The Cost of Implants Contributes to 22.3% of the Total Cost of Primary Total Knee Arthroplasty

Amy K. Ngyuen[1]; Christopher Bacak, MD[2]; Michael D Eckhoff[3], MD; John P Scanaliato[3], MD; Benjamin R Childs, MD[4]; Nata Parnes, MD[5]

[1]University of Texas Health Houston, Houston, TX; [2]Texas Tech Health of El Paso, El Paso, TX; [3]William Beaumont Army Medical Center, El Paso, TX; [4]The Randolph Institute, Palm Beach, FL; [5]Carthage Area Hospital, Carthage, NY

Objectives: The purpose of this study was to characterize the percent contribution of the cost of the standard primary total knee arthroplasty (TKA) implant to the total cost of a primary TKA procedure based on currently published literature.

Design: Systematic literature review

Main Outcome Measurements: cost in inflation-adjusted $USD

Results: An initial PubMed search produced 469 articles regarding "total knee arthroplasty implant cost," of which 14 had novel estimates for the cost of the standard primary TKA implants and the total cost of primary TKA as a procedure. The mean cost of a primary TKA implant was $5,336 ± $1,671, and the mean total cost of a primary TKA procedure was $23,907 ± $9,514. Therefore, the cost of the standard knee implant contributes to 22.3% of the total cost of a primary TKA.

Conclusions: Published estimates of standard knee implant costs are highly variable. The best estimate based on the available literature is $5,336 ± $1,671, contributing to 22.3% of the total cost of a primary TKA. While the overall cost may vary depending on the hospital contracting with each primary TKA implant vendor, this demonstrates that the cost of implants significantly contributes to the overall cost of the procedure.

Level of Evidence: Level 4; systematic review of level IV or higher evidence

Key Words: business, management, human resources, cost, value, efficiency.

INTRODUCTION

Total knee arthroplasty (TKA) is widely considered one of the most successful surgical innovations of the 20th century. This procedure is the definitive treatment for patients affected by end-stage knee osteoarthritis[1]. The United States has the world's highest per capita rate of primary TKA[2]. Due to aging and increasing obesity, the prevalence of osteoarthritis will continue to rise in the American population[3]. By 2050, the demand for primary TKA will grow to 725 procedures/100,000 person-years[2].

Value-based practice weighs the treatment cost against the change in patient quality of life[4,5]. It has become an important consideration in orthopedic surgery treatment planning[6,7]. With advancements in medical technology and rising healthcare expenditures, cost-effectiveness for patients and healthcare organizations is of increasing priority[4–6,8]. While there is a significant amount of existing research measuring patient-reported outcomes [9], the costs involved in total knee arthroplasty must be elucidated.

Studies have shown that over 75% of hospital costs for total joint arthroplasty can be attributed to three main sources: (1) the hospital room cost, (2) the operating room (OR) cost, and (3) implant cost[10–13]. Previous studies have examined the cost of running an operating room[14]. Researchers have expressed concern regarding the declines in per-case reimbursements for total joint arthroplasty while the price of implants has continued to rise[15]. The purpose of this study is to review available literature estimating the cost of the standard knee implant to determine the percent

contribution to the total cost of primary total knee arthroplasty.

METHODS

This literature search was performed using the PubMed database. The search keywords used were "total knee arthroplasty implant cost." Results were obtained from 1991 through 2022. Five additional sources were obtained outside of the PubMed literature search after a subsequent references review.

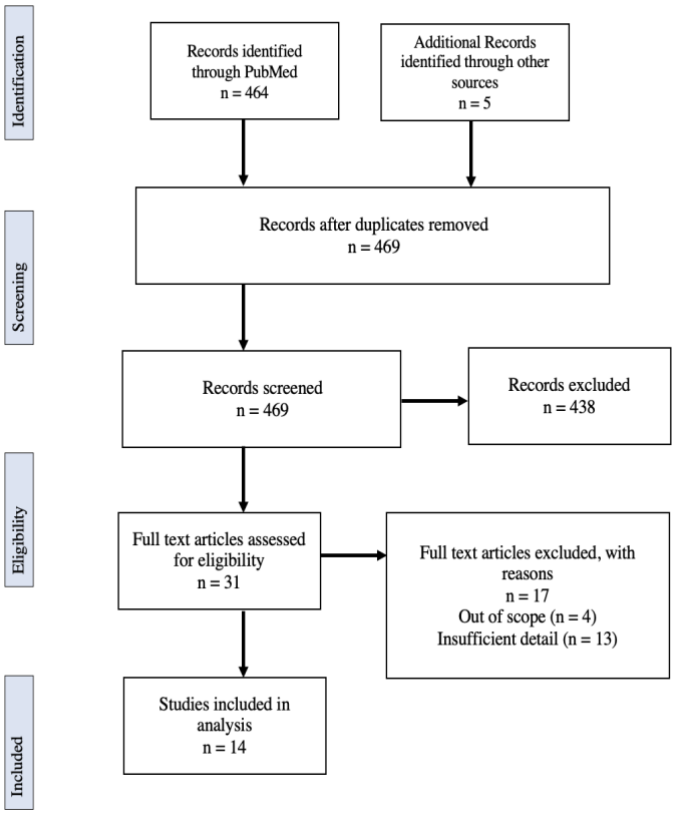
After duplicates were removed, all results were independently reviewed by two authors. First, the titles were screened for eligibility and rejected or selected for further review. Then, abstracts of selected articles were reviewed. Articles containing estimates regarding the cost of a standard implant and/or the total cost of a primary total knee arthroplasty were included. Full texts were then assessed.

For most sources, a single number was used to calculate the cost of a standard knee implant and the total cost of primary TKA. For sources that included costs over multiple fiscal years, the most recent fiscal year was used to estimate the cost. All costs given were converted to USD. All costs were adjusted for inflation to 2023 USD utilizing the online consumer price index calculator provided by the US Bureau of Labor Statistics.

RESULTS

After duplicates were removed, 469 articles were generated from the literature search. After screening the titles, 438 articles were removed. Out of the 31 articles remaining, four articles were excluded for being out of scope (i.e., bilateral TKA, revision TKA), and 13 articles were excluded for insufficient detail. 14 studies were included in the final analysis (Figure 1).

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.



Out of the 14 studies, eight contained information about the cost of the TKA implant and the total cost of the primary TKA procedure. Three studies only contained information about the cost of implants, and three only contained information about the total cost of the procedure. Two studies provided a median cost for the knee implant and total knee arthroplasty, and all other sources provided a mean cost. The mean cost of a standard knee implant adjusted to 2023 USD from 11 studies was $5,331 (SD: $1,666) [13,15–24]. The mean cost of a primary TKA adjusted to 2023 USD from 11

Table 1: Cost of Prosthetic Implant and Total Cost of Knee Arthroplasty

Author	Data Year	Cost of prosthetic implant ($)	Cost of prosthetic implant ($) inf adj	Total cost of knee arthroplasty ($)	Total cost of knee arthroplasty ($) inf adj	Included
Burns et. al	2003			$15,476	$25,838	Median Cost for Primary TKA
Gioe et. al	2008	$3,210	$4,613			Mean Cost for TKA implant
Healy et. al	2008	$2,553	$3,669	$11,002	$15,812	Mean Cost for TKA
Hebert et. al	1992	$3,394	$7,456	$20,117	$44,191	Primary TKA
Ho et. al	2006	$3,351 $3,433 $3,589	$5,126 $5,252 $5,491	$11,767 $9,337 $10,002	$18,001 $14,284 $15,301	Group 1 (Multiple Vendors) Group 2 (Multiple Vendors) Group 3 (Single Vendor)
Johnston et. al	1997	$1,110	$2,116			Mean Cost for TKA implant
Kremers et. al	2010	$2,037	$2,852	$15,673	$21,942	Primary TKA
Macario et. al	1996			$17,618	$34,616	Mean Cost for TKA
Mulloy et. al	2013			$22,837	$30,085	Mean Hospital Cost for TKA
Palsis et. al	2014	$5,385 $5,385	$7,001 $7,001	$29,488 $16,981	$38,243 $22,022	Traditional accounting Time-driven activity-based costing
Robinson et. al	2008	$4,857	$6,980	$11,660	$16,758	Median Cost for TKA
Shankar et. al	2011	$5,006	$6,896	$16,243	$22,375	Mean Cost for TKA
Tseng et. al	2015	$5,023	$6,520			Mean Cost for TKA implant
Younger et. al	2014	$2,876	$3,730	$11,746	$15,233	Mean Cost for TKA
Average		$3,658 ± 1,266	$5,336 ± 1,671	$15,711 ± 5,607	$23,907 ± 9,514	

studies was $23,907 (SD: $9,514) [13,15,17,18,20–22,24–27]. Given these findings, on average, the cost of the standard knee implant contributes to 22.3% of the total cost of a primary TKA.

DISCUSSION

This study aims to estimate the impact of implant cost on the total cost of a primary TKA procedure based on currently published literature. From the 14 articles that met inclusion criteria, it

was determined that the mean inflation-adjusted cost of a primary TKA implant was $5,336 (SD: $1,671) [13,15–24] , and the mean inflation-adjusted cost of a primary TKA procedure was $23,907 (SD: $9,514) [13,15,17,18,20–22,24–27]. Therefore, approximately 22.3% of the total cost of a primary TKA procedure can be attributed to the cost of a standard primary TKA implant.

Quantifying the costs of a primary TKA implant is difficult due to variability in non-patient-specific factors from within and across hospitals[15]. This includes variations in physician preference for implants and differences in prices charged by various vendors to the same hospital. Non-patient-specific factors from across hospitals include device purchasing strategy[15]. Selecting implants from a single vendor rather than multiple vendors does not necessarily impact cost. However, an increase in the volume of TKAs performed can decrease costs because pricing contracts are determined by the projected number of TKAs to be performed by a hospital[18].

There is also difficulty in quantifying the total costs of a primary TKA procedure. Total costs may differ due to differences in the service costs included in the total cost of the TKA. Differences also may exist due to differences in OR time and length of hospital stay[24]. Substantial price differences can exist based on whether the cost was determined by traditional accounting or time-driven activity-based costing (TDABC)[21]. Time-driven activity-based costing is a methodology that examines the costs of healthcare resources consumed as a patient moves along the care process[28]. The true total costs of a primary TKA likely lie between estimates determined by traditional accounting and TDABC[21]. Additional research is needed to develop a reproducible standard for how total costs of orthopaedic procedures are measured and accounted for. Important service costs, namely operating and hospital rooms, should be clearly provided for all total procedural cost estimates. A reproducible standard will further help in measuring patient outcomes through cost-benefit analyses.

CONCLUSION

The cost of primary TKA implants contributes to a notable portion of a primary TKA procedure. This systematic review of contemporary literature resulted in sparse literature discussing the actual cost of primary TKA implants and primary TKA procedures. The mean consumer price index inflation-adjusted cost of a primary TKA implant was $5,336 (SD: $1,671), and the mean inflation-adjusted cost of a primary TKA procedure was $23,907 (SD: $9,514) [13,15,17,18,20–22,24–27]. Therefore, approximately 22.3% of the total cost of a primary TKA procedure can be attributed to the cost of a standard primary TKA implant.

REFERENCES

1. Zhang W, Moskowitz RW, Nuki G, et al. OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines. *Osteoarthritis Cartilage*. 2008;16(2):137-162. doi:10.1016/j.joca.2007.12.013
2. Inacio MCS, Paxton EW, Graves SE, Namba RS, Nemes S. Projected increase in total knee arthroplasty in the United States – an alternative

projection model. *Osteoarthritis Cartilage*. 2017;25(11):1797-1803. doi:10.1016/j.joca.2017.07.022
3. Kim S. Changes in surgical loads and economic burden of hip and knee replacements in the US: 1997–2004. *Arthritis Rheum*. 2008;59(4):481-488. doi:10.1002/art.23525
4. Rajan PV, Qudsi RA, Wolf LL, Losina E. Cost-Effectiveness Analyses in Orthopaedic Surgery: Raising the Bar. *J Bone Jt Surg*. 2017;99(13):e71. doi:10.2106/JBJS.17.00509
5. Hamid KS, Nwachukwu BU, Bozic KJ. Decisions and Incisions: A Value-Driven Practice Framework for Academic Surgeons. *J Bone Jt Surg*. 2017;99(10):e50. doi:10.2106/JBJS.16.00818
6. Thomas N, Sandler A, Fernandez I, et al. Orthopaedic Business is the Focus of 3.4% of Articles in Top General Orthopaedic Journals. *J Orthop Bus*. 2022;2(1):10-18. doi:10.55576/job.v2i1.11
7. Johnson C, Folsom A, Powlan F, et al. Business Articles in Shoulder and Elbow Surgery Support Outpatient Total Shoulder Arthroplasty and Identify Factors Impacting Surgery Cost: Review of Shoulder and Elbow Related Business Publications. *J Orthop Bus*. 2022;2(3):18-31. doi:10.55576/job.v2i3.20
8. Cognetti D, Handcox J, Anderson K, Aden J, Hurley R. Economic Process Behind Surgical Innovation: Changes in Coding and Compensation Correlate with Increased Minimally Invasive Sacroiliac Joint Fusion in the National Surgical Quality Improvement Program (NSQIP) Database. *J Orthop Bus*. 2022;2(4):5-9. doi:10.55576/job.v2i4.24
9. Mercieca-Bebber R, King MT, Calvert MJ, Stockler MR, Friedlander M. The importance of patient-reported outcomes in clinical trials and strategies for future optimization. *Patient Relat Outcome Meas*. 2018;Volume 9:353-367. doi:10.2147/PROM.S156279
10. Bosco JA, Alvarado CM, Slover JD, Iorio R, Hutzler LH. Decreasing Total Joint Implant Costs and Physician Specific Cost Variation Through Negotiation. *J Arthroplasty*. 2014;29(4):678-680. doi:10.1016/j.arth.2013.09.016
11. Rana AJ, Iorio R, Healy WL. Hospital Economics of Primary THA Decreasing Reimbursement and Increasing Cost, 1990 to 2008. *Clin Orthop*. 2011;469(2):355-361. doi:10.1007/s11999-010-1526-y
12. Stranges E, Russo CA, Friedman B. Procedures with the Most Rapidly Increasing Hospital Costs, 2004–2007. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Agency for Healthcare Research and Quality (US); 2006. Accessed June 18, 2023. http://www.ncbi.nlm.nih.gov/books/NBK53597/
13. Healy WL, Rana AJ, Iorio R. Hospital Economics of Primary Total Knee Arthroplasty at a Teaching Hospital. *Clin Orthop*. 2011;469(1):87-94. doi:10.1007/s11999-010-1486-2
14. Smith T, Evans J, Moriel K, et al. Cost of OR Time is $46.04 per Minute. *J Orthop Bus*. 2022;2(4):10-13. doi:10.55576/job.v2i4.23
15. Robinson JC, Pozen A, Tseng S, Bozic KJ. Variability in Costs Associated with Total Hip and Knee Replacement Implants: *J Bone Jt Surg-Am Vol*. 2012;94(18):1693-1698. doi:10.2106/JBJS.K.00355
16. Gioe TJ, Sharma A, Tatman P, Mehle S. Do "Premium" Joint Implants Add Value?: Analysis of High Cost Joint Implants in a Community Registry. *Clin Orthop*. 2011;469(1):48-54. doi:10.1007/s11999-010-1436-z
17. Hebert CK, Williams RE, Levy RS, Barrack RL. Cost of Treating an Infected Total Knee Replacement: *Clin Orthop*. 1996;331:140-145. doi:10.1097/00003086-199610000-00019
18. Ho DM, Huo MH. Are Critical Pathways and Implant Standardization Programs Effective in Reducing Costs in Total Knee Replacement Operations? *J Am Coll Surg*. 2007;205(1):97-100. doi:10.1016/j.jamcollsurg.2007.03.009
19. Johnston DW, Beaupré LA, Davies DM, Hessels R. Reducing arthroplasty costs via vendor contracts. *Can J Surg J Can Chir*. 1999;42(6):445-449.
20. Kremers HM, Visscher SL, Moriarty JP, et al. Determinants of Direct Medical Costs in Primary and Revision Total Knee Arthroplasty. *Clin Orthop*. 2013;471(1):206-214. doi:10.1007/s11999-012-2508-z
21. Palsis JA, Brehmer TS, Pellegrini VD, Drew JM, Sachs BL. The Cost of Joint Replacement: Comparing Two Approaches to Evaluating Costs of Total Hip and Knee Arthroplasty. *J*

Bone Jt Surg. 2018;100(4):326-333. doi:10.2106/JBJS.17.00161
22. Shankar S, Tetreault MW, Jegier BJ, Andersson GB, Della Valle CJ. A cost comparison of unicompartmental and total knee arthroplasty. *The Knee*. 2016;23(6):1016-1019. doi:10.1016/j.knee.2015.11.012
23. Tseng YJ, Mandl KD. Difference Between Estimated Purchase Price and Insurance Payments for Knee and Hip Implants in Privately Insured Patients Younger Than 65 Years. *JAMA*. 2017;317(8):854. doi:10.1001/jama.2016.19579
24. Younger ASE, MacLean S, Daniels TR, et al. Initial Hospital-Related Cost Comparison of Total Ankle Replacement and Ankle Fusion With Hip and Knee Joint Replacement. *Foot Ankle Int*. 2015;36(3):253-257. doi:10.1177/1071100714558844
25. Burns AWR, Bourne RB, Chesworth BM, MacDonald SJ, Rorabeck CH. Cost Effectiveness of Revision Total Knee Arthroplasty: *Clin Orthop*. 2006;446:29-33. doi:10.1097/01.blo.0000214420.14088.76
26. Macario A, Horne M, Goodman S, et al. The Effect of a Perioperative Clinical Pathway for Knee Replacement Surgery on Hospital Costs: *Anesth Analg*. 1998;86(5):978-984. doi:10.1097/00000539-199805000-00012
27. Molloy IB, Martin BI, Moschetti WE, Jevsevar DS. Effects of the Length of Stay on the Cost of Total Knee and Total Hip Arthroplasty from 2002 to 2013. *J Bone Jt Surg*. 2017;99(5):402-407. doi:10.2106/JBJS.16.00019
28. Martin JA, Mayhew CR, Morris AJ, Bader AM, Tsai MH, Urman RD. Using Time-Driven Activity-Based Costing as a Key Component of the Value Platform: A Pilot Analysis of Colonoscopy, Aortic Valve Replacement and Carpal Tunnel Release Procedures. *J Clin Med Res*. 2018;10(4):314-320. doi:10.14740/jocmr3350w