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Cost-Effectiveness of Total Knee Arthroplasty vs Nonoperative Management in Normal, Overweight, Obese, Severely Obese, Morbidly Obese, and Super-Obese Patients: A Markov Model

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ABSTRACT

Background: We estimated the cost-effectiveness of performing total knee arthroplasty (TKA) vs nonoperative management (NM) among 6 body mass index (BMI) cohorts.
Methods: A Markov model was used to compare the cost-utility of TKA and NM in 6 BMI groups (nonobese [BMI 18.5-24.9], overweight [25-29.9], obese [30-34.9], severely obese [35-39.9], morbidly obese [40-49.9], and super-obese [50+] patients) over a 15-year period. Model parameters for transition probability (ie, revision, re-revision, death), utility, and costs were estimated from the literature. Direct medical costs but not indirect societal costs were included in the model. Costs and utilities were discounted 3% annually. The primary outcome was the incremental cost-effectiveness ratio (ICER) of TKA vs NM. One-way and probabilistic sensitivity analyses of the model parameters were performed to determine the robustness of the model.
Results: Over the 15-year period, the ICERs for the TKA vs NM for the different BMI categories were nonobese ($3317/quality-adjusted life years [QALYs]), overweight ($2837/QALY), obese ($2947/QALY), severely obese ($3536/QALY), morbidly obese ($5531/QALY), and super-obese ($11,878/QALY). The higher BMI groups tended to have higher incremental QALYs and also higher incremental costs. The probabilistic sensitivity analysis with an ICER threshold of $30,000/QALY showed that TKA would be cost-effective in 100% of simulations of patients with a BMI<50 and 99.16% of super-obese simulations.
Conclusion: While performing TKA on super-obese patients is more expensive, the substantial improvements in patient outcomes make it cost-effective. Therefore, withholding TKA care based on a BMI would lead to an unjustified loss of health-care access.

The number of total knee arthroplasties (TKAs) performed in the US is projected to increase dramatically from around half a million annually to nearly 3.5 million annually by 2030 [1]. The combined factors of increasing age of the population together with the greater prevalence and degree of obesity are driving this growth [2,3]. However, the patient risks and the cost of performing a TKA increase with the degree of obesity, especially at a body mass index (BMI) level above 40 or 50 [4]. Concurrently, many health-care systems and institutions have incentivized improving short-term complication profiles, for both financial and surgeon or institution ratings. Owing to the focus on short-term risks and the associated costs, some providers have established BMI levels that range from 35 to 45, above which point they do not offer arthroplasty surgery as an option. Thus, the potential long-term benefits of arthroplasty during the lifetime of the implant/patient are not accounted for. The alternative to arthroplasty can include, what is often, suboptimal pain relief from anti-inflammatories, injections, therapy, and bracing. Given that the natural history of knee arthritis is to progress, the quality of life for obese patients who are not offered arthroplasty will almost certainly deteriorate without effective treatment alternatives. This raises the question of whether

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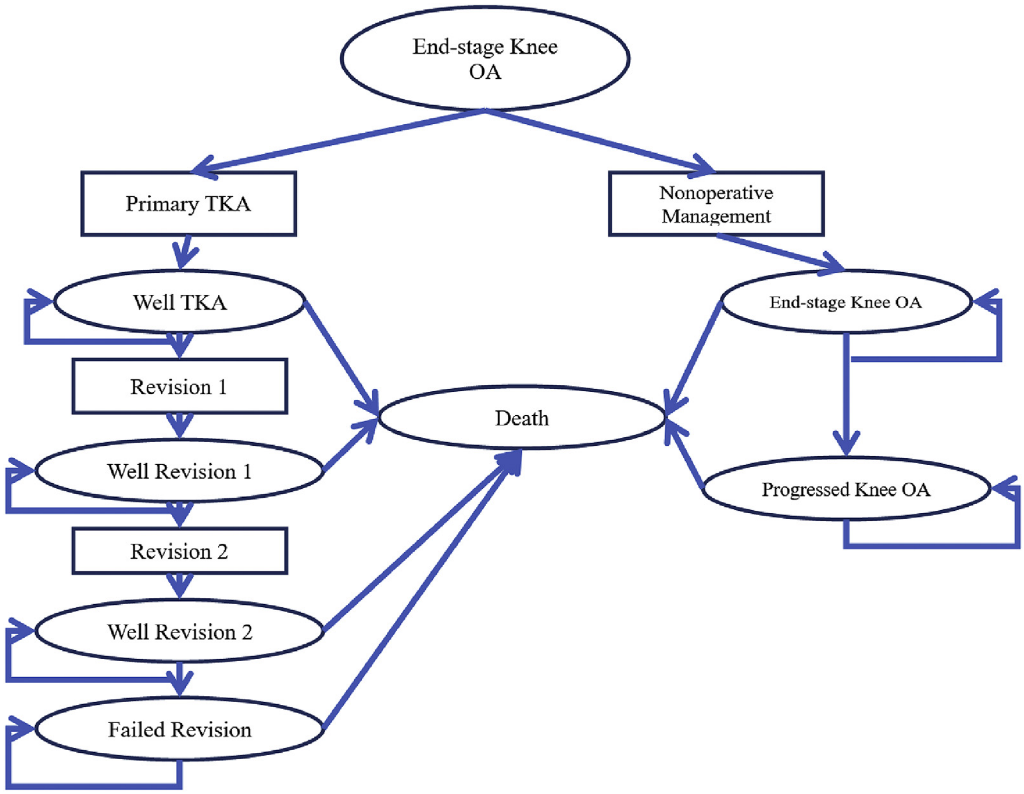

Fig. 1. Markov decision model.

TKA is cost-effective in comparison to nonoperative management, over the long-term, when the risks and benefits are adjusted for BMI.

The purpose of this study is to estimate the cost-effectiveness of TKA vs nonoperative management (NM) for a range of BMI groups. Our hypothesis was that the higher BMI cohorts would have not only increased costs but also improved the quality of life, making the procedure cost-effective by today's health-care standards.

Methods

A Markov model was built using Microsoft Excel 2007 (Microsoft Corp., Redmond, Washington) to compare the cost-effectiveness of NM vs TKA among 6 BMI groups: normal weight (BMI 18.5-24.9), overweight (25-29.9), obese (30-34.9), severely obese (35-39.9), morbidly obese (40-49.9), and super-obese (50+) (Fig. 1). All patients were assumed to be candidates for a TKA after maximizing NM. Patients in the NM treatment arm were expected to continue at the same level of function until it worsened due to the natural history of knee arthritis or they passed away. In the TKA arm, patients either did well after the surgery or had a complication requiring revision. These patients could undergo 2 revisions, after which, if they did not do well, would transition to a chronically failed arthroplasty state (Fig. 1). Transition probabilities, utility scores, and costs for each health state were obtained from the literature (Tables 1-3). Health-related quality of life weights in the form of utility scores were used to calculate quality-adjusted life years (QALYs). QALYs are a measure of the length of time an individual is in a health state multiplied by the utility of that state. We used an annual discount rate of 3% for all costs and utilities.

Transition Probabilities

From the 2016 Australian Registry, we used the revision rate for primary TKA (7.3% at 15 years) and revision of revision 1 (23.7% at 10 years) (Table 1). This was converted to an annual rate for conversion of primary TKA to revision 1 state of 0.47%. We used this value as the base case for the normal weight, overweight, and obese groups. For the remaining BMI groups, we scaled up the revision rate using relative risk values based on a meta-analysis of outcomes after TKA among these BMI cohorts from our institutional data (in press). Similarly, for the conversion of revision 1 to revision 2, the annual rate was scaled up using values from the literature for the 3 largest BMI groups. We could not identify a risk for conversion to a chronically failed revision and therefore assumed a 1.5% greater absolute annualized risk than the transition from revision 1 to revision 2. The 2016 Australian Registry [5] data were used to determine the mortality rate for a primary TKA. We used the relative risk for revision to scale up the mortality rate of the revision 1, revision 2, and failed arthroplasty states. We assumed the mortality rates were the same across the BMI groups, as patients in the higher BMI groups are more likely to be younger but have a higher number of comorbidities. We could not find any estimates on the risk of arthritis progression across all the BMI cohorts; therefore, we assumed a similar rate for each group. As the heavier BMI cohorts likely have a higher risk for progression, our assumption is conservative in favor of NM.

Utilities

We used the EQ-5D utility scores reported by BMI for before and after a TKA from the study by Baker et al [10]. They reported results for 3 BMI cohorts (less than 25, 25-40, and above 40) and found a