Is Minimally Invasive Total Knee Arthroplasty Associated with Lower Costs Than Traditional TKA?

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Abstract

Background Studies of minimally invasive surgery (MIS) approaches to TKA have shown decreased postoperative pain, earlier return to function, and shorter lengths of stay in the hospital. However, it is unclear whether these differences translate into decreased costs or charges associated with care.

Questions/purposes We asked whether a minimally invasive approach to TKA is associated with lower inpatient charges and direct inpatient costs than the traditional approach.

Patients and Methods We retrospectively reviewed one high-volume arthroplasty surgeon's first 100 minimally invasive TKAs with the last 50 traditional TKAs with respect to all perioperative inpatient medical and billing records. Total charges minus implants (which were excluded across groups), total direct costs, and individual cost centers were analyzed.

Results The mean nonimplant total charge was less for patients receiving a minimally invasive TKA than a traditional TKA (\$13,505 versus \$14,552). With the numbers available, there was a trend for lower mean direct cost for minimally invasive TKA (\$6156) versus traditional TKA (\$6410).

Conclusions The total inpatient charges associated with a minimally invasive TKA were less than those associated with a traditional TKA; however, the magnitude of the difference (7.2%) was modest, and there was no reduction in direct hospital costs. Other studies will need to determine whether any economic benefits associated with minimally invasive TKA accrue after discharge. The decision regarding whether to perform minimally invasive TKA should be made on clinical grounds, as the medical-economic case on the inpatient side is not compelling.

Level of Evidence Level II, economic analysis. See Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research.

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Introduction

More than 500,000 TKAs were performed in the United States in 2005 [15]. Despite generally good outcomes in terms of pain and function and high levels of patient demand for the procedure, the frequency with which the procedure is performed makes it a target for further attempts at cost cutting. The reimbursement rate for total joint arthroplasty has declined, while associated costs of implants, hospital facilities, and personnel have continued to climb [5]. The demand for joint arthroplasty is expected to substantially increase during the next few decades [6, 14]. Pressure on hospitals and surgeons to contain costs is expected to build in the coming years.

Numerous studies of MIS TKAs have shown decreased postoperative pain, earlier return to function, shorter length of stay (LOS) in the hospital, and decreased need for stay in a skilled nursing facility during the postoperative period [1, 2, 4, 8, 10–12, 16–18]. However, other factors, such as increased operative times, altered regimens of physical therapy, variations in the use of radiology services, and concerns that improper MIS component position may lead to early revision, may prevent the putative clinical benefits from translating into decreases in hospital costs or patient charges. Coon et al. [7] were among the few authors to detail decreased costs associated with MIS TKA, but several methodologic limitations in their study limit drawing firm conclusions and call into question the magnitude of the reported cost savings. First, they reported a charge reduction of \$8600 per patient using MIS; however, the sources of this reduction were not specified and simply may have been more efficient use of two operating suites. Second, they did not describe actual hospital costs in the discussion of their current practice and present only patient charges. Finally, their study focused primarily on achieving efficiency in the operating room with cost reduction as a secondary concern. As such, the literature does not clarify whether MIS TKA is associated with substantial reductions in charges or costs compared with more traditional approaches. We previously reported inpatient LOS was shortened and early parameters of functional return were improved in patients undergoing MIS TKA compared with patients receiving a traditional medial parapatellar approach to TKA [11]. However, patient charges and hospital costs are dependent on numerous variables and it cannot be assumed decreased LOS or earlier return to function will result in decreased inpatient charges or hospital costs.

Therefore, we asked whether MIS TKA is associated with decreased inpatient charges and hospital costs compared with traditional TKA.

Patients and Methods

We used the same cohort of patients who underwent MIS TKA and traditional TKA reported previously [11]. Briefly, operative logs of the senior author (SSL) were used to identify the last 50 primary TKAs performed using the traditional medial parapatellar approach before he began using the MIS approach, and the first 100 primary TKAs using the MIS (quadriceps-sparing) approach. Patients in the MIS cohort were operated on between April 2004 and June 2005; patients in the traditional TKA cohort were operated on between June 2003 and April 2004. To minimize selection bias, there was no overlap of the dates of

Table 1. Patient demographics and baseline data

Parameter	MIS TKA	Traditional TKA	p Value
Average age (years) (range)	67 (44–84)	66 (42–85)	0.64
Ratio			
Men: women	48:52	19:31	0.3
Average BMI (range)	30 (22–43)	32 (20–49)	0.1
Preoperative extension (degrees)	5	7	0.04
Preoperative flexion (degrees)	115	114	0.4
Average cardiac risk factors	0.24	0.28	0.34

inclusion for the respective procedures. Patient characteristics of the two groups were similar at baseline [11] (Table 1). The average age of the patients was 67 years (range, 44–84 years) in the MIS TKA group and 66 years (range, 42–85 years) in the traditional TKA group ($p = 0.64$). There were 48 men and 52 women in the MIS TKA group and 19 men and 31 women in the traditional group ($p = 0.3$). The study was approved by the hospital's human subjects committee of the Institutional Review Board, which granted a waiver of consent for this low-risk study.

We reviewed all perioperative, inpatient medical records. Patient age, body mass index, preoperative knee ROM, and cardiac risk were analyzed for each cohort. Cardiac risk was estimated for each patient using the revised cardiac risk index as described by Lee et al. [13]. A risk class based on five factors was tabulated for each patient based on their medical history: (1) history of ischemic heart disease; (2) history of congestive heart failure; (3) history of stroke or transient ischemic attack; (4) diabetes with insulin dependence; and (5) baseline creatinine level of greater than 2.0.

The average body mass index was 30 (range, 22–43) in the MIS TKA group and 32 (range, 20–49) in the traditional group ($p = 0.1$). The average preoperative extension in the MIS group was 5°, compared with 7° in the control group ($p = 0.04$). The average preoperative knee flexion in the MIS group was 115°, compared with 114° in the control group ($p = 0.4$). The average number of cardiac risk factors in the MIS group was 0.24, whereas that in the traditional group was 0.28 ($p = 0.34$). Overall, both groups had a low cardiac risk with 80 of 100 patients in the MIS group having none of the five risk factors, compared with 37 of 50 in the traditional group. Four patients in the MIS group and one of the patients in the traditional group had two risk factors. There were no early reoperations in either group.

We reviewed all billing records generated from the admission related to each patient's TKA. Hospital charge records for all patients were available for inclusion in this study. Total patient charges were defined as all in-hospital charges, minus the cost of prosthetic implants, associated with the patient's hospitalization, and these charges were provided to us by the hospital finance department. Direct cost in this analysis was defined as the cost of all professional services, personnel, facilities, and supplies required to perform the surgical procedure [3]. The hospital finance department necessarily uses slightly different methodologies for calculating direct cost in the different cost centers (departments and service areas such as laboratory, pharmacy, or therapy) in the hospital. Typically, direct expenses are recorded in revenue-producing and patient-care departments like nursing and radiology, whereas other methods (including ratio of cost to charge or RVU-based costing) are used where necessary. Data regarding direct cost were provided by the hospital finance department and we made no attempt to adjust how its calculations were made, as they are the data that the finance department provided that the hospital might use when analyzing the cost of different procedures or approaches. To account for changes in methodology during the 3 calendar years the study covered, all charges and costs were normalized to fiscal year 2004 and as such were not inflation-adjusted.

The cost to a hospital for a prosthetic implant can largely impact the overall cost of a TKA. This cost typically varies regionally and often can differ between hospitals in the same city. Each patient in this cohort had the same cemented, modular, condylar prosthesis implanted (NexGen®; Zimmer, Inc, Warsaw, IN, USA). However, both surgical approaches studied here can be used with any contemporary implant, and as costs of TKA prostheses vary widely by manufacturer, case volume, and location across the country, implant costs were not included in the analysis.

Total nonimplant charges, total direct costs, and individual cost centers were analyzed. Billing records were subdivided based on the nature of the services delivered to seven cost centers to allow detailed analysis of where charges were generated. These cost centers included: acute care costs (including room and board), operating room services/anesthesia, physical and occupational therapy, laboratory, materials management (including operating room supplies), radiology, and pharmacy. Issues related to payment of charges or any outstanding balances on patient accounts were not reviewed in this study. Indirect costs (lost wages and time costs), and charges and costs associated with inpatient rehabilitation and/or postdischarge extended-care facility placement and outpatient physical therapy, also might be expected to decrease in the MIS group. However, accurate quantification of these charges

and costs was not possible and therefore not formally included in this study.

Aftercare was similar in both groups, including early aggressive ROM protocols, weightbearing as tolerated, patient-controlled analgesia, preoperative and postoperative antibiotics, and thromboprophylaxis. Most patients in both groups had regional anesthesia (typically spinal anesthesia), according to the preferences of the anesthesiologists at our institution. The same physical therapy team managed all patients. No special emphasis was placed on shortening LOS for the patients who underwent MIS in this state university hospital, and no adjustment to physical therapy protocols were made for the MIS group. Criteria for hospital discharge and for admission to the adjacent inpatient rehabilitation unit were identical in the traditional and MIS groups. The decision regarding appropriate disposition was made by the physical therapy and rehabilitation teams and not by the operating surgeon.

After the initial data verification, independent-sample *t* tests were conducted using SPSS® 13.0 for Windows® (SPSS Inc, Chicago, IL, USA). The significance of the *t* value was computed using a one-tailed probability distribution. A one-tailed test was chosen because the hypothesis was directional, and at the time the *a priori* hypothesis was formulated, there was no suggestion in the literature that MIS approaches result in increased costs or patient charges. Before selecting the *t* test, the data distribution was analyzed to verify that the assumptions required by the *t* test were met.

Results

The average total charge (minus implant) per patient was lower ($p = 0.009$) in the MIS TKA group at \$13,505 than in the traditional TKA group (\$14,552; Table 2). With the numbers available, there were no differences in mean overall direct cost between the two groups, but a trend ($p = 0.091$) was seen in favor of the MIS TKA cohort. The average total direct cost was \$6410 per patient in the traditional TKA group and \$6156 per patient in the MIS TKA

Table 2. Average patient charges and hospital direct costs

Charges and costs	MIS TKA	Traditional TKA	<i>p</i> Value
Total patient charges*	\$13,505	\$14,552	0.009
Total direct hospital costs	\$6156	\$6410	0.091
Operating room direct costs	\$1346	\$1117	< 0.001
Acute care direct costs	\$1472	\$1700	0.007
Pharmacy direct costs	\$308	\$414	< 0.001
Physical therapy direct costs	\$444	\$515	0.011

* Minus implant charges, as defined in [Patients and Methods](#).

group. Contributing to this result was the average operating room cost being slightly higher ($p < 0.001$) in the MIS TKA group at \$1346, compared with \$1177 in the traditional group. Acute care cost was lower ($p = 0.007$) in the MIS TKA cohort (\$1472) than in the traditional TKA cohort (\$1700).

Discussion

As the demand for TKAs is expected to increase during the next several decades, pressure on hospitals and surgeons is expected to increase [5]. Although considerable controversy remains, several studies have shown MIS TKAs result in decreased length of convalescence and shorter hospital LOS than the traditional TKA approaches with which they were compared [2, 4, 8, 11, 12, 16–18]. There is little reported in the literature regarding the cost benefits of MIS TKA. Coon et al. [7] reported a charge reduction of \$8600 per patient using MIS, but as noted, the sources of this reduction were not specified and simply may have been more efficient use of two operating suites. We therefore asked whether MIS TKAs are associated with decreased inpatient charges and hospital costs compared with traditional TKAs.

This study is limited by several factors. First is the potential for selection bias inherent in the retrospective study design. This issue was discussed in the original presentation of this cohort [11]. Although patient allocation was not randomized, baseline analyses showed comparable patient populations in each study group (Table 1), and selection bias was minimized by not using overlapping study dates, so that some of the more complex patients who did not receive MIS early in the cohort at least did not burden the traditional TKA cohort. The MIS series was not a highly selected group; after the first 25 patients (deemed the early learning curve), the senior author used an MIS approach in greater than 90% of TKAs and thus were included in that cohort [11]. Moreover, it seems likely that any selection bias that might have worked in favor of the MIS approach concerning financial analyses would have been more than offset by the fact that the MIS cohort was a learning-curve series, which began with the first patient to undergo TKA performed by the surgeon using this approach, and included all of the first 100 consecutive patients treated with this approach. The inevitable problems associated with using a new technique, such as increased operative time, especially early on, would have been expected to disadvantage the MIS group in the financial analysis. In addition, we included a control group consisting of patients who underwent a familiar procedure from the same high-volume surgeon using similar conventional condylar TKA implant designs in both groups;

patients had the same aftercare, physical therapy protocols, and criteria for inpatient rehabilitation admission [5, 9].

Second, although patient charges and hospital costs are readily accessible, there is general consensus that true costs are hard to define [6], and this represents a limitation for nearly all studies of this design; any limitations inherent to the calculation of hospital costs would apply equally to both study groups. Our hospital's accounting system does not permit a per-day review of hospital costs because hospitals are compensated using the MS-DRG system rather than a per-diem approach; however, the cost-accounting system still renders a reasonably precise estimate of the costs associated with care.

Third, costs and charges associated with inpatient rehabilitation, skilled nursing facility placement, and outpatient physical therapy were not included as cost and charge data from those disparate loci of practice were not available. In light of the fact that 95% of the patients who had MIS TKAs were discharged directly home and 66% of the patients who had traditional TKAs required additional inpatient care after hospital discharge (acute rehabilitation or skilled nursing facility) [11], it seems likely the magnitude of the economic difference between the MIS and traditional TKA cohorts would have been greater had those factors been available for analysis. For example, in our rehabilitation unit (which is where most, but not all patients went when they required inpatient care after hospital discharge), the average patient charge for a rehabilitation stay after traditional TKA was \$7327 and the average direct hospital cost was \$3672. For patients who had MIS TKAs who were discharged to our rehabilitation unit, the average charge and cost were \$7771 and \$3903, respectively. Applying these data, and using the postdischarge disposition data observed in the original series (ie, 5% of patients who had MIS TKAs being discharged to rehabilitation versus 66% of the patients who had traditional TKAs requiring such care) [11], the difference in patient charges for postdischarge care per 100 patients undergoing surgery would be greater than \$400,000, and the difference in direct hospital cost for postdischarge care would be greater than \$220,000, with both differences strongly favoring MIS TKA. Similarly, patients who underwent MIS TKAs required the use of assistive devices for ambulation for a shorter time [11], so one might expect outpatient physical therapy costs and charges for this group to be lower as well, but as patients went to dozens of different physical therapy providers across a large geographic region, we are not able to estimate these costs or charges. Although beyond the scope of the current study, it is conceivable the decreased LOS associated with the MIS TKA potentially could generate additional hospital revenue by turning over the hospital room and admitting patients for the vacated beds at a more rapid rate.

Fourth, we did not analyze costs beyond hospital discharge that might favor the traditional TKA. It has been posited by some investigators that MIS TKAs will be associated with an increase in the need for revision surgery [1, 10]. Although component alignment in our original series was not different between the cohorts [11], a disproportionate number of revisions in the MIS TKA group certainly would affect the results of the economic analysis. We are in the process of reporting on midterm clinical results of this same cohort of patients who had MIS and traditional TKAs, therefore, more data regarding early revision rates will be known when this is completed.

We found MIS TKAs resulted in a decrease in total nonimplant inpatient hospital charges compared with traditional TKAs. However, the difference of \$1047 per patient is only modest (7.2%) and was less than what we expected to find, considering the hospital LOS was decreased by approximately $\frac{1}{3}$ in the MIS cohort [11]. With the numbers available, there was a trend toward but not a reduction in hospital costs in the MIS compared with those for the traditional TKA cohorts. Possible explanations for this include the fact that there was a learning curve for patients undergoing MIS but not for patients undergoing traditional TKAs. We did perform a charge analysis for patients undergoing MIS by quartile; however, this did not show a learning curve trend in costs. A more likely explanation is that the charges and costs are relatively front-loaded (generated during the first day of the hospital experience, particularly in the operating room), such that the large observed reduction in LOS corresponds to only a small difference in hospital costs.

Although our data tended to favor MIS TKA in terms of hospital costs and showed a decrease in patient charges compared with traditional TKA, the magnitude of the effect size and the relatively constrained scope of analysis are insufficient to paint a compelling picture in support of that procedure from an economic standpoint. Rather, we would offer the decision to perform or not to perform MIS TKA should be made on clinical grounds at this time. We remain cautiously optimistic that studies showing equivalent radiographic component alignment of MIS TKAs compared with traditional TKAs [2, 4, 8, 12, 16, 18] may bode well for equivalence of longer-term clinical outcomes, implant durability, and longer-term cost-effectiveness. However, if concerns regarding component alignment [1, 10] with this approach result in a higher revision rate, the opposite may be true.

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