■ **HIP**

A cost-effectiveness assessment of dual-mobility bearings in revision hip arthroplasty

A. Khoshbin,
F. S. Haddad,
S. Ward,
S. O'hEireamhoin,
J. Wu,
L. Nherera,
A. Atrey

From the University of Toronto, Toronto, Canada

Aims
The rate of dislocation when traditional single bearing implants are used in revision total hip arthroplasty (THA) has been reported to be between 8% and 10%. The use of dual mobility bearings can reduce this risk to between 0.5% and 2%. Dual mobility bearings are more expensive, and it is not clear if the additional clinical benefits constitute value for money for the payers. We aimed to estimate the cost-effectiveness of dual mobility compared with single bearings for patients undergoing revision THA.

Methods
We developed a Markov model to estimate the expected cost and benefits of dual mobility compared with single bearing implants in patients undergoing revision THA. The rates of revision and further revision were calculated from the National Joint Registry of England and Wales, while rates of transition from one health state to another were estimated from the literature, and the data were stratified by sex and age. Implant and healthcare costs were estimated from local procurement prices and national tariffs. Quality-adjusted life-years (QALYs) were calculated using published utility estimates for patients undergoing THA.

Results
At a minimum five-year follow-up, the use of dual mobility was cost-effective with an estimated incremental cost-effectiveness ratio (ICER) of between £3,006 and £18,745/QALY for patients aged < 55 years and between 64 and 75 years, respectively. For those aged > 75 years dual mobility was only cost-effective if the timeline was beyond seven years. The use of dual mobility bearings was cost-saving for patients aged < 75 years and cost-effective for those aged > 75 years if the time horizon was beyond ten years.

Conclusion
The use of dual mobility bearings is cost-effective compared with single bearings in patients undergoing revision THA. The younger the patient is, the more likely it is that a dual mobility bearing can be more cost-effective and even cost-saving. The results are affected by the time horizon and cost of bearings for those aged > 75 years. For patients aged > 75 years, the surgeon must decide whether the use of a dual mobility bearing is a viable economic and clinical option.

Cite this article: *Bone Joint J* 2020;102-B(9):1128–1135.

Introduction

Dislocation, after both primary and revision total hip arthroplasty (THA) can be a catastrophic event with a loss of confidence and poor outcome.[1] The costs of relocation and revision surgery for persistently dislocating hips can have an implication to healthcare systems.[2-4] The rate of dislocation after revision THA varies between 8%[5-7] and 10%.[8] A similar incidence has been reported from the Swedish Joint Registry.[9] When recurrent instability is the indication for revision, the rate of further dislocation may be 35%.[10] In 2009, Bozic et al[11] reported recurrent dislocation as the main indication for revision THA in 22% of all revisions performed, using a regional registry with more than 50,000 THAs.[11]

Dual mobility implants have been widely used in parts of Europe for both primary and revision THA with good results, for over two decades.[12] The rationale for this is to reduce instability by increasing the jump distance without resorting to larger femoral heads.[13] A recent systematic review

of revision THA using modern dual mobility bearings reported a dislocation rate of 2.2% at short-term follow-up, but only 1.2% needed re-revision, with the other 1% being stable after relocation.[14]

This is in keeping with a report from the Swedish Joint Registry, which recorded that, in revision THA procedures for instability, the incidence of further recurrent dislocation was 2.1% when using dual mobility implants compared with 35.3% when using conventional implants.[6] Incidences of between 0% and 1.4% after dual mobility implants were used at revision THA have been reported in smaller series.[15–18] Similarly, Darrith et al[19] reported an incidence of 0.46% in a recent systematic review.

Some have advocated the use of larger heads rather than dual mobility implants. However, Hartzler et al[20] found that dual mobility implants had lower dislocation rates when compared with the use of 40 mm diameter heads in a series of 355 revision THAs in 2018. Although generally dual mobility implants were more likely to be used in patients felt to be at high risk of instability, they found a redislocation rate of 3.1% for dual mobility implants compared with 10% when 40 mm heads were used (hazard ratio 3.2).[20]

To date, there are no cost-effectiveness models that assess whether the clinical benefits of using dual mobility components compared with conventional bearings in revision THA represent value for money in the UK NHS. While we acknowledge that when deciding on implants and bearings, many factors have to be considered and the final decision will depend on surgeon preferences and individual patient characteristics, we aimed to assess the cost-effectiveness of using a dual mobility rather than a single bearing in patients undergoing revision THA using the National Joint Registry (NJR) of England and Wales[21] and an updated meta-analysis.

Methods

A Markov model with five health states was developed in Microsoft Excel (Microsoft, Redmond, Washington, USA) from the perspective of the NHS.

Markov models[22] are 'repetitive decision trees' that are used for modelling outcomes.[22] These trees indicate the various possibilities or movements between different health states that can occur to a patient at any given time. The health states which were assessed in this study were successful revision, dislocation, re-revision, and death. A patient can only be in one state at any one time. However, they may move from one state to another, and this rate of movement is determined by the effectiveness of the intervention. In this study, the comparison was between the use of dual mobility or single bearings at revision THA. We then assessed the health states over time periods, or cycles. In this model we set the length of a cycle at one year which was considered clinically meaningful, to assess the impact of the intervention[23,24] and to be consistent with previous studies.[25,26]

As more than 95% of patients' outcomes are captured in the NJR, 'loss to follow-up' was not imputed in the model.[22] Figure 1 shows a representation of the model, which considers a cohort of 1,000 patients, men and women, aged < 55 years, 55 to 64, 65 to 74, and > 75 years who are deemed eligible for revision surgery. These age groups are in keeping with the way data are categorized in the NJR.[27]
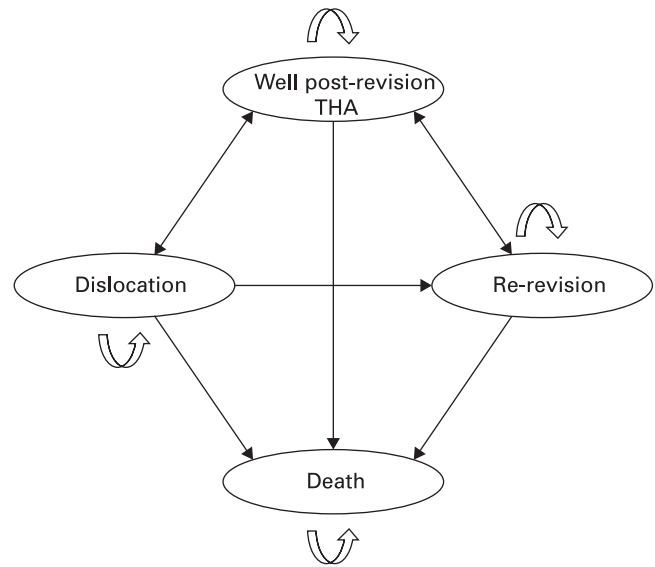

Fig. 1

Diagram of a Markov model. THA, total hip arthroplasty.

The model estimates the costs and outcomes of treating patients with either a single bearing (32 or 36 mm head) or a dual mobility bearing. These head sizes are the ones most commonly used for revision THA in the registry. The model does not distinguish the effectiveness of particular implant designs, head composition, or inner diameter of the dual mobility construct because these data are not available from the Registry at present, and this is a known limitation. We also assumed that all other things would be the same between the patient groups such as type of fixation, postoperative weight-bearing and activity levels or restrictions, and the only difference was the use of single or dual bearings.

Following revision surgery with either single or dual bearings, patients can enter the following health states: a) successful revision. Patients in this state may stay successful, or at any point can transition into any of the health states listed below. The rate of movement into another state is called the 'transition probability' and is governed by the success of the intervention, in this study being revision THA using single or dual bearings. b) Dislocation: patients that transition into this state can enter a successful post-dislocation state following closed reduction or are at further risk of transition to a re-revision state (state c). c) Patients that had a re-revision are at further risk of another revision, but no further surgical options were considered beyond a second revision. d) Lastly, patients may transition to the death state from any other state at any time. The death state is called the 'absorbing health state' as no further transitions can occur.

The model has a 14-year time horizon in line with the NJR data and estimates the number of patients in each health state every year. However, we explored a lifetime horizon in a sensitivity analysis.

Clinical data on the surface of a single bearing. Clinical data on revisions for single bearings were derived from the 2018 NJR.[28] Thus, the failure rate (revisions) for single bearings reported at five-, ten-, and 14-year follow-ups were used in the

Table I. Risk ratios and model parameters.

Characteristic	Mean 5-yr revision rates (SE)		Mean 10-yr revision rates (SE)		Mean 14-yr revision rates (SE)		Source
Age groups	**Men**	**Females**	**Men**	**Females**	**Men**	**Females**	
< 55 yrs	0.037 (0.001)	0.041 (0.001)	0.078 (0.002)	0.097 (0.002)	0.107 (0.003)	0.14 (0.004)	NJR 2018
55 to 64 yrs	0.029 (0.001)	0.027 (0.001)	0.062 (0.001)	0.064 (0.001)	0.090 (0.003)	0.094 (0.003)	NJR 2018
65 to 74 yrs	0.022 (0.000)	0.019 (0.000)	0.045 (0.001)	0.039 (0.001)	0.066 (0.002)	0.054 (0.001)	NJR 2018
> 75 yrs	0.02 (0.000)	0.015 (0.000)	0.035 (0.001)	0.025 (0.001)	0.050 (0.004)	0.034 (0.001)	NJR 2018
Re-revision rates for both males and females							
Re-revision	0.116 (0.002)	N/A	0.177 (0.005)	N/A	0.216 (0.012)	N/A	NJR 2018
Dislocation	0.07 (0.003)	N/A	N/A	N/A	N/A	N/A	Meta-analysis
Postoperative mortality							
< 55 yrs	0.022 (0.001)	0.025 (0.001)	0.050 (0.001)	0.050 (0.001)	0.080 (0.003)	0.075 (0.003)	NJR 2018
55 to 64 yrs	0.048 (0.001)	0.038 (0.001)	0.123 (0.002)	0.094 (0.002)	0.209 (0.006)	0.161 (0.004)	NJR 2018
65 to 74 yrs	0.106 (0.001)	0.072 (0.001)	0.292 (0.003)	0.215 (0.002)	0.507 (0.007)	0.400 (0.005)	NJR 2018
≥ 75 yrs	0.271 (0.003)	0.186 (0.002)	0.666 (0.005)	0.535 (0.003)	0.878 (0.009)	0.793 (0.006)	NJR 2018
All-cause mortality							
< 55 yrs	0.001	0.001	N/A	N/A	ONS 2018	N/A	N/A
55 to 64 yrs	0.005	0.006	N/A	N/A	ONS 2018	N/A	N/A
65 to 74 yrs	0.012	0.015	N/A	N/A	ONS 2018	N/A	N/A
≥ 75 yrs	0.133	0.145	N/A	N/A	ONS 2018	N/A	N/A

N/A, not applicable; NJR, National Joint Registry; SE, standard error.

Table II. Risk ratios and model parameters

Clinical-effectiveness of dual mobility	Mean value (range; SE)	Source
All revision	0.45 (0.28 to 0.74; 0.117)	Meta-analysis
Dislocation	0.32 (0.17 to 0.61; 0.112)	Meta-analysis
Revision due to dislocation	0.35 (0.16 to 0.74; 0.148)	Meta-analysis

N/A, not applicable; ONS, Office of National Statistics; SE, standard error.

Table III. Risk ratios and model parameters

Health state cost data	Mean (SE)	Source
Health state utility		
Well post-revision THA, £	489 (62.37)	NHS reference costs
Dislocation, £	2,500 (318.88)	NHS reference costs
Revision costs, £	10,390 (1,325.26)	NHS reference costs
Re-revision, £	10,390 (1,325.26)	NHS reference costs
Intervention cost data		
Single bearing, £	900 (115)	NHS supply chain
Dual mobility, £	2,000 (255)	NHS supply chain
Health utility data by age		
< 55 yrs	0.736 (0.018)	Fawsitt et al[30] (2019)
55 to 64 yrs	0.767 (0.007)	Fawsitt et al[30] (2019)
65 to 74, yrs	0.762 (0.004)	Fawsitt et al[30] (2019)
≥ 75 yrs	0.79 (0.003)	Fawsitt et al[30] (2019)
Health state utility		
Post-surgery	0.750 (0.020)	N/A
Revision	0.565 (0.012)	N/A
Re-revision	0.4630 (0.013)	N/A

N/A, not applicable; SE, standard error; THA, total hip arthroplasty.

model (Tables I–III). Because they are reported as rates, we converted them to probabilities needed for the modelling using the following formula $p = 1-e^{-rt}$[29] where p = the probability, r = the rate and t = the unit of time.

Re-revision was defined as a subsequent operation to deal with a failed revision, due, for instance, to dislocation. To have a more accurate level of rates of dislocation, we updated three recent meta-analyses that compared single and dual bearings in revision THA[11,27,31] since the NJR does not accurately report this information.

Clinical data on dual mobility. As previously stated, the NJR data enabled us to report how many patients lie in one particular health state without intervention, thus providing baseline data without dual mobility. In order to compare the effectiveness of the intervention (single or dual bearing) we had to also perform a meta-analysis. This gives us an overall estimate of effectiveness of the intervention, thus how much using dual mobility bearings mitigates dislocation or any cause re-revision. A meta-analysis combines many studies which ask and answer the same question with outcomes to give an overall estimate of effect.

We conducted a systematic literature review to identify studies which compared single and dual bearings in PubMED (MeSH: with heading of instability, dual mobility; total hip arthroplasty; total hip replacement, revision hip arthroplasty) and identified three systematic reviews that were published in 2018.[12,19,25] There were five studies that compared single and dual bearings in these reviews. However, none of the three reviews captured all the five studies in their analysis. All revision hip arthroplasties were considered with exclusion of those under the age of 18 and in those who had revision done for cancer.

Consequently, we performed a meta-analysis of the five studies using RevMan v. 5.3 (The Nordic Cochrane Centre, Copenhagen, Denmark). All studies reported the following outcomes, which were included in the meta-analysis: 1) all cause revisions, 2) dislocation, 3) re-revision due to dislocation. We reported risk ratios as the summary statistic since all the outcomes were dichotomous, and p-values ≤ 0.05 were considered statistically significant. All potential studies were reviewed by staff orthopaedic surgeons (AA and AK) for accuracy and inclusion. If a dispute was encountered, it was reviewed by a third orthopaedic surgeon (SEW).

The follow-ups ranged from six months to three years. In the base model, the effect of dual mobility on the rates of dislocation and revision was limited to three years after surgery in line with the maximum follow-up in the studies. After three years, the risks of dislocation and revision were assumed to be equivalent for single and dual bearings. This assumption was made due to the lack of longer-term follow up data suggesting otherwise. The risk ratios applied in the model are shown in Table I. **Mortality rates.** As also previously reported, the all-cause sex- and age-specific mortality was obtained from UK Life Tables 2015/17[32] which reports mortality rates by age and sex (Table I). Postoperative mortality was obtained from the NJR. Both all-cause and postoperative mortality were assumed to be the same in patients treated with both single and dual bearings as currently there is no evidence suggesting otherwise.

Health-related quality of life (HRQOL) and utility data used in the model. Quality of life data or health utilities were obtained from a previously published economic evaluation from the UK.[30] The authors of this study estimated the health state utilities from the Patient-Reported Outcome Measures (PROMs) dataset for 32,577 patients aged > 40 years who had a THA in 2010/2011.[27] We assumed the same utilities for the first and subsequent revisions. Different implants were also assumed to have similar utility on patients as there is no evidence to suggest otherwise. The data on utilities were combined with survival to estimate quality-adjusted life-years (QALYs).

Healthcare resource costs. The model adopted the health and social care payer perspectives, considering only those costs and benefits that are incurred by the single payer health service (NHS). The costs of revision surgery, closed reduction and follow-up care were obtained from the NHS reference costs and were estimated as a weighted average based on the relevant HGRs (Healthcare Group Resources) codes.[33] Costs of implants were obtained from NHS Supply chain. In line with current standard practice in the UK including the National Institute for Health and Care Excellence (NICE)[34] guidelines for economic analysis, a 3.5% annual discount rate was applied for both cost and outcomes. Discounting is an economic term that indicates the rate at which society is willing to trade off present costs against future benefits and is commonly used in cost-effectiveness studies. All costs are reported in 2018/19 British pounds.

Cost-effectiveness analysis and SA. The base-case analysis compared the cost-effectiveness of single and dual bearing THAs for all patients aged > 18 years undergoing revision THA in the UK. In order to summarize the cost-effectiveness of an intervention, an incremental cost-effectiveness ratio (ICER) is calculated. This is the difference in costs between the two interventions, divided by the difference in their effects. In this study, this is the overall costs of using dual mobility bearings minus the overall costs of using single bearings divided by the overall clinical benefits of using dual mobility bearings minus the overall clinical benefits of using single bearings.

ICER = Δ COSTS ÷ Δ QALYs (Δ= incremental difference or delta). In order to determine if the intervention is cost-effective, the ICER is compared with the maximum amount that the healthcare payer is willing to pay for an additional unit of health benefit. In this context, NICE has a threshold figure of between £20,000 and £30,000/QALY. When the difference in costs (ΔC) is a negative value and the difference in benefits is positive (ΔQALYs) we conclude that the intervention (dual mobility) is a dominant strategy which represents a cost-saving to the system. If the ICER is below the threshold, we conclude that the intervention is cost-effective; if it is above the threshold, we conclude that it is not cost-effective according to the guidance issued by NICE.[32]

Sensitivity analysis. A one-way sensitivity analysis and a probabilistic sensitivity analysis were also conducted and the results presented in a table for one-way sensitivity analysis and cost-effectiveness acceptability curves for the probabilistic sensitivity analysis. A sensitivity analysis is done in order to address the impact of possible uncertainty in the best information available on clinical benefits and treatment costs by alternately assigning low and high values and then recording the results. For the one-way sensitivity analysis, baseline values were varied SD 20% if ranges were not reported in the literature in accordance with other economic studies.[35]

A probabilistic sensitivity analysis was also performed. This entails specifying a distribution for each parameter in the model to represent the uncertainty about the point estimate. This means that the uncertainty about multiple input assumptions can be tested simultaneously (in this case the costs of implants and utility values). This is distinct from one-way sensitivity analysis, which allows uncertainty about single inputs to be tested individually.[36]

The lognormal distribution was implemented to capture the uncertainty surrounding the treatment effect; gamma and beta distributions were used to capture the uncertainty in cost and utility values respectively.

Results

Dual mobility bearings had fewer dislocations and re-revisions and therefore resulted in increased QALYs over five-, ten-, and 14-year follow-up periods compared with single bearings for both sexes in all age groups.

Follow-up of up to five years. For all age groups at a shorter follow-up period of five years, the use of dual mobility resulted in an increase in mean cost per patient (Table IV) as well as increased QALYs. The estimated ICERs fell below £30,000/QALY for both sexes for age groups < 75 years and would be deemed cost-effective in accordance with NICE guidance. For those aged > 75 years, the ICERs were £45,032/QALY for males and £50,625 for females and would not be deemed to be cost-effective.

Follow-up of up of between ten and 14 years. For follow-up periods between ten years and 14 years, the use of dual mobility was cost-saving for all ages ≤ 75 years resulting in better clinical outcomes and less cost overall. For those aged > 75 years dual mobility would only be deemed to be cost-effective at a willingness to pay threshold of between £20,000 and 30,000/QALY. Overall, the cost-effectiveness results are more favourable for younger patients compared with older patients. Table II and Table III summarize the results for both males and females by age group.

Sensitivity analysis. At five-year follow-up, the results for those aged < 55 years are robust for all follow-up periods and remain cost-effective. For those aged between 55 to 64 years,

Table IV. Expected results by age and sex at five-, ten-, and 14 year time periods.

Characteristic	Results for 5-yr follow-up			Results for 10-yr follow-up			Results for 14-yr follow-up		
Men	Costs, £	QALYs	ICER, £	Costs, £	QALYs	ICER, £	Costs, £	QALYs	ICER, £
< 55 yrs			6,756			Dominant			Dominant
Single bearing	4,741	4.04		10,245	6.66		14,830	8.36	
Dual mobility	4,921	4.07		9,346	6.72		13,361	8.43	
55 to 64 yrs			12,642			Dominant			Dominant
Single bearing	4,436	3.96		9,055	6.36		12,870	7.78	
Dual mobility	4,744	3.98		8,484	6.41		11,796	7.84	
65 to 74 yrs			20,384			Dominant			Dominant
Single bearing	4,067	3.80		7,536	5.81		10,083	6.85	
Dual mobility	4,510	3.82		7,353	5.85		9,569	6.90	
≥ 75 yrs			45,032			23,216			17,422
Single bearing	2,969	2.74		3,984	3.37		4,545	3.65	
Dual mobility	3,633	2.76		4,475	3.39		4,958	3.68	
Women									
< 55 yrs			4,398			Dominant			Dominant
Single bearing	4,853	4.03		11,008	6.64		16,478	8.33	
Dual mobility	4,974	4.06		9,847	6.70		14,571	8.41	
55 to 64 yrs			13,795			Dominant			Dominant
Single bearing	4,395	3.97		9,165	6.40		13,194	7.86	
Dual mobility	4,726	3.99		8,567	6.45		12,050	7.92	
65 to 74 yrs			22,307			Dominant			
Single bearing	4,023	3.83		7,411	5.89		9,725	6.94	Dominant
Dual mobility	4,499	3.85		7,292	5.93		9,334	6.99	
≥ 75 yrs									
Single bearing	2,886	2.76	50,625	3,752	3.33	29,009	4,117	3.53	24,923

ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-years.

the cost of dual mobility affects the results. If the price of dual mobility bearings falls to £1,500, it becomes cost-saving compared with single bearing. If the price of dual mobility increases to £2,500 the ICER increases to > £30,000/QALY for both males and females and is thus no longer cost-effective.

In those aged > 75 years, the cost-effectiveness remains uncertain emphasizing that dual mobility is not cost-effective using the base-case assumptions in this age group. However, if its cost is reduced to £1,500 then it may become cost-effective. A threshold analysis, an assessment to see at what follow-up time dual mobility would become cost-effective with base case assumptions, showed that it was cost-effective in those aged > 75 years after seven years.

At a ten-year follow-up. Beyond ten years, the level of uncertainty decreases in all groups aged < 75 years, and dual mobility is a dominant strategy; it results in less costs overall and has improved clinical outcomes, and is thus a cost-saving compared with single bearing. In those aged > 75 years, dual mobility is cost-effective, but not cost-saving compared with single bearing. The results of one-way sensitivity analysis are summarized in Table V.

We also conducted a probabilistic sensitivity analysis and presented the results using cost-effectiveness acceptability curves. This confirmed the findings of the one-way sensitivity analysis, suggesting that our base case conclusions are unlikely to be a chance finding. The cost-effectiveness acceptability curves show the probability that an intervention is cost-effective at a given willingness to pay threshold by the payers. These are available in the supplementary material.

Discussion

Dual mobility bearings were developed in an attempt to reduce the risk of dislocation in primary THA.[37] However, the higher rates of dislocation associated with revision THA can make them an option for revision procedures.

With much higher costs of these implants, a balance between the clinical value of limiting the risk of dislocation and potential further revision has to be struck with the economic benefits. We therefore designed this study to assess the cost-effectiveness of dual mobility compared with traditional single bearing implants over a five-, ten-, and 14-year follow-up period for both sexes and for differing age groups.

We found that over the time frame assessed for all groups, considering a cohort of 1,000 patients, the use of dual mobility can decrease the risk of dislocation and further revision, resulting in higher QALYs. The economic analyses showed that over a five-year follow-up period, the use of dual mobility can be cost-effective for all patients aged < 75 years. The results are more favourable for younger patients and over a longer period of follow-up. For those aged > 75 years, dual mobility is not cost-effective over a five-year period and becomes effective beyond seven years. Sensitivity analysis showed that the results in those aged > 75 years remain uncertain until after ten years.

Over a ten-year period, the use of dual mobility is cost-saving in those aged < 75 years and cost-effective in those aged > 75 years. As mentioned earlier, the model favours younger patients and those with longer follow-up. The estimated savings increase with increased follow-up and there are also more savings in the younger age groups. For instance, for females

Table V. One-way sensitivity analysis of the incremental cost-effectiveness ratio for lower and upper model values over five- and ten-year follow-up.

Parameters	Five years		Ten years	
55 to 64 yrs	Lower value, £	Upper value, £	Lower value, £	Upper value, £
Males				
Effectiveness of DM on dislocation	8,090	27,278	Dominant	Dominant
Cost of SB	21,884	3,400	Dominant	Dominant
Cost of DM	Dominant	32,412	Dominant	Dominant
Discount rate	7,516	14,950	Dominant	Dominant
Females				
Effectiveness of DM on dislocation	9,015	29,312	Dominant	Dominant
Cost of SB	23,166	4,423	Dominant	Dominant
Cost of DM	Dominant	33,884	Dominant	Dominant
Discount rate	8,595	16,135	Dominant	Dominant
65 to 74 yrs				
Males				
Effectiveness of DM on dislocation	14,402	40,467	Dominant	3,272
Cost of DM	Dominant	42,769	Dominant	6,914
Cost of SB	30,739	10,030	993	Dominant
Discount rate	14,686	22,947	Dominant	Dominant
Females				
Effectiveness of DM on dislocation	15,887	44,263	Dominant	5,924
Cost of SB	32,855	11,758	2,577	Dominant
Cost of DM	Dominant	45,183	Dominant	8,667
Discount rate	16,493	24,922	Dominant	Dominant
Age > 75 yrs				
Males				
Effectiveness of DM on dislocation	35,222	78,402	21,078	57,517
Cost of SB	60,283	29,780	40,412	17,607
Cost of DM	11,722	78,342	4,082	53,937
Discount rate	37,237	48,510	20,736	32,758
Females				
Effectiveness of DM on dislocation	39,459	90,092	16,544	46,257
Cost of DM	15,549	85,700	115	46,317
Cost of SB	66,615	34,634	33,853	12,578
Discount rate	42,440	54,277	15,449	26,737

DM, dual mobility; SB, single bearing

aged < 55 years, there are mean savings of £1,161 at ten years compared with £1,907 at 14 years. This compares with mean savings of £119 and £391, respectively, for those aged between 65 and 74 years. These results are further confirmed by both the one way and probabilistic sensitivity analyses. For instance, in those aged < 75 years, there is a high probability that dual mobility is cost-effective, while for those aged > 75 years the probability of dual mobility being cost-effective is low.

The results for patients aged > 75 years are sensitive to assumptions about the cost of the implants and effectiveness of dual mobility in preventing dislocation. If the price differential is estimated to be about £1,000 between dual and single bearings, the use of dual mobility bearings is more likely to be cost-effective in this age group. Otherwise, for all other age groups, the model is not sensitive to these assumptions.

Older patients have a shorter life expectancy and the cost difference may make it difficult to justify the extra cost, especially in patients with comorbidities. However, as has been previously reported, the chronological age of a patient can 'not be a perfect proxy for years of remaining active life, but it is a known factor for all patients'.[28] Additionally, the average life expectancy in the UK is approximately 82 years and is continuing to rise,[38] which may justify the additional costs of dual mobility, but this is to be at the discretion of the treating surgeon, the indication for revision, the resources available to the healthcare institution and the overall health of the patient.

To the best of our knowledge, this is the first study that has assessed the cost-effectiveness of single and dual bearings in the NHS in the UK. A strength of the study is the use of NJR data which are relevant and correctly characterize the UK population. Furthermore, robust sensitivity analysis was performed, a one-way and a probabilistic sensitivity analysis, to ensure confidence in the results. The limitations of this study include the fact that it is primarily applicable to the UK healthcare system, as the baseline data and cost-assumptions were from the perspective of the NHS. However, we believe that the results may be extrapolated to other healthcare systems, especially those with a universal single payer platform. We suspect that the NJR reflects similar outcomes as many other healthcare systems, and implant cost-ratios would not be too different. We acknowledge that the data also use an older generation of polyethylene for survivorship and this may have an effect on the cost-effectiveness conclusions and we urge caution on the interpretation of the results.

Dual mobility bearings may be associated with high wear rates in the long term as there are two metal/polyethyelene interfaces and a much larger surface area of contact on the outer bearing. There is also a risk of adverse local tissue reaction and corrosion of the liner/cup interface.[39]

An in vivo study with ultra-high molecular polyethylene dual mobility bearings showed that rates of wear of more than a threshold of 0.1 mm/year may risk the development of osteolysis.[40] More recently, a radioisometric analysis of highly cross-linked polyethylene showed no higher rates of wear than with traditional single bearings.[41] However, comparison of wear is beyond the scope of this study. Additionally, there have never been reported case reports of osteolysis being associated with particles of debris.

However, a small study involving matched cohorts of patients aged < 55 years showed no difference in functional scores.[42] With the lack of long-term wear rates and associated survivorship, dual mobility implants should be used with caution,[35] especially in patients with risk factors for recurrent dislocation. We acknowledge that cost should not be the only reason for the choice of implant.

Surgeons, patients, and manufacturers will attempt to improve the survivorship of revision THAs and minimize the risk of dislocation using one of these strategies. This analysis

suggests that dual mobility may be a cost-effective option for revision THA especially in patients aged < 75 years for the five-year postoperative period, and it becomes cost-saving beyond ten years in all age groups. For those aged > 75 years, cost-effectiveness is uncertain at five years but dual mobility is predicted to become cost-effective beyond seven years postoperatively.

This study was not intended to dictate the choice of bearings to be used in revision surgery. We solely aimed to advise surgeons in their decision-making process as to the cost-effectiveness of dual mobility bearings in revision hip surgery, with the costs in different age groups and the potential sequalae.

The findings do not suggest that dual mobility is a panacea for all revision cases and clinical judgement cannot be superseded by economic analysis. This analysis does, however, provide some justification for the use of these more expensive implants when the surgeon feels that they may be clinically indicated, particularly in revision THAs in younger patients in whom instability is the indication for surgery.

Take home message

- Dual mobility bearings may be cost-effective in all patients aged < 75 years undergoing revision total hip arthroplasty. This is especially true of those with instability as the indication for revision surgery.
- In those aged > 75 years, dual mobility bearings become cost-saving after seven years.

Twitter

Follow A. Atrey @hipdoc75

References

1. **Bozic KJ**, **Kamath AF**, **Ong K**, **et al**. Comparative epidemiology of revision arthroplasty: failed THA poses greater clinical and economic burdens than failed TKA. *Clin Orthop Relat Res*. 2015;473(6):2131–2138.
2. **Malik AT**, **Li M**, **Scharschmidt TJ**, **Khan SN**. Revision of an infected total hip arthroplasty: the need for the adjustment of risk in bundled payment models for revision arthroplasty. *Bone Joint J*. 2019;101-B(5):547–551.
3. **Phillips JLH**, **Rondon AJ**, **Vannello C**, **et al**. How Much Does a Readmission Cost the Bundle Following Primary Hip and Knee Arthroplasty? *J Arthroplasty*. 2019;34(5):819–823.
4. **Koenig L**, **Feng C**, **He F**, **Nguyen JT**. The Effects of Revision Total Hip Arthroplasty on Medicare Spending and Beneficiary Outcomes: Implications for the Comprehensive Care for Joint Replacement Model. *J Arthroplasty*. 2018;33(9):2764–2769.
5. **Kosashvili Y**, **Drexler M**, **Backstein D**, **et al**. Dislocation after the first and multiple revision total hip arthroplasty: comparison between acetabulum-only, femur-only and both component revision hip arthroplasty. *Can J Surg*. 2014;57(2):E15–E18.
6. **Garbuz DS**, **Masri BA**, **Duncan CP**, **et al**. The Frank Stinchfield Award: Dislocation in revision THA: do large heads (36 and 40 mm) result in reduced dislocation rates in a randomized clinical trial? *Clin Orthop Relat Res*. 2012;470(2):351–356.
7. **Salassa T**, **Hoeffel D**, **Mehle S**, **Tatman P**, **Gioe TJ**. Efficacy of revision surgery for the dislocating total hip arthroplasty: report from a large community registry. *Clin Orthop Relat Res*. 2014;472(3):962–967.
8. **Wetters NG**, **Murray TG**, **Moric M**, **et al**. Risk factors for dislocation after revision total hip arthroplasty. *Clin Orthop Relat Res*. 2013;471(2):410–416.
9. **Kärrholm J**, **Lindahl H**, **Malchau H**, **et al**. The Swedish Hip Arthroplasty Register Annual Report 2016. The Swedish Hip Arthroplasty Register. https://registercentrum.blob.core.windows.net/shpr/r/Annual-Report-2016-B1eWEH-mHM.pdf (date last accessed 26 June 2020).
10. **Jo S**, **Jimenez Almonte JH**, **Sierra RJ**. The Cumulative Risk of Re-dislocation After Revision THA Performed for Instability Increases Close to 35% at 15 years. *J Arthroplasty*. 2015;30(7):1177–1182.
11. **Bozic KJ**, **Kurtz SM**, **Lau E**, **et al**. The epidemiology of revision total hip arthroplasty in the United States. *J Bone Joint Surg Am*. 2009;91-A(1):128–133.
12. **Farizon F**, **de Lavison R**, **Azoulai JJ**, **Bousquet G**. Results with a cementless alumina-coated cup with dual mobility. A twelve-year follow-up study. *Int Orthop*. 1998;22(4):219–224.
13. **Guyen O**. Constrained liners, dual mobility or large diameter heads to avoid dislocation in THA. *EFORT Open Rev*. 2017;1(5):197–204.
14. **Levin JM**, **Sultan AA**, **O'Donnell JA**, **et al**. Modern Dual-Mobility Cups in Revision Total Hip Arthroplasty: A Systematic Review and Meta-Analysis. *J Arthroplasty*. 2018;33(12):3793–3800.
15. **van Heumen M**, **Heesterbeek PJ**, **Swierstra BA**, **Van Hellemondt GG**, **Goosen JH**. Dual mobility acetabular component in revision total hip arthroplasty for persistent dislocation: no dislocations in 50 hips after 1-5 years. *J Orthop Traumatol*. 2015;16(1):15–20.
16. **Mohammed R**, **Hayward K**, **Mulay S**, **Bindi F**, **Wallace M**. Outcomes of dual-mobility acetabular cup for instability in primary and revision total hip arthroplasty. *J Orthop Traumatol*. 2015;16(1):9–13.
17. **Simian E**, **Chatellard R**, **Druon J**, **Berhouet J**, **Rosset P**. Dual mobility cup in revision total hip arthroplasty: dislocation rate and survival after 5 years. *Orthop Traumatol Surg Res*. 2015;101(5):577–581.
18. **Wegrzyn J**, **Tebaa E**, **Jacquel A**, **et al**. Can Dual Mobility Cups prevent Dislocation in All Situations After Revision Total Hip Arthroplasty? *J Arthroplasty*. 2015;30(4):631–640.
19. **Darrith B**, **Courtney PM**, **Della Valle CJ**. Outcomes of dual mobility components in total hip arthroplasty: a systematic review of the literature. *Bone Joint J*. 2018;100-B(1):11–19.
20. **Hartzler MA**, **Abdel MP**, **Sculco PK**, **et al**. Otto Aufranc Award: Dual-Mobility Constructs in revision THA. Reduced dislocation, re-revision, and reoperation compared with large femoral heads. *Clin Orthop Relat Res*. 2018;476(2):293–301.
21. **No authors listed**. 16th Annual Report 2019. National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. https://reports.njrcentre.org.uk/Portals/0/PDFdownloads/NJR%2016th%20Annual%20Report%202019.pdf (date last accessed 8 July 2020).
22. **Sonnenberg FA**, **Beck JR**. Markov models in medical decision making: a practical guide. *Med Decis Making*. 1993;13(4):322–338.
23. **Husereau D**, **Drummond M**, **Petrou S**, **et al**. Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement. *Value Health*. 2013;16(2):e1–e5.
24. **Briggs A**, **Sculpher M**. An introduction to Markov modelling for economic evaluation. *Pharmacoeconomics*. 1998;13(4):397–409.
25. **Epinette JA**, **Lafuma A**, **Robert J**, **Doz M**. Cost-effectiveness model comparing dual-mobility to fixed-bearing designs for total hip replacement in France. *Orthop Traumatol Surg Res*. 2016;102(2):143–148.
26. **Abdel MP**, **Miller LE**, **Hanssen AD**, **Pagnano MW**. Cost Analysis of Dual-Mobility Versus Large Femoral Head Constructs in Revision Total Hip Arthroplasty. *J Arthroplasty*. 2019;34(2):260–264.
27. **No authors listed**. 15th Annual Report 2018. National Joint Registry for England, Wales, Northern Ireland and the Isle of Man (NJR). https://www.hqip.org.uk/wp-content/uploads/2018/11/NJR-15th-Annual-Report-2018.pdf (date last accessed 26 June 2020).
28. **Carnes KJ**, **Odum SM**, **Troyer JL**, **Fehring TK**. Cost Analysis of Ceramic Heads in Primary Total Hip Arthroplasty. *J Bone Joint Surg Am*. 2016;98-A(21):1794–1800.
29. **Fleurence RL**, **Hollenbeak CS**. Rates and probabilities in economic modelling: transformation, translation and appropriate application. *Pharmacoeconomics*. 2007;25(1):3–6.
30. **Fawsitt CG**, **Thom HHZ**, **Hunt LP**, **et al**. Choice of Prosthetic Implant Combinations in Total Hip Replacement: Cost-Effectiveness Analysis Using UK and Swedish Hip Joint Registries Data. *Value Health*. 2019;22(3):303–312.
31. **Romagnoli M**, **Grassi A**, **Costa GG**, **et al**. The efficacy of dual-mobility cup in preventing dislocation after total hip arthroplasty: a systematic review and meta-analysis of comparative studies. *Int Orthop*. 2019;43(5):1071–1082.
32. **No authors listed**. Dataset(s): National life tablets: UK. Office for National Statistics. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/datasets/nationallifetablesunitedkingdomreferencetables/current (date last accessed 26 June 2020).
33. **No authors listed**. Healthcare resource group. http://www.hcrg.com/ (date last accessed 8 July 2020).
34. **No authors listed**. NICE guidelines. National Institute for Health and Care Excellence (NICE). https://www.nice.org.uk/about/what-we-do/our-programmes/nice-guidance/nice-guidelines (date last accessed 26 June 2020).
35. **Gold MR**, **Siegel JE**, **Russel LB**, **Weinstein MC, eds**. *Cost-effectiveness in Health and Medicine*. New York: Oxford University Press, 1996.
36. **Claxton K**, **Sculpher M**, **McCabe C**, **et al**. Probabilistic sensitivity analysis for NICE technology assessment: not an optional extra. *Health Econ*. 2005;14(4):339–347.
37. **Aubriot JH**, **Lesimple P**, **Leclercq S**. Study of Bousquet's non-cemented acetabular implant in 100 hybrid total hip prostheses (Charnley type cemented

femoral component). *Average 5-year follow-up]. Acta Orthop Belg.* 1993;59(suppl 1):267–271. [Article in French].

38. **No authors listed**. Life Expectancies. Office for National Statistics. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies (date last accessed 8 July 2020).

39. **Matsen Ko LJ**, **Pollag KE**, **Yoo JY**, **Sharkey PF**. Serum Metal Ion Levels Following Total Hip Arthroplasty With Modular Dual Mobility Components. *J Arthroplasty.* 2016;31(1):186–189.

40. **Tabori-Jensen S**, **Frølich C**, **Hansen TB**, **et al**. Higher UHMWPE wear-rate in cementless compared with cemented cups with the Saturne® Dual-Mobility acetabular system. *Hip Int.* 2018;28(2):125–132.

41. **Laende EK**, **Richardson CG**, **Dunbar MJ**. Migration and Wear of a Dual Mobility Acetabular Construct at 3 Years Measured by Radiostereometric Analysis. *J Arthroplasty.* 2020;35(4):1109–1116.

42. **Rowan FE**, **Salvatore AJ**, **Lange JK**, **Westrich GH**. Dual-Mobility vs Fixed-Bearing Total Hip Arthroplasty in Patients Under 55 Years of Age: A Single-Institution, Matched-Cohort Analysis. *J Arthroplasty.* 2017;32(10):3076–3081.

Author information:
A. Khoshbin, MD, FRCSC, MSc, Assistant Professor of Orthopaedics, Attending Surgeon
S. Ward, MD, FRCSC, MSc, Assistant Professor of Orthopaedics, Attending Surgeon
A. Atrey, MD, FRCS, Msc, Assistant Professor of Orthopaedics, Attending Surgeon
University of Toronto, Toronto, Canada; St Michael's Hospital, Toronto, Canada.

F. S. Haddad, BSc MD(Res), FRCS(Tr&Orth), Professor of Orthopaedic Surgery, University College London Hospitals, The Princess Grace Hospital, and The NIHR Biomedical Research Centre at UCLH, London, UK.

S. O'hEireamhoin, MB BS, FRCS(Tr&Orth), Orthopaedic Fellow, St Michael's Hospital, Toronto, Canada.

J. Wu, MD, Orthopaedic Resident, University of Toronto, Toronto, Canada.

L. Nherera, BSc, PhD, Health Economist, Smith & Nephew, Memphis, Tennessee, USA.

This article was primary edited by J. Scott.