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Original Article

Determining Cost-Effectiveness of Total Hip and Knee Arthroplasty Using the Short Form-6D Utility Measure

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ABSTRACT

Background: With the implementation of the Patient Protection and Affordable Care Act, cost-effectiveness analyses are becoming increasingly important for resource allocation, and particularly for the justification of costly procedures, such as total knee and total hip arthroplasties (TKAs and THAs). Therefore, using the Short Form-6D (SF-6D) utility values, the purpose of this study was to determine (1) the quality-adjusted life years (QALYs) gained and (2) and the cost-effectiveness of undergoing THA and TKA.
Methods: A total of 844 patients (357 men, 487 women) who had a mean age of 65 years (range, 39 to 80 years) underwent primary TKA, and 224 patients who had a mean age of 69 years (range, 44 to 88 years) underwent primary THAs at 7 institutions. The SF-6D values were derived for each patient preoperatively and at 1-year follow-up. QALYs were estimated at 1 year, and lifetime QALYs gained were determined using predicted life-expectancy values, at a discounted rate of 3% per year of life expectancy, to reflect a diminishing gain with time. National-level costs were determined using the 2011 Nationwide Inpatient Sample, and incremental cost-effectiveness ratios (ICER) were deduced for both groups.
Results: The preoperative SF-6D values for the THA and TKA cohorts were 0.614 (range, 0.37 to 1) and 0.62 (range, 0.3 to 0.93). Postoperatively, SF-6D values improved significantly at 1 year in both groups. One-year QALYs for TKA and THA were 0.768 and 0.799. Lifetime QALYs gained for the groups were 2.07 and 1.85 (1.39 and 1.34 if discounted at a rate of 3% per year). The estimated ICER for TKA vs baseline presurgery was $43,107 per QALY, and $39,453 per QALY for THA vs baseline presurgery.
Conclusion: The ICER showed that THA and TKA are cost-effective, compared to the $50,000 USD/QALY threshold for cost-effectiveness, and justify resources allocated to these surgeries. The SF-6D can utilize existing functional outcome data, which makes these cost calculations considerably easier and more feasible for practicing orthopedists.

The success of lower extremity total joint arthroplasty (TJA) is difficult to dispute given the projected rise in the number of procedures by 2030 [1]. However, the economic burden associated with these surgeries is considerable [2,3]. In fact, the cost burden to Medicare for primary total hip arthroplasty (THA) exceeds $13 billion [4]. Given these cost issues, as well as the dynamic state of our health-care system, hospitals are facing increasing pressures from payers, including the Centers for Medicare and Medicaid Services, to justify the costs of these procedures [3].

Consequently, utility measures and associated cost-effectiveness analyses have been introduced to quantify the benefits gained and changes in quality of life following surgery. The

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numerical value placed on these subjective changes can be compared to the costs associated with the treatment to assess the cost-effectiveness of the intervention. However, the results have been considerably variable as a consequence of different pricing sources, location of the analyses, and the type of measures used [3]. In addition, these often do not take into account patient-reported outcomes and functional status following surgery, which are a considerable determinant of clinically perceived success. However, newer utility measures, such as the Short Form-6D (SF-6D), introduce a set of health states that are derived from the patient-reported SF-36 [5,6]. As a result, these measures allow clinicians and health-care providers to assess the cost-effectiveness of procedures from previously reported SF-36 values. In addition, this measure has been previously shown to correlate with functional outcomes [7].

To the best of our knowledge, there have been no published analyses on the cost-effectiveness of THAs and TKAs in the United States derived from the SF-6D. Given its ease of use and its previously determined correlation with functional outcomes, we aimed at deducing the cost-effectiveness of THAs and total knee arthroplasties (TKAs) using this measure. Specifically, we determined (1) the SF-6D values before and after THA and TKA; (2) the quality-adjusted life years (QALYs) gained for patients treated with arthroplasty; and (3) the incremental cost-effectiveness ratios (ICER) for THA and TKA.

Methods

We prospectively evaluated 844 patients (357 men, 487 women) who had a mean age of 65 years (range, 39 to 80) and a mean body mass index (BMI) of 30.6 kg/m^2 (range, 17.7 to 40) who underwent primary TKA and 224 patients who had a mean age of 69 years (range, 44 to 88) and mean BMI of 28.8 kg/m^2 (range, 19.8 to 38.9) who underwent primary THAs at 7 institutions. This cohort of patients underwent primary THA or TKA at 7 different institutions, and they were recruited for a longitudinal postmarket trial. Patients were included if they underwent primary surgery for a diagnosis of osteoarthritis and were excluded if they (1) had a previous infection within the affected joint; (2) were immunologically suppressed or received more than 30 days of corticosteroids; (3) had a neuromuscular or neurosensory deficit; or (4) had a BMI of 40 kg/m^2 or greater. These patients had a variety of comorbidities which included cardiovascular disease, diabetes, endocrine disease, gastrointestinal disease, hematological disease, hepatic disease, hypertension, dermatological disease, pulmonary disease, renal disease, thrombosis/embolic disease, or urogenital disease.

All of the THAs and TKAs were performed by fellowship-trained joint reconstruction surgeons. Those who underwent a THA were implanted with a proximally coated tapered titanium cementless stem design (Accolade TMZF; Stryker Orthopaedics, Mahwah, NJ). Patients who underwent a TKA had either a cruciate-retaining or posterior-stabilized prosthesis implanted using standard cutting blocks (Triathlon Total Knee Replacement System; Stryker Orthopaedics, Mahwah, NJ).

Utility Values

All patients completed the Short Form-36 preoperatively and postoperatively at 6 months and 1, 2, 3, and 5 years. From these scores, the utility values were retrospectively determined using the SF-6D, and the means of these were calculated for each of the follow-up time points.

The SF-6D can be derived from the SF-36 or SF-12 questionnaire and encompasses the following domains: vitality, pain, mental health, social functioning, physical functioning, and role limitations, each of which is subdivided into 4 to 6 levels of severity. Based on combinations of these levels, up to 18,000 health states can be produced by the SF-6D. Using a random sample from the UK general population, Brazier et al [5] selected 249 of the 18,000 states and asked them to assign a “preference” to each one. Using the standard gamble technique, the chosen population was asked to decide between remaining in the selected state of health and undergoing a medical prevention that may either give them perfect health or kill them [5,7]. The preferences that were generated were then converted into single-index utility scores on a scale from 0 to 1, where 0 is equal to death and 1 is full health. Negative utility scores were assigned for health states perceived to be worse than death [8,9]. Using the scores from this sample population, utility values for all possible 18,000 health states were extrapolated using regression models [5,10].

Quality-Adjusted Life Years

Using the SF-6D values, the 1-year and lifetime QALYs were determined in patients undergoing THA or TKA.

QALYs are quantitative tools that assign a numerical value to the effects of health interventions on morbidity and mortality. Using information from utility values such as the SF-6D, it provides a weight on the time spent in that health state, where a year of perfect health is 1 and death is equivalent to 0. The use of this unit allows comparisons across different interventions and can provide insights into which one provides “superior improvement” in quality of life.

The QALYs in the THA and TKA patients were calculated by multiplying the health state, or the SF-6D utility value, by the time spent in that state. To determine 1-year QALYs, the SF-6D value at 1 year was multiplied by the time spent in that state. Lifetime QALYs were also determined using predicted life-expectancy values, at a discounted rate of 3% per year of life expectancy, to reflect a diminishing gain with time. To calculate QALYs gained or lost, the change in QALYs following THA or TKA from preoperatively was determined.

Incremental Cost-Effectiveness Ratios

Our secondary objective was to determine ICER. This was performed using a “before/after” design, where all improvements in outcomes after the procedure were attributed to the TKA or THA. In the alternative “before” scenario, where patients did not undergo surgery, it was assumed that their baseline functional status and costs would at best remain static, based on previous reports demonstrating either no significant change or worsening, in patients who were on waiting lists for surgery [11-14].

The aforementioned QALYs were combined with the costs of the intervention to generate these ratios (see Fig. 1).

Costs for an individual patient stay were taken from the 2011 Nationwide Inpatient Sample, which is the largest publicly available all-payer inpatient health-care database in the United States that provides national estimates of hospital inpatient stays. Using hospital-specific cost-to-charge ratios, costs were derived from the data on total charges for each hospital. The ratios were based on all-payer inpatient costs and further information was obtained from

$$\text{ICER} = \frac{\text{Cost of the intervention} - \text{Cost of no intervention}}{\text{Effect of intervention} - \text{Effect of no intervention}}$$

Fig. 1. Formula used to generate ICER. Effect signifies the change in health status associated with intervention or no intervention. ICER, incremental cost-effectiveness ratios.