Use of cost-effectiveness analysis to evaluate new technologies in orthopaedics: the case of alternative bearing surfaces in total hip arthroplasty

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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The use of conventional and alternative bearings for total hip arthroplasty (THA). Conventional bearings consisted of ultra-high molecular weight polyethylene. A range of alternative bearings was considered, such as highly cross-linked polyethylene and second-generation ceramic-on-ceramic and metal-on-metal bearings.

Type of intervention
Treatment.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised a hypothetical cohort of male patients who were 50 years of age, had advanced osteoarthritis of the hip, and were candidates for THA.

Setting
The setting was a hospital. The economic study was carried out in the USA.

Dates to which data relate
The effectiveness data were derived from studies published between 1988 and 2004. No dates for resource use were reported. The price year was not given.

Source of effectiveness data
The effectiveness evidence was derived from a synthesis of published studies.

Modelling
A Markov model was constructed to simulate the initial management, clinical course, and clinical or economic outcomes associated with the use of alternative bearings in comparison with conventional ones. The time horizon of the model was the remaining life expectancy of the patient. The cycle length was 1 year. The six health states included in the model were initial primary THA, post-primary total hip arthroplasty, post-revision total hip arthroplasty, post-2nd revision total hip arthroplasty, death due to total hip arthroplasty, and death due to all other causes. The latter two states were absorbing conditions.

Outcomes assessed in the review
The outcomes estimated from the literature were the transition probabilities, death rates, and estimates of quality of life
associated with specific conditions.

**Study designs and other criteria for inclusion in the review**
It was unclear whether a systematic review of the literature was undertaken to identify primary studies. No information on the design of the primary sources was provided. All-cause mortality was obtained from age-specific actuarial life tables.

**Sources searched to identify primary studies**
Not reported.

**Criteria used to ensure the validity of primary studies**
Not reported.

**Methods used to judge relevance and validity, and for extracting data**
Not reported.

**Number of primary studies included**
Eleven primary studies appear to have provided the model inputs.

**Methods of combining primary studies**
Not reported.

**Investigation of differences between primary studies**
Not reported.

**Results of the review**
Transition probabilities were not reported.

The all-cause mortality rate was 0.004443.

The rate of mortality due to primary THA was 0.006 (range: 0.001 - 0.015).

The rate of mortality due to revision THA was 0.012 (range: 0.003 - 0.026).

The utility value was:
- 0.5 (range: 0.32 to 0.85) for osteoarthritis before primary THA,
- 0.92 (range: 0.66 to 0.98) for successful primary THA, and
- 0.80 (range: 0.6 to 0.95) for successful revision THA.

**Measure of benefits used in the economic analysis**
The summary benefit measure was the expected number of quality-adjusted life-years (QALYs). These were obtained by combining utility values and expected survival in a modelling approach. A discount rate of 3% was applied to future benefits.
Direct costs
The perspective of the cost analysis was not explicitly stated, although only the direct medical costs were considered. The costs included were those associated with primary or revision THA and the use of bearings. The unit costs were not presented separately from the resource quantities and were reported as macro categories. The costs were derived from outpatient billing records and from an activity-based hospital cost accounting system. The costs of alternative bearings were based on published studies. The source of the resource use data was not explicitly stated. Discounting was relevant, as long-term costs were estimated, and an annual rate of 3% was applied. The price year was not reported.

Statistical analysis of costs
The costs were treated deterministically.

Indirect Costs
The indirect costs were not included.

Currency
US dollars ($).

Sensitivity analysis
Multi-way sensitivity analyses were carried out to assess the impact of changes in the age of the patients, implant costs and the probability of implant failure at 20 years on the relative cost-effectiveness of alternative versus conventional bearings. The analyses were based on threshold values for alternative bearings being cost-saving or cost-effective.

Estimated benefits used in the economic analysis
The total QALYs were not reported.

Cost results
The expected costs were not reported.

Synthesis of costs and benefits
The costs and benefits were combined using a cost-utility ratio. However, these ratios were not reported as the analysis used an approach based on thresholds. Two thresholds were chosen for parameter values. One threshold considered the alternative bearing surfaces to be cost-saving in comparison with conventional bearings, while the other threshold assumed a willingness-to-pay of $50,000 per QALY.

The threshold analysis revealed that, in a population of 50-year-old patients, the use of an alternative bearing with an incremental cost of $2,000 (which represents the average incremental cost associated with a hard-on-hard bearing couple) would be cost-saving over the individual's lifetime if it were associated with a reduction in the 20-year implant failure rate of at least a 18.7% in comparison with the failure rate for a conventional bearing. The same implant in the same population would have to result in a 3.8% reduction in the 20-year implant failure rate in order to be considered cost-effective (less than $50,000 per QALY).

In a population of patients over the age of 63 years, the same implant would be associated with higher lifetime costs than a conventional bearing, regardless of the presumed reduction in the revision rate. In addition, it would have to result in an 11.3% reduction in the 20-year implant failure rate in order to be considered cost-effective.

An alternative bearing with an incremental cost of $2,000 in a population of patients over the age of 70 years would need to be associated with at least a 45.5% reduction in the 20-year implant failure rate in order to be considered cost-
In a population of patients over the age of 75 years, no alternative bearing would be associated with lifetime cost-savings or would be cost-effective, regardless of the cost or the presumed reduction in the revision rate.

The use of alternative bearings that added only $500 to the cost of a conventional THA could be cost-saving in a population of patients over the age of 50 years, even if it were associated with only a modest reduction in the revision rate (≥4.6%). The alternative bearings could be cost-effective if the incremental reduction in the probability of revision at 20 years was at least 1.1%.

The multivariate sensitivity analysis showed that, as the incremental cost of the alternative bearing surface increased, the age threshold for cost-savings decreased. A higher reduction in the probability of implant failure at 20 years compared with conventional bearings was required to justify the incremental cost.

**Authors' conclusions**
The cost-effectiveness of alternative bearings for total hip arthroplasty (THA) was highly dependent on the age of the patient at the time of surgery, the cost of the implant, and the associated reduction in the probability of revision relative to that associated with conventional bearings. Specifically, the study results suggested that, at current US pricing, hard-on-hard bearing surfaces such as ceramic-ceramic and meta-metal couples could be cost-saving for patients under the age of 63 years, while less costly bearing surfaces such as highly cross-linked polyethylene could be cost-saving for patients up to 70 years old.

**CRD COMMENTARY - Selection of comparators**
The choice of the comparator was appropriate as conventional bearings were selected to represent usual care. You should decide whether this is a valid comparator in your own setting.

**Validity of estimate of measure of effectiveness**
The effectiveness data used to populate the decision model were obtained from published studies. However, it was unclear whether these studies were identified selectively as the methods and conduct of a systematic review of the literature were not reported. No information on the design of the primary studies, or details of patient samples and follow-up, were given. Therefore, it was not possible to assess the validity of the primary studies. The issue of heterogeneity among the primary studies was not addressed. The sensitivity analysis investigated the impact of variations in key estimates.

**Validity of estimate of measure of benefit**
QALYs were the most appropriate benefit measure because they capture the impact of the interventions on both quality of life and survival, which are the most relevant dimensions of health. Little information on the instrument used to derive the utility was reported. The use of QALYs enables comparisons with the benefits of other health care interventions. Discounting was applied, as recommended by economic evaluation guidelines in the USA.

**Validity of estimate of costs**
The analysis of the costs included only the costs associated with primary or revision THA. Other medical costs were not considered. The authors did not specify the perspective of the economic study, although the sources of data reflected hospital costs. Data on the unit costs and the quantities of resources used were not presented separately, which will limit the possibility of replicating the analysis in other settings. The cost estimates were treated deterministically and were specific to the study setting, and only the cost of bearings was varied in the sensitivity analysis. The price year was unclear, which will make reflation exercises in other time periods difficult. The authors acknowledged that the use of a broad perspective and the inclusion of other categories of costs would have been more appropriate, but this was not possible because of the lack of available cost data.
Other issues
The authors reported the results from a few published studies but did not perform any direct comparison with the current findings. They also noted that the overall validity of the analysis was limited by the use of secondary data. This could also limit the generalisability of the study results to other settings. However, the authors carried out some sensitivity analyses on key estimates. A further limitation of the analysis was that the authors did not report the total QALYs, total costs and incremental cost-utility ratios separately. In general, this article appears to have been a preliminary study on the cost-effectiveness of alternative bearings in THA. Further data are required.

Implications of the study
The study results suggested that patient age and the cost of the implant should be considered when choosing the most cost-effective bearings in THA. The authors stated that their findings support the need for evidence of effectiveness in reducing the probability of implant failure when more costly alternative bearings are being considered.

Source of funding
Supported by the Orthopedic Research and Education Foundation.

Bibliographic details

PubMedID
16595459

DOI
10.2106/JBJS.E.00614

Other publications of related interest


Indexing Status
Subject indexing assigned by NLM

MeSH
Aged; Aged, 80 and over; Arthroplasty, Replacement, Hip /economics; Cost-Benefit Analysis; Hip Prosthesis /economics; Humans; Middle Aged; Prosthesis Design

AccessionNumber
22006000815

Date bibliographic record published
31/10/2006

Date abstract record published