the least expensive THA implant was used throughout with no effect on observed outcomes, to reflect the potential concern that the THA arm might not reflect cost-effective practice.

### Adjustment for baseline differences

As the baseline randomisation did not stratify by quality of life, the impact of potential baseline differences are corrected for using regression analysis. The number of QALYs received (average quality of life over 12 months) is assumed to be a normal distribution, conditional on whether a resurfacing was intended, gender and baseline EQ-5D value. Likewise, total cost over 12 months is assumed to be lognormal, so that the natural logarithm of costs is a normal distribution, conditional on resurfacing, gender and baseline EQ-5D.

As any relationship between uncertainty in the extra costs and benefits associated with RSA is important when assessing the likelihood of cost-effectiveness, equations for cost and QALYs must be estimated together. As the statistical methods to do this are not established with multiply-imputed data, the data were first averaged across imputations before the equations were estimated as seemingly-unrelated regression<sup>20</sup>. Estimates of both cost and QALY outcomes were generated by considering the impact of clinical option (RSA vs. THA), the impact of covariates on outcomes (baseline EQ-5D and gender) for the population enrolled in the trial, and the relationships between each of these parameters. An overall ICER and cost-effectiveness acceptability curve (CEACs)<sup>21</sup> was obtained by sampling for all parameters within the variance-covariance matrix. As gender so heavily affects the clinical use of RSA, this analysis was also repeated allowing the effects of RSA to be assessed separately for men and women.



## Results

### Trial recruitment

The trial recruited a total of 126 patients (RSA=60; THA=66) between May 2007 to February 2010. Two patients from each arm of the study did not have surgery and provided only baseline quality of life/demographic data, leaving a total of 58 and 64 patients in each arm. As the analysis estimates data on costs and outcomes conditional on baseline quality of life, these patients cannot contribute any data to our analysis and are excluded from the analyses here.

### Quality of life

Table 1 summarises quality of life estimates at the four time points and calculates QALY estimates both with and without data imputation in the two arms. Overall, those in the RSA group started in worse health (as measured by the EQ-5D) and received 0.033 more QALYs within the 12 months of the trial. Within the trial, the difference in quality of life between the RSA and THA arms of the trial appears to increase at each post-operative time point.

### Costs and resource usage

Overall, NHS and social care costs were significantly higher amongst the RSA group with an average of £410 more spent within the first 12 months from the operation (Table 2), of which the majority is due to further inpatient care after initial discharge (£279) and outpatient care (£83). Relatively little of the cost difference between RSA and THA was due to the initial operation, as the deflated cost of the RSA implants including operative consumables used in this study was £1,850 vs. an average of £1,738 for THA operations. The trial used surgeon's preference of THA implant and as expected this implant as well as consumables cost varied by the type of implant, with the most expensive being ceramic on ceramic implants (£2,042) and those using metal on metal implants costing slightly less than RSA implants (£1,625). Implants and consumables in metal on polyethylene operations (£843) were associated with only 40% of the cost of ceramic on ceramic implant. Whilst the resurfacing implants were more expensive, they were also associated with a slightly shorter length of stay (5.7 vs. 5.5 days), although this difference was not statistically significant ( $P = 0.528$ ). In total, costs in the

1  
2  
3 initial operative period were only £31 more expensive in the resurfacing group, although it is  
4 acknowledged that this might differ if less expensive types of implant were used.  
5  
6

7  
8 Those in the RSA arm had significantly more outpatient visits than those in the THA arm (5.155 vs.  
9 3.063,  $P = 0.0054$ ). Here, both the number of physiotherapy sessions and the use of DVT  
10 assessments were significantly higher amongst this group ( $P = 0.002$ ,  $P = 0.011$ ). For inpatient care,  
11 only subsequent inpatient attendances (0.155 vs. 0.047,  $P = 0.066$ ) approached significance, with the  
12 only significant difference ( $P = 0.009$ ) in aids and adaptations favouring RSA. For full details on  
13 individual resource use items and their unit costs, please see the tables available as a Web Extra.  
14  
15  
16  
17

### 18 19 Cost-effectiveness and sensitivity analyses

20  
21  
22 Whilst RSA is expected to cost more over the first 12 months following an operation, it appears to  
23 provide a difference in quality of life. Here, the incremental cost-effectiveness ratio (ICER) for RSA is  
24 £12,374 per QALY (£410/0.033 QALY). Within most of the sensitivity tests explored here, the figure  
25 appears to remain below the £20k-£30k per QALY range used by the National Institute for Health  
26 and Clinical Excellence as its estimate of the cost-effectiveness threshold, except where cheaper THA  
27 implants are used in place of surgeon's preference (Table 3). If cheaper (metal-on-polyethylene)  
28 implants are used, the increased cost of RSA vs. THA implants is enough to raise the average cost  
29 difference above £1,000 which, given the small quality of life difference observed here, is enough to  
30 prevent RSA being cost effective.  
31  
32  
33  
34  
35  
36  
37

### 38 39 Adjustment for baseline differences

40  
41  
42 Once baseline differences in EQ-5D and the numbers of men and women in each arm are  
43 considered, the QALY estimates for the first 12 months appear to change. Within the regression  
44 analysis, those treated in the RSA arm receive 0.059 more QALYs than those treated with THA  
45 ( $P=0.064$ ), as do women ( $P=0.126$ ) and people with better baseline EQ-5D scores ( $P<0.001$ ). In  
46 contrast, incremental costs appears to be relatively unaffected by either EQ-5D or gender, with no  
47 significant relationships found on either regressions ( $P=0.769$ ;  $P=0.211$ ). When considering the  
48 revised base case, costs are 4.9% higher (95%CI: 1.1%-8.9%) for those who received RSA when other  
49 factors are removed.  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 Whilst correcting for baseline differences leaves the incremental costs largely unchanged (£354;  
4 95%CI: 85-623), the estimated QALY benefit almost doubles (0.059, 95%CI: -0.004-0.122).  
5  
6 Consequently, the ICER is around half as large (£5,980 per QALY) as the non-adjusted case. In 89% of  
7 cases investigated, RSA is recommended when valuing health at £20,000 per QALY – suggesting that  
8 there is very little parameter uncertainty that RSA is the most cost-effective option within the first  
9  
10 12 months of treatment (Figure 1).  
11  
12

13  
14  
15  
16 Whilst the incremental cost and QALY figures are not significantly related to gender (cost interaction  
17 0.034, P=0.373; QALY interaction -0.385, P=0.551), their potential impact is relatively large. For  
18 women, RSA had higher costs and lower benefits, with the latter exacerbated by a much lower  
19 baseline quality of life (female 0.257, male 0.389). This led to an ICER of £13,800 per QALY for RSA,  
20 with a 58% chance of being cost-effective at £20,000 per QALY. Correspondingly, the ICER for men  
21 decreased to £3,445 per QALY, with a 92% chance of cost-effectiveness at £20,000 per QALY.  
22  
23  
24  
25  
26  
27  
28  
29

## 30 Discussion

31  
32  
33 In comparison to standard total hip arthroplasty, hip resurfacing arthroplasty appears to provide a  
34 modest QALY gain for a modest sum within the first 12 months from surgery; whilst the additional  
35 costs of RSA are statistically significant, the additional benefits are not. The analysis presented here  
36 analyses the data by considering potential confounding due to both gender and baseline quality of  
37 life, and this nearly doubles the estimate of RSA effect size. Whilst the main analysis of the trial  
38 data<sup>12</sup> found no statistically significant difference between the RSA and THA groups at 12 months, it  
39 seems likely that some short term difference in quality of life exists favouring RSA and that – again  
40 within 12 months – there is enough evidence to suggest that it may be cost-effective.  
41  
42  
43  
44  
45  
46  
47  
48

49  
50 Within the first 12 months of treatment, the main caveat to our results deals with the comparator  
51 THA arm. The pragmatic nature of the trial data used here<sup>12</sup> is one of its key strengths, since it  
52 reflects current practice. Any changes to this practice may affect cost-effectiveness though, so that  
53 RSA may become more/less cost-effective as less/more cost-effective THA implants are used. A  
54 recent (US) analysis of registry data suggests that more expensive implants do not provide a  
55  
56  
57  
58  
59  
60

1  
2  
3 substantive age-adjusted advantage over less expensive prostheses.<sup>22</sup> Where the sensitivity analysis  
4 assumed the use of the cheapest metal-on-polyethylene implants (without incorporating a possible  
5 impact on quality of life), RSA was no longer cost-effective within-trial.  
6  
7  
8  
9

10  
11 Clearly, the cost-effectiveness of resurfacing is likely to require assessment over a longer period of  
12 time – as is typically the case for any health economic analysis of trial data.<sup>23</sup> Importantly, the higher  
13 revision rates reported for resurfacing arthroplasty suggest that the additional costs of RSA may be  
14 higher if a longer period is considered. On the benefit side of the equation, the impact of extending  
15 the time period is unclear as RSA may improve quality of life in the short term but lead to a quicker  
16 deterioration once revisions are necessary. One method to explore these questions may be decision  
17 analytic modelling.<sup>23</sup> The trial provides an estimate of short term clinical benefits from hip function  
18 and quality of life (conditional on EQ-5D), with longer follow up series (from trials or registry data)  
19 needed to model implant survival for both RSA and THA.  
20  
21  
22  
23  
24  
25  
26  
27  
28

29 As THA revision surgery may be surgically more complex, financially more costly, and less effective  
30 than a primary THA, a key question when interpreting this study is the prognosis for patients after  
31 their RSA is revised. An Australian registry analysis suggests poor implant survival amongst patients  
32 receiving a revision of only the acetabular RSA component, and some evidence of higher revision  
33 risks among other types of RSA revisions such as where both components are revised.<sup>24</sup> It is unclear,  
34 however, whether a revised RSA is more similar, in terms of quality of life, to a primary THA or a  
35 revision THA. Further research is necessary to assess the likely impact of this and other questions to  
36 guide future research, and the findings of this paper are by no means a complete answer to the  
37 decision problem.  
38  
39  
40  
41  
42  
43  
44  
45  
46

47 Registry data reveals that women represent 61% of primary THA patients in the UK but make up only  
48 25% of RSA patients.<sup>3</sup> These figures reflect relevant gender differences from both a clinical and a  
49 health economic perspective as women appear to obtain higher quality of life gains from THA, and  
50 face an increased revision rate from RSA.<sup>4,25</sup> This trial may also suggest a lower benefit from RSA  
51 relative to THA amongst women, although the finding was not statistically significant (or powered to  
52 be so). Despite the conclusions of the within-trial analysis, it seems clear that until such work is done  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 and further data is available, the cost-effectiveness of resurfacing arthroplasty in a UK context  
4 remains potentially promising but as yet unproven.  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

**Table 1. EQ-5D quality of life at each measurement and converted into QALYs (missing data imputed)**

Quality of life	RSA (SD) n =58	THA (SD) n =64	Difference (95% CI)
Baseline	0.308 (0.338)	0.356 (0.335)	-0.048 (-0.168, 0.073)
3 months	0.722 (0.229)	0.698 (0.284)	0.023 (-0.711, 0.118)
6 months	0.796 (0.244)	0.747 (0.287)	0.050 (-0.046, 0.146)
12 months	0.795 (0.282)	0.727 (0.319)	0.067 (-0.042, 0.177)
QALYs	0.716 (0.216)	0.683 (0.252)	0.033 (-0.053, 0.120)
QALYs*	0.713 (0.216)	0.680 (0.251)	0.033 (-0.053, 0.120)

\* With imputed data

For peer review only

Table 2. Costs by type, summed across trial period (missing data imputed)

Costs	RSA (SD) n =58	THA (SD) n =64	Difference (95% CI)
Initial operation/care	6740 (528)	6710 (482)	31 (-155, 217)
Subsequent inpatient	464 (953)	184 (556)	279 (-11, 569)
Outpatient	359 (292)	276 (211)	83 (-13, 179)
Primary/community	63 (98)	49 (70)	14 (-18, 45)
Aids and adaptations	21 (34)	21 (40)	0 (-13, 14)
Medication	26 (41)	23 (39)	3 (-12, 18)
Total Costs	7675 (1078)	7265 (647)	410 (79, 740)

Table 3. Incremental cost effectiveness

Scenario	Incremental costs	Incremental QALYs	ICER (Cost per QALY)
Base case (BC)	410 (79, 740)	0.033 (-0.053, 0.120)	12,374
Per protocol	472 (117, 826)	0.025 (-0.64, 0.114)	19,187
Complete case data (no imputation)	420 (70, 770)	0.032 (-0.062, 0.127)	12,961
BC + cheaper THA implants	1130 (777, 1484)	0.033 (-0.053, 0.120)	31,134
BC + quicker initial recovery	410 (79, 740)	0.039 (-0.048, 0.125)	10,518
Adjustments for EQ-5D, gender (all)	356 (84, 630)	0.059 (-0.003, 0.122)	6,054
Adjustments for EQ-5D, gender (male)	258 (-96, 612)	0.075 (-0.006, 0.156)	3,445
Adjustments for EQ-5D, gender (female)	499 (81, 916)	0.036 (-0.061, 0.134)	13,799



## References

- Please ensure that all references are in the following format:

1 (list 3 authors et al if there are more than 3, or all author names if there are fewer) Surname AB, Surname CD. Article title. Journal abbreviation Year;Vol:Start page-End page. (see punctuation and no month after year of publication)

1. Health Episodes Statistics Online. Finalised PROMs data 2009-10, 2011.
2. Health Episodes Statistics Online. PROMs Score Comparisons April 2009 to February 2011: The NHS Information Centre for Health and Social Care, 2011.
3. Ellams D, Forsyth O, Mistry A, et al. *7th Annual Report*. National Joint Registry for England and Wales, 2010.
4. Garellick G, Kärrholm J, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2008. Shortened Version*. Department of Ortopaedics, Sahlgrenska University Hospital, 2009.
5. Bozic KJ, Morshed S, Silverstein MD, et al. Use of cost-effectiveness analysis to evaluate new technologies in orthopaedics: the case of alternative bearing surfaces in total hip arthroplasty. *Journal of Bone and Joint Surgery* 2006;88(4):706-14.
6. Briggs A, Sculpher M, Dawson J, et al. Modelling the cost-effectiveness of primary hip replacement: how cost-effective is the Spectron compared to the Charnley prosthesis? *York - CHE - Technical Paper* 2003;28.
7. Fitzpatrick R, Shortall E, Sculpher M, et al. Modelling of cost-effectiveness of THR: methods and results and discussion in primary total hip replacement surgery: a systematic review of outcomes and modelling of cost-effectiveness associated with different prostheses. *Health Technology Assessment* 1998;2(20):17-32.
8. Vale L, Wyness L, McCormack K, et al. A systematic review of the effectiveness and cost-effectiveness of metal-on-metal hip resurfacing arthroplasty for treatment of hip disease. *Health Technology Assessment* 2002;6(15).
9. Bozic KJ, Pui CM, Ludeman MJ, et al. Do the Potential Benefits of Metal-on-Metal Resurfacing Justify the Increased Cost and Risk of Complications? *Clinical Orthopaedics andn Related Research* 2010;468:2301-12.
10. Achten JA, Parsons NR, Edlin RE, et al. A randomised controlled trial of total hip arthroplasty versus resurfacing arthroplasty in the treatment of young patients with arthritis of the hip joint. *BMC Musculoskeletal Disorders* 2010;11(8).
11. Curtis L. Unit Costs of Health & Social Care 2010. Personal and Social Services Research Unit, 2010.
12. Costa ML, Achten J, Parsons NR, et al. A Randomised Controlled Trial of Total Hip Arthroplasty Versus Resurfacing Arthroplasty in the Treatment of Young Patients with Arthritis of the Hip Joint. *British Medical Journal* 2012;(IN PRESS).
13. Dolan P. Modeling valuations for EuroQol health. *Medical Care* 1997;35(11):1095-108.
14. *HRG version 3.5 & HRG4 Comparative Chapter Analysis*: The Health & Social Care Information Centre., 2008.
15. *National Schedule of Reference Costs 2009-10. Appendix NSRC04: NHS Trusts and PCTs combined reference cost schedules*. London: Crown Copyright, 2011.
16. *NHS. Electronic Drug Tariff: May 2011*. National Health Service England and Wales, 2011.
17. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine* 2011;30(4):377-99.
18. Royston P. Multiple imputation of missing values: further update of ice, with an emphasis on interval censoring. *The Stata Journal* 2007;7(4):445-64.
19. Royston P, Carlin JB, White IR. Multiple imputation of missing values: New features for mim. *The Stata Journal* 2009;9(2):252-64.

- 1  
2  
3 20. Willan AR, Briggs AH, Hoch JS. Regression methods for covariate adjustment and subgroup  
4 analysis for non-censored cost-effectiveness data. *Health Economics* 2004;13:461-75.  
5 21. Fenwick E, Byford S. A guide to cost-effectiveness acceptability curves. *British Journal of*  
6 *Psychiatry* 2005;187:106-8.  
7 22. Gioe TJ, Sharma A, Tatman P, et al. Do "Premium" Joint Implants Add Value? *Clinical*  
8 *Orthopaedics and Related Research* 2011;469:48-54.  
9 23. Petrou S, Gray A. Economic evaluation using decision analytical modelling: decision, conduct,  
10 analysis, and reporting. *British Medical Journal* 2011;342:doi: 10.1136/bmj.d766.  
11 24. de Steiger RN, Miller LN, Prosser GH, et al. Poor outcome of revised resurfacing hip arthroplasty.  
12 397 cases from the Australian Joint Replacement Registry. *Acta Orthopaedica* 2010;81(1):72-  
13 76.  
14 25. Kärrholm J, Garellick G, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2007*:  
15 Department of Ortopaedics, Sahlgrenska University Hospital, 2008.  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



Figure 1: Cost-Effectiveness Acceptability Curve for Resurfacing Arthroplasty (vs. THA) 189x109mm (96 x 96 DPI)

review only

Web Extra: Table 1 – Unit cost of resources

Item	Cost	Source
<b>Initial Operation</b>		
Cost for average THA	£6381	Uses weighted average of outcomes from HB11B, HB11C, HB12A, HB12B, HB12C.*
Average LOS for THA	6.57 days	
Adjustment per day ± av. LOS	£296	
THA: implant + consumables	£2,042	Ceramic femoral head, ceramic socket
	£1,625	Metal femoral head, metal socket
	£843	Metal femoral head, polyurethane socket
	£1,738	Weighted average of THA implants + consumables
RSA: implant + consumables	£1,850	Cornet resurfacing
<b>Subsequent Inpatient Care</b>		
<b>Inpatient (orthopaedics)</b>		
Day case	£874	TPCTDC. Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Cost for average LOS	£1,888	TPCTEI: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Average LOS	1.98 days	TPCTEI: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Adjustment per day ± av. LOS	£340	TPCTEIXS: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
<b>Inpatient (other)</b>		
Elective, non-investigational	£668	Average across all day cases (TPCTDC)*
Elective, investigational	£243	Average cost radiotherapy inpatient, PSSRU 2010
Acute surgical/medical	£535	Average across all non-elective (short stay) cases (TPCTNEI_S)
<b>Outpatient care</b>		
Orthopaedics	£96	OPATT: Trauma & Orthopaedics: Non-Trauma (110N)*
Haematology	£128	OPATT: Clinical Haematology (303)*
Pathology or radiology	£114	Average cost per outpatient radiotherapy contact, PSSRU 2010
Ophthalmology	£80	OPATT: Ophthalmology (130)*
Orthotics	£96	OPATT: Trauma & Orthopaedics: Non-Trauma (110N)*
Physiotherapy	£39	OPATT: Physiotherapy Total Attendances - Adult (19 and Over (650A))*
Chiropractor	£17	Ongoing treatment session from UK BEAM trial <a href="http://www.bmj.com/content/329/7479/1381.full">http://www.bmj.com/content/329/7479/1381.full</a> costed at £12.17 in 2000 base year. Reflated using NHS Pay and Prices Index.
Dermatology	£92	OPATT: Dermatology (330)*
Acupuncture	£30	Ongoing treatment session from RCT <a href="http://www.bmj.com/content/333/7569/626.full">http://www.bmj.com/content/333/7569/626.full</a> costed at £24 in 2002-3 base year. Reflated using NHS Pay and Prices Index.
Accident and Emergency	£113	OPATT: Accident and Emergency (180)*
DVT assessment service	£129	TPCTDC. Deep Vein Thrombosis (QZ20Z)*
Heart specialist/cardiologist	£124	OPATT: Cardiology (320)*
Urology	£99	OPATT: Urology (101)*
Neurophysiologist/neurologist	£166	OPATT: Neurology (400)*
Eye clinic	£80	OPATT: Ophthalmology (130)*
Oncologist	£107	OPATT: Clinical Oncology (800)*
Dietician	£32	PSSRU 2009-10: Cost per hour in clinic, incl. qualifications

Item	Cost	Source
Dentist	£100	OPATT: Dental Medicine Specialties (450) <sup>†</sup>
Thoracic	£216	OPATT: Thoracic Surgery (173) <sup>†</sup>
<b>Primary and community care</b>		
<b>In surgery/clinic</b>		
GPs	£28	Cost per surgery consultation, PSSRU Unit Costs 2010
Practice Nurse	£9	Cost per surgery consultation, PSSRU Unit Costs 2010
District nurse	£22	Cost per 15.5 minutes community nurse, PSSRU Unit Costs 2010
Physiotherapist	£15	Cost per clinic visit, PSSRU Unit Costs 2010
Occupational therapist	£15	Cost per surgery visit, PSSRU Unit Costs 2010
<b>At home</b>		
GPs	£94	Cost per home visit, PSSRU Unit Costs 2010
Practice Nurse	£13	Cost per home visit, PSSRU Unit Costs 2010
District Nurse	£37	Cost per home visit, community nurse, PSSRU Unit Costs 2010
Physiotherapist	£41	Cost per home visit, PSSRU Unit Costs 2010
Chiroprapist	£20	Cost per home visit, PSSRU Unit Costs 2010
Dermatologist	£92	As for outpatient. OPATT: Dermatology (330) <sup>†</sup>
<b>Aids and adaptation</b>		
Walking stick	£8.02 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/sticks-crutches-canes/walking-sticks-canes/metal-sticks-canes/economy-ergonomic-walking-stick-p-16711.html">http://www.mobilitysmart.cc/sticks-crutches-canes/walking-sticks-canes/metal-sticks-canes/economy-ergonomic-walking-stick-p-16711.html</a>
Crutches	£25.03 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/sticks-crutches-canes/crutches/closed-cuff-crutches/coopers-elbow-crutches-plastic-handles-p-13037.html">http://www.mobilitysmart.cc/sticks-crutches-canes/crutches/closed-cuff-crutches/coopers-elbow-crutches-plastic-handles-p-13037.html</a>
Wheelchair	£146.54 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/wheelchairs/self-propelled-wheelchairs/lightweight-self-propelling-wheelchair-p-14090.html">http://www.mobilitysmart.cc/wheelchairs/self-propelled-wheelchairs/lightweight-self-propelling-wheelchair-p-14090.html</a>
Insoles	£22.15 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/footcare/insoles-heel-pads/cosyfeet-orthaheel-workforce-p-17086.html">http://www.mobilitysmart.cc/footcare/insoles-heel-pads/cosyfeet-orthaheel-workforce-p-17086.html</a>
Zimmer	£44.29 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html</a>
Toilet seat	£12.84 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/toileting/toilet-seat-cushions/padded-toilet-seat-with-rim-vinyl-cover-p-671.html">http://www.mobilitysmart.cc/toileting/toilet-seat-cushions/padded-toilet-seat-with-rim-vinyl-cover-p-671.html</a>
Sock aid	£4.01 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/by-activity/getting-dressed/sock-stocking-aid-p-14742.html">http://www.mobilitysmart.cc/by-activity/getting-dressed/sock-stocking-aid-p-14742.html</a>
Grabber	£5.89 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/home-garden-aids/reachers-grabbers/reacher-grabber-pick-up-tool-p-13495.html">http://www.mobilitysmart.cc/home-garden-aids/reachers-grabbers/reacher-grabber-pick-up-tool-p-13495.html</a>
Shoe horn	£3.85 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/plastic-shoe-horn-p-9955.html">http://www.mobilitysmart.cc/plastic-shoe-horn-p-9955.html</a>
Trolley	£28.53 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/trolleys-steps-stools/trolleys/tri-wheeled-shopping-trolley-p-10107.html">http://www.mobilitysmart.cc/trolleys-steps-stools/trolleys/tri-wheeled-shopping-trolley-p-10107.html</a>
Perching stool	£43.33 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/trolleys-steps-stools/perching-">http://www.mobilitysmart.cc/trolleys-steps-stools/perching-</a>

Item	Cost	Source
		<a href="http://stools/standard-perching-stool-p-765.html">stools/standard-perching-stool-p-765.html</a>
Frame	£44.29 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html</a>
Clothes aid	£11.08 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/comfort-dressing/dressing-aids/dressing-stick-p-300.html">http://www.mobilitysmart.cc/comfort-dressing/dressing-aids/dressing-stick-p-300.html</a>
Medications (price per tablet /tube)		
Co-codamol	£0.05 <sup>†</sup>	30mg/500mg capsules (from pack of 100)
Codeine	£0.04 <sup>†</sup>	30mg tablets (from pack of 28)
Paracetamol	£0.03 <sup>†</sup>	500mg capsules (from pack of 32)
Tramadol	£0.04 <sup>†</sup>	50mg capsules (from pack of 30)
Amitriptyline	£0.03 <sup>†</sup>	25mg tablets (from pack of 28)
Dihydrocodeine	£0.03 <sup>†</sup>	30mg tablets (from pack of 100)
Diclofenac	£0.28 <sup>†</sup>	50mg tablets (from pack of 21)
Ibuprofen	£0.02 <sup>†</sup>	400mg tablets (from pack of 84)
Naproxen	£0.06 <sup>†</sup>	500mg tablets (from pack of 28)
Aspirin	£0.01 <sup>†</sup>	300mg tablets (from pack of 32)
Warfarin	£0.03 <sup>†</sup>	5mg tablets (from pack of 28)
Zopiclone	£0.05 <sup>†</sup>	7.5mg tablets (from pack of 28)
Flucloxacillin	£0.10 <sup>†</sup>	500mg capsules (from pack of 28)
Morphine	£0.09 <sup>†</sup>	10mg tablets (from pack of 56)
Hydrocortisone	£3.44 <sup>†</sup>	Cream 1% tube (from single tube)
Furosemide	£0.03 <sup>†</sup>	40mg tablets (from pack of 28)
Buprenorphine	£0.24 <sup>†</sup>	400µg tablets (from pack of 7)
Omeprazole	£0.20 <sup>†</sup>	10mg tables (from pack of 28)

\* 2009-10 Reference Costs

<sup>†</sup> Figure shown is inflation adjusted.

Web Extra: Table 2 - Resource use by patients according to the arm intervention

	Mean Costs (SD)		Difference: p-value of t test
	RSA (n =58)	THA (n =64)	
<b>Subsequent Inpatient Care</b>			
Orthopaedics	0.155 (0.410)	0.047 (0.213)	0.066
Elective, non-investigational	0.034 (0.184)	0 (0)	0.136
Elective, investigational	0 (0)	0.016 (0.125)	0.343
Acute surgical/medical	0.086 (0.283)	0.063 (0.302)	0.656
<b>Outpatient care</b>			
Orthopaedics	1.569 (1.464)	1.672 (1.196)	0.670
Haematology	0.121 (0.378)	0.109 (0.475)	0.885
Pathology or radiology	0.397 (1.388)	0.234 (0.660)	0.405
Ophthalmology	0 (0)	0.016 (0.125)	0.343
Orthotics	0.017 (0.131)	0 (0)	0.295
Physiotherapy	2.534 (4.096)	0.656 (2.169)	0.002
Chiropractor	0.103 (0.552)	0 (0)	0.136
Dermatology	0.172 (0.131)	0 (0)	0.295
Acupuncture	0.052 (0.394)	0 (0)	0.295
A and E	0.052 (0.223)	0.047 (0.213)	0.903
DVT assessment service	0.155 (0.410)	0.016 (0.125)	0.011
Heart specialist/ cardiologist	0.034 (0.263)	0.094 (0.635)	0.510
Urology	0 (0)	0.047 (0.278)	0.201
Neurophysiologist/neurologist	0.017 (0.131)	0.016 (0.125)	0.945
Eye clinic	0.0344 (0.263)	0.063 (0.393)	0.648
Oncologist	0.017 (0.131)	0 (0)	0.295
Dietician	0.172 (0.131)	0 (0)	0.295
Dentist	0.172 (0.131)	0.031 (0.25)	0.703
Thoracic	0 (0)	0.016 (0.125)	0.343
<b>Primary and community care</b>			
<b>In surgery/clinic</b>			
GPs	1.224 (2.193)	0.938 (1.833)	0.434
Practice Nurse	0.345 (1.101)	0.516 (1.553)	0.489
District nurse	0.034 (0.263)	0 (0)	0.295
Physiotherapist	0.103 (0.788)	0.125 (1)	0.896
Occupational therapist	0 (0)	0.016 (0.125)	0.343
<b>At home</b>			
GPs	0 (0)	0.047 (0.278)	0.201
Practice Nurse	0.103 (0.447)	0.047 (0.035)	0.067

		Mean Costs (SD)		Difference: p-value of t test
		RSA (n =58)	THA (n =64)	
	Chiroprapist	0.034 (0.263)	0 (0)	0.295
	District Nurse	0.155 (0.951)	0.031 (0.175)	0.308
	Physiotherapist	0.121 (0.796)	0 (0)	0.228
	Dermatologist	0.052 (0.292)	0.016 (0.125)	0.368
<b>Aids and adaptation</b>				
	Walking stick	0.269 (0.597)	0.259 (0.902)	0.946
	Crutches	0.431 (0.901)	0.421 (0.826)	0.950
	Wheelchair	0.017 (0.131)	0 (0)	0.295
	Insoles	0.034 (0.184)	0 (0)	0.136
	Zimmer	0.017 (0.131)	0 (0)	0.295
	Toilet seat	0.103 (0.307)	0.125 (0.333)	0.712
	Sock aid	0.017 (0.131)	0.031 (0.175)	0.621
	Grabber	0 (0)	0.109 (0.315)	0.009
	Shoe horn	0 (0)	0.031 (0.175)	0.178
	Trolley	0 (0)	0.031 (0.25)	0.343
	Perching stool	0 (0)	0.047 (0.278)	0.201
	Frame	0.017 (0.131)	0.016 (0.125)	0.945
	Clothes aid	0.017 (0.131)	0 (0)	0.295
<b>Medications</b>				
	Co-codamol 30mg/500mg	77.51 (141.29)	84.02 (172.51)	0.821
	Codeine 30mg tablets	6.62 (33.08)	0 (0)	0.130
	Paracetamol 500mg capsules	53.07 (148.95)	46.54 (136.14)	0.811
	Tramadol 50mg capsules	54.98 (169.59)	17.88 (63.05)	0.124
	Amitriptyline 25mg tablets	2.30 (16.45)	8.04 (33.61)	0.270
	Dihydrocodeine 30mg tablets	7.42 (53.00)	1.51 (11.46)	0.409
	Diclofenac 50mg tablets	44.67 (121.91)	38.15 (103.72)	0.764
	Ibuprofen 400mg tablets	54.63 (146.76)	25.44 (100.35)	0.224
	Naproxen 500mg tablets	21.34 (106.88)	13.59 (77.87)	0.662
	Aspirin 300mg tablets	6.94 (34.69)	0 (0)	0.130
	Warfarin 5mg tablets	13.76 (98.25)	0 (0)	0.288
	Zopiclone 7.5mg tablets	2.30 (11.53)	0.97 (7.37)	0.467
	Flucloxacillin 500mg capsules	6.94 (34.69)	3.05 (23.23)	0.489
	Morphine 10mg tablets	0 (0)	5.06 (27.06)	0.184
	Hydrocortisone cream 1%	0 (0)	0.02 (0.13)	0.351
	Furosemide 40mg tablets	0 (0)	3.05 (23.24)	0.351
	Buprenorphine 400µg tablets	0 (0)	4.73 (35.99)	0.351
	Omeprazole 10 mg tablets	3.21 (24.48)	2.91 (23.30)	0.945





**Cost-effectiveness of total hip arthroplasty versus resurfacing arthroplasty: economic evaluation alongside a clinical trial**

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-001162.R1
Article Type:	Research
Date Submitted by the Author:	06-Jul-2012
Complete List of Authors:	Edlin, Richard; University of Auckland, Health Systems, School of Population Health Tubeuf, Sandy; University of Leeds, Academic Unit of Health Economics Achten, Juul; University of Warwick, Division of Health Sciences Parsons, Nicholas; University of Warwick, Division of Health Sciences Costa, Matthew; University of Warwick, Warwick Clinical Trials Unit
<b>Primary Subject Heading</b>:	Health economics
Secondary Subject Heading:	Surgery
Keywords:	Hip < ORTHOPAEDIC & TRAUMA SURGERY, Adult orthopaedics < ORTHOPAEDIC & TRAUMA SURGERY, Orthopaedic & trauma surgery < SURGERY

SCHOLARONE™  
Manuscripts

only

**Objectives:** To report on the relative cost-effectiveness of total hip arthroplasty and resurfacing arthroplasty (replacement of articular surface of femoral head only) in patients with severe arthritis suitable for hip joint resurfacing arthroplasty.

**Design:** Cost-effectiveness analysis (cost per QALY) on an intention to treat basis of a single-centre, single-blind randomised controlled trial of 126 adult patients within 12 months of treatment. Missing data ~~was assessed~~ ~~were imputed~~ using multiple imputations with differences in baseline quality of life and gender adjusted using regression techniques.

**Setting:** A large teaching hospital trust in the UK

**Participants:** 126 adult patients with severe arthritis of the hip joint suitable for a resurfacing arthroplasty of the hip.

**Results:** Data was received for 126 patients, 4 of whom did not provide any resource use data. For the remainder, data was imputed for costs or quality of life in at least one time point (baseline, 3 months, 6 months, 1 year) for 18 patients. Patients in the resurfacing arm had higher quality of life at 12 months (0.795 vs. 0.727) and received 0.033-0.032 more QALYs within the first 12 months post operation. At an additional cost of £564440, resurfacing arthroplasty offers benefits at £1217,451,374 per QALY within the first 12 months of treatment. When covariates are considered, the health economic case is stronger in men than women.

**Conclusions:** Resurfacing arthroplasty appears to offer very short term efficiency benefits over total hip arthroplasty within a selected patient group. This conclusion should be tested over a longer period through longer series following up resurfacing arthroplasty and through decision analytic modelling.

**Trial registration:** Current controlled Trials ISRCTN33354155. UKCRN 4093.

1  
2  
3  
4  
5  
6  
7 **Funding statement**

8 The work described in this manuscript has been funded through the Research for Patient Benefit  
9 scheme of the NIHR, grant number PB-PG-0706-10080. This manuscript presents independent  
10 research commissioned by the National Institute of Health Research. The views expressed are those  
11 of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## Introduction

Hip arthroplasty is acknowledged to be a highly effective and cost-effective procedure for treating patients with severe arthritis of the hip joint, with 87% of patients reporting an improvement in their general health following surgery.<sup>1</sup> The total health gain is expected to be substantial given the effectiveness of treatment; [EuroQol \(EQ-5D-3L\)](#) based quality of life improvements following surgery are estimated to be 0.409, within the 45,000 cases measured in the UK Patient Reported Outcomes programme<sup>2</sup>. 97% of UK hip replacements are still working (unrevised) at 5 years<sup>3</sup> and 83% of all primary hip arthroplasty (all age, all implant types) are unrevised at 17 years post surgery in Sweden<sup>4</sup>. If the initial quality of life gains are maintained, each unrevised surgery represents over five discounted [quality-adjusted life-years \(QALYs\)](#) gained and a benefit of over one hundred thousand pounds at the £20,000 per QALY threshold used by [the National Institute of Health and Clinical Excellence \(NICE\)](#). Compared to these gains, the costs of hip arthroplasty surgery appear modest. As a result, most analyses considering health economics have concentrated on questions of which type of prosthesis to use, and many cost-effectiveness analyses have involved analysis of newer, more expensive operations against older, established comparators.<sup>5-7</sup> Resurfacing arthroplasty of the hip is a newer alternative form of arthroplasty designed for younger, active patients with severe arthritis of the hip.

Hip resurfacing arthroplasty involves the insertion of an acetabular component and the 'capping' of the femoral neck, rather than its removal and replacement with a femoral component in a standard total hip arthroplasty. Of the 70,000 hip arthroplasty operations conducted in England and Wales every year<sup>3</sup>, approximately 6% are hip resurfacings. The equivalent figure amongst men aged under 55 is 33%. As resurfacing preserves the bone of the proximal femur, it may be expected to provide better clinical outcomes on revision of this component than available with a standard hip arthroplasty. Despite advances in their construction, there are still questions about the durability of modern resurfacing implants and there have been few explicit economic evaluations comparing resurfacing arthroplasties against total hip arthroplasties.<sup>8,9</sup> Few [randomised controlled trials \(RCTs\)](#) have been conducted to assess the outcomes of hip resurfacing, and those that exist provide little detail about the economic costs and benefits within the initial year following surgery. This paper reports the first within-trial economic evaluation of resurfacing arthroplasty versus total hip arthroplasty.

## Methods

### Interventions and sample

This evaluation reports on the efficiency of resurfacing arthroplasty ([RSA](#)) versus total hip arthroplasty ([THA](#)). Patients were deemed eligible for the trial if they were aged over 18 years of age, were medically fit for an operation, and were deemed suitable to receive a resurfacing arthroplasty. Patients were only excluded from the study if there was evidence that the patient would be unable to adhere to trial procedures or complete questionnaires. Patients were randomised on a 1:1 basis between THA and RSA, with each patient operated on according to the preferred technique of the operating surgeon. Other perioperative interventions, such as prophylactic antibiotics and thrombo-prophylaxis were the same for all patients and the same standardised rehabilitation plan was employed for both trial arms. Further details on recruitment, ~~and~~ ethics, and randomisation procedures are reported elsewhere.<sup>10</sup> [The main outcome measure of the trial was hip function \(Oxford Hip Score; Harris Hip Score\) at 12 months, and the trial found no evidence of a difference between RSA and THA.](#)

### Perspective

The aim of the economic study is to determine the intervention that would maximise health outcomes within the limited [National Health Service \(NHS\)](#) budget in this period, and so a cost-effectiveness (cost-utility) analysis with an NHS and Personal Social Services (PSS) perspective is adopted [in the base case](#). This paper considers the within-trial period (as intention to treat) of the first 12 months follow up. It considers only resources used within the NHS setting including any aids and adaptations required. The base year for all costs figures was 2009/10, with figures from other years converted using the [hospital and community health services HCHS](#) Pay and Prices Index (for adults, excluding capital).<sup>11</sup> For current costs, figures are deflated assuming an estimated inflation rate of 1.9% to 2010 from this index for both 2009/10 and 2010/11. As the analysis uses a one year time horizon, discounting for the future cost and health outcome is not necessary in this analysis. The currency used was the pound sterling (£).

### Quality of life

Responses from the EQ-5D-3L were obtained from patients at baseline, 3 months, 6 months and 12 months as secondary outcomes of the trial<sup>10</sup>; results from other outcomes are reported in greater

1  
2  
3  
4  
5  
6  
7 depth elsewhere.<sup>12</sup> The standard tariff values<sup>13</sup> were applied to these responses at each time point  
8 to provide EQ-5D-3L quality of life values. Quality-adjusted life-years (QALYs) were calculated as an  
9 “area under the curve” and form the main outcome measure of the study. Where comparisons  
10 between the RSA and THA arms are based on non-imputed data, a two-sample t-test assuming equal  
11 variances is used.

#### 14 Resource use and valuation

15  
16 The costs of THA and RSA treatments were considered across six broad categories – the costs of the  
17 initial operation, of inpatient care post-discharge, of outpatient care, of primary/community care,  
18 and of medications, and aids/adaptations required whilst in the community.

19  
20  
21 These initial cost figures were calculated for both THA and RSA groups, and used as costs for the  
22 initial operation in the THA group. For the RSA group, the operative costs for THA are adjusted for  
23 differences in the expected implant/operative costs. All RSA patients received a Cormet resurfacing  
24 (Corin Group, Cirencester, UK), whilst THA patients received their surgeon’s preference of  
25 prosthesis. For the patients having RSA this was a Cormet resurfacing implant (Corin Group,  
26 Cirencester, UK). For the patients having THA, the prosthesis type was identified from  
27 patient records, with three types of bearing surface (ceramic femoral head on ceramic socket, metal-  
28 on-metal and metal-on-polyethylene) accounting for 95% of cases. The University Hospitals  
29 Coventry and Warwickshire NHS Trust Finance Department provided implant costs for both the  
30 resurfacing implant and representative cost figures for these three types of prosthesis used. In the  
31 remaining 5% of cases, implant type was treated as missing and were imputed to fall in one of these  
32 groups.

33  
34  
35  
36  
37  
38  
39  
40 The current Healthcare Resource Group v.4 (HRG4) reference costs include the cost of prosthesis  
41 across all ages, and in most cases this will be a THR as HRG4 does not include a single category for  
42 primary replacements (as appeared in previous versions). Identified national-level HRG4  
43 frequencies for primary hip replacements are available<sup>14</sup> and these are used to calculate an average  
44 cost, average length of stay, and average cost per excess bed day. By deducting the expected  
45 THA cost from the average cost, we obtain a non-prosthesis average cost, to which it is possible to  
46 add the appropriate prosthesis cost relevant to each individual. From here, using these figures, the  
47 an average average cost of the initial hospitalisation is calculated for each patient by using the mean  
48 cost and LOS figures and adjusting for each patient’s length of stay (as a number of bed days from  
49 the mean). In this way, a person admitted for the average length of stay would be assigned the  
50  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7 average cost of treatment, with those staying shorter and longer periods assigned lower and higher  
8 costs, respectively.  
9

10  
11 [Data regarding length of stay and implant received were obtained from hospital records, with the](#)  
12 [remainder of the costing information obtained from patient-reported data. Resource usage](#) ~~These~~  
13 ~~initial cost figures were calculated for both THA and RSA groups, and used as costs for the initial~~  
14 ~~operation in the THA group. For the RSA group, the operative costs for THA are adjusted for~~  
15 ~~differences in the expected implant/operative costs. All RSA patients received a Cormet resurfacing~~  
16 ~~(Corin Group, Cirencester, UK), whilst THA patients received their surgeon's preference of~~  
17 ~~prosthesis. For THA, prosthesis type was identified from patient records with three types of bearing~~  
18 ~~surface (ceramic femoral head on ceramic socket, metal on metal and metal on polyethylene)~~  
19 ~~accounting for 95% of cases. The University Hospitals Coventry and Warwickshire NHS Trust Finance~~  
20 ~~Department provided implant costs for both the resurfacing implant and representative cost figures~~  
21 ~~for the three types of prosthesis used. The expected difference in implant costs between RSA and~~  
22 ~~THA patients was added to the operative costs for RSA patients and adjusted for inflation.~~  
23  
24  
25  
26  
27  
28

29 [Patient reported data on resource usage were collected](#) ~~was assessed~~ alongside other outcomes at 3  
30 months, 6 months and 12 months. For the 3 month data, the recall period was since discharge from  
31 hospital. ~~For the other cases, it was since the last questionnaire was due to be completed.~~ The  
32 questionnaires included sections on further inpatient care following the initial operation (speciality  
33 and length of stay/day case), outpatient care, primary and community care, aids and adaptations  
34 provided by the NHS/social services, and medication (pain relief and other NHS medication).  
35 Medicines usage was estimated based on mean dosage when used and average usage within the  
36 three budgetary periods (discharge to 3 months, 3-6 months, 6-12 months). ~~In order to convert~~  
37 ~~resource usage figures into costs, unit cost figures were assigned from NHS Reference costs<sup>15</sup>, PSSRU~~  
38 ~~unit costs<sup>11</sup>, NHS Electronic Drug Tariff<sup>16</sup>, and reported unit costs of acupuncture and chiropractic~~  
39 ~~from previous studies, and relevant RCTs in the relevant year.~~ Individual resource items and unit  
40 prices, including for aids and adaptations, are available in Tables provided as a Web Extra. ~~Where~~  
41 ~~statistical tests analyse resource usage data, t-tests are used to test for differences in expected~~  
42 ~~usage (assuming equal variance and non-imputed data)~~ ~~Where resource usage data is analysed~~  
43 ~~between trials, t tests are used to calculate for significance in expected usage.~~  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7 Data on personal costs (~~private treatments~~, out of pocket ~~medicine usage expenditures~~ and time off  
8 work ~~for either the patient or a carer~~) were also collected, ~~but are not reported in the present~~  
9 ~~analysis~~. NHS unit costs were used to provide an indicative figure for private medicines costs, whilst  
10 ~~2009 median gross weekly earnings from full time jobs (£488.70) was used to identify a daily~~  
11 ~~productivity cost of £97.74. These are used in the sensitivity analysis considering societal~~  
12 ~~costs~~. ~~Productivity data may be of some relevance given the age of participants but is outside the~~  
13 ~~scope of the perspective used here.~~

#### 14 15 16 17 18 Missing data

19  
20  
21 Where data was incomplete we used multiple imputation via chained equations (ice)<sup>17</sup> to complete  
22 missing data using STATA 11 (StataCorp 2009, TX, USA).<sup>18,19</sup> Missing cost data was predicted in terms  
23 of QALYs, treatment received, length of stay (LOS), age, gender, height, weight, and baseline clinical  
24 scores (Oxford Hip Score, Harris Hip Score); missing QALY data was predicted in terms of this same  
25 list (excluding QALYs), plus each of the cost items; missing LOS was predicted using the same list as  
26 for QALYs, with QALYs included. In order to remove implausible data, missing cost data was  
27 constrained to be positive and length of stay was constrained to be at least three days post-  
28 imputation. A total of 50 imputations were used to inform each item of missing data. Where tests  
29 are conducted to detect significant differences in mean values between the RSA and THA groups  
30 based on imputed data (i.e. incremental costs and QALYs), the analysis uses an OLS regression within  
31 the STATA's mim command.

#### 32 33 34 35 36 37 38 39 Cost-effectiveness

40  
41  
42 Using the methods identified above, total costs and QALY figures were calculated for all patients  
43 ~~including imputed data. where response data was available. For those cases in which either~~  
44 ~~resource usage or quality of life data was unavailable, these figures cannot be calculated. In these~~  
45 ~~cases, we used multiple imputation via chained equations<sup>17</sup> to complete missing data using STATA 11~~  
46 ~~(StataCorp 2009, TX, USA).<sup>18-19</sup> Missing cost data was predicted in terms of QALYs, treatment~~  
47 ~~received, length of stay (LOS), age, gender, height, weight, and baseline clinical scores (Oxford Hip,~~  
48 ~~Harris Hip); missing QALY data was predicted in terms of this same list (excluding QALYs), plus each~~  
49 ~~of the cost items; missing LOS was predicted using the same list as for QALYs, with QALYs included.~~  
50 ~~In order to remove implausible data, missing cost data was constrained to be positive and length of~~  
51  
52  
53  
54



1  
2  
3  
4  
5  
6  
7 stay was constrained to be at least 3 days post-imputation. A total of 500 imputations were used to  
8 inform each item of missing data.  
9

10  
11 For the cost-effectiveness analysis, we identified the differences between costs and QALYs between  
12 the two arms, dividing the former by the latter to compute an incremental cost-effectiveness ratio  
13 (ICER). ~~—~~When compared against the marginal trade-off for the NHS as a whole – the cost-  
14 effectiveness threshold – the ICER gives a broad indication of whether spending additional money  
15 on hip arthroplasty appears efficient. ~~The ICER figure is not. This analysis is used as our base~~  
16 ~~case, presented with a confidence interval due to difficulties in interpreting a ratio of two random~~  
17 ~~variables. Instead, we assume that each QALY is valued at £20,000 and subtract costs from this~~  
18 ~~'monetised' QALY in order to obtain a net monetary benefit (NMB). Any treatment with an ICER~~  
19 ~~below £20,000 will have a positive NMB, with higher NMB figures unambiguously better and lower~~  
20 ~~NMB figures unambiguously worse. As before, a 95% confidence interval is formed for NMB using~~  
21 ~~linear regression using STATA's mim command.~~  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

### Scenarios/univariate sensitivity analyses

Key uncertainties in the scenarios considered were explored using univariate sensitivity analyses. The results for complete cost and quality of life data (i.e. those with no missing data) were provided to identify the impact of missing data on the analysis. ~~A~~ ~~as is a~~ strict per-protocol analysis of the data is also used to reflect any sensitivity to protocol violations. A societal perspective was also explored by adding the patient medicines and productivity costs outlined above to the NHS + PSS costs. As patients might also recover function within the first three months (rather than continuously to three months), a quicker initial recovery was explored in QALY calculations, where each patient's quality of life was assumed to reach its observed 3-month level at 6 weeks post-operatively. ~~(When imputing for missing data, this was performed alongside the main imputation, using the same predictors as when imputing for the base case QALY measure.)~~ The cost assumptions in the analysis were modified by assessing the impact of assuming the least expensive (metal on polyethylene) THA implant was used throughout with no effect on observed outcomes, to reflect the potential concern that the THA arm might not reflect cost-effective practice. ~~The recent (after the trial) current recommendations against the use of metal on metal THA prostheses are briefly considered by setting all 'metal on metal' implants to missing, estimating which THA prosthesis (i.e. metal on polyethylene or ceramic on ceramic) each patient will receive using multiple imputation, and considering the cost implications within these alternative estimates.~~

### Adjustment for potential baseline differences

As the baseline randomisation did not stratify by quality of life, the impact of potential baseline differences are corrected for using regression analysis. The number of QALYs received (average quality of life over 12 months) is assumed to be a normal distribution, conditional on ~~whether a resurfacing was intended, gender and baseline EQ-5D value. Likewise, total trial arm (RSA or THA) and baseline EQ-5D-3L value.~~ Total cost over 12 months is assumed to be lognormal, so that the natural logarithm of costs is a normal distribution, conditional on ~~resurfacing trial arm, gender and baseline EQ-5D-3L.~~

QALYs and (log-)costs for each person are estimated using ordinary least squares regression (using STATA's mim command to handle imputed data).

As any relationship between uncertainty in the extra costs and benefits associated with RSA is important when assessing the likelihood of cost-effectiveness, ~~we use a seemingly unrelated regression to do this, equations for cost and QALYs must be estimated together.~~ By using a Cholesky Decomposition of the variance-covariance matrix, (log-)costs and QALYs are modelled as if they come from a multivariate normal distribution. Uncertainty in the value of other items in the regression is ignored. From here, costs are estimated as if all patients receive THA, and incremental costs are calculated as a proportion of the average THA cost. In this way, a distribution is built up for incremental costs and incremental QALYs that can be analysed using ~~As the statistical methods to do this are not established with multiply imputed data, the data were first averaged across imputations before the equations were estimated as seemingly unrelated regression<sup>20</sup>.~~ Estimates of both cost and QALY outcomes were generated by considering the impact of clinical option (RSA vs. THA), the impact of covariates on outcomes (baseline EQ-5D and gender) for the population enrolled in the trial, and the relationships between each of these parameters. An overall ICER and cost-effectiveness acceptability curve (CEACCEACs) can be formed for this analysis.<sup>21</sup> ~~This CEAC indicates the likelihood that RSA will be cost-effective at different 'values' for a QALY.~~

~~was obtained by sampling for all parameters within the variance-covariance matrix.~~ As gender so heavily affects the clinical use of RSA, this analysis was ~~re-run for both male patients only and female patients only. This allows the also repeated allowing the~~ effects of RSA to be assessed separately for men and women, ~~with this figure presented as the likelihood of that RSA would be cost-effective, at a threshold value of £20,000 per QALY.~~

## Results

### Trial recruitment

The trial<sup>12</sup> recruited a total of 126 patients (RSA=60; THA=66) between May 2007 to February 2010. Two patients from each arm of the study did not have surgery and provided only baseline quality of life/demographic data, leaving a total of 58 and 64 patients in each arm. ~~The sample was representative of the broader population undergoing resurfacing in the UK during the period of recruitment; no significant differences were identified between those who took part and those who were eligible but chose not to take part. Further details on both the ethical approval for the study and the demographics of the patients are provided in the clinical paper.<sup>12</sup>~~ As the analysis estimates

1  
2  
3  
4  
5  
6  
7 data on costs and outcomes conditional on baseline quality of life, these patients cannot contribute  
8 any data to our analysis and are excluded from the analyses here.  
9

#### 10 11 Quality of life

12  
13 Table 1 summarises quality of life estimates at the four time points and calculates QALY estimates  
14 both with and without data imputation in the two arms. Overall, those in the RSA group started in  
15 worse health (as measured by the EQ-5D-3L) and received 0.033 more QALYs within the 12 months  
16 of the trial (n=118 observations). [When the small amount of missing data is imputed, the estimated](#)  
17 [benefit remains very similar at 0.032 \(95%CI, -0.054, 0.119\).](#) Within the trial, the difference in  
18 quality of life between the RSA and THA arms of the trial appears to increase at each post-operative  
19 time point.  
20  
21  
22  
23

#### 24 25 Costs and resource usage

26  
27 Overall, NHS and social care costs were significantly higher amongst the RSA group with an average  
28 of ~~£410-564~~ more spent within the first 12 months from the operation (Table 2), of which the  
29 majority is due to [the higher cost of implants and length of stay following the initial operation](#)  
30 [\(£184\), further subsequent inpatient care after initial discharge \(£279\) and outpatient care \(£84\)](#)  
31 [\(£83\). Relatively little of the cost difference between RSA and THA was due to the initial operation, as](#)  
32 [the deflated cost of the RSA implants including operative consumables used in this study was £1,850](#)  
33 [826 vs. an average of £1,738-700 for THA operations, based on imputed data.](#) ~~The trial used~~  
34 ~~surgeon's preference of THA implant and as expected this implant-THA implants differed in costs,~~  
35 ~~with as well as consumables cost varied by the type of implant, with~~ the most expensive being  
36 ceramic on ceramic implants (£2,042) and those using metal on metal implants costing slightly less  
37 than RSA implants (£1,625). Implants and consumables in metal on polyethylene operations (£843)  
38 were associated with only 40% of the cost of ceramic on ceramic implant. Whilst the resurfacing  
39 implants were more expensive, they were also associated with a slightly ~~shorter longer~~ length of stay  
40 (5.7 vs. 5.5 days), although this difference was not statistically significant (P = 0.536; [imputed](#)  
41 [data](#)). ~~In total, costs in the initial operative period were only £31 more expensive in the~~  
42 ~~resurfacing group, although it is acknowledged that this might differ if less expensive types of~~  
43 ~~implant were used.~~  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7 Those in the RSA arm had significantly more outpatient visits than those in the THA arm (5.155 vs.  
8 3.063, P = 0.0054; [non-imputed data](#)). Here, both the number of physiotherapy sessions and the  
9 use of [DVT-deep vein thrombosis](#) assessments were significantly higher amongst this group (P =  
10 0.002, P = 0.011; [non-imputed data](#)). For inpatient care, only subsequent inpatient attendances  
11 (0.155 vs. 0.047, P = 0.066; [non-imputed data](#)) approached significance, with the only significant  
12 difference (P = 0.009) in aids and adaptations favouring RSA. For full details on individual resource  
13 use items and their unit costs, please see the tables available as a Web Extra.  
14  
15

16  
17  
18 [The private costs to patients following arthroplasty surgery are considerable, although relatively](#)  
19 [little of this is due to the purchase of medication. There are no significant differences in medication](#)  
20 [usage between the RSA and THA arms, and the total costs of this treatment is similar \(£12 RSA vs. £9](#)  
21 [THA, P = 0.667\). RSA patients report an average of 73 days off work, as against 57 days for THA](#)  
22 [patients \(P = 0.333\). Whilst surgery results in a large number of days off work for the patient, carers](#)  
23 [tend to take very few days off work \(2.1 days RSA vs. 1.6 days THA; P = 0.595\). Overall, RSA patients](#)  
24 [report costs valued at £5,917, as against £5,853 in the THA arm \(imputed data\). This difference is](#)  
25 [small but highly uncertain, such that there is no significant difference in costs from a societal](#)  
26 [perspective \(£629 higher costs in RSA, 95%CI: -£2,456 -£3,713\).](#)  
27  
28  
29  
30  
31

### 32 33 Cost-effectiveness and sensitivity analyses

34  
35  
36 Whilst RSA is expected to cost more over the first 12 months following an operation, it appears to  
37 provide a difference in quality of life. Here, the incremental cost-effectiveness ratio (ICER) for RSA is  
38 [£17,42,374 451](#) per QALY ([£564440/0.033 032](#) QALY). Within most of the sensitivity tests explored  
39 here, the figure appears to remain [within or](#) below the £20k-£30k per QALY range used by the  
40 National Institute for Health and Clinical Excellence as its estimate of the cost-effectiveness  
41 threshold, except where cheaper THA implants are used in place of surgeon's preference (Table 3).  
42 If cheaper (metal-on-polyethylene) implants are used, the increased cost of RSA vs. THA implants is  
43 enough to raise the average cost difference above £1,000 which, given the small quality of life  
44 difference observed here, is enough to prevent RSA being cost effective. [As is normally the case in](#)  
45 [economic evaluations, however, the confidence interval for net benefit in every analysis span zero](#)  
46 [\(Table 4\) so that the findings do not reach statistical significance. As clinical trials are very rarely](#)  
47 [designed with the power of cost-effectiveness conclusions in mind, very little can be inferred from](#)  
48 [this lack of significance.](#)  
49  
50  
51  
52  
53  
54

### Adjustment for baseline differences

Once baseline differences in EQ-5D-3L are considered, the QALYWAT estimates for the first 12 months appear to change, and the numbers of men and women in each arm are considered, the QALY estimates for the first 12 months appear to change. Within the regression analysis, those treated in the RSA arm receive 0.059 more QALYs than those treated with THA ( $P=0.064$ ), as do women ( $P=0.126$ ) and people with better baseline EQ-5D scores ( $P<0.001$ ). In contrast, incremental costs appears to be relatively unaffected by either EQ-5D or gender, with no significant relationships found on either regressions ( $P=0.769$ ;  $P=0.211$ ). When considering the revised base case, costs are 4.9% higher (95%CI: 1.1%-8.9%) for those who received RSA when other factors are removed. QALYs are higher generally amongst those who are healthier at baseline (EQ-5D-3L;  $P=0.000$ ), with those treated in the RSA arm receiving 0.053 more QALYs than those treated with THA ( $P=0.119$ ). Likewise, log-costs appear to be affected by baseline health ( $P=0.034$ ), with costs 7.1% higher (95%CI: 1.7%-12.9%) for those who received RSA after bootstrapping.

Whilst correcting for baseline differences leaves the incremental costs largely unchanged (£473354; 95%CI: 107-84085-623), the estimated QALY benefit almost doubles (0.053059, 95%CI: -0.014004-0.120122). Consequently, the ICER is around half as large (£58,905,980 per QALY) as the non-adjusted case. In 79.89% of cases investigated, RSA is recommended when valuing health at £20,000 per QALY – suggesting that there is very little quite high confidence that parameter uncertainty that RSA is the most more cost-effective option within the first 12 months of treatment across the £20k-£30k range used by NICE (Figure 1). Where this analysis is re-run for male patients only ( $n = 71$ ), neither incremental costs nor incremental QALYs reach statistical significance and the ICER falls to £5,519 per QALY. For female patients ( $n=51$ ), the ICER is about three times as large as for males (£16,272 per QALY) due to

Whilst the incremental cost and QALY figures are not significantly related to gender (cost interaction 0.034,  $P=0.373$ ; QALY interaction 0.385,  $P=0.551$ ), their potential impact is relatively large. For women, RSA had higher costs and lower benefits, with the latter exacerbated by a much lower baseline quality of life (female 0.257, male 0.389;  $P=0.032$ ). This led to an ICER of £13,800 per QALY for RSA, with a 58% chance of being cost-effective at £20,000 per QALY. Correspondingly, the

1  
2  
3  
4  
5  
6  
7 ICER for men decreased to £3,445 per QALY, with a 92% chance of cost-effectiveness at £20,000 per  
8 QALY. Within the scenarios used here, RSA is only 54% likely to be cost-effective for female patients  
9 at £20,000 per QALY, compared to an 86% likelihood for male patients.  
10  
11

## 12 13 14 Discussion

15  
16  
17 In comparison to standard total hip arthroplasty, hip resurfacing arthroplasty appears to provide a  
18 modest QALY gain for a modest sum within the first 12 months from surgery; whilst the additional  
19 costs of RSA are statistically significant, the additional benefits are not. [The higher costs of RSA](#)  
20 [treatments are largely due to slightly higher costs for the initial operative and recovery periods, and](#)  
21 [higher usage of outpatient services. Whilst the RSA group achieves slightly better health outcomes](#)  
22 [and requires more services, this may be due to heterogeneity in outcomes; if resurfacing works well](#)  
23 [for most but poor for some, then this could produce this type of phenomenon. If so, this emphasises](#)  
24 [the need to follow patients up in the longer term.](#)  
25  
26  
27  
28  
29

30  
31 The analysis presented here analyses the data by considering potential confounding due to both  
32 gender and baseline quality of life, and this nearly doubles the estimate of RSA effect size. Whilst  
33 the main analysis of the trial data<sup>12</sup> found no statistically significant difference [in hip function](#)  
34 between the RSA and THA groups at 12 months, it seems likely that some short term difference in  
35 quality of life exists favouring RSA and that – again within 12 months – there is enough evidence to  
36 suggest that it may be cost-effective.  
37  
38  
39  
40  
41

42  
43 Within the first 12 months of treatment, the main caveat to our results deals with the comparator  
44 THA arm. The pragmatic nature of the trial data used here<sup>12</sup> is one of its key strengths, since it  
45 reflects current practice. Any changes to this practice may affect cost-effectiveness though, so that  
46 RSA may become more/less cost-effective as less/more cost-effective THA implants are used. A  
47 recent (US) analysis of registry data suggests that more expensive implants do not provide a  
48 substantive age-adjusted advantage over less expensive prostheses.<sup>22</sup> Where the sensitivity analysis  
49 assumed the use of the cheapest metal-on-polyethylene implants (without incorporating a possible  
50 impact on quality of life), RSA was no longer cost-effective within-trial. [However, this is somewhat](#)  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7 [unrealistic to assume, as the main alternative to metal on metal THA implants appears to be the](#)  
8 [more expensive ceramic on ceramic type. Restrictions in the use of MOM THA implants within the](#)  
9 [UK are likely to lead to more of these \(likely\) less cost-effective implants being used, and so an](#)  
10 [increase in the cost-effectiveness of resurfacing implants.](#)

11  
12  
13  
14  
15 [Beyond the issues surrounding the choice of THA, the trial is inevitably unable to consider all](#)  
16 [possible cost items. The trial did not explicitly consider any differences in operative time between](#)  
17 [the RSA and THA arms; no difference was expected and an informal analysis of the data suggests](#)  
18 [very similar operative times between the arms. This evaluation was also unable to consider the](#)  
19 [impact of variation in cost within each type of prostheses \(i.e. within the three types of THA, or](#)  
20 [beyond the single RSA used in the trial\) as this information is not generally available. The clinical](#)  
21 [trial upon which this analysis is based used a single type of Cormet prosthesis that has been used in](#)  
22 [the UK for around 15 years. As such, our findings are not necessarily generalisable to other types of](#)  
23 [resurfacing and we cannot identify the most cost-effective type of resurfacing as this is beyond the](#)  
24 [scope of the trial. Whilst the list price of the Cormet prosthesis is similar to other prostheses](#)  
25 [available locally, prices are hospital-specific and so some caution is warranted when seeking to](#)  
26 [generalise findings to other locations.](#)

27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37 Clearly, the cost-effectiveness of resurfacing is likely to require assessment over a longer period of  
38 time – as is typically the case for any health economic analysis of trial data.<sup>23</sup> Importantly, the higher  
39 revision rates reported for resurfacing arthroplasty suggest that the additional costs of RSA may be  
40 higher if a longer period is considered. On the benefit side of the equation, the impact of extending  
41 the time period is unclear as RSA may improve quality of life in the short term but lead to a quicker  
42 deterioration once revisions are necessary, [or require additional monitoring or revisions by virtue](#)  
43 [of its 'metal-on-metal' nature.](#) One method to explore these questions may be decision analytic  
44 modelling.<sup>23</sup> The trial provides an estimate of short term clinical benefits from hip function and  
45 quality of life (conditional on EQ-5D-3L), with longer follow up series (from trials or registry data)  
46 needed to model implant survival for both RSA and THA.  
47  
48  
49  
50  
51  
52  
53  
54



1  
2  
3  
4  
5  
6  
7 As THA revision surgery may be surgically more complex, financially more costly, and less effective  
8 than a primary THA, a key question when interpreting this study is the prognosis for patients after  
9 their RSA is revised. An Australian registry analysis suggests poor implant survival amongst patients  
10 receiving a revision of only the acetabular RSA component, and some evidence of higher revision  
11 risks among other types of RSA revisions such as where both components are revised.<sup>24</sup> It is unclear,  
12 however, whether a revised RSA is more similar, in terms of quality of life, to a primary THA or a  
13 revision THA. Further research is necessary to assess the likely impact of this and other questions  
14 to guide future research, and the findings of this paper are by no means a complete answer to the  
15 decision problem.  
16  
17  
18  
19

20  
21  
22 Registry data reveals that women represent 61% of primary THA patients in the UK but make up only  
23 25% of RSA patients.<sup>3</sup> These figures reflect relevant gender differences from both a clinical and a  
24 health economic perspective as women appear to obtain higher quality of life gains from THA, and  
25 face an increased revision rate from RSA.<sup>4,25</sup> This trial may also suggest a lower benefit from RSA  
26 relative to THA amongst women, although the finding was not statistically significant (or powered to  
27 be so). Despite the conclusions of the within-trial analysis, it seems clear that until such work is  
28 done and further data is available, the cost-effectiveness of resurfacing arthroplasty in a UK context  
29 remains potentially promising but as yet unproven.  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54

**Table 1. EQ-5D-3L quality of life at each measurement and converted into QALYs (missing data imputed)**

Quality of life	RSA (SD) n =58	THA (SD) n =64	Difference <sup>±</sup> (95% CI)
Baseline	0.308 (0.338)	0.356 (0.335)	-0.048 (-0.168, 0.073)
3 months	0.722 (0.229)	0.698 (0.284)	0.023 (-0.711, 0.118)
6 months	0.796 (0.244)	0.747 (0.287)	0.050 (-0.046, 0.146)
12 months	0.795 (0.282)	0.727 (0.319)	0.067 (-0.042, 0.177)
QALYs ( <a href="#">n = 118</a> )	0.716 (0.216)	0.683 (0.252)	0.033 (-0.053, 0.120)
QALYs* ( <a href="#">n = 122</a> )	0.713 (0.216)	<del>0.680 (0.251)</del> <a href="#">0.681</a>	<del>0.033 (-0.053,</del>

\* With imputed data

**Table 2. Costs by type, summed across trial period (missing data imputed)**

Costs	% imputed	RSATHA (SD) n=5864		THA (SD) n	Difference (95% CI)
Initial	7%	£6275 (557)	£6710 (482)	£6091	£184 (-18, 386)
Subsequent	11%	£470 (956)	£184 (556)	£191	£279 (-11, 569)
Outpatient	11%	£360 (294)	£276 (211)	£276	£84 (-13, 181)
Primary/comm	11%	£63 (98)	£49 (70)	£49 (67)	£14 (-17, 45)
Aids and	11%	£21 (33)	£40	£21 (40)	£0 (-14, 14)
Medication	11%	£27 (43)	£39	£24 (41)	£3 (-13, 19)
NHS + PSS	--	£7217 (1320)	£7265 (647)	£6653	£564 (144, 985)
Private costs	61%	£5917	£5853	£64 (-3017, 3146)	
Societal cost	--	£13,134	£12,506	£629 (-2456, 3713)	

**Table 2. Costs by type, summed across trial period (missing data imputed)**

Costs	% imputed	RSA (SD) n=58	THA (SD) n=64	Difference (95% CI)
Initial	7%	£6275 (557)	£6091 (532)	£184 (-18, 386)
Subsequent	11%	£470 (956)	£191 (558)	£279 (-11, 569)
Outpatient	11%	£360 (294)	£276 (210)	£84 (-13, 181)
Primary/comm	11%	£63 (98)	£49 (67)	£14 (-17, 45)
Aids and	11%	£21 (33)	£21 (40)	£0 (-14, 14)
Medication	11%	£27 (43)	£24 (41)	£3 (-13, 19)
NHS + PSS	--	£7217	£6653 (917)	£564 (144, 985)
Private costs	61%	£5917	£5853	£64 (-3017, 3146)
Societal cost	--	£13,134	£12,506	£629 (-2456, 3713)

Formatted Table

Deleted Cells

Deleted Cells

Formatted: Normal

**Table 3. Incremental cost effectiveness**

<u>Scenario</u>	<u>Incremental costs (95%CI)</u>	<u>Incremental QALYs (95%CI)</u>	<u>ICER</u>
<u>Base case (BC)</u>	<u>£564 (144, 985)</u>	<u>0.032 (-0.054, 0.119)</u>	<u>£17,451 per QALY</u>
<u>Per protocol</u>	<u>£528 (85, 970)</u>	<u>0.024(-0.066, 0.113)</u>	<u>£22,227 per QALY</u>
<u>Complete case data (N=98)</u>	<u>£721 (286,</u>	<u>0.053 (-0.042, 0.149)</u>	<u>£13,443 per QALY</u>
<u>Societal costs</u>	<u>£629 (-2456,</u>	<u>0.032 (-0.054, 0.119)</u>	<u>£19,435 per QALY</u>
<u>Metal/polyethylene THA implants</u>	<u>£1271 (859,</u>	<u>0.032 (-0.054, 0.119)</u>	<u>£39,318 per QALY</u>
<u>No metal on metal THA implants</u>	<u>£522 (76, 968)</u>	<u>0.032 (-0.054, 0.119)</u>	<u>£16,137 per QALY</u>
<u>Quicker initial recovery</u>	<u>£564 (144, 985)</u>	<u>0.039 (-0.048, 0.127)</u>	<u>£14,310 per QALY</u>
<u>Adjustments for quality of life</u>	<u>£473 (113, 853)</u>	<u>0.053 ( -0.014-0.120)</u>	<u>£8,905 per QALY</u>
<u>Adjustments for quality of life,</u>	<u>£402 (-82, 916)</u>	<u>0.073 (-0.012, 0.158)</u>	<u>£5,519 per QALY</u>
<u>Adjustments for quality of life,</u>	<u>£598 (64, 1172)</u>	<u>0.037 (-0.070, 0.144)</u>	<u>£16,272 per QALY</u>

**Table 4. Net Monetary Benefit**

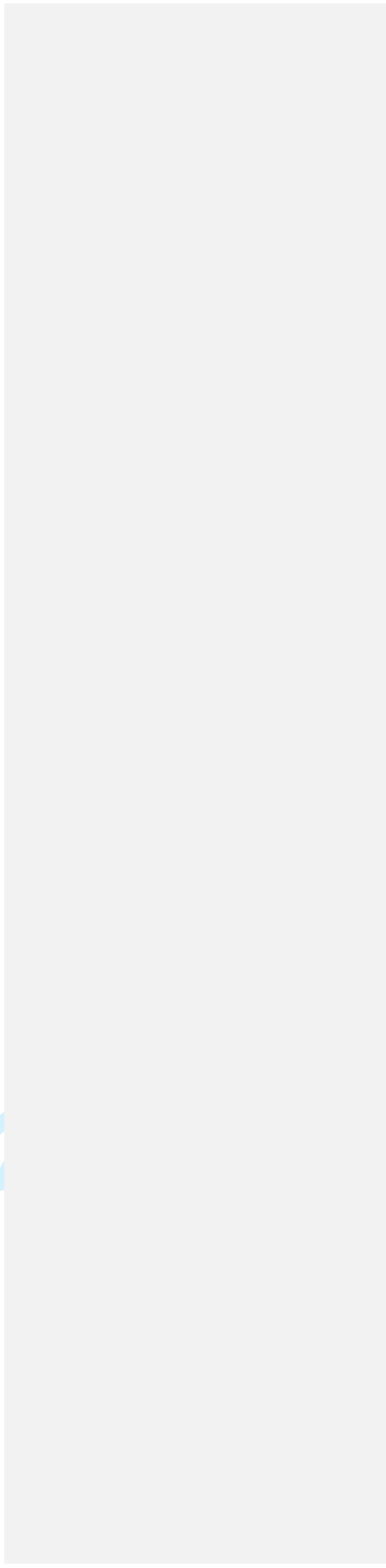
<u>Scenario</u>	<u>NMB (95%CI)*</u>
<u>Base case (BC)</u>	<u>£82.46 (-1795, 1960)</u>
<u>Per protocol</u>	<u>-£53 (-2011, 1905)</u>
<u>Complete case data (N=98)</u>	<u>£353 (-1719, 2426)</u>
<u>Societal costs</u>	<u>£19 (-3641, 3680)</u>
<u>Metal/polyethylene THA implants</u>	<u>-£625 (-2515, 1265)</u>
<u>No metal on metal THA implants</u>	<u>£125 (-1750, 1999)</u>
<u>Quicker initial recovery</u>	<u>£224 (-1658, 2107)</u>
<u>Adjustments for quality of life</u>	<u>£590 (-834, 2014)</u>
<u>Adjustments for quality of life, males</u>	<u>£1055 (-843, 2954)</u>
<u>Adjustments for quality of life, females</u>	<u>£137 (-1988, 2262)</u>

QALYs valued at £20k each

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

|

For peer review only



## References

1. Health Episodes Statistics Online. Finalised PROMs data 2009-10, 2011.
2. Health Episodes Statistics Online. PROMs Score Comparisons April 2009 to February 2011: The NHS Information Centre for Health and Social Care, 2011.
3. Ellams D, Forsyth O, Mistry A, et al. *7th Annual Report*. National Joint Registry for England and Wales, 2010.
4. Garellick G, Kärrholm J, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2008. Shortened Version*. Department of Ortopaedics, Sahlgrenska University Hospital, 2009.
5. Bozic KJ, Morshed S, Silverstein MD, et al. Use of cost-effectiveness analysis to evaluate new technologies in orthopaedics: the case of alternative bearing surfaces in total hip arthroplasty. *Journal of Bone and Joint Surgery* 2006;88(4):706-14.
6. Briggs A, Sculpher M, Dawson J, et al. Modelling the cost-effectiveness of primary hip replacement: how cost-effective is the Spectron compared to the Charnley prosthesis? *York - CHE - Technical Paper* 2003;28.
7. Fitzpatrick R, Shortall E, Sculpher M, et al. Modelling of cost-effectiveness of THR: methods and results and discussion in primary total hip replacement surgery: a systematic review of outcomes and modelling of cost-effectiveness associated with different prostheses. *Health Technology Assessment* 1998;2(20):17-32.
8. Vale L, Wyness L, McCormack K, et al. A systematic review of the effectiveness and cost-effectiveness of metal-on-metal hip resurfacing arthroplasty for treatment of hip disease. *Health Technology Assessment* 2002;6(15).
9. Bozic KJ, Pui CM, Ludeman MJ, et al. Do the Potential Benefits of Metal-on-Metal Resurfacing Justify the Increased Cost and Risk of Complications? *Clinical Orthopaedics and Related Research* 2010;468:2301-12.
10. Achten JA, Parsons NR, Edlin RE, et al. A randomised controlled trial of total hip arthroplasty versus resurfacing arthroplasty in the treatment of young patients with arthritis of the hip joint. *BMC Musculoskeletal Disorders* 2010;11(8).
11. Curtis L. Unit Costs of Health & Social Care 2010. Personal and Social Services Research Unit, 2010.
12. ~~Costa ML, Achten J, Parsons NR, et al. A Randomised Controlled Trial of Total Hip Arthroplasty Versus Resurfacing Arthroplasty in the Treatment of Young Patients with Arthritis of the Hip Joint. *British Medical Journal* 2012;(IN PRESS).~~
12. [Costa ML, Achten J, Parsons NR, et al. Total Hip Arthroplasty Versus Resurfacing Arthroplasty in the Treatment of Young Patients with Arthritis of the Hip Joint: A single centre, parallel group, assessor blind, randomised control trial. \*British Medical Journal\* 2012; 344:e2147.](#)
13. Dolan P. Modeling valuations for EuroQol health. *Medical Care* 1997;35(11):1095-108.
14. *HRG version 3.5 & HRG4 Comparative Chapter Analysis*: The Health & Social Care Information Centre., 2008.
15. *National Schedule of Reference Costs 2009-10. Appendix NSRC04: NHS Trusts and PCTs combined reference cost schedules*. London: Crown Copyright, 2011.
16. *NHS. Electronic Drug Tariff: May 2011*. National Health Service England and Wales, 2011.
17. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine* 2011;30(4):377-99.
18. Royston P. Multiple imputation of missing values: further update of ice, with an emphasis on interval censoring. *The Stata Journal* 2007;7(4):445-64.
19. Royston P, Carlin JB, White IR. Multiple imputation of missing values: New features for mim. *The Stata Journal* 2009;9(2):252-64.
20. Willan AR, Briggs AH, Hoch JS. Regression methods for covariate adjustment and subgroup analysis for non-censored cost-effectiveness data. *Health Economics* 2004;13:461-75.

21. Fenwick E, Byford S. A guide to cost-effectiveness acceptability curves. *British Journal of Psychiatry* 2005;187:106-8.
22. Gioe TJ, Sharma A, Tatman P, et al. Do "Premium" Joint Implants Add Value? *Clinical Orthopaedics and Related Research* 2011;469:48-54.
23. Petrou S, Gray A. Economic evaluation using decision analytical modelling: decision, conduct, analysis, and reporting. *British Medical Journal* 2011;342:doi: 10.1136/bmj.d766.
24. de Steiger RN, Miller LN, Prosser GH, et al. Poor outcome of revised resurfacing hip arthroplasty. 397 cases from the Australian Joint Replacement Registry. *Acta Orthopaedica* 2010;81(1):72-76.
25. Kärrholm J, Garellick G, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2007*: Department of Ortopaedics, Sahlgrenska University Hospital, 2008.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

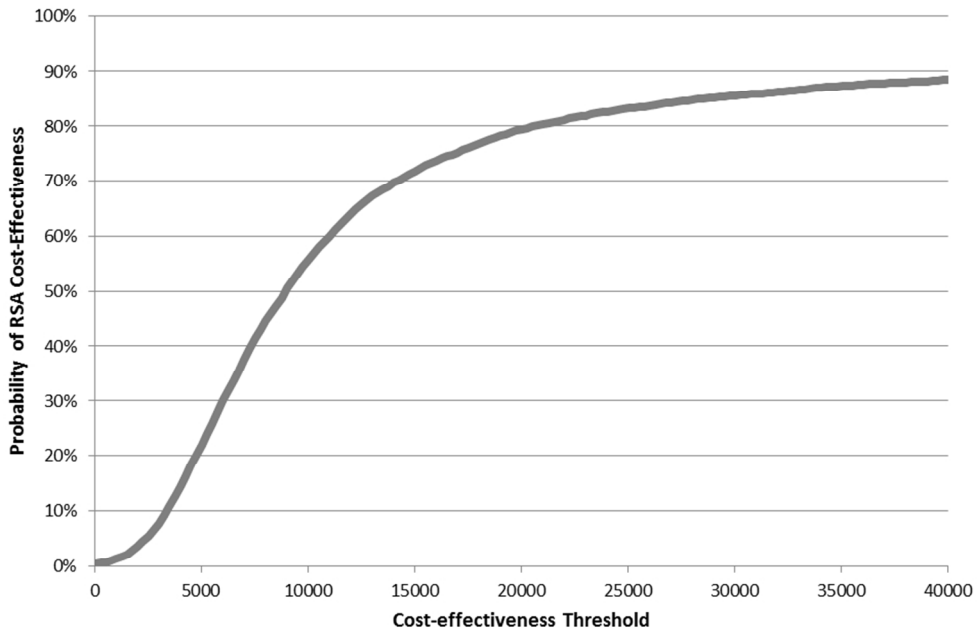


Figure 1: Cost-Effectiveness Acceptability Curve for Resurfacing Arthroplasty (vs. THA) 258x168mm (96 x 96 DPI)

Review only



Web Extra: Table 1 – Unit cost of resources

Item	Cost	Source
<b>Initial Operation</b>		
Cost for average THA	£6381	Uses weighted average of outcomes from HB11B, HB11C, HB12A, HB12B, HB12C.*
Average LOS for THA	6.57 days	
Adjustment per day ± av. LOS	£296	
THA: implant + consumables	£2,042	Ceramic femoral head, ceramic socket
	£1,625	Metal femoral head, metal socket
	£843	Metal femoral head, polyurethane socket
	£1,738	Weighted average of THA implants + consumables
RSA: implant + consumables	£1,850	Cornet resurfacing
<b>Subsequent Inpatient Care</b>		
<b>Inpatient (orthopaedics)</b>		
Day case	£874	TPCTDC: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Cost for average LOS	£1,888	TPCTEI: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Average LOS	1.98 days	TPCTEI: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Adjustment per day ± av. LOS	£340	TPCTEIXS: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
<b>Inpatient (other)</b>		
Elective, non-investigational	£668	Average across all day cases (TPCTDC)*
Elective, investigational	£243	Average cost radiotherapy inpatient, PSSRU 2010
Acute surgical/medical	£535	Average across all non-elective (short stay) cases (TPCTNEI_S)
<b>Outpatient care</b>		
Orthopaedics	£96	OPATT: Trauma & Orthopaedics: Non-Trauma (110N)*
Haematology	£128	OPATT: Clinical Haematology (303)*
Pathology or radiology	£114	Average cost per outpatient radiotherapy contact, PSSRU 2010
Ophthalmology	£80	OPATT: Ophthalmology (130)*
Orthotics	£96	OPATT: Trauma & Orthopaedics: Non-Trauma (110N)*
Physiotherapy	£39	OPATT: Physiotherapy Total Attendances - Adult (19 and Over (650A)*
Chiropractor	£17	Ongoing treatment session from UK BEAM trial <a href="http://www.bmj.com/content/329/7479/1381.full">http://www.bmj.com/content/329/7479/1381.full</a> costed at £12.17 in 2000 base year. Reflated using NHS Pay and Prices Index.
Dermatology	£92	OPATT: Dermatology (330)*
Acupuncture	£30	Ongoing treatment session from RCT <a href="http://www.bmj.com/content/333/7569/626.full">http://www.bmj.com/content/333/7569/626.full</a> costed at £24 in 2002-3 base year. Reflated using NHS Pay and Prices Index.
Accident and Emergency	£113	OPATT: Accident and Emergency (180)*
DVT assessment service	£129	TPCTDC: Deep Vein Thrombosis (QZ20Z)*
Heart specialist/cardiologist	£124	OPATT: Cardiology (320)*
Urology	£99	OPATT: Urology (101)*
Neurophysiologist/neurologist	£166	OPATT: Neurology (400)*
Eye clinic	£80	OPATT: Ophthalmology (130)*
Oncologist	£107	OPATT: Clinical Oncology (800)*
Dietician	£32	PSSRU 2009-10: Cost per hour in clinic, incl. qualifications

Item	Cost	Source
Dentist	£100	OPATT: Dental Medicine Specialties (450) <sup>†</sup>
Thoracic	£216	OPATT: Thoracic Surgery (173) <sup>†</sup>
<b>Primary and community care</b>		
<b>In surgery/clinic</b>		
GPs	£28	Cost per surgery consultation, PSSRU Unit Costs 2010
Practice Nurse	£9	Cost per surgery consultation, PSSRU Unit Costs 2010
District nurse	£22	Cost per 15.5 minutes community nurse, PSSRU Unit Costs 2010
Physiotherapist	£15	Cost per clinic visit, PSSRU Unit Costs 2010
Occupational therapist	£15	Cost per surgery visit, PSSRU Unit Costs 2010
<b>At home</b>		
GPs	£94	Cost per home visit, PSSRU Unit Costs 2010
Practice Nurse	£13	Cost per home visit, PSSRU Unit Costs 2010
District Nurse	£37	Cost per home visit, community nurse, PSSRU Unit Costs 2010
Physiotherapist	£41	Cost per home visit, PSSRU Unit Costs 2010
Chiropodist	£20	Cost per home visit, PSSRU Unit Costs 2010
Dermatologist	£92	As for outpatient. OPATT: Dermatology (330) <sup>†</sup>
<b>Aids and adaptation</b>		
Walking stick	£8.02 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/sticks-crutches-canes/walking-sticks-canes/metal-sticks-canes/economy-ergonomic-walking-stick-p-16711.html">http://www.mobilitysmart.cc/sticks-crutches-canes/walking-sticks-canes/metal-sticks-canes/economy-ergonomic-walking-stick-p-16711.html</a>
Crutches	£25.03 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/sticks-crutches-canes/crutches/closed-cuff-crutches/coopers-elbow-crutches-plastic-handles-p-13037.html">http://www.mobilitysmart.cc/sticks-crutches-canes/crutches/closed-cuff-crutches/coopers-elbow-crutches-plastic-handles-p-13037.html</a>
Wheelchair	£146.54 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/wheelchairs/self-propelled-wheelchairs/lightweight-self-propelling-wheelchair-p-14090.html">http://www.mobilitysmart.cc/wheelchairs/self-propelled-wheelchairs/lightweight-self-propelling-wheelchair-p-14090.html</a>
Insoles	£22.15 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/footcare/insoles-heel-pads/cosyfeet-orthaheel-workforce-p-17086.html">http://www.mobilitysmart.cc/footcare/insoles-heel-pads/cosyfeet-orthaheel-workforce-p-17086.html</a>
Zimmer	£44.29 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html</a>
Toilet seat	£12.84 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/toileting/toilet-seat-cushions/padded-toilet-seat-with-rim-vinyl-cover-p-671.html">http://www.mobilitysmart.cc/toileting/toilet-seat-cushions/padded-toilet-seat-with-rim-vinyl-cover-p-671.html</a>
Sock aid	£4.01 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/by-activity/getting-dressed/sock-stocking-aid-p-14742.html">http://www.mobilitysmart.cc/by-activity/getting-dressed/sock-stocking-aid-p-14742.html</a>
Grabber	£5.89 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/home-garden-aids/reachers-grabbers/reacher-grabber-pick-up-tool-p-13495.html">http://www.mobilitysmart.cc/home-garden-aids/reachers-grabbers/reacher-grabber-pick-up-tool-p-13495.html</a>
Shoe horn	£3.85 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/plastic-shoe-horn-p-9955.html">http://www.mobilitysmart.cc/plastic-shoe-horn-p-9955.html</a>
Trolley	£28.53 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/trolleys-steps-stools/trolleys/tri-wheeled-shopping-trolley-p-10107.html">http://www.mobilitysmart.cc/trolleys-steps-stools/trolleys/tri-wheeled-shopping-trolley-p-10107.html</a>
Perching stool	£43.33 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/trolleys-steps-stools/perching-">http://www.mobilitysmart.cc/trolleys-steps-stools/perching-</a>

Item	Cost	Source
		<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">stools/standard-perching-stool-p-765.html</a>
Frame	£44.29 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html</a>
Clothes aid	£11.08 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/comfort-dressing/dressing-aids/dressing-stick-p-300.html">http://www.mobilitysmart.cc/comfort-dressing/dressing-aids/dressing-stick-p-300.html</a>
<b>Medications (price per tablet /tube) related to hip/hip pain</b>		
Co-codamol	£0.05 <sup>†</sup>	30mg/500mg capsules (from pack of 100)
Codeine	£0.04 <sup>†</sup>	30mg tablets (from pack of 28)
Paracetamol	£0.03 <sup>†</sup>	500mg capsules (from pack of 32)
Tramadol	£0.04 <sup>†</sup>	50mg capsules (from pack of 30)
Amitriptyline	£0.03 <sup>†</sup>	25mg tablets (from pack of 28)
Dihydrocodeine	£0.03 <sup>†</sup>	30mg tablets (from pack of 100)
Diclofenac	£0.28 <sup>†</sup>	50mg tablets (from pack of 21)
Ibuprofen	£0.02 <sup>†</sup>	400mg tablets (from pack of 84)
Naproxen	£0.06 <sup>†</sup>	500mg tablets (from pack of 28)
Aspirin	£0.01 <sup>†</sup>	300mg tablets (from pack of 32)
Warfarin	£0.03 <sup>†</sup>	5mg tablets (from pack of 28)
Zopiclone	£0.05 <sup>†</sup>	7.5mg tablets (from pack of 28)
Flucloxacillin	£0.10 <sup>†</sup>	500mg capsules (from pack of 28)
Morphine	£0.09 <sup>†</sup>	10mg tablets (from pack of 56)
Hydrocortisone	£3.44 <sup>†</sup>	Cream 1% tube (from single tube)
Furosemide	£0.03 <sup>†</sup>	40mg tablets (from pack of 28)
Buprenorphine	£0.24 <sup>†</sup>	400µg tablets (from pack of 7)
Omeprazole	£0.20 <sup>†</sup>	10mg tablets (from pack of 28)
<b>Productivity costs</b>		
Day off work	£97.74	As 20% of £488.70; Median Gross Weekly Earnings from Full Time, Pay Unaffected by Absence, Office of National Statistics 2009 Annual Survey of Hours and Earnings. <a href="http://www.ons.gov.uk/ons/rel/ashe/annual-survey-of-hours-and-earnings/2009-results/stb-ashe-2009.pdf">http://www.ons.gov.uk/ons/rel/ashe/annual-survey-of-hours-and-earnings/2009-results/stb-ashe-2009.pdf</a>

\* 2009-10 Reference Costs

<sup>†</sup> Figure shown is inflation adjusted.

Web Extra: Table 2 - Resource use by patients according to the arm intervention

	Mean Usage (SD)		P-value*
	RSA (n =58)	THA (n =64)	
<b>Subsequent Inpatient Care</b>			
Orthopaedics	0.155 (0.410)	0.047 (0.213)	0.066
Elective, non-investigational	0.034 (0.184)	0 (0)	0.136
Elective, investigational	0 (0)	0.016 (0.125)	0.343
Acute surgical/medical	0.086 (0.283)	0.063 (0.302)	0.656
<b>Outpatient care</b>			
Orthopaedics	1.569 (1.464)	1.672 (1.196)	0.670
Haematology	0.121 (0.378)	0.109 (0.475)	0.885
Pathology or radiology	0.397 (1.388)	0.234 (0.660)	0.405
Ophthalmology	0 (0)	0.016 (0.125)	0.343
Orthotics	0.017 (0.131)	0 (0)	0.295
Physiotherapy	2.534 (4.096)	0.656 (2.169)	0.002
Chiropractor	0.103 (0.552)	0 (0)	0.136
Dermatology	0.172 (0.131)	0 (0)	0.295
Acupuncture	0.052 (0.394)	0 (0)	0.295
A and E	0.052 (0.223)	0.047 (0.213)	0.903
DVT assessment service	0.155 (0.410)	0.016 (0.125)	0.011
Heart specialist/ cardiologist	0.034 (0.263)	0.094 (0.635)	0.510
Urology	0 (0)	0.047 (0.278)	0.201
Neurophysiologist/neurologist	0.017 (0.131)	0.016 (0.125)	0.945
Eye clinic	0.0344 (0.263)	0.063 (0.393)	0.648
Oncologist	0.017 (0.131)	0 (0)	0.295
Dietician	0.172 (0.131)	0 (0)	0.295
Dentist	0.172 (0.131)	0.031 (0.25)	0.703
Thoracic	0 (0)	0.016 (0.125)	0.343
<b>Primary and community care</b>			
<b>In surgery/clinic</b>			
GPs	1.224 (2.193)	0.938 (1.833)	0.434
Practice Nurse	0.345 (1.101)	0.516 (1.553)	0.489
District nurse	0.034 (0.263)	0 (0)	0.295
Physiotherapist	0.103 (0.788)	0.125 (1)	0.896
Occupational therapist	0 (0)	0.016 (0.125)	0.343
<b>At home</b>			
GPs	0 (0)	0.047 (0.278)	0.201
Practice Nurse	0.103 (0.447)	0.047 (0.035)	0.067
Chiroprapist	0.034 (0.263)	0 (0)	0.295
District Nurse	0.155 (0.951)	0.031 (0.175)	0.308

	Mean Usage (SD)		P-value*	
	RSA (n =58)	THA (n =64)		
Physiotherapist	0.121 (0.796)	0 (0)	0.228	
Dermatologist	0.052 (0.292)	0.016 (0.125)	0.368	
<b>Aids and adaptation</b>				
Walking stick	0.269 (0.597)	0.259 (0.902)	0.946	
Crutches	0.431 (0.901)	0.421 (0.826)	0.950	
Wheelchair	0.017 (0.131)	0 (0)	0.295	
Insoles	0.034 (0.184)	0 (0)	0.136	
Zimmer	0.017 (0.131)	0 (0)	0.295	
Toilet seat	0.103 (0.307)	0.125 (0.333)	0.712	
Sock aid	0.017 (0.131)	0.031 (0.175)	0.621	
Grabber	0 (0)	0.109 (0.315)	0.009	
Shoe horn	0 (0)	0.031 (0.175)	0.178	
Trolley	0 (0)	0.031 (0.25)	0.343	
Perching stool	0 (0)	0.047 (0.278)	0.201	
Frame	0.017 (0.131)	0.016 (0.125)	0.945	
Clothes aid	0.017 (0.131)	0 (0)	0.295	
<b>Medications</b>				
Co-codamol	30mg/500mg	77.51 (141.29)	84.02 (172.51)	0.821
Codeine	30mg tablets	6.62 (33.08)	0 (0)	0.130
Paracetamol	500mg capsules	53.07 (148.95)	46.54 (136.14)	0.811
Tramadol	50mg capsules	54.98 (169.59)	17.88 (63.05)	0.124
Amitriptyline	25mg tablets	2.30 (16.45)	8.04 (33.61)	0.270
Dihydrocodeine	30mg tablets	7.42 (53.00)	1.51 (11.46)	0.409
Diclofenac	50mg tablets	44.67 (121.91)	38.15 (103.72)	0.764
Ibuprofen	400mg tablets	54.63 (146.76)	25.44 (100.35)	0.224
Naproxen	500mg tablets	21.34 (106.88)	13.59 (77.87)	0.662
Aspirin	300mg tablets	6.94 (34.69)	0 (0)	0.130
Warfarin	5mg tablets	13.76 (98.25)	0 (0)	0.288
Zopiclone	7.5mg tablets	2.30 (11.53)	0.97 (7.37)	0.467
Flucloxacillin	500mg capsules	6.94 (34.69)	3.05 (23.23)	0.489
Morphine	10mg tablets	0 (0)	5.06 (27.06)	0.184
Hydrocortisone	cream 1%	0 (0)	0.02 (0.13)	0.351
Furosemide	40mg tablets	0 (0)	3.05 (23.24)	0.351
Buprenorphine	400µg tablets	0 (0)	4.73 (35.99)	0.351
Omeprazole	10 mg tablets	7.12 (50.81)	6.26 (47.64)	0.927

\* P-value, based on a two-sample t-test assuming equal variance

## EVEREST STATEMENT / BMJ Checklist

Item	Y/N	Where?
(1) The research question is stated	Y	Page 4 "Perspective"
(2) The economic importance of the research question is justified	Y	Page 3 "Introduction"
(3) The viewpoint(s) of the analysis are clearly stated and justified	Y	Page 4 "Perspective"
(4) The rationale for choosing the alternative programmes or interventions compared is stated	Y	As a within trial analysis, this is determined by the trial design. This is varied in sensitivity analyses.
(5) The alternatives being compared are clearly described	Y	Page 3 "Introduction"
(6) The form of economic evaluation used is stated	Y	Page 4 "Perspective"
(7) The choice of form of economic evaluation is justified in relation to the questions addressed	Y	Page 4 "Perspective"
(8) The source(s) of effectiveness estimates used are stated	Y	Within trial, plus Methods section
(9) Details of the design and results of effectiveness study are given (if based on a single study)	Y	Within trial, plus Methods section. Findings of the main trial have been added.
(10) Details of the method of synthesis or meta-analysis of estimates are given (if based on an overview of a number of effectiveness studies)	NA	
(11) The primary outcome measure(s) for the economic evaluation are clearly stated	Y	Page 4-5, "Quality of life"
(12) Methods to value health states and other benefits are stated	Y	Page 4-5, "Quality of life"
(13) Details of the subjects from whom valuations were obtained are given	Y	Uses standard UK tariff to value EQ-5D outcomes, see "Quality of life"
(14) Productivity changes (if included) are reported separately	Y	These are reported in brief as a sensitivity analysis.
(15) The relevance of productivity changes to the study question is discussed	Y	Page 5-6, "Resource use and valuation". Brevity prevents this being included in depth
(16) Quantities of resources are reported separately from their unit costs	Y	Within Web Extra tables
(17) Methods for the estimation of quantities and unit costs are described	Y	Pages 5-6, "Resource use and valuation"
(18) Currency and price data are recorded	Y	Page 4 "Perspective"
(19) Details of currency of price adjustments for inflation or currency conversion are given	Y	Page 4 "Perspective"
(20) Details of any model used are given	NA	
(21) The choice of model used and the key parameters on which it is based are justified	NA	
(22) Time horizon of costs and benefits	Y	Page 4 "Perspective"
(23) The discount rate(s) is stated	NA	
(24) The choice of rate(s) is justified	NA	
(25) An explanation is given if costs or benefits are not discounted	Y	Justification is given by virtue of a 1-year timeframe.
(26) Details of statistical tests and confidence intervals are given for stochastic data	Y	Confidence intervals are inappropriate for ICERs but confidence intervals are provided for NMB. Detail on statistical tests are given throughout the methods (pp.4-8, and more detail is given

		specifically within the section on "Missing data" (p6) and "Adjustment for baseline differences" (p8)
(27) The approach to sensitivity analysis is given	Y	See Pages 7, "Cost-effectiveness", pp7-8 "Scenarios/Univariate sensitivity analysis", and p.8 "Adjustment for baseline differences"
(28) The choice of variables for sensitivity analysis is justified	Y	See Pages 7, "Cost-effectiveness", pp7-8 "Scenarios/Univariate sensitivity analysis", and p.8 "Adjustment for baseline differences"
(29) The ranges over which the variables are varied are stated	Y	We do not use one-way sensitivity analyses, and so this is not massively relevant (as are many parts of this checklist in 2012). The analyses relate more to specific changes to assumptions than arbitrary values for potentially key parameters.
(30) Relevant alternatives are compared	Y	Page 3 "Introduction"
(31) Incremental analysis is reported	Y	Page 10, "Cost-effectiveness and sensitivity analyses", Table 3
(32) Major outcomes are presented in a disaggregated as well as aggregated form		Table 1 provides disaggregated quality of life data, Table 2 provides cost data by general area, Web Extras provide disaggregated resource data.
(33) The answer to the study question is given	Y	Pages 10-11 provide firstly results where no adjustments are made for baseline differences, and then with this adjustment.
(34) Conclusions follow from the data reported	Y	Page 11-13, "Discussion" follows on from themes introduced in results
(35) Conclusions are accompanied by the appropriate caveats	Y	Page 12-13, Particularly with respect to time and the choice of THA implant.



**Cost-effectiveness of total hip arthroplasty versus resurfacing arthroplasty: economic evaluation alongside a clinical trial**

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-001162.R2
Article Type:	Research
Date Submitted by the Author:	17-Aug-2012
Complete List of Authors:	Edlin, Richard; University of Auckland, Health Systems, School of Population Health Tubeuf, Sandy; University of Leeds, Academic Unit of Health Economics Achten, Juul; University of Warwick, Division of Health Sciences Parsons, Nicholas; University of Warwick, Division of Health Sciences Costa, Matthew; University of Warwick, Warwick Clinical Trials Unit
<b>Primary Subject Heading</b>:	Health economics
Secondary Subject Heading:	Surgery
Keywords:	Hip < ORTHOPAEDIC & TRAUMA SURGERY, Adult orthopaedics < ORTHOPAEDIC & TRAUMA SURGERY, Orthopaedic & trauma surgery < SURGERY

SCHOLARONE™  
Manuscripts

only



1  
2  
3 **Objectives:** To report on the relative cost-effectiveness of total hip arthroplasty and resurfacing  
4 arthroplasty (replacement of articular surface of femoral head only) in patients with severe arthritis  
5 suitable for hip joint resurfacing arthroplasty.  
6

7 **Design:** Cost-effectiveness analysis on an intention to treat basis of a single-centre, single-blind  
8 randomised controlled trial of 126 adult patients within 12 months of treatment. Missing data were  
9 imputed using multiple imputations with differences in baseline quality of life and gender adjusted  
10 using regression techniques.  
11

12 **Setting:** A large teaching hospital trust in the UK  
13

14 **Participants:** 126 adult patients with severe arthritis of the hip joint suitable for a resurfacing  
15 arthroplasty of the hip.  
16

17 **Results:** Data was received for 126 patients, 4 of whom did not provide any resource use data. For  
18 the remainder, data was imputed for costs or quality of life in at least one time point (baseline, 3  
19 months, 6 months, 1 year) for 18 patients. Patients in the resurfacing arm had higher quality of life  
20 at 12 months (0.795 vs. 0.727) and received 0.032 more QALYs within the first 12 months post  
21 operation. At an additional cost of £564, resurfacing arthroplasty offers benefits at £17,451 per  
22 QALY within the first 12 months of treatment. When covariates are considered, the health economic  
23 case is stronger in men than women.  
24  
25  
26  
27

28 **Conclusions:** Resurfacing arthroplasty appears to offer very short term efficiency benefits over total  
29 hip arthroplasty within a selected patient group. The short-term follow-up in this trial should be  
30 noted, particularly in light of the concerns raised regarding adverse reactions to metal debris from  
31 MOM bearing surfaces in the longer term. Longer term follow up of resurfacing arthroplasty patients  
32 and decision analytic modelling is also advised.  
33  
34

35 **Trial registration:** Current controlled Trials ISRCTN33354155. UKCRN 4093.  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**ARTICLE SUMMARY**

## Article focus:

- Hip resurfacing provides a clinical alternative to total hip arthroplasty in active patients with severe arthritis of the hip.
- This paper presents the first health economic analysis of resurfacing arthroplasty versus total hip arthroplasty in the immediate period after surgery.
- This paper analyses the impact of both baseline (EQ-5D) quality of life and gender, and presents separate findings for both men and women.

## Key messages:

- Resurfacing arthroplasty appears cost-effective within the first 12 months of surgery, with modest gains in QALYs.
- The incremental cost-effectiveness ratio for resurfacing arthroplasty was below £20k per QALY in the base case and in all but two scenarios considered as sensitivity analyses.
- The effect of gender may be important, with incremental cost-effectiveness ratios for RSA vs. THA higher (worse) when treating women.

## Strengths and limitations:

- The paper considers the cost and QALY consequences following THA and RSA surgery in a pragmatic RCT.
- Results within the period covered by the paper are not a definitive answer to the resource allocation decisions. Unanswered questions relate particularly to the impact of longer timeframes and the impact of implant choice.

**Funding statement**

The work described in this manuscript has been funded through the Research for Patient Benefit scheme of the NIHR, grant number PB-PG-0706-10080. This manuscript presents independent research commissioned by the National Institute of Health Research. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

**Contributorship Statement**

RE designed the health economic analysis, with input from MC. ST managed data entry, with both RE and ST conducting elements of the health economic analysis. All authors were responsible for writing the manuscript. All authors read and approved the final manuscript.

**Competing Interests Statement**

All authors declare grant funding via the NIHR. In addition, MC and NP declare that manufacturers of resurfacing and total hip replacements have paid research grants to their host institutions, but not in relation to this work

**Data Sharing Statement**

no additional data available.

## Introduction

Hip arthroplasty is acknowledged to be a highly effective and cost-effective procedure for treating patients with severe arthritis of the hip joint, with 87% of patients reporting an improvement in their general health following surgery.<sup>1</sup> The total health gain is expected to be substantial given the effectiveness of treatment; EuroQol (EQ-5D-3L) based quality of life improvements following surgery are estimated to be 0.409, within the 45,000 cases measured in the UK Patient Reported Outcomes programme<sup>2</sup>. 97% of UK hip replacements are still working (unrevised) at 5 years<sup>3</sup> and 83% of all primary hip arthroplasty (all age, all implant types) are unrevised at 17 years post surgery in Sweden<sup>4</sup>. If the initial quality of life gains are maintained, each unrevised surgery represents over five discounted quality-adjusted life-years (QALYs) gained and a benefit of over one hundred thousand pounds at the £20,000 per QALY threshold used by the National Institute of Health and Clinical Excellence (NICE). Compared to these gains, the costs of hip arthroplasty surgery appear modest. As a result, most analyses considering health economics have concentrated on questions of which type of prosthesis to use, and many cost-effectiveness analyses have involved analysis of newer, more expensive operations against older, established comparators.<sup>5-7</sup> Resurfacing arthroplasty of the hip is a newer alternative form of arthroplasty designed for younger, active patients with severe arthritis of the hip.

Hip resurfacing arthroplasty involves the insertion of an acetabular component and the 'capping' of the femoral neck, rather than its removal and replacement with a femoral component in a standard total hip arthroplasty. Of the 70,000 hip arthroplasty operations conducted in England and Wales every year<sup>3</sup>, approximately 6% are hip resurfacings. The equivalent figure amongst men aged under 55 is 33%. As resurfacing preserves the bone of the proximal femur, it may be expected to provide better clinical outcomes on revision of this component than available with a standard hip arthroplasty. Despite advances in their construction, there are still questions about the durability of modern resurfacing implants and there have been few explicit economic evaluations comparing resurfacing arthroplasties against total hip arthroplasties.<sup>8,9</sup> Few randomised controlled trials have been conducted to assess the outcomes of hip resurfacing, and those that exist provide little detail about the economic costs and benefits within the initial year following surgery. This paper reports the first within-trial economic evaluation of resurfacing arthroplasty versus total hip arthroplasty.

## Methods

### Interventions and sample

This evaluation reports on the efficiency of resurfacing arthroplasty (RSA) versus total hip arthroplasty (THA). Patients were deemed eligible for the trial if they were aged over 18 years of age, were medically fit for an operation, and were deemed suitable to receive a resurfacing arthroplasty. Patients were only excluded from the study if there was evidence that the patient would be unable to adhere to trial procedures or complete questionnaires. Patients were randomised on a 1:1 basis between THA and RSA, with each patient operated on according to the preferred technique of the operating surgeon. Other perioperative interventions, such as prophylactic antibiotics and thrombo-prophylaxis were the same for all patients and the same standardised rehabilitation plan was employed for both trial arms. Further details on recruitment, ethics, and randomisation procedures are reported in both the RCT's protocol and reporting papers.<sup>10, 12</sup> The main outcome measure of the trial was hip function (Oxford Hip Score; Harris Hip Score) at 12 months, and the trial found no evidence of a difference between RSA and THA.

### Perspective

The aim of the economic study is to determine the intervention that would maximise health outcomes within the limited National Health Service (NHS) budget in this period, and so a cost-effectiveness (cost-utility) analysis with an NHS and Personal Social Services (PSS) perspective is adopted in the base case. This paper considers the within-trial period (as intention to treat) of the first 12 months follow up. It considers only resources used within the NHS setting including any aids and adaptations required. The base year for all costs figures was 2009/10, with figures from other years converted using the hospital and community health services Pay and Prices Index (for adults, excluding capital).<sup>11</sup> For current costs, figures are deflated assuming an estimated inflation rate of 1.9% to 2010 from this index for both 2009/10 and 2010/11. As the analysis uses a one year time horizon, discounting for the future cost and health outcome is not necessary in this analysis. The currency used was the pound sterling (£).

### Quality of life

Responses from the EQ-5D-3L were obtained from patients at baseline, 3 months, 6 months and 12 months as secondary outcomes of the trial<sup>10</sup>; results from other outcomes are reported in greater

1  
2  
3 depth elsewhere.<sup>12</sup> The standard tariff values<sup>13</sup> were applied to these responses at each time point  
4 to provide EQ-5D-3L quality of life values. Quality-adjusted life-years (QALYs) were calculated as an  
5 “area under the curve” and form the main outcome measure of the study. Where comparisons  
6 between the RSA and THA arms are based on non-imputed data, a two-sample t-test assuming equal  
7 variances is used.  
8  
9

### 10 11 12 Resource use and valuation

13  
14 The costs of THA and RSA treatments were considered across six broad categories – the costs of the  
15 initial operation, of inpatient care post-discharge, of outpatient care, of primary/community care,  
16 and of medications, and aids/adaptations required whilst in the community. The analysis considered  
17 inpatient and outpatient attendances for all reasons, and requested details of other resource usage  
18 only where it related to pain or hip surgery.  
19  
20  
21

22  
23 All RSA patients received a Cormet metal-on-metal resurfacing (Corin Group, Cirencester, UK), whilst  
24 THA patients received their surgeon’s preference of prosthesis. For the patients having THA the  
25 prosthesis type was identified from patient records, with three types of bearing surface (ceramic  
26 femoral head on ceramic socket, metal-on-metal and metal-on-polyethylene) accounting for 95% of  
27 cases. The University Hospitals Coventry and Warwickshire NHS Trust Finance Department provided  
28 implant list prices for both the resurfacing implant and representative cost figures for these three  
29 types of prosthesis. In the remaining 5% of cases, implant type was treated as missing and were  
30 imputed to fall in one of these groups.  
31  
32  
33  
34  
35  
36  
37

38 The current Healthcare Resource Group v.4 (HRG4) reference costs include the cost of prosthesis  
39 across all ages, and in most cases this will be a THR as HRG4 does not include a single category for  
40 primary replacements (as appeared in previous versions). Identified national-level HRG4 frequencies  
41 for primary hip replacements are available<sup>14</sup> and these are used to calculate an average cost,  
42 average length of stay, and average cost per excess bed day. By deducting the expected THA cost  
43 from the average cost, we obtain a non-prosthesis average cost, to which it is possible to add the  
44 appropriate prosthesis cost relevant to each individual. From here, an average cost of the initial  
45 hospitalisation is calculated for each patient by adjusting for each patient’s length of stay (as a  
46 number of bed days from the mean). In this way, a person admitted for the average length of stay  
47 would be assigned the average cost of treatment, with those staying shorter and longer periods  
48 assigned lower and higher costs, respectively.  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 Data regarding length of stay and implant received were obtained from hospital records, with the  
4 remainder of the costing information obtained from patient-reported data. Resource usage was  
5 assessed alongside other outcomes at 3 months, 6 months and 12 months. For the 3 month data,  
6 the recall period was since discharge from hospital. For the other cases, it was since the last  
7 questionnaire was due to be completed. The questionnaires included sections on further inpatient  
8 care following the initial operation (speciality and length of stay/day case), outpatient care, primary  
9 and community care, aids and adaptations provided by the NHS/social services, and medication  
10 (pain relief and other NHS medication). Medicines usage was estimated based on mean dosage  
11 when used and average usage within the three budgetary periods (discharge to 3 months, 3-6  
12 months, 6-12 months). In order to convert resource usage figures into costs, unit cost figures were  
13 assigned from NHS Reference costs<sup>15</sup>, PSSRU unit costs<sup>11</sup>, NHS Electronic Drug Tariff<sup>16</sup>, and reported  
14 unit costs of acupuncture and chiropractic from previous studies. Individual resource items and unit  
15 prices, including for aids and adaptations, are available in Tables provided as a Web Extra. Where  
16 statistical tests analyse resource usage data, t-tests are used to test for differences in expected  
17 usage (assuming equal variance and non-imputed data).  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27

28  
29 Data on personal costs (out of pocket medicine usage and time off work for either the patient or a  
30 carer) were also collected. NHS unit costs were used to provide an indicative figure for private  
31 medicines costs, whilst 2009 median gross weekly earnings from full time jobs (£488.70) was used to  
32 identify a daily productivity cost of £97.74. These are used in the sensitivity analysis considering  
33 societal costs.  
34  
35  
36  
37

### 38 Missing data

39  
40  
41  
42 Where data was incomplete we used multiple imputation via chained equations (ice)<sup>17</sup> to complete  
43 missing data using STATA 11 (StataCorp 2009, TX, USA).<sup>18,19</sup> Missing cost data was predicted in terms  
44 of QALYs, treatment received, length of stay (LOS), age, gender, height, weight, and baseline clinical  
45 scores (Oxford Hip Score, Harris Hip Score); missing QALY data was predicted in terms of this same  
46 list (excluding QALYs), plus each of the cost items; missing LOS was predicted using the same list as  
47 for QALYs, with QALYs included. In order to remove implausible data, missing cost data was  
48 constrained to be positive and length of stay was constrained to be at least three days post-  
49 imputation. A total of 50 imputations were used to inform each item of missing data. Where tests  
50 are conducted to detect significant differences in mean values between the RSA and THA groups  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 based on imputed data (i.e. incremental costs and QALYs), the analysis uses an OLS regression within  
4 the STATA's mim command.  
5  
6  
7  
8

### 9 Cost-effectiveness

10  
11  
12 Using the methods identified above, total costs and QALY figures were calculated for all patients  
13 including imputed data. For the cost-effectiveness analysis, we identified the differences between  
14 costs and QALYs between the two arms, dividing the former by the latter to compute an incremental  
15 cost-effectiveness ratio (ICER). When compared against the marginal trade-off for the NHS as a  
16 whole – the cost-effectiveness threshold – the ICER gives a broad indication of whether spending  
17 additional money on hip arthroplasty appears efficient. The ICER figure is not presented with a  
18 confidence interval due to difficulties in interpreting a ratio of two random variables. Instead, we  
19 assume that each QALY is valued at £20,000 and subtract costs from this 'monetised' QALY in order  
20 to obtain a net monetary benefit (NMB). Any treatment with an ICER below £20,000 will have a  
21 positive NMB, with higher NMB figures unambiguously better and lower NMB figures unambiguously  
22 worse. As before, a 95% confidence interval is formed for NMB using linear regression using STATA's  
23 mim command.  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33

### 34 Scenarios/univariate sensitivity analyses

35  
36  
37 Key uncertainties in the scenarios considered were explored using univariate sensitivity analyses.  
38 The results for complete cost and quality of life data (i.e. those with no missing data) were provided  
39 to identify the impact of missing data on the analysis. A strict per-protocol analysis of the data is  
40 also used to reflect any sensitivity to protocol violations. A societal perspective was also explored by  
41 adding the patient medicines and productivity costs outlined above to the NHS + PSS costs. As  
42 patients might also recover function within the first three months (rather than continuously to three  
43 months), a quicker initial recovery was explored in QALY calculations, where each patient's quality of  
44 life was assumed to reach its observed 3-month level at 6 weeks post-operatively. The cost  
45 assumptions in the analysis were modified by assessing the impact of assuming the least expensive  
46 (metal on polyethylene) THA implant was used throughout with no effect on observed outcomes, to  
47 reflect the potential concern that the THA arm might not reflect cost-effective practice. The recent  
48 (after the trial)current recommendations against the use of metal on metal THA prostheses are  
49 briefly considered by setting all 'metal on metal' implants to missing, estimating which THA  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



1  
2  
3 prosthesis (i.e. metal on polyethylene or ceramic on ceramic) each patient will receive using multiple  
4 imputation, and considering the cost implications within these alternative estimates.  
5  
6

#### 7 8 Adjustment for potential baseline differences 9

10  
11 The base case analysis was conducted to allow for comparability between this within-trial analysis  
12 and the reporting of the main RCT<sup>12</sup>. These quality of life and gender-based analyses are conducted  
13 as *sensitivity* analyses to allow comparability with the main RCT, which did not find a significant  
14 difference in baseline quality of life and did not test for an interaction between efficacy and gender.  
15 Given that these issues may be important within the economic evaluation, they are considered as  
16 sensitivity analyses.  
17  
18  
19

20  
21  
22 The impact of potential baseline differences in quality of life are corrected for using regression  
23 analysis within a sensitivity analysis. The number of QALYs received (average quality of life over 12  
24 months) is assumed to be a normal distribution, conditional on trial arm (RSA or THA) and baseline  
25 EQ-5D-3L value. Total cost over 12 months is assumed to be lognormal, so that the natural  
26 logarithm of costs is a normal distribution, conditional on trial arm, baseline EQ-5D-3L.  
27  
28  
29

30  
31  
32 QALYs and (log-)costs for each person are estimated using ordinary least squares regression (using  
33 STATA's *mim* command to handle imputed data). As any relationship between uncertainty in the  
34 extra costs and benefits associated with RSA is important when assessing the likelihood of cost-  
35 effectiveness, we use a seemingly unrelated regression to do this.. By using a Cholesky  
36 Decomposition of the variance-covariance matrix, (log-)costs and QALYs are modelled as if they  
37 come from a multivariate normal distribution. Uncertainty in the value of other items in the  
38 regression is ignored. From here, costs are estimated as if all patients receive THA, and incremental  
39 costs are calculated as a proportion of the average THA cost. In this way, a distribution is built up for  
40 incremental costs and incremental QALYs that can be analysed using cost-effectiveness acceptability  
41 curve (CEAC) can be formed for this analysis.<sup>21</sup> This CEAC indicates the likelihood that RSA will be  
42 cost-effective at different 'values' for a QALY.  
43  
44  
45  
46  
47  
48  
49

50  
51  
52 As gender so heavily affects the clinical use of RSA, this analysis was re-run for both male patients  
53 only and female patients only. This allows the effects of RSA to be assessed separately for men and  
54 women, with this figure presented as the likelihood of that RSA would be cost-effective at a  
55 threshold value of £20,000 per QALY.  
56  
57  
58  
59  
60

## Results

### Trial recruitment

The trial<sup>12</sup> recruited a total of 126 patients (RSA=60; THA=66) between May 2007 to February 2010. Two patients from each arm of the study did not have surgery and provided only baseline quality of life/demographic data, leaving a total of 58 and 64 patients in each arm. The sample was representative of the broader population undergoing resurfacing in the UK during the period of recruitment; no significant differences were identified between those who took part and those who were eligible but chose not to take part. Further details on both the ethical approval for the study and the demographics of the patients are provided in the clinical paper.<sup>12</sup> As the analysis estimates data on costs and outcomes conditional on baseline quality of life, these patients cannot contribute any data to our analysis and are excluded from the analyses here.

### Quality of life

Table 1 summarises quality of life estimates at the four time points and calculates QALY estimates both with and without data imputation in the two arms. Overall, those in the RSA group started in worse health (as measured by the EQ-5D-3L) and received 0.033 more QALYs within the 12 months of the trial (n=118 observations). When the small amount of missing data is imputed, the estimated benefit remains very similar at 0.032 (95%CI, -0.054, 0.119). Within the trial, the difference in quality of life between the RSA and THA arms of the trial appears to increase at each post-operative time point.

### Costs and resource usage

Overall, NHS and social care costs were significantly higher amongst the RSA group with an average of £564 more spent within the first 12 months from the operation (Table 2), of which the majority is due to the higher cost of implants and length of stay following the initial operation (£184), subsequent inpatient care (£279) and outpatient care (£84). The deflated cost of the RSA implants including operative consumables used in this study was £1,826 vs. an average of £1,700 for THA operations, based on imputed data. THA implants differed in costs, with the most expensive being

1  
2  
3 ceramic on ceramic implants (£2,042) and those using metal on metal implants costing slightly less  
4 than RSA implants (£1,625). Implants and consumables in metal on polyethylene operations (£843)  
5 were associated with only 40% of the cost of ceramic on ceramic implant. Whilst the resurfacing  
6 implants were more expensive, they were also associated with a slightly longer length of stay (5.7 vs.  
7 5.5 days), although this difference was not statistically significant ( $P = 0.536$ ; imputed data).  
8  
9

10  
11  
12 Those in the RSA arm had significantly more outpatient visits than those in the THA arm (5.155 vs.  
13 3.063,  $P = 0.0054$ ; non-imputed data). Here, both the number of physiotherapy sessions and the use  
14 of deep vein thrombosis assessments were significantly higher amongst this group ( $P = 0.002$ ,  $P =$   
15  $0.011$ ; non-imputed data). For inpatient care, only subsequent inpatient attendances (0.155 vs.  
16 0.047,  $P = 0.066$ ; non-imputed data) approached significance, with the only significant difference ( $P$   
17  $= 0.009$ ) in aids and adaptations favouring RSA. For full details on individual resource use items and  
18 their unit costs, please see the tables available as a Web Extra.  
19  
20  
21  
22  
23

24  
25 The private costs to patients following arthroplasty surgery are considerable, although relatively  
26 little of this is due to the purchase of medication. There are no significant differences in medication  
27 usage between the RSA and THA arms, and the total costs of this treatment is similar (£12 RSA vs. £9  
28 THA,  $P = 0.667$ ). RSA patients report an average of 73 days off work, as against 57 days for THA  
29 patients ( $P = 0.333$ ). Whilst surgery results in a large number of days off work for the patient, carers  
30 tend to take very few days off work (2.1 days RSA vs. 1.6 days THA;  $P = 0.595$ ). Overall, RSA patients  
31 report costs valued at £5,917, as against £5,853 in the THA arm (imputed data). This difference is  
32 small but highly uncertain, such that there is no significant difference in costs from a societal  
33 perspective (£629 higher costs in RSA, 95%CI: -£2,456 -£3,713).  
34  
35  
36  
37  
38  
39  
40  
41  
42

#### 43 Cost-effectiveness and sensitivity analyses

44  
45  
46 Whilst RSA is expected to cost more over the first 12 months following an operation, it appears to  
47 provide a difference in quality of life. Here, the incremental cost-effectiveness ratio (ICER) for RSA is  
48 £17,451 per QALY (£564/0.032 QALY). Within most of the sensitivity tests explored here, the figure  
49 appears to remain within or below the £20k-£30k per QALY range used by the National Institute for  
50 Health and Clinical Excellence as its estimate of the cost-effectiveness threshold, except where  
51 cheaper THA implants are used in place of surgeon's preference, which was mostly MOM THA within  
52 the trial (Table 3). If the cheaper (metal-on-polyethylene) implants are used, the increased cost of  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 RSA vs. THA implants is enough to raise the average cost difference above £1,000 which, given the  
4 small quality of life difference observed here, is enough to prevent RSA being cost effective.  
5  
6 However, if we consider *both* types of non-MOM implants (ceramic-on-ceramic and metal-on-  
7 polythene), this difference disappears entirely as the non-MOM implants were slightly more  
8 expensive on average than the MOM ones. The confidence interval for net benefit in every analysis  
9 spans zero (Table 4) so that the findings do not reach statistical significance. As clinical trials are very  
10 rarely designed with the power of cost-effectiveness conclusions in mind, very little can be inferred  
11 from this lack of significance.  
12  
13  
14  
15

### 16 17 18 Adjustment for baseline differences

19  
20  
21 Once baseline differences in EQ-5D-3L are considered, the QALYWAT estimates for the first 12  
22 months appear to change. QALYs are higher generally amongst those who are healthier at baseline  
23 (EQ-5D-3L;  $P=0.000$ ), with those treated in the RSA arm receiving 0.053 more QALYs than those  
24 treated with THA ( $P=0.119$ ). Likewise, log-costs appear to be affected by baseline health ( $P=0.034$ ),  
25 with costs 7.1% higher (95%CI: 1.7%-12.9%) for those who received RSA after bootstrapping.  
26  
27  
28  
29

30  
31 Whilst correcting for baseline differences leaves the incremental costs largely unchanged (£473;  
32 95%CI: 107-840), the estimated QALY benefit almost doubles (0.053, 95%CI: -0.014-0.120).  
33  
34 Consequently, the ICER is around half as large (£8,905 per QALY) as the non-adjusted case. In 79% of  
35 cases investigated, RSA is recommended when valuing health at £20,000 per QALY – suggesting  
36 quite high confidence that RSA is the more cost-effective option within the first 12 months of  
37 treatment across the £20k-£30k range used by NICE (Figure 1). Where this analysis is re-run for male  
38 patients only ( $n = 71$ ), neither incremental costs nor incremental QALYs reach statistical significance  
39 and the ICER falls to £5,519 per QALY. For female patients ( $n=51$ ), the ICER is about three times as  
40 large as for males (£16,272 per QALY) due to higher costs and lower benefits, with the latter  
41 exacerbated by a much lower baseline quality of life (female 0.257, male 0.389;  $P=0.032$ ). Within  
42 the scenarios used here, RSA is only 54% likely to be cost-effective for female patients at £20,000 per  
43 QALY, compared to an 86% likelihood for male patients.  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54

## 55 **Discussion**

1  
2  
3 In comparison to standard total hip arthroplasty, hip resurfacing arthroplasty appears to provide a  
4 modest QALY gain for a modest sum within the first 12 months from surgery; whilst the additional  
5 costs of RSA are statistically significant, the additional benefits are not. The higher costs of RSA  
6 treatments are largely due to slightly higher costs for the initial operative and recovery periods, and  
7 higher usage of outpatient services. Whilst the RSA group achieves slightly better health outcomes  
8 and requires more services, this may be due to heterogeneity in outcomes; if resurfacing works well  
9 for most but poor for some, then this could produce this type of phenomenon. If so, this emphasises  
10 the need to follow patients up in the longer term.  
11  
12  
13  
14  
15  
16  
17  
18

19 The analysis presented here analyses the data by considering potential confounding due to both  
20 gender and baseline quality of life, and this nearly doubles the estimate of RSA effect size. Whilst  
21 the main analysis of the trial data<sup>12</sup> found no statistically significant difference in hip function  
22 between the RSA and THA groups at 12 months, it seems likely that some short term difference in  
23 quality of life exists favouring RSA and that – again within 12 months – there is enough evidence to  
24 suggest that it may be cost-effective.  
25  
26  
27  
28  
29  
30  
31

32 Within the first 12 months of treatment, the main caveat to our results deals with the comparator  
33 THA arm. The pragmatic nature of the trial data used here<sup>12</sup> is one of its key strengths, since it  
34 reflects current practice. Any changes to this practice may affect cost-effectiveness though, so that  
35 RSA may become more/less cost-effective as less/more cost-effective THA implants are used. A  
36 recent (US) analysis of registry data suggests that more expensive implants do not provide a  
37 substantive age-adjusted advantage over less expensive prostheses.<sup>22</sup> Where the sensitivity analysis  
38 assumed the use of the cheapest metal-on-polyethylene implants (without incorporating a possible  
39 impact on quality of life), RSA was no longer cost-effective within-trial. However, these implants  
40 were used relatively rarely in practice, and the main alternative to metal on metal THA implants was  
41 the more expensive ceramic on ceramic type. Restrictions in the use of MOM THA implants within  
42 the UK are likely to lead to more costly THA implants being used, and so a net increase in the cost-  
43 effectiveness of resurfacing by comparison.  
44  
45  
46  
47  
48  
49  
50  
51

52  
53  
54  
55 Beyond the issues surrounding the choice of THA, the trial is inevitably unable to consider all  
56 possible cost items. The trial did not explicitly consider any differences in operative time between  
57  
58  
59  
60

1  
2  
3 the RSA and THA arms; no difference was expected and an informal analysis of the data suggests  
4 very similar operative times between the arms. This evaluation was also unable to consider the  
5 impact of variation in cost within each type of prostheses (i.e. within the three types of THA, or  
6 beyond the single RSA used in the trial) as this information is not generally available. The clinical  
7 trial upon which this analysis is based used a single type of Cormet prosthesis that has been used in  
8 the UK for around 15 years. Whilst the list price of the Cormet prosthesis is similar to other  
9 prostheses available locally, prices are hospital-specific and so some caution is warranted when  
10 seeking to generalise findings to other locations. We note also that our findings are not necessarily  
11 generalizable to other types of resurfacing, including emerging technologies such as ceramic on  
12 ceramic resurfacings. Whilst the cost-effectiveness of these newer treatments may differ from  
13 standard resurfacings, we cannot identify the most cost-effective type of resurfacing as this was  
14 beyond the scope of the trial and relatively little data exists on which to base even a preliminary  
15 estimate. To the degree that this may prove possible, it is an issue for subsequent decision analytic  
16 modelling.  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28

29 Clearly, the cost-effectiveness of resurfacing is likely to require assessment over a longer period of  
30 time – as is typically the case for any health economic analysis of trial data.<sup>23</sup> Importantly, the higher  
31 revision rates reported for resurfacing arthroplasty suggest that the additional costs of RSA may be  
32 higher if a longer period is considered. On the benefit side of the equation, the impact of extending  
33 the time period is unclear as RSA may improve quality of life in the short term but lead to a quicker  
34 deterioration once revisions are necessary, or require additional monitoring or revisions by virtue of  
35 its ‘metal-on-metal’ nature. One method to explore these questions may be decision analytic  
36 modelling.<sup>23</sup> The trial provides an estimate of short term clinical benefits from hip function and  
37 quality of life (conditional on EQ-5D-3L), with longer follow up series (from trials or registry data)  
38 needed to model implant survival for both RSA and THA.  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49

50 As THA revision surgery may be surgically more complex, financially more costly, and less effective  
51 than a primary THA, a key question when interpreting this study is the prognosis for patients after  
52 their RSA is revised. An Australian registry analysis suggests poor implant survival amongst patients  
53 receiving a revision of only the acetabular RSA component, and some evidence of higher revision  
54 risks among other types of RSA revisions such as where both components are revised.<sup>24</sup> It is unclear,  
55 however, whether a revised RSA is more similar, in terms of quality of life, to a primary THA or a  
56  
57  
58  
59  
60

1  
2  
3 revision THA. Further research is necessary to assess the likely impact of this and other questions to  
4 guide future research, and the findings of this paper are by no means a complete answer to the  
5 decision problem.  
6  
7  
8  
9

10  
11 Registry data reveals that women represent 61% of primary THA patients in the UK but make up only  
12 25% of RSA patients.<sup>3</sup> These figures reflect relevant gender differences from both a clinical and a  
13 health economic perspective as women appear to obtain higher quality of life gains from THA, and  
14 face an increased revision rate from RSA.<sup>4,25</sup> This trial may also suggest a lower benefit from RSA  
15 relative to THA amongst women, although the finding was not statistically significant (or powered to  
16 be so). Despite the conclusions of the within-trial analysis, it seems clear that until such work is  
17 done and further data is available, the cost-effectiveness of resurfacing arthroplasty in a UK context  
18 remains potentially promising but as yet unproven.  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**Table 1. EQ-5D-3L quality of life at each measurement and converted into QALYs (missing data imputed)**

Quality of life	RSA (SD) n =58	THA (SD) n =64	Difference <sup>+</sup> (95% CI)
Baseline	0.308 (0.338)	0.356 (0.335)	-0.048 (-0.168, 0.073)
3 months	0.722 (0.229)	0.698 (0.284)	0.023 (-0.711, 0.118)
6 months	0.796 (0.244)	0.747 (0.287)	0.050 (-0.046, 0.146)
12 months	0.795 (0.282)	0.727 (0.319)	0.067 (-0.042, 0.177)
QALYs (n = 118)	0.716 (0.216)	0.683 (0.252)	0.033 (-0.053, 0.120)
QALYs* (n = 122)	0.713 (0.216)	0.681 (0.251)	0.032 (-0.054, 0.119)

\* With imputed data

For peer review only



**Table 2. Costs by type, summed across trial period (missing data imputed)**

Costs	% impute	RSA (SD) n =58	THA (SD) n =64	Difference (95% CI)
Initial	7%	£6275 (557)	£6091 (532)	£184 (-18, 386)
Subsequent	11%	£470 (956)	£191 (558)	£279 (-11, 569)
Outpatient	11%	£360 (294)	£276 (210)	£84 (-13, 181)
Primary/community	11%	£63 (98)	£49 (67)	£14 (-17, 45)
Aids and	11%	£21 (33)	£21 (40)	£0 (-14, 14)
Medication	11%	£27 (43)	£24 (41)	£3 (-13, 19)
NHS + PSS Costs	--	£7217 (1320)	£6653 (917)	£564 (144, 985)
Private costs	61%	£5917 (5145)	£5853 (5520)	£64 (-3017, 3146)
Societal cost	--	£13,134 (5146)	£12,506 (5568)	£629 (-2456, 3713)

**Table 2. Costs by type, summed across trial period (missing data imputed)**

Costs	% impute	RSA (SD) n =58	THA (SD) n =64	Difference (95% CI)
Initial	7%	£6275 (557)	£6091 (532)	£184 (-18, 386)
Subsequent	11%	£470 (956)	£191 (558)	£279 (-11, 569)
Outpatient	11%	£360 (294)	£276 (210)	£84 (-13, 181)
Primary/community	11%	£63 (98)	£49 (67)	£14 (-17, 45)
Aids and	11%	£21 (33)	£21 (40)	£0 (-14, 14)
Medication	11%	£27 (43)	£24 (41)	£3 (-13, 19)
NHS + PSS Costs	--	£7217 (1320)	£6653 (917)	£564 (144, 985)
Private costs	61%	£5917 (5145)	£5853 (5520)	£64 (-3017, 3146)
Societal cost	--	£13,134 (5146)	£12,506 (5568)	£629 (-2456, 3713)

**Table 3. Incremental cost effectiveness**

Scenario	Incremental costs (95%CI)	Incremental QALYs (95%CI)	ICER (per QALY)
Base case (BC)	£564 (144, 985)	0.032 (-0.054, 0.119)	£17,451
Per protocol	£528 (85, 970)	0.024(-0.066, 0.113)	£22,227
Complete case data (N=98)	£721 (286, 1157)	0.053 (-0.042, 0.149)	£13,443
Societal costs	£629 (-2456, 3713)	0.032 (-0.054, 0.119)	£19,435
Metal/polyethylene THA implants	£1271 (859, 1684)	0.032 (-0.054, 0.119)	£39,318
No metal on metal THA implants	£522 (76, 968)	0.032 (-0.054, 0.119)	£16,137
Quicker initial recovery	£564 (144, 985)	0.039 (-0.048, 0.127)	£14,310
Quality of life (QoL) adjustments	£473 (113, 853)	0.053 ( -0.014-0.120)	£8,905
QoL adjustments , males only	£402 (-82, 916)	0.073 (-0.012, 0.158)	£5,519
QoL adjustments, females only	£598 (64, 1172)	0.037 (-0.070, 0.144)	£16,272

**Table 4. Net Monetary Benefit**

Scenario	NMB (95%CI)*
Base case (BC)	£82.46 (-1795, 1960)
Per protocol	-£53 (-2011, 1905)
Complete case data (N=98)	£353 (-1719, 2426)
Societal costs	£19 (-3641, 3680)
Metal/polyethylene THA implants	-£625 (-2515, 1265)
No metal on metal THA implants	£125 (-1750, 1999)
Quicker initial recovery	£224 (-1658, 2107)
Adjustments for quality of life	£590 (-834, 2014)
Adjustments for quality of life, males	£1055 (-843, 2954)
Adjustments for quality of life, females	£137 (-1988, 2262)

QALYs valued at £20k each

## References

1. Health Episodes Statistics Online. Finalised PROMs data 2009-10, 2011.
2. Health Episodes Statistics Online. PROMs Score Comparisons April 2009 to February 2011: The NHS Information Centre for Health and Social Care, 2011.
3. Ellams D, Forsyth O, Mistry A, et al. *7th Annual Report*. National Joint Registry for England and Wales, 2010.
4. Garellick G, Kärrholm J, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2008. Shortened Version*. Department of Ortopaedics, Sahlgrenska University Hospital, 2009.
5. Bozic KJ, Morshed S, Silverstein MD, et al. Use of cost-effectiveness analysis to evaluate new technologies in orthopaedics: the case of alternative bearing surfaces in total hip arthroplasty. *Journal of Bone and Joint Surgery* 2006;88(4):706-14.
6. Briggs A, Sculpher M, Dawson J, et al. Modelling the cost-effectiveness of primary hip replacement: how cost-effective is the Spectron compared to the Charnley prosthesis? *York - CHE - Technical Paper* 2003;28.
7. Fitzpatrick R, Shortall E, Sculpher M, et al. Modelling of cost-effectiveness of THR: methods and results and discussion in primary total hip replacement surgery: a systematic review of outcomes and modelling of cost-effectiveness associated with different prostheses. *Health Technology Assessment* 1998;2(20):17-32.
8. Vale L, Wyness L, McCormack K, et al. A systematic review of the effectiveness and cost-effectiveness of metal-on-metal hip resurfacing arthroplasty for treatment of hip disease. *Health Technology Assessment* 2002;6(15).
9. Bozic KJ, Pui CM, Ludeman MJ, et al. Do the Potential Benefits of Metal-on-Metal Resurfacing Justify the Increased Cost and Risk of Complications? *Clinical Orthopaedics and Related Research* 2010;468:2301-12.
10. Achten JA, Parsons NR, Edlin RE, et al. A randomised controlled trial of total hip arthroplasty versus resurfacing arthroplasty in the treatment of young patients with arthritis of the hip joint. *BMC Musculoskeletal Disorders* 2010;11(8).
11. Curtis L. Unit Costs of Health & Social Care 2010. Personal and Social Services Research Unit, 2010.
12. Costa ML, Achten J, Parsons NR, et al. Total Hip Arthroplasty Versus Resurfacing Arthroplasty in the Treatment of Young Patients with Arthritis of the Hip Joint: A single centre, parallel group, assessor blind, randomised control trial. *British Medical Journal* 2012; 344:e2147.
13. Dolan P. Modeling valuations for EuroQol health. *Medical Care* 1997;35(11):1095-108.
14. *HRG version 3.5 & HRG4 Comparative Chapter Analysis*: The Health & Social Care Information Centre., 2008.
15. *National Schedule of Reference Costs 2009-10. Appendix NSRC04: NHS Trusts and PCTs combined reference cost schedules*. London: Crown Copyright, 2011.
16. *NHS. Electronic Drug Tariff: May 2011*. National Health Service England and Wales, 2011.
17. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine* 2011;30(4):377-99.
18. Royston P. Multiple imputation of missing values: further update of ice, with an emphasis on interval censoring. *The Stata Journal* 2007;7(4):445-64.
19. Royston P, Carlin JB, White IR. Multiple imputation of missing values: New features for mim. *The Stata Journal* 2009;9(2):252-64.
20. Willan AR, Briggs AH, Hoch JS. Regression methods for covariate adjustment and subgroup analysis for non-censored cost-effectiveness data. *Health Economics* 2004;13:461-75.
21. Fenwick E, Byford S. A guide to cost-effectiveness acceptability curves. *British Journal of Psychiatry* 2005;187:106-8.
22. Gioe TJ, Sharma A, Tatman P, et al. Do "Premium" Joint Implants Add Value? *Clinical Orthopaedics and Related Research* 2011;469:48-54.

- 1  
2  
3 23. Petrou S, Gray A. Economic evaluation using decision analytical modelling: decision, conduct,  
4 analysis, and reporting. *British Medical Journal* 2011;342:doi: 10.1136/bmj.d766.  
5 24. de Steiger RN, Miller LN, Prosser GH, et al. Poor outcome of revised resurfacing hip arthroplasty.  
6 397 cases from the Australian Joint Replacement Registry. *Acta Orthopaedica* 2010;81(1):72-  
7 76.  
8 25. Kärrholm J, Garellick G, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2007*:  
9 Department of Ortopaedics, Sahlgrenska University Hospital, 2008.  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

1  
2  
3  
4  
5  
6  
7 **Objectives:** To report on the relative cost-effectiveness of total hip arthroplasty and resurfacing  
8 arthroplasty (replacement of articular surface of femoral head only) in patients with severe arthritis  
9 suitable for hip joint resurfacing arthroplasty.

10 **Design:** Cost-effectiveness analysis on an intention to treat basis of a single-centre, single-blind  
11 randomised controlled trial of 126 adult patients within 12 months of treatment. Missing data were  
12 imputed using multiple imputations with differences in baseline quality of life and gender adjusted  
13 using regression techniques.

14 **Setting:** A large teaching hospital trust in the UK

15  
16  
17 **Participants:** 126 adult patients with severe arthritis of the hip joint suitable for a resurfacing  
18 arthroplasty of the hip.

19  
20 **Results:** Data was received for 126 patients, 4 of whom did not provide any resource use data. For  
21 the remainder, data was imputed for costs or quality of life in at least one time point (baseline, 3  
22 months, 6 months, 1 year) for 18 patients. Patients in the resurfacing arm had higher quality of life  
23 at 12 months (0.795 vs. 0.727) and received 0.032 more QALYs within the first 12 months post  
24 operation. At an additional cost of £564, resurfacing arthroplasty offers benefits at £17,451 per  
25 QALY within the first 12 months of treatment. When covariates are considered, the health economic  
26 case is stronger in men than women.

27  
28 **Conclusions:** Resurfacing arthroplasty appears to offer very short term efficiency benefits over total  
29 hip arthroplasty within a selected patient group. [The short-term follow-up in this trial should be](#)  
30 [noted, particularly in light of the concerns raised regarding adverse reactions to metal debris from](#)  
31 [MOM bearing surfaces in the longer term. Longer term follow up of resurfacing arthroplasty patients](#)  
32 [and decision analytic modelling is also advised. This conclusion should be tested over a longer period](#)  
33 [through longer series following up resurfacing arthroplasty and through decision analytic modelling.](#)

34  
35  
36 **Trial registration:** Current controlled Trials ISRCTN33354155. UKCRN 4093.

1  
2  
3  
4  
5  
6  
7 **Funding statement**

8 The work described in this manuscript has been funded through the Research for Patient Benefit  
9 scheme of the NIHR, grant number PB-PG-0706-10080. This manuscript presents independent  
10 research commissioned by the National Institute of Health Research. The views expressed are those  
11 of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

## Introduction

Hip arthroplasty is acknowledged to be a highly effective and cost-effective procedure for treating patients with severe arthritis of the hip joint, with 87% of patients reporting an improvement in their general health following surgery.<sup>1</sup> The total health gain is expected to be substantial given the effectiveness of treatment; EuroQol (EQ-5D-3L) based quality of life improvements following surgery are estimated to be 0.409, within the 45,000 cases measured in the UK Patient Reported Outcomes programme<sup>2</sup>. 97% of UK hip replacements are still working (unrevised) at 5 years<sup>3</sup> and 83% of all primary hip arthroplasty (all age, all implant types) are unrevised at 17 years post surgery in Sweden<sup>4</sup>. If the initial quality of life gains are maintained, each unrevised surgery represents over five discounted quality-adjusted life-years (QALYs) gained and a benefit of over one hundred thousand pounds at the £20,000 per QALY threshold used by the National Institute of Health and Clinical Excellence (NICE). Compared to these gains, the costs of hip arthroplasty surgery appear modest. As a result, most analyses considering health economics have concentrated on questions of which type of prosthesis to use, and many cost-effectiveness analyses have involved analysis of newer, more expensive operations against older, established comparators.<sup>5-7</sup> Resurfacing arthroplasty of the hip is a newer alternative form of arthroplasty designed for younger, active patients with severe arthritis of the hip.

Hip resurfacing arthroplasty involves the insertion of an acetabular component and the 'capping' of the femoral neck, rather than its removal and replacement with a femoral component in a standard total hip arthroplasty. Of the 70,000 hip arthroplasty operations conducted in England and Wales every year<sup>3</sup>, approximately 6% are hip resurfacings. The equivalent figure amongst men aged under 55 is 33%. As resurfacing preserves the bone of the proximal femur, it may be expected to provide better clinical outcomes on revision of this component than available with a standard hip arthroplasty. Despite advances in their construction, there are still questions about the durability of modern resurfacing implants and there have been few explicit economic evaluations comparing resurfacing arthroplasties against total hip arthroplasties.<sup>8,9</sup> Few randomised controlled trials have been conducted to assess the outcomes of hip resurfacing, and those that exist provide little detail about the economic costs and benefits within the initial year following surgery. This paper reports the first within-trial economic evaluation of resurfacing arthroplasty versus total hip arthroplasty.

## Methods

### Interventions and sample

This evaluation reports on the efficiency of resurfacing arthroplasty (RSA) versus total hip arthroplasty (THA). Patients were deemed eligible for the trial if they were aged over 18 years of age, were medically fit for an operation, and were deemed suitable to receive a resurfacing arthroplasty. Patients were only excluded from the study if there was evidence that the patient would be unable to adhere to trial procedures or complete questionnaires. Patients were randomised on a 1:1 basis between THA and RSA, with each patient operated on according to the preferred technique of the operating surgeon. Other perioperative interventions, such as prophylactic antibiotics and thrombo-prophylaxis were the same for all patients and the same standardised rehabilitation plan was employed for both trial arms. Further details on recruitment, ethics, and randomisation procedures are reported [elsewhere in both the RCT's protocol and reporting papers](#).<sup>10,12</sup> The main outcome measure of the trial was hip function (Oxford Hip Score; Harris Hip Score) at 12 months, and the trial found no evidence of a difference between RSA and THA.

### Perspective

The aim of the economic study is to determine the intervention that would maximise health outcomes within the limited National Health Service (NHS) budget in this period, and so a cost-effectiveness (cost-utility) analysis with an NHS and Personal Social Services (PSS) perspective is adopted in the base case. This paper considers the within-trial period (as intention to treat) of the first 12 months follow up. It considers only resources used within the NHS setting including any aids and adaptations required. The base year for all costs figures was 2009/10, with figures from other years converted using the hospital and community health services Pay and Prices Index (for adults, excluding capital).<sup>11</sup> For current costs, figures are deflated assuming an estimated inflation rate of 1.9% to 2010 from this index for both 2009/10 and 2010/11. As the analysis uses a one year time horizon, discounting for the future cost and health outcome is not necessary in this analysis. The currency used was the pound sterling (£).

### Quality of life



1  
2  
3  
4  
5  
6  
7 Responses from the EQ-5D-3L were obtained from patients at baseline, 3 months, 6 months and 12  
8 months as secondary outcomes of the trial<sup>10</sup>; results from other outcomes are reported in greater  
9 depth elsewhere.<sup>12</sup> The standard tariff values<sup>13</sup> were applied to these responses at each time point  
10 to provide EQ-5D-3L quality of life values. Quality-adjusted life-years (QALYs) were calculated as an  
11 “area under the curve” and form the main outcome measure of the study. Where comparisons  
12 between the RSA and THA arms are based on non-imputed data, a two-sample t-test assuming equal  
13 variances is used.  
14  
15

#### 16 17 18 Resource use and valuation

19 The costs of THA and RSA treatments were considered across six broad categories – the costs of the  
20 initial operation, of inpatient care post-discharge, of outpatient care, of primary/community care,  
21 and of medications, and aids/adaptations required whilst in the community. [The analysis considered](#)  
22 [inpatient and outpatient attendances for all reasons, and requested details of other resource usage](#)  
23 [only where it related to pain or hip surgery.](#)  
24  
25

26  
27  
28 All RSA patients received a Cormet [metal-on-metal](#) resurfacing (Corin Group, Cirencester, UK), whilst  
29 THA patients received their surgeon’s preference of prosthesis. ~~For the patients having RSA this was~~  
30 ~~a Cormet resurfacing implant (Corin Group, Cirencester, UK).~~ For the patients having THA the  
31 prosthesis type was identified from patient records, with three types of bearing surface (ceramic  
32 femoral head on ceramic socket, metal-on-metal and metal-on-polyethylene) accounting for 95% of  
33 cases. The University Hospitals Coventry and Warwickshire NHS Trust Finance Department provided  
34 implant [costs-list prices](#) for both the resurfacing implant and representative cost figures for these  
35 three types of prosthesis. In the remaining 5% of cases, implant type was treated as missing and  
36 were imputed to fall in one of these groups.  
37  
38  
39

40  
41  
42 The current Healthcare Resource Group v.4 (HRG4) reference costs include the cost of prosthesis  
43 across all ages, and in most cases this will be a THR as HRG4 does not include a single category for  
44 primary replacements (as appeared in previous versions). Identified national-level HRG4 frequencies  
45 for primary hip replacements are available<sup>14</sup> and these are used to calculate an average cost,  
46 average length of stay, and average cost per excess bed day. By deducting the expected THA cost  
47 from the average cost, we obtain a non-prosthesis average cost, to which it is possible to add the  
48 appropriate prosthesis cost relevant to each individual. From here, an average cost of the initial  
49 hospitalisation is calculated for each patient by adjusting for each patient’s length of stay (as a  
50 number of bed days from the mean). In this way, a person admitted for the average length of stay  
51  
52  
53

54  
55  
56  
57  
58  
59  
60  
5

1  
2  
3  
4  
5  
6  
7 would be assigned the average cost of treatment, with those staying shorter and longer periods  
8 assigned lower and higher costs, respectively.  
9

10  
11 Data regarding length of stay and implant received were obtained from hospital records, with the  
12 remainder of the costing information obtained from patient-reported data. Resource usage was  
13 assessed alongside other outcomes at 3 months, 6 months and 12 months. For the 3 month data,  
14 the recall period was since discharge from hospital. For the other cases, it was since the last  
15 questionnaire was due to be completed. The questionnaires included sections on further inpatient  
16 care following the initial operation (speciality and length of stay/day case), outpatient care, primary  
17 and community care, aids and adaptations provided by the NHS/social services, and medication  
18 (pain relief and other NHS medication). Medicines usage was estimated based on mean dosage  
19 when used and average usage within the three budgetary periods (discharge to 3 months, 3-6  
20 months, 6-12 months). In order to convert resource usage figures into costs, unit cost figures were  
21 assigned from NHS Reference costs<sup>15</sup>, PSSRU unit costs<sup>11</sup>, NHS Electronic Drug Tariff<sup>16</sup>, and reported  
22 unit costs of acupuncture and chiropractic from previous studies. Individual resource items and unit  
23 prices, including for aids and adaptations, are available in Tables provided as a Web Extra. Where  
24 statistical tests analyse resource usage data, t-tests are used to test for differences in expected  
25 usage (assuming equal variance and non-imputed data).  
26  
27  
28  
29  
30  
31  
32

33 Data on personal costs (out of pocket medicine usage and time off work for either the patient or a  
34 carer) were also collected. NHS unit costs were used to provide an indicative figure for private  
35 medicines costs, whilst 2009 median gross weekly earnings from full time jobs (£488.70) was used to  
36 identify a daily productivity cost of £97.74. These are used in the sensitivity analysis considering  
37 societal costs.  
38  
39  
40

#### 41 Missing data

42  
43  
44 Where data was incomplete we used multiple imputation via chained equations (ice)<sup>17</sup> to complete  
45 missing data using STATA 11 (StataCorp 2009, TX, USA).<sup>18,19</sup> Missing cost data was predicted in terms  
46 of QALYs, treatment received, length of stay (LOS), age, gender, height, weight, and baseline clinical  
47 scores (Oxford Hip Score, Harris Hip Score); missing QALY data was predicted in terms of this same  
48 list (excluding QALYs), plus each of the cost items; missing LOS was predicted using the same list as  
49 for QALYs, with QALYs included. In order to remove implausible data, missing cost data was  
50 constrained to be positive and length of stay was constrained to be at least three days post-  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7 imputation. A total of 50 imputations were used to inform each item of missing data. Where tests  
8 are conducted to detect significant differences in mean values between the RSA and THA groups  
9 based on imputed data (i.e. incremental costs and QALYs), the analysis uses an OLS regression within  
10 the STATA's mim command.  
11

### 12 13 14 15 Cost-effectiveness

16  
17  
18 Using the methods identified above, total costs and QALY figures were calculated for all patients  
19 including imputed data. For the cost-effectiveness analysis, we identified the differences between  
20 costs and QALYs between the two arms, dividing the former by the latter to compute an incremental  
21 cost-effectiveness ratio (ICER). When compared against the marginal trade-off for the NHS as a  
22 whole – the cost-effectiveness threshold – the ICER gives a broad indication of whether spending  
23 additional money on hip arthroplasty appears efficient. The ICER figure is not presented with a  
24 confidence interval due to difficulties in interpreting a ratio of two random variables. Instead, we  
25 assume that each QALY is valued at £20,000 and subtract costs from this 'monetised' QALY in order  
26 to obtain a net monetary benefit (NMB). Any treatment with an ICER below £20,000 will have a  
27 positive NMB, with higher NMB figures unambiguously better and lower NMB figures unambiguously  
28 worse. As before, a 95% confidence interval is formed for NMB using linear regression using STATA's  
29 mim command.  
30  
31  
32  
33  
34

### 35 36 Scenarios/univariate sensitivity analyses

37  
38  
39 Key uncertainties in the scenarios considered were explored using univariate sensitivity analyses.  
40 The results for complete cost and quality of life data (i.e. those with no missing data) were provided  
41 to identify the impact of missing data on the analysis. A strict per-protocol analysis of the data is  
42 also used to reflect any sensitivity to protocol violations. A societal perspective was also explored by  
43 adding the patient medicines and productivity costs outlined above to the NHS + PSS costs. As  
44 patients might also recover function within the first three months (rather than continuously to three  
45 months), a quicker initial recovery was explored in QALY calculations, where each patient's quality of  
46 life was assumed to reach its observed 3-month level at 6 weeks post-operatively. The cost  
47 assumptions in the analysis were modified by assessing the impact of assuming the least expensive  
48 (metal on polyethylene) THA implant was used throughout with no effect on observed outcomes, to  
49 reflect the potential concern that the THA arm might not reflect cost-effective practice. The recent  
50  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7 (after the trial)current recommendations against the use of metal on metal THA prostheses are  
8 briefly considered by setting all 'metal on metal' implants to missing, estimating which THA  
9 prosthesis (i.e. metal on polyethylene or ceramic on ceramic) each patient will receive using multiple  
10 imputation, and considering the cost implications within these alternative estimates.  
11

#### 12 13 Adjustment for potential baseline differences

14  
15  
16 [The base case analysis was conducted to allow for comparability between this within-trial analysis](#)  
17 [and the reporting of the main RCT<sup>12</sup>. These quality of life and gender-based analyses are conducted](#)  
18 [as sensitivity analyses to allow comparability with the main RCT, which did not find a significant](#)  
19 [difference in baseline quality of life and did not test for an interaction between efficacy and gender.](#)  
20 [Given that these issues may be important within the economic evaluation, they are considered as](#)  
21 [sensitivity analyses.](#)  
22  
23  
24

25  
26 ~~As the baseline randomisation did not stratify by quality of life, t~~The impact of potential baseline  
27 differences [in quality of life](#) are corrected for using regression analysis [within a sensitivity analysis](#).  
28 The number of QALYs received (average quality of life over 12 months) is assumed to be a normal  
29 distribution, conditional on trial arm (RSA or THA))and baseline EQ-5D-3L value. Total cost over 12  
30 months is assumed to be lognormal, so that the natural logarithm of costs is a normal distribution,  
31 conditional on trial arm, baseline EQ-5D-3L.  
32  
33  
34

35  
36 QALYs and (log-)costs for each person are estimated using ordinary least squares regression (using  
37 STATA's mim command to handle imputed data). As any relationship between uncertainty in the  
38 extra costs and benefits associated with RSA is important when assessing the likelihood of cost-  
39 effectiveness, we use a seemingly unrelated regression to do this.. By using a Cholesky  
40 Decomposition of the variance-covariance matrix, (log-)costs and QALYs are modelled as if they  
41 come from a multivariate normal distribution. Uncertainty in the value of other items in the  
42 regression is ignored. From here, costs are estimated as if all patients receive THA, and incremental  
43 costs are calculated as a proportion of the average THA cost. In this way, a distribution is built up for  
44 incremental costs and incremental QALYs that can be analysed using cost-effectiveness acceptability  
45 curve (CEAC) can be formed for this analysis.<sup>21</sup> This CEAC indicates the likelihood that RSA will be  
46 cost-effective at different 'values' for a QALY.  
47  
48  
49  
50  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7 As gender so heavily affects the clinical use of RSA, this analysis was re-run for both male patients  
8 only and female patients only. This allows the effects of RSA to be assessed separately for men and  
9 women, with this figure presented as the likelihood of that RSA would be cost-effective at a  
10 threshold value of £20,000 per QALY.  
11

## 12 13 14 15 **Results**

### 16 17 Trial recruitment

18  
19  
20 The trial<sup>12</sup> recruited a total of 126 patients (RSA=60; THA=66) between May 2007 to February 2010.  
21 Two patients from each arm of the study did not have surgery and provided only baseline quality of  
22 life/demographic data, leaving a total of 58 and 64 patients in each arm. The sample was  
23 representative of the broader population undergoing resurfacing in the UK during the period of  
24 recruitment; no significant differences were identified between those who took part and those who  
25 were eligible but chose not to take part. Further details on both the ethical approval for the study  
26 and the demographics of the patients are provided in the clinical paper.<sup>12</sup> As the analysis estimates  
27 data on costs and outcomes conditional on baseline quality of life, these patients cannot contribute  
28 any data to our analysis and are excluded from the analyses here.  
29  
30  
31  
32

### 33 34 Quality of life

35  
36  
37 Table 1 summarises quality of life estimates at the four time points and calculates QALY estimates  
38 both with and without data imputation in the two arms. Overall, those in the RSA group started in  
39 worse health (as measured by the EQ-5D-3L) and received 0.033 more QALYs within the 12 months  
40 of the trial (n=118 observations). When the small amount of missing data is imputed, the estimated  
41 benefit remains very similar at 0.032 (95%CI, -0.054, 0.119). Within the trial, the difference in  
42 quality of life between the RSA and THA arms of the trial appears to increase at each post-operative  
43 time point.  
44  
45  
46

### 47 48 Costs and resource usage

49  
50  
51 Overall, NHS and social care costs were significantly higher amongst the RSA group with an average  
52 of £564 more spent within the first 12 months from the operation (Table 2), of which the majority is  
53  
54

1  
2  
3  
4  
5  
6  
7 due to the higher cost of implants and length of stay following the initial operation (£184),  
8 subsequent inpatient care (£279) and outpatient care (£84). The deflated cost of the RSA implants  
9 including operative consumables used in this study was £1,826 vs. an average of £1,700 for THA  
10 operations, based on imputed data. THA implants differed in costs, with the most expensive being  
11 ceramic on ceramic implants (£2,042) and those using metal on metal implants costing slightly less  
12 than RSA implants (£1,625). Implants and consumables in metal on polyethylene operations (£843)  
13 were associated with only 40% of the cost of ceramic on ceramic implant. Whilst the resurfacing  
14 implants were more expensive, they were also associated with a slightly longer length of stay (5.7 vs.  
15 5.5 days), although this difference was not statistically significant ( $P = 0.536$ ; imputed data).  
16  
17  
18  
19

20 Those in the RSA arm had significantly more outpatient visits than those in the THA arm (5.155 vs.  
21 3.063,  $P = 0.0054$ ; non-imputed data). Here, both the number of physiotherapy sessions and the use  
22 of deep vein thrombosis assessments were significantly higher amongst this group ( $P = 0.002$ ,  $P =$   
23  $0.011$ ; non-imputed data). For inpatient care, only subsequent inpatient attendances (0.155 vs.  
24 0.047,  $P = 0.066$ ; non-imputed data) approached significance, with the only significant difference ( $P$   
25  $= 0.009$ ) in aids and adaptations favouring RSA. For full details on individual resource use items and  
26 their unit costs, please see the tables available as a Web Extra.  
27  
28  
29  
30

31 The private costs to patients following arthroplasty surgery are considerable, although relatively  
32 little of this is due to the purchase of medication. There are no significant differences in medication  
33 usage between the RSA and THA arms, and the total costs of this treatment is similar (£12 RSA vs. £9  
34 THA,  $P = 0.667$ ). RSA patients report an average of 73 days off work, as against 57 days for THA  
35 patients ( $P = 0.333$ ). Whilst surgery results in a large number of days off work for the patient, carers  
36 tend to take very few days off work (2.1 days RSA vs. 1.6 days THA;  $P = 0.595$ ). Overall, RSA patients  
37 report costs valued at £5,917, as against £5,853 in the THA arm (imputed data). This difference is  
38 small but highly uncertain, such that there is no significant difference in costs from a societal  
39 perspective (£629 higher costs in RSA, 95%CI: -£2,456 -£3,713).  
40  
41  
42  
43  
44  
45  
46

#### 47 Cost-effectiveness and sensitivity analyses

48  
49  
50 Whilst RSA is expected to cost more over the first 12 months following an operation, it appears to  
51 provide a difference in quality of life. Here, the incremental cost-effectiveness ratio (ICER) for RSA is  
52 £17,451 per QALY (£564/0.032 QALY). Within most of the sensitivity tests explored here, the figure  
53  
54

1  
2  
3  
4  
5  
6  
7 appears to remain within or below the £20k-£30k per QALY range used by the National Institute for  
8 Health and Clinical Excellence as its estimate of the cost-effectiveness threshold, except where  
9 cheaper THA implants are used in place of surgeon's preference, [which was mostly MOM THA within](#)  
10 [the trial](#) (Table 3). If [the](#) cheaper (metal-on-polyethylene) implants are used, the increased cost of  
11 RSA vs. THA implants is enough to raise the average cost difference above £1,000 which, given the  
12 small quality of life difference observed here, is enough to prevent RSA being cost effective.  
13  
14 [However, if we consider both types of non-MOM implants \(ceramic-on-ceramic and metal-on-](#)  
15 [polythene\), this difference disappears entirely as the non-MOM implants were slightly more](#)  
16 [expensive on average than the MOM ones. As is normally the case in economic evaluations,](#)  
17 [however,](#) the confidence interval for net benefit in every analysis spans zero (Table 4) so that the  
18 findings do not reach statistical significance. As clinical trials are very rarely designed with the power  
19 of cost-effectiveness conclusions in mind, very little can be inferred from this lack of significance.  
20  
21  
22  
23

#### 24 Adjustment for baseline differences

25  
26  
27  
28 Once baseline differences in EQ-5D-3L are considered, the QALYWAT estimates for the first 12  
29 months appear to change. QALYs are higher generally amongst those who are healthier at baseline  
30 (EQ-5D-3L; P=0.000), with those treated in the RSA arm receiving 0.053 more QALYs than those  
31 treated with THA (P=0.119). Likewise, log-costs appear to be affected by baseline health (P=0.034),  
32 with costs 7.1% higher (95%CI: 1.7%-12.9%) for those who received RSA after bootstrapping.  
33  
34

35  
36 Whilst correcting for baseline differences leaves the incremental costs largely unchanged (£473;  
37 95%CI: 107-840), the estimated QALY benefit almost doubles (0.053, 95%CI: -0.014-0.120).  
38  
39 Consequently, the ICER is around half as large (£8,905 per QALY) as the non-adjusted case. In 79% of  
40 cases investigated, RSA is recommended when valuing health at £20,000 per QALY – suggesting  
41 quite high confidence that RSA is the more cost-effective option within the first 12 months of  
42 treatment across the £20k-£30k range used by NICE (Figure 1). Where this analysis is re-run for male  
43 patients only (n = 71), neither incremental costs nor incremental QALYs reach statistical significance  
44 and the ICER falls to £5,519 per QALY. For female patients (n=51), the ICER is about three times as  
45 large as for males (£16,272 per QALY) due to higher costs and lower benefits, with the latter  
46 exacerbated by a much lower baseline quality of life (female 0.257, male 0.389; P=0.032). Within  
47 the scenarios used here, RSA is only 54% likely to be cost-effective for female patients at £20,000 per  
48 QALY, compared to an 86% likelihood for male patients.  
49  
50  
51  
52  
53

## Discussion

In comparison to standard total hip arthroplasty, hip resurfacing arthroplasty appears to provide a modest QALY gain for a modest sum within the first 12 months from surgery; whilst the additional costs of RSA are statistically significant, the additional benefits are not. The higher costs of RSA treatments are largely due to slightly higher costs for the initial operative and recovery periods, and higher usage of outpatient services. Whilst the RSA group achieves slightly better health outcomes and requires more services, this may be due to heterogeneity in outcomes; if resurfacing works well for most but poor for some, then this could produce this type of phenomenon. If so, this emphasises the need to follow patients up in the longer term.

The analysis presented here analyses the data by considering potential confounding due to both gender and baseline quality of life, and this nearly doubles the estimate of RSA effect size. Whilst the main analysis of the trial data<sup>12</sup> found no statistically significant difference in hip function between the RSA and THA groups at 12 months, it seems likely that some short term difference in quality of life exists favouring RSA and that – again within 12 months – there is enough evidence to suggest that it may be cost-effective.

Within the first 12 months of treatment, the main caveat to our results deals with the comparator THA arm. The pragmatic nature of the trial data used here<sup>12</sup> is one of its key strengths, since it reflects current practice. Any changes to this practice may affect cost-effectiveness though, so that RSA may become more/less cost-effective as less/more cost-effective THA implants are used. A recent (US) analysis of registry data suggests that more expensive implants do not provide a substantive age-adjusted advantage over less expensive prostheses.<sup>22</sup> Where the sensitivity analysis assumed the use of the cheapest metal-on-polyethylene implants (without incorporating a possible impact on quality of life), RSA was no longer cost-effective within-trial. However, [these implants were used relatively rarely in practice, and the this is somewhat unrealistic to assume, as the](#) main alternative to metal on metal THA implants [appears to be was](#) the more expensive ceramic on ceramic type. Restrictions in the use of MOM THA implants within the UK are likely to lead to [more](#)



1  
2  
3  
4  
5  
6  
7 of these (likely) less cost-effective more costly THA implants being used, and so a net increase in  
8 the cost-effectiveness of resurfacing by comparison implants.  
9

10  
11  
12 Beyond the issues surrounding the choice of THA, the trial is inevitably unable to consider all  
13 possible cost items. The trial did not explicitly consider any differences in operative time between  
14 the RSA and THA arms; no difference was expected and an informal analysis of the data suggests  
15 very similar operative times between the arms. This evaluation was also unable to consider the  
16 impact of variation in cost within each type of prostheses (i.e. within the three types of THA, or  
17 beyond the single RSA used in the trial) as this information is not generally available. The clinical  
18 trial upon which this analysis is based used a single type of Cormet prosthesis that has been used in  
19 the UK for around 15 years. As such, our findings are not necessarily generalisable to other types of  
20 resurfacing and we cannot identify the most cost-effective type of resurfacing as this is beyond the  
21 scope of the trial. Whilst the list price of the Cormet prosthesis is similar to other prostheses  
22 available locally, prices are hospital-specific and so some caution is warranted when seeking to  
23 generalise findings to other locations. We note also that our findings are not necessarily  
24 generalizable to other types of resurfacing, including emerging technologies such as ceramic on  
25 ceramic resurfacings. Whilst the cost-effectiveness of these newer treatments may differ from  
26 standard resurfacings, we cannot identify the most cost-effective type of resurfacing as this was  
27 beyond the scope of the trial and relatively little data exists on which to base even a preliminary  
28 estimate. To the degree that this may prove possible, it is an issue for subsequent decision analytic  
29 modelling.  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39

40  
41 Clearly, the cost-effectiveness of resurfacing is likely to require assessment over a longer period of  
42 time – as is typically the case for any health economic analysis of trial data.<sup>23</sup> Importantly, the higher  
43 revision rates reported for resurfacing arthroplasty suggest that the additional costs of RSA may be  
44 higher if a longer period is considered. On the benefit side of the equation, the impact of extending  
45 the time period is unclear as RSA may improve quality of life in the short term but lead to a quicker  
46 deterioration once revisions are necessary, or require additional monitoring or revisions by virtue of  
47 its ‘metal-on-metal’ nature. One method to explore these questions may be decision analytic  
48 modelling.<sup>23</sup> The trial provides an estimate of short term clinical benefits from hip function and  
49 quality of life (conditional on EQ-5D-3L), with longer follow up series (from trials or registry data)  
50 needed to model implant survival for both RSA and THA.  
51  
52  
53  
54

1  
2  
3  
4  
5  
6  
7  
8  
9 As THA revision surgery may be surgically more complex, financially more costly, and less effective  
10 than a primary THA, a key question when interpreting this study is the prognosis for patients after  
11 their RSA is revised. An Australian registry analysis suggests poor implant survival amongst patients  
12 receiving a revision of only the acetabular RSA component, and some evidence of higher revision  
13 risks among other types of RSA revisions such as where both components are revised.<sup>24</sup> It is unclear,  
14 however, whether a revised RSA is more similar, in terms of quality of life, to a primary THA or a  
15 revision THA. Further research is necessary to assess the likely impact of this and other questions to  
16 guide future research, and the findings of this paper are by no means a complete answer to the  
17 decision problem.  
18  
19  
20  
21

22  
23  
24 Registry data reveals that women represent 61% of primary THA patients in the UK but make up only  
25 25% of RSA patients.<sup>3</sup> These figures reflect relevant gender differences from both a clinical and a  
26 health economic perspective as women appear to obtain higher quality of life gains from THA, and  
27 face an increased revision rate from RSA.<sup>4,25</sup> This trial may also suggest a lower benefit from RSA  
28 relative to THA amongst women, although the finding was not statistically significant (or powered to  
29 be so). Despite the conclusions of the within-trial analysis, it seems clear that until such work is  
30 done and further data is available, the cost-effectiveness of resurfacing arthroplasty in a UK context  
31 remains potentially promising but as yet unproven.  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**Table 1. EQ-5D-3L quality of life at each measurement and converted into QALYs (missing data imputed)**

Quality of life	RSA (SD) n =58	THA (SD) n =64	Difference <sup>†</sup> (95% CI)
Baseline	0.308 (0.338)	0.356 (0.335)	-0.048 (-0.168, 0.073)
3 months	0.722 (0.229)	0.698 (0.284)	0.023 (-0.711, 0.118)
6 months	0.796 (0.244)	0.747 (0.287)	0.050 (-0.046, 0.146)
12 months	0.795 (0.282)	0.727 (0.319)	0.067 (-0.042, 0.177)
QALYs (n = 118)	0.716 (0.216)	0.683 (0.252)	0.033 (-0.053, 0.120)
QALYs* (n = 122)	0.713 (0.216)	0.681 (0.251)	0.032 (-0.054, 0.119)

\* With imputed data

**Table 2. Costs by type, summed across trial period (missing data imputed)**

Costs	% impute	RSA (SD) n =58	THA (SD) n =64	Difference (95% CI)
Initial	7%	£6275 (557)	£6091 (532)	£184 (-18, 386)
Subsequent	11%	£470 (956)	£191 (558)	£279 (-11, 569)
Outpatient	11%	£360 (294)	£276 (210)	£84 (-13, 181)
Primary/community	11%	£63 (98)	£49 (67)	£14 (-17, 45)
Aids and	11%	£21 (33)	£21 (40)	£0 (-14, 14)
Medication	11%	£27 (43)	£24 (41)	£3 (-13, 19)
NHS + PSS Costs	--	£7217 (1320)	£6653 (917)	£564 (144, 985)
Private costs	61%	£5917 (5145)	£5853 (5520)	£64 (-3017, 3146)
Societal cost	--	£13,134 (5146)	£12,506 (5568)	£629 (-2456, 3713)

**Table 2. Costs by type, summed across trial period (missing data imputed)**

Costs	% impute	RSA (SD) n =58	THA (SD) n =64	Difference (95% CI)
Initial	7%	£6275 (557)	£6091 (532)	£184 (-18, 386)
Subsequent	11%	£470 (956)	£191 (558)	£279 (-11, 569)
Outpatient	11%	£360 (294)	£276 (210)	£84 (-13, 181)
Primary/community	11%	£63 (98)	£49 (67)	£14 (-17, 45)
Aids and	11%	£21 (33)	£21 (40)	£0 (-14, 14)
Medication	11%	£27 (43)	£24 (41)	£3 (-13, 19)
NHS + PSS Costs	--	£7217 (1320)	£6653 (917)	£564 (144, 985)
Private costs	61%	£5917 (5145)	£5853 (5520)	£64 (-3017, 3146)
Societal cost	--	£13,134 (5146)	£12,506 (5568)	£629 (-2456, 3713)

Table 3. Incremental cost effectiveness

Formatted Table

Scenario	Incremental costs (95%CI)	Incremental QALYs (95%CI)	ICER (per QALY)
Base case (BC)	£564 (144, 985)	0.032 (-0.054, 0.119)	£17,451-per
Per protocol	£528 (85, 970)	0.024(-0.066, 0.113)	£22,227-per
Complete case data (N=98)	£721 (286, 1157)	0.053 (-0.042, 0.149)	£13,443-per
Societal costs	£629 (-2456, 3713)	0.032 (-0.054, 0.119)	£19,435-per
Metal/polyethylene THA implants	£1271 (859, 1684)	0.032 (-0.054, 0.119)	£39,318-per
No metal on metal THA implants	£522 (76, 968)	0.032 (-0.054, 0.119)	£16,137-per
Quicker initial recovery	£564 (144, 985)	0.039 (-0.048, 0.127)	£14,310-per
Adjustments for quality of	£473 (113, 853)	0.053 ( -0.014-0.120)	£8,905-per
Adjustments for QoL adjustments	£402 (-82, 916)	0.073 (-0.012, 0.158)	£5,519-per
Adjustments for quality of life QoL	£598 (64, 1172)	0.037 (-0.070, 0.144)	£16,272-per

Table 4. Net Monetary Benefit

Scenario	NMB (95%CI)*
Base case (BC)	£82.46 (-1795, 1960)
Per protocol	-£53 (-2011, 1905)
Complete case data (N=98)	£353 (-1719, 2426)
Societal costs	£19 (-3641, 3680)
Metal/polyethylene THA implants	-£625 (-2515, 1265)
No metal on metal THA implants	£125 (-1750, 1999)
Quicker initial recovery	£224 (-1658, 2107)
Adjustments for quality of life	£590 (-834, 2014)
Adjustments for quality of life, males	£1055 (-843, 2954)
Adjustments for quality of life, females	£137 (-1988, 2262)

QALYs valued at £20k each

## References

1. Health Episodes Statistics Online. Finalised PROMs data 2009-10, 2011.
2. Health Episodes Statistics Online. PROMs Score Comparisons April 2009 to February 2011: The NHS Information Centre for Health and Social Care, 2011.
3. Ellams D, Forsyth O, Mistry A, et al. *7th Annual Report*. National Joint Registry for England and Wales, 2010.
4. Garellick G, Kärrholm J, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2008. Shortened Version*. Department of Ortopaedics, Sahlgrenska University Hospital, 2009.
5. Bozic KJ, Morshed S, Silverstein MD, et al. Use of cost-effectiveness analysis to evaluate new technologies in orthopaedics: the case of alternative bearing surfaces in total hip arthroplasty. *Journal of Bone and Joint Surgery* 2006;88(4):706-14.
6. Briggs A, Sculpher M, Dawson J, et al. Modelling the cost-effectiveness of primary hip replacement: how cost-effective is the Spectron compared to the Charnley prosthesis? *York - CHE - Technical Paper* 2003;28.
7. Fitzpatrick R, Shortall E, Sculpher M, et al. Modelling of cost-effectiveness of THR: methods and results and discussion in primary total hip replacement surgery: a systematic review of outcomes and modelling of cost-effectiveness associated with different prostheses. *Health Technology Assessment* 1998;2(20):17-32.
8. Vale L, Wyness L, McCormack K, et al. A systematic review of the effectiveness and cost-effectiveness of metal-on-metal hip resurfacing arthroplasty for treatment of hip disease. *Health Technology Assessment* 2002;6(15).
9. Bozic KJ, Pui CM, Ludeman MJ, et al. Do the Potential Benefits of Metal-on-Metal Resurfacing Justify the Increased Cost and Risk of Complications? *Clinical Orthopaedics and Related Research* 2010;468:2301-12.
10. Achten JA, Parsons NR, Edlin RE, et al. A randomised controlled trial of total hip arthroplasty versus resurfacing arthroplasty in the treatment of young patients with arthritis of the hip joint. *BMC Musculoskeletal Disorders* 2010;11(8).
11. Curtis L. Unit Costs of Health & Social Care 2010. Personal and Social Services Research Unit, 2010.
12. Costa ML, Achten J, Parsons NR, et al. Total Hip Arthroplasty Versus Resurfacing Arthroplasty in the Treatment of Young Patients with Arthritis of the Hip Joint: A single centre, parallel group, assessor blind, randomised control trial. *British Medical Journal* 2012; 344:e2147.
13. Dolan P. Modeling valuations for EuroQol health. *Medical Care* 1997;35(11):1095-108.
14. *HRG version 3.5 & HRG4 Comparative Chapter Analysis*: The Health & Social Care Information Centre., 2008.
15. *National Schedule of Reference Costs 2009-10. Appendix NSRC04: NHS Trusts and PCTs combined reference cost schedules*. London: Crown Copyright, 2011.
16. *NHS. Electronic Drug Tariff: May 2011*. National Health Service England and Wales, 2011.
17. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine* 2011;30(4):377-99.
18. Royston P. Multiple imputation of missing values: further update of ice, with an emphasis on interval censoring. *The Stata Journal* 2007;7(4):445-64.
19. Royston P, Carlin JB, White IR. Multiple imputation of missing values: New features for mim. *The Stata Journal* 2009;9(2):252-64.
20. Willan AR, Briggs AH, Hoch JS. Regression methods for covariate adjustment and subgroup analysis for non-censored cost-effectiveness data. *Health Economics* 2004;13:461-75.
21. Fenwick E, Byford S. A guide to cost-effectiveness acceptability curves. *British Journal of Psychiatry* 2005;187:106-8.
22. Gioe TJ, Sharma A, Tatman P, et al. Do "Premium" Joint Implants Add Value? *Clinical Orthopaedics and Related Research* 2011;469:48-54.

- 23. Petrou S, Gray A. Economic evaluation using decision analytical modelling: decision, conduct, analysis, and reporting. *British Medical Journal* 2011;342:doi: 10.1136/bmj.d766.
- 24. de Steiger RN, Miller LN, Prosser GH, et al. Poor outcome of revised resurfacing hip arthroplasty. 397 cases from the Australian Joint Replacement Registry. *Acta Orthopaedica* 2010;81(1):72-76.
- 25. Kärrholm J, Garellick G, Rogmark C, et al. *Swedish Hip Arthroplasty Register: Annual Report 2007*: Department of Ortopaedics, Sahlgrenska University Hospital, 2008.

For peer review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

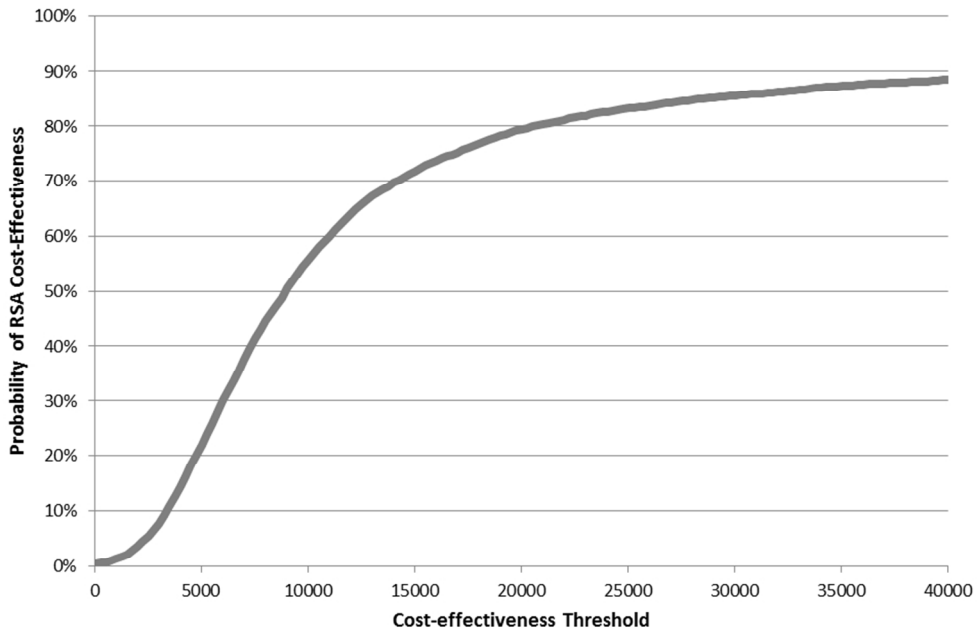


Figure 1: Cost-Effectiveness Acceptability Curve for Resurfacing Arthroplasty (vs. THA) 258x168mm (96 x 96 DPI)

Review only



Web Extra: Table 1 – Unit cost of resources

Item	Cost	Source
<b>Initial Operation</b>		
Cost for average THA	£6381	Uses weighted average of outcomes from HB11B, HB11C, HB12A, HB12B, HB12C.*
Average LOS for THA	6.57 days	
Adjustment per day ± av. LOS	£296	
THA: implant + consumables	£2,042	Ceramic femoral head, ceramic socket
	£1,625	Metal femoral head, metal socket
	£843	Metal femoral head, polyurethane socket
	£1,738	Weighted average of THA implants + consumables
RSA: implant + consumables	£1,850	Cornet resurfacing
<b>Subsequent Inpatient Care</b>		
<b>Inpatient (orthopaedics)</b>		
Day case	£874	TPCTDC: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Cost for average LOS	£1,888	TPCTEI: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Average LOS	1.98 days	TPCTEI: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
Adjustment per day ± av. LOS	£340	TPCTEIXS: Minor Hip Procedures for non Trauma Category 1 without CC (HB16C)*
<b>Inpatient (other)</b>		
Elective, non-investigational	£668	Average across all day cases (TPCTDC)*
Elective, investigational	£243	Average cost radiotherapy inpatient, PSSRU 2010
Acute surgical/medical	£535	Average across all non-elective (short stay) cases (TPCTNEI_S)
<b>Outpatient care</b>		
Orthopaedics	£96	OPATT: Trauma & Orthopaedics: Non-Trauma (110N)*
Haematology	£128	OPATT: Clinical Haematology (303)*
Pathology or radiology	£114	Average cost per outpatient radiotherapy contact, PSSRU 2010
Ophthalmology	£80	OPATT: Ophthalmology (130)*
Orthotics	£96	OPATT: Trauma & Orthopaedics: Non-Trauma (110N)*
Physiotherapy	£39	OPATT: Physiotherapy Total Attendances - Adult (19 and Over (650A))*
Chiropractor	£17	Ongoing treatment session from UK BEAM trial <a href="http://www.bmj.com/content/329/7479/1381.full">http://www.bmj.com/content/329/7479/1381.full</a> costed at £12.17 in 2000 base year. Reflated using NHS Pay and Prices Index.
Dermatology	£92	OPATT: Dermatology (330)*
Acupuncture	£30	Ongoing treatment session from RCT <a href="http://www.bmj.com/content/333/7569/626.full">http://www.bmj.com/content/333/7569/626.full</a> costed at £24 in 2002-3 base year. Reflated using NHS Pay and Prices Index.
Accident and Emergency	£113	OPATT: Accident and Emergency (180)*
DVT assessment service	£129	TPCTDC: Deep Vein Thrombosis (QZ20Z)*
Heart specialist/cardiologist	£124	OPATT: Cardiology (320)*
Urology	£99	OPATT: Urology (101)*
Neurophysiologist/neurologist	£166	OPATT: Neurology (400)*
Eye clinic	£80	OPATT: Ophthalmology (130)*
Oncologist	£107	OPATT: Clinical Oncology (800)*
Dietician	£32	PSSRU 2009-10: Cost per hour in clinic, incl. qualifications

Item	Cost	Source
Dentist	£100	OPATT: Dental Medicine Specialties (450) <sup>†</sup>
Thoracic	£216	OPATT: Thoracic Surgery (173) <sup>†</sup>
<b>Primary and community care</b>		
<b>In surgery/clinic</b>		
GPs	£28	Cost per surgery consultation, PSSRU Unit Costs 2010
Practice Nurse	£9	Cost per surgery consultation, PSSRU Unit Costs 2010
District nurse	£22	Cost per 15.5 minutes community nurse, PSSRU Unit Costs 2010
Physiotherapist	£15	Cost per clinic visit, PSSRU Unit Costs 2010
Occupational therapist	£15	Cost per surgery visit, PSSRU Unit Costs 2010
<b>At home</b>		
GPs	£94	Cost per home visit, PSSRU Unit Costs 2010
Practice Nurse	£13	Cost per home visit, PSSRU Unit Costs 2010
District Nurse	£37	Cost per home visit, community nurse, PSSRU Unit Costs 2010
Physiotherapist	£41	Cost per home visit, PSSRU Unit Costs 2010
Chiroprapist	£20	Cost per home visit, PSSRU Unit Costs 2010
Dermatologist	£92	As for outpatient. OPATT: Dermatology (330) <sup>†</sup>
<b>Aids and adaptation</b>		
Walking stick	£8.02 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/sticks-crutches-canes/walking-sticks-canes/metal-sticks-canes/economy-ergonomic-walking-stick-p-16711.html">http://www.mobilitysmart.cc/sticks-crutches-canes/walking-sticks-canes/metal-sticks-canes/economy-ergonomic-walking-stick-p-16711.html</a>
Crutches	£25.03 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/sticks-crutches-canes/crutches/closed-cuff-crutches/coopers-elbow-crutches-plastic-handles-p-13037.html">http://www.mobilitysmart.cc/sticks-crutches-canes/crutches/closed-cuff-crutches/coopers-elbow-crutches-plastic-handles-p-13037.html</a>
Wheelchair	£146.54 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/wheelchairs/self-propelled-wheelchairs/lightweight-self-propelling-wheelchair-p-14090.html">http://www.mobilitysmart.cc/wheelchairs/self-propelled-wheelchairs/lightweight-self-propelling-wheelchair-p-14090.html</a>
Insoles	£22.15 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/footcare/insoles-heel-pads/cosyfeet-orthaheel-workforce-p-17086.html">http://www.mobilitysmart.cc/footcare/insoles-heel-pads/cosyfeet-orthaheel-workforce-p-17086.html</a>
Zimmer	£44.29 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html</a>
Toilet seat	£12.84 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/toileting/toilet-seat-cushions/padded-toilet-seat-with-rim-vinyl-cover-p-671.html">http://www.mobilitysmart.cc/toileting/toilet-seat-cushions/padded-toilet-seat-with-rim-vinyl-cover-p-671.html</a>
Sock aid	£4.01 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/by-activity/getting-dressed/sock-stocking-aid-p-14742.html">http://www.mobilitysmart.cc/by-activity/getting-dressed/sock-stocking-aid-p-14742.html</a>
Grabber	£5.89 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/home-garden-aids/reachers-grabbers/reacher-grabber-pick-up-tool-p-13495.html">http://www.mobilitysmart.cc/home-garden-aids/reachers-grabbers/reacher-grabber-pick-up-tool-p-13495.html</a>
Shoe horn	£3.85 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/plastic-shoe-horn-p-9955.html">http://www.mobilitysmart.cc/plastic-shoe-horn-p-9955.html</a>
Trolley	£28.53 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/trolleys-steps-stools/trolleys/tri-wheeled-shopping-trolley-p-10107.html">http://www.mobilitysmart.cc/trolleys-steps-stools/trolleys/tri-wheeled-shopping-trolley-p-10107.html</a>
Perching stool	£43.33 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/trolleys-steps-stools/perching-">http://www.mobilitysmart.cc/trolleys-steps-stools/perching-</a>

Item	Cost	Source
		<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">stools/standard-perching-stool-p-765.html</a>
Frame	£44.29 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html">http://www.mobilitysmart.cc/walkers-shoppers/walkers-zimmer-frames/folding-walking-zimmer-frame-with-wheels-p-10599.html</a>
Clothes aid	£11.08 <sup>†</sup>	<a href="http://www.mobilitysmart.cc/comfort-dressing/dressing-aids/dressing-stick-p-300.html">http://www.mobilitysmart.cc/comfort-dressing/dressing-aids/dressing-stick-p-300.html</a>
<b>Medications (price per tablet /tube) related to hip/hip pain</b>		
Co-codamol	£0.05 <sup>†</sup>	30mg/500mg capsules (from pack of 100)
Codeine	£0.04 <sup>†</sup>	30mg tablets (from pack of 28)
Paracetamol	£0.03 <sup>†</sup>	500mg capsules (from pack of 32)
Tramadol	£0.04 <sup>†</sup>	50mg capsules (from pack of 30)
Amitriptyline	£0.03 <sup>†</sup>	25mg tablets (from pack of 28)
Dihydrocodeine	£0.03 <sup>†</sup>	30mg tablets (from pack of 100)
Diclofenac	£0.28 <sup>†</sup>	50mg tablets (from pack of 21)
Ibuprofen	£0.02 <sup>†</sup>	400mg tablets (from pack of 84)
Naproxen	£0.06 <sup>†</sup>	500mg tablets (from pack of 28)
Aspirin	£0.01 <sup>†</sup>	300mg tablets (from pack of 32)
Warfarin	£0.03 <sup>†</sup>	5mg tablets (from pack of 28)
Zopiclone	£0.05 <sup>†</sup>	7.5mg tablets (from pack of 28)
Flucloxacillin	£0.10 <sup>†</sup>	500mg capsules (from pack of 28)
Morphine	£0.09 <sup>†</sup>	10mg tablets (from pack of 56)
Hydrocortisone	£3.44 <sup>†</sup>	Cream 1% tube (from single tube)
Furosemide	£0.03 <sup>†</sup>	40mg tablets (from pack of 28)
Buprenorphine	£0.24 <sup>†</sup>	400µg tablets (from pack of 7)
Omeprazole	£0.20 <sup>†</sup>	10mg tables (from pack of 28)
<b>Productivity costs</b>		
Day off work	£97.74	As 20% of £488.70; Median Gross Weekly Earnings from Full Time, Pay Unaffected by Absence, Office of National Statistics 2009 Annual Survey of Hours and Earnings. <a href="http://www.ons.gov.uk/ons/rel/ashe/annual-survey-of-hours-and-earnings/2009-results/stb-ashe-2009.pdf">http://www.ons.gov.uk/ons/rel/ashe/annual-survey-of-hours-and-earnings/2009-results/stb-ashe-2009.pdf</a>

\* 2009-10 Reference Costs

<sup>†</sup> Figure shown is inflation adjusted.

Web Extra: Table 2 - Resource use by patients according to the arm intervention

	Mean Usage (SD)		P-value*
	RSA (n =58)	THA (n =64)	
<b>Subsequent Inpatient Care</b>			
Orthopaedics	0.155 (0.410)	0.047 (0.213)	0.066
Elective, non-investigational	0.034 (0.184)	0 (0)	0.136
Elective, investigational	0 (0)	0.016 (0.125)	0.343
Acute surgical/medical	0.086 (0.283)	0.063 (0.302)	0.656
<b>Outpatient care</b>			
Orthopaedics	1.569 (1.464)	1.672 (1.196)	0.670
Haematology	0.121 (0.378)	0.109 (0.475)	0.885
Pathology or radiology	0.397 (1.388)	0.234 (0.660)	0.405
Ophthalmology	0 (0)	0.016 (0.125)	0.343
Orthotics	0.017 (0.131)	0 (0)	0.295
Physiotherapy	2.534 (4.096)	0.656 (2.169)	0.002
Chiropractor	0.103 (0.552)	0 (0)	0.136
Dermatology	0.172 (0.131)	0 (0)	0.295
Acupuncture	0.052 (0.394)	0 (0)	0.295
A and E	0.052 (0.223)	0.047 (0.213)	0.903
DVT assessment service	0.155 (0.410)	0.016 (0.125)	0.011
Heart specialist/ cardiologist	0.034 (0.263)	0.094 (0.635)	0.510
Urology	0 (0)	0.047 (0.278)	0.201
Neurophysiologist/neurologist	0.017 (0.131)	0.016 (0.125)	0.945
Eye clinic	0.0344 (0.263)	0.063 (0.393)	0.648
Oncologist	0.017 (0.131)	0 (0)	0.295
Dietician	0.172 (0.131)	0 (0)	0.295
Dentist	0.172 (0.131)	0.031 (0.25)	0.703
Thoracic	0 (0)	0.016 (0.125)	0.343
<b>Primary and community care</b>			
<b>In surgery/clinic</b>			
GPs	1.224 (2.193)	0.938 (1.833)	0.434
Practice Nurse	0.345 (1.101)	0.516 (1.553)	0.489
District nurse	0.034 (0.263)	0 (0)	0.295
Physiotherapist	0.103 (0.788)	0.125 (1)	0.896
Occupational therapist	0 (0)	0.016 (0.125)	0.343
<b>At home</b>			
GPs	0 (0)	0.047 (0.278)	0.201
Practice Nurse	0.103 (0.447)	0.047 (0.035)	0.067
Chiroprapist	0.034 (0.263)	0 (0)	0.295
District Nurse	0.155 (0.951)	0.031 (0.175)	0.308

	Mean Usage (SD)		P-value*	
	RSA (n =58)	THA (n =64)		
Physiotherapist	0.121 (0.796)	0 (0)	0.228	
Dermatologist	0.052 (0.292)	0.016 (0.125)	0.368	
<b>Aids and adaptation</b>				
Walking stick	0.269 (0.597)	0.259 (0.902)	0.946	
Crutches	0.431 (0.901)	0.421 (0.826)	0.950	
Wheelchair	0.017 (0.131)	0 (0)	0.295	
Insoles	0.034 (0.184)	0 (0)	0.136	
Zimmer	0.017 (0.131)	0 (0)	0.295	
Toilet seat	0.103 (0.307)	0.125 (0.333)	0.712	
Sock aid	0.017 (0.131)	0.031 (0.175)	0.621	
Grabber	0 (0)	0.109 (0.315)	0.009	
Shoe horn	0 (0)	0.031 (0.175)	0.178	
Trolley	0 (0)	0.031 (0.25)	0.343	
Perching stool	0 (0)	0.047 (0.278)	0.201	
Frame	0.017 (0.131)	0.016 (0.125)	0.945	
Clothes aid	0.017 (0.131)	0 (0)	0.295	
<b>Medications</b>				
Co-codamol	30mg/500mg	77.51 (141.29)	84.02 (172.51)	0.821
Codeine	30mg tablets	6.62 (33.08)	0 (0)	0.130
Paracetamol	500mg capsules	53.07 (148.95)	46.54 (136.14)	0.811
Tramadol	50mg capsules	54.98 (169.59)	17.88 (63.05)	0.124
Amitriptyline	25mg tablets	2.30 (16.45)	8.04 (33.61)	0.270
Dihydrocodeine	30mg tablets	7.42 (53.00)	1.51 (11.46)	0.409
Diclofenac	50mg tablets	44.67 (121.91)	38.15 (103.72)	0.764
Ibuprofen	400mg tablets	54.63 (146.76)	25.44 (100.35)	0.224
Naproxen	500mg tablets	21.34 (106.88)	13.59 (77.87)	0.662
Aspirin	300mg tablets	6.94 (34.69)	0 (0)	0.130
Warfarin	5mg tablets	13.76 (98.25)	0 (0)	0.288
Zopiclone	7.5mg tablets	2.30 (11.53)	0.97 (7.37)	0.467
Flucloxacillin	500mg capsules	6.94 (34.69)	3.05 (23.23)	0.489
Morphine	10mg tablets	0 (0)	5.06 (27.06)	0.184
Hydrocortisone	cream 1%	0 (0)	0.02 (0.13)	0.351
Furosemide	40mg tablets	0 (0)	3.05 (23.24)	0.351
Buprenorphine	400µg tablets	0 (0)	4.73 (35.99)	0.351
Omeprazole	10 mg tablets	7.12 (50.81)	6.26 (47.64)	0.927

\* P-value, based on a two-sample t-test assuming equal variance

## EVEREST STATEMENT / BMJ Checklist

Item	Y/N	Where?
(1) The research question is stated	Y	Page 4 "Perspective"
(2) The economic importance of the research question is justified	Y	Page 3 "Introduction"
(3) The viewpoint(s) of the analysis are clearly stated and justified	Y	Page 4 "Perspective"
(4) The rationale for choosing the alternative programmes or interventions compared is stated	Y	As a within trial analysis, this is determined by the trial design. This is varied in sensitivity analyses.
(5) The alternatives being compared are clearly described	Y	Page 3 "Introduction"
(6) The form of economic evaluation used is stated	Y	Page 4 "Perspective"
(7) The choice of form of economic evaluation is justified in relation to the questions addressed	Y	Page 4 "Perspective"
(8) The source(s) of effectiveness estimates used are stated	Y	Within trial, plus Methods section
(9) Details of the design and results of effectiveness study are given (if based on a single study)	Y	Within trial, plus Methods section. Findings of the main trial have been added.
(10) Details of the method of synthesis or meta-analysis of estimates are given (if based on an overview of a number of effectiveness studies)	NA	
(11) The primary outcome measure(s) for the economic evaluation are clearly stated	Y	Page 4-5, "Quality of life"
(12) Methods to value health states and other benefits are stated	Y	Page 4-5, "Quality of life"
(13) Details of the subjects from whom valuations were obtained are given	Y	Uses standard UK tariff to value EQ-5D outcomes, see "Quality of life"
(14) Productivity changes (if included) are reported separately	Y	These are reported in brief as a sensitivity analysis.
(15) The relevance of productivity changes to the study question is discussed	Y	Page 5-6, "Resource use and valuation". Brevity prevents this being included in depth
(16) Quantities of resources are reported separately from their unit costs	Y	Within Web Extra tables
(17) Methods for the estimation of quantities and unit costs are described	Y	Pages 5-6, "Resource use and valuation"
(18) Currency and price data are recorded	Y	Page 4 "Perspective"
(19) Details of currency of price adjustments for inflation or currency conversion are given	Y	Page 4 "Perspective"
(20) Details of any model used are given	NA	
(21) The choice of model used and the key parameters on which it is based are justified	NA	
(22) Time horizon of costs and benefits	Y	Page 4 "Perspective"
(23) The discount rate(s) is stated	NA	
(24) The choice of rate(s) is justified	NA	
(25) An explanation is given if costs or benefits are not discounted	Y	Justification is given by virtue of a 1-year timeframe.
(26) Details of statistical tests and confidence intervals are given for stochastic data	Y	Confidence intervals are inappropriate for ICERs but confidence intervals are provided for NMB. Detail on statistical tests are given throughout the methods (pp.4-8, and more detail is given

		specifically within the section on "Missing data" (p6) and "Adjustment for baseline differences" (p8)
(27) The approach to sensitivity analysis is given	Y	See Pages 7, "Cost-effectiveness", pp7-8 "Scenarios/Univariate sensitivity analysis", and p.8 "Adjustment for baseline differences"
(28) The choice of variables for sensitivity analysis is justified	Y	See Pages 7, "Cost-effectiveness", pp7-8 "Scenarios/Univariate sensitivity analysis", and p.8 "Adjustment for baseline differences"
(29) The ranges over which the variables are varied are stated	Y	We do not use one-way sensitivity analyses, and so this is not massively relevant (as are many parts of this checklist in 2012). The analyses relate more to specific changes to assumptions than arbitrary values for potentially key parameters.
(30) Relevant alternatives are compared	Y	Page 3 "Introduction"
(31) Incremental analysis is reported	Y	Page 10, "Cost-effectiveness and sensitivity analyses", Table 3
(32) Major outcomes are presented in a disaggregated as well as aggregated form		Table 1 provides disaggregated quality of life data, Table 2 provides cost data by general area, Web Extras provide disaggregated resource data.
(33) The answer to the study question is given	Y	Pages 10-11 provide firstly results where no adjustments are made for baseline differences, and then with this adjustment.
(34) Conclusions follow from the data reported	Y	Page 11-13, "Discussion" follows on from themes introduced in results
(35) Conclusions are accompanied by the appropriate caveats	Y	Page 12-13, Particularly with respect to time and the choice of THA implant.