Economics of All-Polyethylene Versus Metal-Backed Tibial Prosthesis Designs

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abstract

With the large number of total knee arthroplasties being performed and expectations that these numbers will be on the rise over the coming decades, efforts to provide cost-efficient care are of greater interest. The preferred design of knee arthroplasty implants has changed over time, with the original all-polyethylene tibial (APT) design being replaced by metal-backed tibial (MBT) components, as well as more recent considerations of newer APT designs. Modern APT components have been shown to have similar or superior outcomes than MBT components. Despite their limitations, APT components can be used to reduce the economic burden to the provider, medical institution, and health care system as a whole. There is a paucity of evidence-based literature directly comparing the cost associated with APT and MBT components. The purpose of this report is to review the literature to assess the available data regarding direct and indirect costs of both designs so that orthopedic surgeons can account for economic differences in everyday practice. [Orthopedics. 2016; 39(3):S61-S66.]

Total knee arthroplasty (TKA) is one of the most commonly performed procedures. At the turn of the century, TKAs accounted for the most dramatic increase for hospital inpatient cost among all payer types. From 2003 to 2012, knee arthroplasty was the most common operating room procedure for Medicare and private insurance hospital stays. The demand for TKA is constantly increasing and has had the second greatest increase in rate of procedures from 145 per 100,000 population in 2003 to a rate of 223 per 100,000 population in 2012. Projections predict a continuous rise in the number of procedures expected to be as high as 3.48 million TKAs by 2030. Indications for the procedure also continue to expand to younger, more active patients in need of knee replacements. Patients have substantial improvement in pain, functional stability, and quality of life, making TKA a cost-effective procedure.

The upward trend of spending, combined with the fact that US health care quality is ranked 37th in the world, has led to many concerns among lawmakers and health care leaders. With more TKA procedures being performed, the appreciation for cost associated with care is gaining additional focus. Several provisions within the Patient Protection and Accountable Care Act (ACA)
address the need to reduce health care expenditures. Current US health care expenditure is as high as $1.2 trillion and is projected to reach $2 trillion per year by 2023.\textsuperscript{14,15} Specifically, total joint arthroplasty accounts for 4.7% of Medicare procedures and consumes the greatest proportion of Medicare expenditures, with costs reaching as high as 6.3%.\textsuperscript{16} The average length of hospital stay for knee arthroplasty procedures is 3.9 days with an associated mean aggregate cost of $13,200 per admission.\textsuperscript{17} While Medicare reimbursements for this older population have risen to help offset the growing expenses of health care, the cost of providing quality care with newer technologies, particularly joint implants, is rising considerably faster.\textsuperscript{18,19} This challenging economic environment requires physicians to play an active role in optimizing the quality of care while delivering a cost-considerate care for impactful savings to be realized. To address these concerns, efforts have been made to reduce cost by altering the payment system, regulating indications for elective procedures such as total knee reconstruction, and encouraging providers to use alternative materials without compromising the quality of care.

<table>
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<th>Table 1</th>
<th>Studies on All-Polyethylene Tibial Survivorship, With Revision for Aseptic Loosening</th>
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\textit{Abbreviation: APT, all-polyethylene tibial.}

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<tr>
<th>Table 2</th>
<th>Summary of Studies Comparing All-Polyethylene Tibial and Metal-Backed Tibial Survivorship, with Revision for Any Reason</th>
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<tr>
<td>Gioe et al,\textsuperscript{13} 2000</td>
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\textit{Abbreviations: APT, all-polyethylene tibial; MBT, metal-backed tibial.}

Quality and Clinical Outcomes

Over the last decade, several studies have shown that long-term outcomes of modern APT designs are comparable to their metal-backed counterparts (Table 2).\textsuperscript{22,26-28} Outcomes based on clinical scoring systems, patient-reported outcomes, and postoperative complications or adverse events have been reported. A systematic review found that several studies reported no difference in Oxford Knee Scores, Hospital for Special Surgery Knee Scores, and Knee Society Scores between patients with MBT and those with APT components.\textsuperscript{29} These findings suggest that APT is at least...
equal to MBT when comparing assessment scores designed to measure pain and function following TKA. In the same systematic review, the authors found data that included 10,111 primary total knee implants that revealed a lower risk for patients enduring adverse events with APT components compared with MBT implants. In summary, the study concluded that the performance of APT implants is equal to MBT implants in terms of survivorship and incidence of adverse events. However, the risk for revision was lower in APT cohorts.20

**Cost Reflections Associated With TKA Implants**

The cost of implants for knee replacements is the largest single unit cost in the hospital for a total joint arthroplasty.30 As hospital revenues for joint arthroplasty increased at a rate lower than the rate of inflation, expenses for TKA follow the same trend. To profit from the use of implants and provisions of care for TKA, hospitals are required to control expenses related to care delivery.31 To adequately control expenses, an accurate depiction of total cost of care is necessary. Additionally, key decision makers should understand the total cost of care provided across various settings, including the inpatient, outpatient clinical care or rehabilitation, and urgent care settings. Clinicians should also be empowered with information that allows them to understand the cost associated with an episode of care and equipped with the necessary tools to incorporate costs in management decisions. Full knowledge of an episode of care includes the preoperative and postoperative clinical visits, operating room costs, implant expenses, postoperative in-hospital care and complications or readmission related to the procedure. Unplanned readmissions carry a cost burden of $17.5 billion for Medicare patients alone, with the average cost of a readmission for TKA being $13,008.32

Additionally, indirect costs to consider include cost related to the need for a future revision, the inability to return to work with associated economic impact, and the financial cost per quality-adjusted life year gained as a result of the procedure.

There are 700,100 hospital admissions associated with TKA procedures for patients older than 45 years.1 The total cost for hospital stays related to knee arthroplasty procedures was $6.3 billion.33 In addition to the cost of the operation, several other factors make up the total amount spent during the episode of care. Knee implants fall into a category of medical devices known as physician preference items.34 Without the proper guidance and boundaries from hospital administrators, more physician preference items can lead to higher costs and providers making cost-insensitive preferences in regard to implant use. Physicians have traditionally been the primary decision maker in deciding which implants are used in a given procedure. However, the medical institution carries the burden of the costs associated with a particular implant and are the ones to suffer should the reimbursement be substantially lower than the cost of the implant. Implant cost ranges from $1,797 to $12,093 per total knee replacement procedure and account for approximately 50% of the total cost.35 This has led to increased pressure on the orthopedic surgeon to consider cost as part of their implant choices. Additionally, some hospitals have moved to standardization of implant options and stocking to provide the most cost-effective solution.30 Medical institutions endure an increased cost to maintain a fully stocked supply of all the various types of medical implants, and providing both APT and MBT implants may be a drawback. However, reduction of unit costs has shown to be successfully accomplished by standardizing operating room packs and reducing inventory by stocking knee implants on consignment.31 Additionally, the push to estimate medical reimbursements based on quality of care include cost-efficiency criteria.36

Use of APT implants has increased over a 3-year period due to greater circulation of products, encouraged by better price negotiations.19 Price negotiations have led to a price decrease in cost after 1995 by 24%.19 The median profit for primary TKA operations is $5,209.28 All-polyethylene tibial inserts are 42% less expensive than MBT components.28,37 Reduced costs associated with APT components is expected to result in a net gain of $1,650 per case in implant costs.28,37 Other related costs that contribute are the operational costs for the procedure. The operating room is often considered the primary center of financial flow for many hospitals, accounting for about 35% to 40% of its costs and 60% to 70% of revenue. The average cost to use an operating room can be as high as $133/min with an average $62/min.38 Surgical cost reduction is especially relevant in orthopedic surgery, as TKA procedures in the older population are one of the highest of all health care expenses.19 Because surgical time plays a main role in contributing to the cost of the intervention, further studies evaluating variations in average procedure-time of APT compared with MBT components are warranted.

Increased operative time is strongly correlated with an increase in complications, such as wound infection, deep vein thrombosis, pulmonary embolism, wound dehiscence, and pneumonia.39 Increased risk for potential complications mean even higher expenditures associated with a single episode of care, thereby increasing total economic burden and decreasing profit margins that comes when efficient care is provided. With the future of medicine moving toward a pay-for-performance metric system, this concept will be of increasing importance, further emphasizing the
Early initiatives by hospitals to influence implant use and cost assess products based on value analysis, informal gain-sharing, and implant formulary models. In adjusted models, the risk for early all-cause revision and aseptic revision was lower for the monoblock all-polyethylene cohort than for the modular metal-backed cohort. In older patients, the early risk for all-cause revision was 0.6 (CI: 0.4-1.0) for the monoblock cohort compared with the modular cohort. In younger patients, the adjusted risk for all-cause revision and for aseptic revision was also lower for the monoblock cohort than for the modular cohort. Overall, monoblock tibial constructs had a 49% lower early risk for all-cause revision and a 41% lower risk for aseptic revision than modular constructs. In younger patients with monoblock components, the early risk for revision for any cause was even lower, possibly due to the decreased rate of overall wear associated with APT implants. Use of implants with lower rates of revision rates will lead to an overall reduction in cost burden.

**Cost Variation in TKA**

Cost variation is prevalent throughout the market. The cost for TKA implants varies greatly based on payer type. Medicare payments attribute 64% to the total costs for arthroplasty procedures. Medicare payments for primary TKA cost approximately $11,000 in 2006. Geographic location plays a significant role in the cost of knee arthroplasty procedures, ranging from $16,096 in Alabama to as high as $61,266 in New York for private payers. Cost variations within a region are also quite flexible, with the highest cost variance in Texas where prices can have a 267% difference within one region. The growing gap between cost and reimbursements has provoked new strategies that limit the traditional approach of allowing physicians unrestrained choice of implants.

**Cost Reduction via Standardization Programs**

Early initiatives by hospitals to influence implant use and cost assess products based on value analysis, informal gain-sharing, and implant formulary models. Addressing supplier-mandated nondisclosure agreements prevent the transparency needed to foster competition in the market, and ultimately allows negotiations that drive up cost. Bundling of payments would make the use of APT components even more cost-effective for the hospital, since reimbursements will account for the entire episode of care. Therefore, hospital administrators and providers will want to maximize their profit margin by choosing a less costly implant, without compromising quality of care or survival of the implant. Additionally, cost should be considered for the hospital institution, as well as the patient and the overall cost to society.

In an effort to address the many factors that impact total cost, the Lahey Clinic implemented a knee-implant standardization program and a clinical pathway to assess the impact of targeted hospital cost reduction approaches on patient outcomes and hospital resource allocation. Changes in utilization and unit costs were implemented to attempt to drive costs down. Orthopedic surgeons and hospital administrators worked in tandem to develop and implement the cost containment programs. Early discharge to post-acute care facilities shifts costs and overall total cost related to the single episode. Thorough evaluation of every product used for TKAs was conducted to search for ways to decrease costs. All aspects of hospital expenses should be allocated and accounted for, such as anesthesia, blood bank services, laboratory analysis, pharmacy, and in-hospital rehabilitation. Additionally, efforts to standardize operating room routines, and length of operation, and eliminate routine pathologic evaluation of surgical specimens if not clinically indicated were made. These strategic approaches created a model that led to a change from $2,172 loss on each TKA case to a profit of $2,986 per case over a 17-year period. Improved economics were reflected in the decreased revenue in inflation-adjusted dollars and cost containment that resulted in reduced hospital expenses for TKA due to lowering length of hospital stay and reducing costs directly related to knee implants.

**Conclusion**

All-polyethylene tibial components have been used in lower numbers than
MBT prostheses due to the prior perceptions of inferiority, despite the success of newer designs and the decreased financial burden of the design.\textsuperscript{8,41,44} The projected increase in TKA procedures should motivate policymakers, hospital administrators, and surgeons to address concerns with cost-effective approaches. Implants remain costly, with a large disconnect among the stakeholders that are responsible for the cost due to different incentives and end-goals. Exploring strategies for equal-performance, less costly surgical options presents an encouraging solution to manage the large financial demand that is sure to come with the large increase in TKAs performed. Increased costs, lower reimbursements, and narrowed profit margins for hospitals create a cumulative problem that should lead to closer evaluation of the financial viability for TKA service lines.\textsuperscript{45} Policy considerations that promote price transparency will not only help to fill some of the gaps of knowledge identified in this review, but would also address key aspects of care that drive cost higher than necessary. Surgeons are encouraged to help their hospitals control cost of implants related to joint replacement procedures. For TKA procedures, APT components provide a similar postoperative profile in terms of functionality and pain relief, better outcomes with lower revision and complication rates, and increased survivorship, and are financially superior than metal-backed modular components, and thus achieve many of the goals outlined in the ACA and represent a model for the future of health care reimbursements.

\textbf{References}


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