Appendix E-1

Details of Methods

Model Design

A Markov decision model[23] was used to determine the impact of a hospital's volume of total knee arthroplasties on the cost-effectiveness of computer-assisted surgery for the management of end-stage arthritis. The Markov model depicting the risks faced annually by patients undergoing total knee arthroplasty with and without computer navigation is shown in Figure 1. Each intervention is associated with a cost and an outcome or utility. The utilities are a measurement of the effectiveness of each intervention. The unit for cost is 2007 United States (U.S.) dollars, and the unit for effectiveness, or utility, is the quality-adjusted life-year (QALY)[23,24]. Patients transition through the model accumulating costs and utilities during each cycle, which are used to estimate the cost and effectiveness of each treatment over time. After completion of the model, the total tabulated costs and QALYs are used to evaluate the overall cost-effectiveness of the total knee arthroplasties with and without computer-assisted surgery. The model was constructed with use of decision analysis software (TreeAge Pro 2007; TreeAge Software, Williamstown, Massachusetts).

Model Parameters

The following general assumptions were made in the construction of the model shown in Figure 1: (1) patients undergoing a successful total knee arthroplasty with or without computer assistance have the same utility, or QALY value, after the initial postoperative period; (2) once the ninety-day perioperative period has passed after a knee replacement operation, with or without computer assistance, patient mortality rates are not different from the age-adjusted mortality rates of individuals who have not had a knee replacement; (3) a revision of a total knee arthroplasty, with or without computer assistance, would be to a total knee arthroplasty and would have the same cost and functional outcome in each case; (4) patients will undergo only a single revision procedure and then will remain in the well-with-revision health state until death. The parameter values used in the decision model are shown in Table I and are individually described in more detail below.

Implant Survival Rates

The survival rates for the total knee implants, as determined with the methods described in the article, in years 1 through 10, year 15, and year 20 are shown in Table E-1.

Costs

The annual cost of computer navigation as determined with use of the data described in the Materials and Methods section was $48,000 per year for five years. To determine the cost per procedure done with computer navigation at different joint-replacement centers, this yearly cost was then divided by the number of cases performed per year at the center. For example, a center at which 250 procedures are performed per year would have a cost of $192 per procedure ($48,000 per year/250 procedures per year), a center at which 150 procedures are performed per year would have a cost of $320 per procedure ($48,000 per year/150 procedures per year), and a center at which twenty-five procedures are performed per year would have a cost of $1920 per procedure ($48,000 per year/twenty-five procedures per year).

Analysis

Cost-effectiveness is typically expressed as the incremental cost-effectiveness ratio, which is the ratio of the difference in cost divided by the difference in effectiveness (expressed in QALYs in this model) between two different treatment strategies when they are ranked in order of increasing cost[23,24]. The incremental cost-effectiveness ratio reflects the cost of purchasing each additional QALY when one treatment strategy is selected over the other. In this study, the difference between the total accumulated costs of the computer-assisted and non-computer-assisted total knee arthroplasty strategies, including the cost of future revision procedures, is divided by the difference between the two arms with regard to the total accumulated QALYs obtained by patients over their entire lifetime to determine the incremental cost-effectiveness ratio: $(\text{total cost}_{\text{computer-assisted surgery strategy}} - \text{total cost}_{\text{non-computer-assisted surgery strategy}})/(\text{total QALYs}_{\text{computer-assisted surgery strategy}} - \text{total QALYs}_{\text{non-computer-assisted surgery strategy}})$ = incremental cost-effectiveness ratio. For example, if the total cost of a cohort of total knee replacements without computer assistance (including the cost of the primary procedure and revisions) is $2000, the total cost of a similar cohort of computer-assisted total knee replacements (including the cost of the primary procedure and revisions) is $2300, and the total quality-adjusted life-years gained for the two groups are ten and 10.2 years, respectively, then the incremental cost-effectiveness ratio would be calculated as: ($2300 – $2000)/(10.2 – 10 years) = $300/0.2 year = $1500 per quality-adjusted life-year. In this example, the incremental cost-effectiveness ratio would be far below the $50,000 threshold needed to make an intervention cost-effective.

TABLE E-1 Implant Survival and Failure Rates Used in the Model

Year	Implant Survival Rate*	Annual Failure Rate
1	99.3%	0.7%
2	98.6%	0.7%
3	98%	0.6%
4	97.5%	0.5%
5	97.1%	0.4%
6	96.7%	0.4%
7	96.2%	0.5%
8	95.9%	0.7%
9	95.1%	0.8%
10	94.3%	0.8%
15	90.1%	1.0%
20	85.1%	1.0%

*The survival rates for years 1 through 8 are based on a Medicare cohort and those for years 9 through 20 are based on estimates as described in the Materials and Methods section.