Appendix

Addendum 1: Elaboration on Direct Costs

Surgical costs were 1-time costs accrued by the patient at the time of unicompartmental knee arthroplasty (UKA), total knee arthroplasty (TKA), or revision TKA. Minor complication costs were 1-time costs that could be accrued in addition to the surgical costs if the patient experienced stiffness, pneumonia, sepsis, venous thrombosis, or myocardial infarction. Major complication costs were 1-time costs that could be accrued if the patient experienced a complication that warranted early surgical intervention (early implant failure or infection). In addition to initial surgical costs and major complication costs, patients with a postoperative infection or early failure also accrued the cost of a revision TKA. All patients who experienced a successful surgical outcome accrued a 1-time rehabilitation cost in the year after surgery. Patients also accrued the 1-time health service utilization cost during their recovery year. Fully recovered patients would then accrue postoperative costs on a yearly basis, the value of which was determined by the level of benefit (full benefit or limited benefit) that the patient received from the operation. Patients in the late-failure group could "elect" to have a revision TKA, and would accrue the surgical costs in addition to the same potential costs associated with their initial surgical procedure.

Addendum 2: Elaboration on Indirect Costs

Because the majority of patients who undergo UKA for end-stage osteoarthritis have received NST during the previous year, Short Form-36 (SF-36) scores obtained <1 year before UKA were used to estimate indirect costs for patients undergoing NST in our model. SF-36 scores obtained from patients <1 year after UKA or TKA were used to estimate indirect costs in the recovery year following UKA, TKA, and revision TKA. Scores obtained from patients >1 year after UKA or TKA were used to estimate indirect costs in the year following UKA, TKA, and revision TKA. Preoperative and <1-year postoperative SF-36 scores were collected retrospectively. Because the majority of patients who proactively return for follow-up visits after 1 year tend to be experiencing difficulties with the knee replacement, SF-36 scores for the >1-year assessment of postoperative indirect costs were collected prospectively.

Because we used SF-36 scores to assess patient function, these scores first needed to be converted into National Health Interview Survey (NHIS) survey responses in order to utilize the regressions developed by Dall et al.[18] to estimate indirect costs. Using methods previously described by Dall et al.[18] and Ruiz et al.[16], SF-36 responses were mapped to responses in the NHIS. The procedure used for this mapping and conversion is described in detail in Tables E-1 and E-2. The regressions developed by Dall et al.[18] were then used to calculate estimates of employment probability, Social Security disability (SSD) collections, income, and missed workdays.

Equation 1: Lost wages

Lost wages = [(reference employment probability) × (reference annual income)] − [(postoperative employment probability) × (postoperative annual income)]

Equation 2: SSD Collections

SSD collections = (average SSD payment) × (reference SSD collection probability − postoperative SSD collection probability)

Equation 3: Indirect Costs Relating to Missed Workdays

$$\text{Value of missed workdays} = \left(\frac{\text{reference employment probability} \times \text{reference annual income} \times \text{reference number of missed workdays}}{240}\right) - \left(\frac{\text{reference employment probability} \times \text{reference annual income} \times \text{postoperative number of missed workdays}}{240}\right)$$

Addendum 3: Model Assumptions

The percentage of individuals who elected to undergo revision TKA after early failure of a UKA or TKA was assumed to be 100%. The percentage of individuals who elected to undergo revision TKA after late failure of a UKA or TKA was assumed to be 80%, and the remaining 20% of the patients remained chronically in the late-failure state. These transition probabilities were consistent with previous assumptions made regarding revision rates after late failure[9,13]. The percentage of individuals who elected to undergo a second, third, or additional revision TKA after late failure of a previous revision TKA was assumed to be the same as the percentage of individuals who elected to undergo a revision TKA after the initial failure of a primary knee replacement. We also assumed that the rates of failure of these subsequent revision procedures were the same as the rates of revisions after an initial TKA revision.

The percentage of patients who experienced early mechanical failures after knee arthroplasty was assumed to be equal to the infection rate for that procedure (0.2% for UKA and 0.8% for TKA and revision TKA).

The QALY value associated with the limited-benefit state after UKA was assumed to be 0.81, representing a 10% decrease in QALYs compared with the full-benefit state. This assumption was consistent with assumptions made by Ghomrawi et al.[9]. Late failure of UKA and chronic late failure of UKA were assumed to be equivalent to the QALY value associated with late failure and chronic late failure of TKA (0.5175) presented by Ruiz et al.[16].

Several assumptions were made when calculating direct costs. The cost associated with the full-benefit state after UKA, TKA, and revision TKA was assumed to be 15% less than the cost associated with NST, which was consistent with assumptions made by Losina et al.[13] and Ruiz et al.[16] regarding costs after TKA. The cost associated with the limited-benefit state after UKA, TKA, and revision TKA was assumed to be equal to the cost associated with NST, which was consistent with assumptions made by Ruiz et al. regarding costs after TKA[16]. The cost associated with the chronic late-failure state after UKA, TKA, and revision TKA was assumed to be 1.5 times the cost associated with NST, which was consistent with assumptions made by Ruiz et al. regarding costs after TKA[16].

As described above, SF-36 scores were used to calculate indirect costs. We assumed that the sampled patient population had a similar distribution of SF-36 scores compared with the general population. Additionally, as a result of the methods used to collect SF-36 data and calculate indirect costs, our model assumed that each patient experienced the same indirect costs regardless of the states to which they transitioned after surgery. Because the patient population from which the SF-36 scores were gathered was selected randomly, we assumed that this sample had a representative distribution that properly estimated the indirect costs of the overall population.

Addendum 4: Cost-Effectiveness

Direct Costs

Lifetime direct costs were generally inversely proportional to age, with older patients experiencing the lowest lifetime direct costs. When surgical options were compared with NST, lifetime direct costs were minimized by utilizing NST for all ages assessed in the model. Despite absolute decreases in lifetime direct costs as ATIT increased, the relative differences in direct costs between surgical treatments and NST increased, indicating that NST became comparatively less expensive at older ages. The difference in lifetime direct costs between UKA and NST was lowest when the ATIT was 40 years ($18,434) and greatest when it was 90 years ($29,352). Similarly, the difference in direct costs between TKA and NST was lowest when the ATIT was 40 years ($2,127) and greatest when it was 90 years ($33,962).

The lifetime direct costs for TKA were lower than those for UKA in younger patients, but costs favored UKA as the treatment modality as the ATIT increased. TKA was less expensive for patients with ATITs between 40 and 69 years, but UKA was less expensive between the ages of 69 and 90 years. Cost differences were most in favor of TKA at the age of 40 years ($16,371) and UKA at the age of 90 years ($3,592). The lifetime direct cost associated with each treatment is shown as a function of ATIT in Figure E-1.

Indirect Costs

Indirect costs were inversely proportional to the ATIT for all surgical and nonsurgical treatments, with the lifetime indirect costs dropping below $5,000 for all treatments by the age of 83 years and approaching $0 as age increased further. As patients exit the workforce and the average income in these age groups sharply decreases, the opportunity cost of spending time recovering from surgery rather than working falls drastically. The lifetime indirect cost associated with each treatment is shown as a function of ATIT in Figure E-2.

Lifetime indirect costs were minimized for patients with unicompartmental osteoarthritis by utilizing UKA between the ages of 40 and 82 years and NST between the ages of 83 and 90 years. Differences in indirect costs ranged from $579,819 in favor of UKA at the age of 40 years to $1,367 in favor of NST at the age of 90 years.

Indirect costs were minimized for patients with unicompartmental osteoarthritis by utilizing TKA at all ages. Differences in lifetime indirect costs were minimized when the ATIT was 90 years ($536) and maximized when it was 40 years ($574,751). Lifetime indirect costs for patients for whom either UKA or TKA was indicated were maximized by performing UKA for all patients between the ages of 40 and 72 years and TKA for all patients between the ages of 73 and 90 years. Differences in indirect costs ranged from $42,331 in favor of TKA at an ATIT of 40 years to $1,834 in favor of NST at an ATIT of 90 years.

http://dx.doi.org/10.2106/JBJS.17.00837

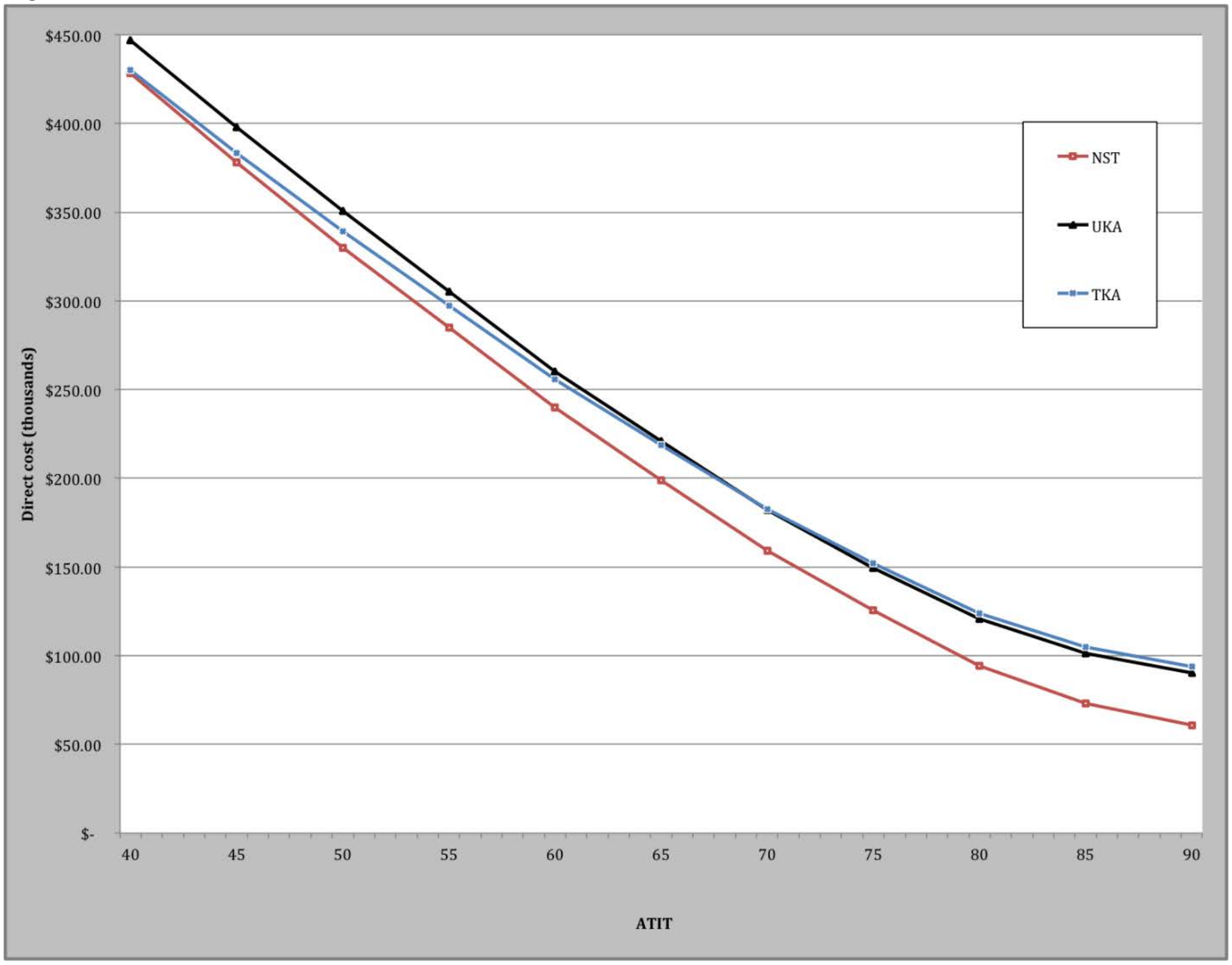

Fig. E-1
Lifetime direct costs (shown in thousands of dollars) associated with each treatment as a function of ATIT. Costs are discounted 3% per year.

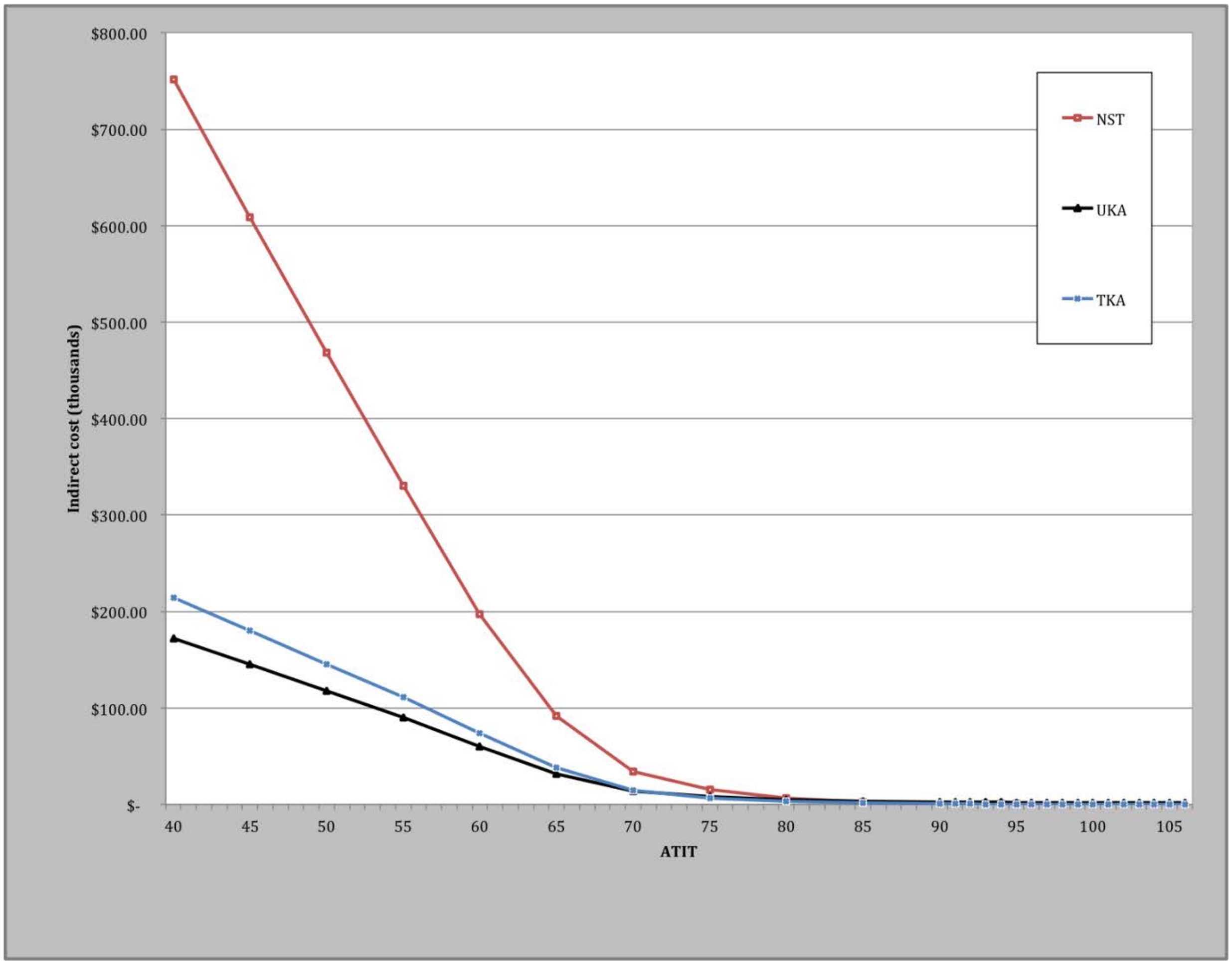

Fig. E-2
Lifetime indirect costs (shown in thousands of dollars) associated with each treatment as a function of ATIT. Costs are discounted 3% per year.

TABLE E-1 Conversion of SF-36 Responses to NHIS Responses

SF-36 Response	NHIS Response
"Not limited at all"	"Not at all difficult"
"Limited a little"	"Only a little difficult"/"somewhat difficult"
"Limited a lot"	"Very difficult"/"can't do at all"

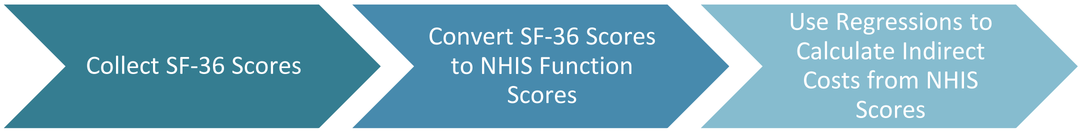

TABLE E-2 Conversion of SF-36 Scores to NHIS Scores*

<table>
<tr><th>SF-36 Physical Function</th><th>NHIS Physical Function</th></tr>
<tr><td>Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf</td><td>Push or pull large objects like a living room chair</td></tr>
<tr><td>Lifting or carrying groceries</td><td>Lift or carry something as heavy as 10 pounds such as a full bag of groceries</td></tr>
<tr><td>Bending, kneeling, or stooping</td><td>Stoop, bend, or kneel</td></tr>
<tr><td>Climbing several flights of stairs</td><td rowspan="2">Walk up 10 steps without resting</td></tr>
<tr><td>Climbing 1 flight of stairs</td></tr>
<tr><td>Walking more than a mile</td><td rowspan="3">Walk 1/4 of a mile—about 3 city blocks</td></tr>
<tr><td>Walking several blocks</td></tr>
<tr><td>Walking 1 block</td></tr>
</table>

*The SF-36 functional assessments of “vigorous activities, such as running, lifting heavy objects, participating in strenuous sports” and “bathing or dressing yourself” could not be mapped to an NHIS assessment, and the NHIS functional assessments of standing, sitting, and reaching could not be mapped to questions on the SF-36. Therefore, it was not possible for us to incorporate these factors into our assessment of indirect costs. Additionally, while the SF-36 contains 3 questions regarding a patient’s ability to walk and 2 regarding a patient’s ability to climb stairs, the NHIS survey has only 1 question addressing each of these functional abilities. In order to address this issue, SF-36 responses regarding walking ability were given triple weight when they were converted to NHIS responses, and SF-36 responses regarding climbing ability were given double weight when they were converted to NHIS responses in our regression.

TABLE E-3 Transition Probabilities*

Start State	End State	Transition Probability (%)		
		UKA	TKA	Revision TKA
Surgery	Death	2.2† (age-based probability of all-cause mortality)[12-14]		
Surgery	Infection	0.20[14]	0.80[14]	0.80[14]
Surgery	Other early failure	0.20[14]	0.80[14]	0.80[14]
Surgery	Successful surgery: recovery	99.6†	98.4†	98.4†
Surgery	Stiffness	0.40[14]	5.00[14]	5.00[14]
Surgery	Pneumonia	1.40[24]	1.40[24]	1.40[24]
Surgery	Sepsis	0.20[3]	0.20[3]	0.20[3]
Surgery	Venous thromboses	0.60[14]	1.00[14]	1.00[14]
Surgery	Myocardial infarction	0.30[3,25]	0.30[3,25]	0.30[3,25]
Surgery	Inpatient rehabilitation	0.00[26]	33.4[26]†	33.4[26]†
Surgery	Skilled nursing facility	46.68[26]	30.1[26]†	30.1[26]†
Surgery	Home health care	16.32[26]	22.2[26]†	22.2[26]†
Surgery	No postoperative care	37.00[26]	14.3[26]†	14.3[26]†
Successful surgery: recovery	Successful surgery: full benefit	91.60[13]	91.60[13]	88[13,19]
Successful surgery: recovery	Successful surgery: limited benefit	8.40[13]	8.40[13]	12[13,19]
Infection	Revision TKA	100.00[13]	100.00[13]	100.00[13]
Other failure	Revision TKA	100.00[13]	100.00[13]	100.00[13]
Successful surgery: full benefit	Late failure	Varies by age and years since implantation[9,19]	Varies by age and years since implantation[9,19]	Varies by age and years since implantation[9.19]
Successful surgery: limited benefit	Late failure	Varies by age and years since implantation[9,19]	Varies by age and years since implantation[9,19]	Varies by age and years since implantation[9,19]
Late failure	Late failure	20[13]	20[13]	20[13]
Late failure	Revision TKA	80[13]	80[13]	80[13]

*The probability of having a successful UKA recovery varies by age as a result of its dependence on the age-based probability of mortality of the patient. †Calculations performed in the current study.