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Initial Hospital-Related Cost Comparison of Total Ankle Replacement and Ankle Fusion With Hip and Knee Joint Replacement

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Abstract

Background: Total hip and knee arthroplasty (THA and TKA) are accessible to patients with end-stage hip and knee arthritis in most health care systems. The availability of total ankle arthroplasty (TAA) to patients with end-stage ankle arthritis is often restricted because of prosthesis cost. Ankle fusion (AF) is often offered as the only alternative. Patients should have equal access to procedures that are equivalent in total cost. We compared total costs of TAA, AF, THA, and TKA for similar cohorts in a government-funded teaching hospital.

Methods: A subset of 13 TAA and 13 AF patients were selected from the Canadian Orthopaedic Foot and Ankle Society Prospective Ankle Reconstruction Database, and 13 THA and 13 TKA patients were randomly selected from the Canadian Joint Replacement Registry. Total cost was estimated from operating room time, hospital stay, surgeon billing, and equipment used.

Results: Mean total cost associated with TAA was $13,500 ± 1000 and was the same as THA ($14,500 ± 1500) and TKA ($12,500 ± 1000). Mean total cost associated with AF was significantly less at $5500 ± 500. Mean operating room time was longer, but mean hospital stay was shorter for the ankle procedures compared with THA and TKA.

Conclusion: All arthroplasties had similar total costs. Total ankle arthroplasty should not be denied based on prosthetic cost alone, as total procedure cost is equivalent to THA and TKA. We believe ankle fusion is a less expensive and preferable alternative for some patient groups.

Level of Evidence: Level II, comparative series.

Keywords: ankle fusion, ankle arthroplasty, arthroplasty, cost analysis

Ankle osteoarthritis represents a painful, debilitating condition that can result in a dramatic reduction in mobility and health-related quality of life (HRQOL).[5,9] The reduction in HRQOL in patients with end-stage ankle arthritis (ESAA) is as severe as the reduction in HRQOL observed in patients with end-stage hip arthritis.[9] Sixteen percent of the Canadian population aged 15 years and older are affected by arthritis, representing the second and third most common chronic disease in women and men, respectively.[11] Arthritis is the most common cause of disability in the United States, where 22.2% (49.9 million) of adults have arthritis, and 42.4% of these individuals (21.1 million) have limitations in activity attributable to arthritis.[2]

Ankle fusion is the current standard of care for ESAA, and total ankle arthroplasty (TAA) has historically been associated with poor outcomes and early failures related to implant design and wear.[14] There has been a resurgence of TAA for the treatment of ESAA[20,28] due to improved implant designs and subsequent improved implant survival,[10] as well as potential poor long-term outcomes with ankle fusion (AF) due to ipsilateral hind- and mid-foot arthritis.[3] To date, no study has directly compared costs for these ankle procedures with THA and TKA. Patients will often select ankle replacement over fusion for the greater ankle range of motion and improved gait kinematics.[26] If the overall cost

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of TAA is similar to THA and TKA, then the cost of the TAA can be justified based on the provision of THA and TKA for similarly disabled patients.

The costs of total knee arthroplasty (TKA) and total hip arthroplasty (THA) are well documented. In the United States, the reported average cost for primary THA in 2011 ranged from $10,732 to $14,573 USD.[7,8,15,21,24,29] Average costs for TKA in the United States were similar, ranging from $11,660 to $14,573.[7,24,29] Studies consistently demonstrate marked improvement in HRQOL,[19,22,23] making THA and TKA cost-effective. Furthermore, THA has been suggested to be one of the best operations that medicine has to offer.[16]

The purpose of this study was to determine if the cost of TAA was similar to costs for AF, THA, and TKA.

Methods

Patients

Patients who underwent TAA or AF between October 2005 and March 2007 at a large, urban teaching hospital were selected from the Canadian Orthopaedic Foot and Ankle Society (COFAS) Prospective Ankle Reconstruction Database, which examines the clinical outcomes of all Canadian patients who have undergone operative treatment for symptomatic ESAA. Patients were eligible for inclusion if they had ESAA, were older than 18 years, and were able to communicate in English and follow up with the study coordinators. Patients with diabetic Charcot arthropathy, which is a clear contraindication for TAA, were excluded from the study, since ankle fusion in these patients is more complex, usually involves a longer hospital stay, and would falsely bias costs in favor of TAA. Revisions of previous ankle replacements or fusions were excluded from the study. Patients undergoing fusion for infection were excluded from the study. After initial assessment, patients were treated with either AF or TAA. The treatment decision was mutually agreed upon by the surgeon and the patient. Thirteen patients who underwent AF qualified for this study; 13 patients who underwent TAA and met inclusion criteria were then randomly selected for the study.

Thirteen subjects who underwent THA and 13 who underwent TKA during the same period were randomly selected from the Canadian Joint Replacement Registry. Patients were included in the database if they had end-stage hip or knee arthritis. Patients were excluded from the study if their procedure was a revision of a previous joint replacement. Hip and knee fusions were excluded.

All patients in this study had procedures performed at the same teaching hospital, which is a referral center for a population of 250,000 patients and the only source of foot and ankle care for this patient population. The hospital is funded by a government body through a global hospital budget. Physician billings are reimbursed on a fee-for-service basis by the same government body through a services plan.

Table 1. Baseline Demographic Information on Patients Included in Cost Analysis.

	Age, Mean ± SD, y	Male, No.	Female, No.
Total hip arthroplasty (THA)	76 ± 4	5	8
Total knee arthroplasty (TKA)	65 ± 7	10	3
Total ankle arthroplasty (TAA)	58 ± 13	10	3
Ankle fusion (AF)	50 ± 11	6	7

Informed consent was received from all patients prior to their inclusion in the respective databases and questionnaire administration. Ethics approval for this study was obtained from our institution's Research Ethics Board.

Cost Analysis

A chart review of the patients who underwent TAA, AF, THA, or TKA (n = 13 in each group) determined the costs using methods modified from Sanchez-Sotelo et al.[25] Four measures were evaluated: operating room (OR) time, hospital stay, surgeon billing, and implant or hardware cost. Implant cost was determined by using the cost of the single most commonly used brand of total ankle prosthesis, total knee prosthesis, and total hip prosthesis in these patients at the study institution. The 4 variables were summed to form a "Summary Cost" for each procedure. All amounts are in Canadian dollars and based on year 2006 values.

Statistical Methods

Summary cost, OR time, surgeon cost, implant cost, and hospital stay were compared between groups using analysis of variance (ANOVA), with Tukey's honestly significant difference post hoc test. A value of $P < .05$ was considered significant.

Results

Demographic data for the cohorts are found in Table 1. Total hip arthroplasty patients were older than TKA patients. Total ankle arthroplasty patients were younger than both THA and TKA patients and older than AF patients. Matching by age and sex was considered inappropriate for this study, since this would create an artificial bias by excluding post-traumatic ankle arthritis patients (who are younger than THA or TKA patients)[6] and including more rheumatoid arthritis patients (who are predominantly women).

The total cost of the procedure was similar for all joint replacements, ranging from $12,500 for TKA to $14,500

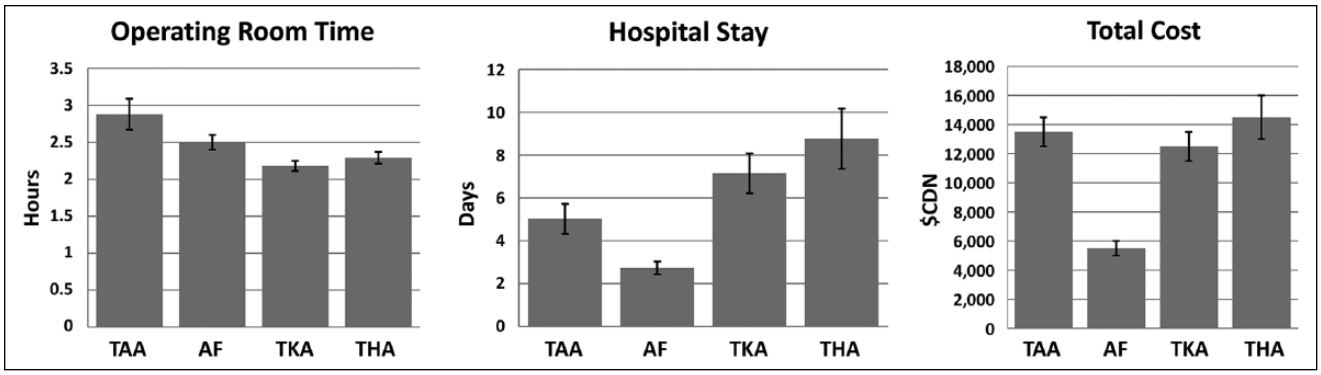

Figure 1. Operating room time (in hours), hospital stay (in days), and total cost (in Canadian dollars) associated with total ankle arthroplasty (TAA), ankle fusion (AF), total knee arthroplasty (TKA), and total hip arthroplasty (THA), with n = 13 for each group.

Table 2. Fixed Costs Associated With Operative Treatments of End-Stage Hip, Knee, and Ankle Arthritis.

Operative Intervention	Orthopaedic Surgeon Cost, $CDN	Implant Cost, $CDN
Total ankle arthroplasty	419.90	6420.00
Ankle fusion	442.00	1200.00[a]
Total knee arthroplasty	660.79	3060.00
Total hip arthroplasty	660.79	3200.00
Operating room cost (per hour, $CDN)		230.00
Hospital stay cost (per diem, $CDN)		1173.00

[a]Based on 2 Magna-FX large fragment cannulated screws (Zimmer Orthopedics, Warsaw, Indiana), one 8-hole AO Foundation–approved semitubular plate, six 3.5-mm cortex screws, and 5 cc DBX demineralized bone matrix putty (Synthes, West Chester, Pennsylvania) for ankle fusion. Platelet-rich plasma and bone allograft were *not* included in the cost.

for THA, and was significantly less for ankle fusion, at $5500 ± 500 ($P < .0002$) (Figure 1). Mean OR time was significantly longer for TAA (2.9 ± 0.21 hours) compared with THA (2.3 ± 0.08 hours, $P = .0086$) and TKA (2.2 ± 0.07 hours, $P = .0014$). The mean OR time for AF was intermediate in length. Hospital stay was shorter for ankle procedures compared with stays for THA and TKA (Figure 1). Significant differences in the length of hospital stay were noted between TAA and THA ($P = .03$), between AF and THA ($P < .0002$), and between AF and TKA ($P < .008$).

Fixed costs associated with implant hardware, surgeon billing costs, and per diem rates are found in Table 2.

Discussion

This study showed that TAA has a greater equipment cost but, because of shorter hospital stays, has an overall cost ($13,500 ± 1000) similar to THA ($14,500 ± 1500) and TKA ($12,500 ± 1500). Ankle fusion was a less expensive procedure ($5500 ± 500); however, it is not always an equivalent procedure. These values compare well with the mean hospital cost for THA and TKA of $12,958 reported by Marshall and colleagues,[18] also in 2006 Canadian dollars. They also fall within the mid-range of recently reported total costs of THA and TKA in the United States, which are summarized in Table 3.[1,7,12,13,15,17,18,21,24,27,29]

For TAA, the cost of the prosthesis remains the major factor that restricts access to the procedure in most health systems. Ankle, hip, and knee implant prices are fairly consistent across Canada. Globally funded hospitals operate with cost centers that need to remain on budget. The total cost of a procedure for an individual patient may transcend different cost centers and providers. In our billing system, 1 of the 4 costs evaluated in this study (implant/hardware) falls within an equipment budget, 2 costs (operating room time, hospital stay) fall within staffing costs at 2 different cost centers, and 1 (surgeon billing) falls under a nonhospital cost. Within our system, access to TAA is likely to be declined to ensure that the equipment budget remains on target, with no assessment of the other costs. The total cost of a procedure should define health care policy and access to care for individual patients, where procedures with similar results are equally funded. In a Markov model analysis of a 60-year-old hypothetical cohort with end-stage ankle arthritis, TAA was found to be a cost-effective alternative to AF.[4]

While AF may be a less expensive alternative than TAA, it is not always an equivalent operation, and the operations are not equivalent in their indications. Ankle fusion is preferable in patients with diabetes or severe deformity, as well as in younger or more active patients in whom the replacement may wear out. Ankle replacement is preferable in older patients and in patients with arthritis of the surrounding joints, in whom a fusion may cause pain in the surrounding joints, or in whom a subsequent fusion performed in the surrounding joints would cause stiffness in the hindfoot that

Table 3. Costs of Total Hip Arthroplasty and Total Knee Arthroplasty as Reported in the Literature.

Study	Country	Mean Cost[a]	Notes
Total hip replacement			
Birkmeyer et al, 2012[1]	United States	$19,651 to $22,051	Based on Medicare claims
Doman and Gerlinger, 2012[7]	United States	$14,440	
Lavernia and Alcerro, 2011[15]	United States	$10,732	Primary procedures only
Rana et al, 2011[21]	United States	$11,688	
Robinson et al, 2012[24]	United States	$12,458	Median total operative costs
Stundner et al, 2013[27]	United States	$13,981	Patients with concomitant diagnosis of depression, anxiety, or both
Vekeman et al, 2012[29]	United States	$14,573	Total cost per inpatient stay with no bleeding or VTE
Marshall et al, 2012[18]	Canada	$12,958 CDN	Acute inpatient stay only
Higashi and Barendregt, 2011[12]	Australia	$13,648 AUD	
Jimenez-Garcia et al, 2011[13]	Spain	€9474	
Lernout et al, 2010[17]	France	€7529 to €8105	Without, or with, comorbidities
Total knee replacement			
Doman and Gerlinger, 2012[7]	United States	$12,929	
Robinson et al, 2012[24]	United States	$11,660	Median total operative costs
Stundner et al, 2013[27]	United States	$15,259	Patients with concomitant diagnosis of depression, anxiety, or both
Vekeman et al, 2012[29]	United States	$14,573	Total cost per inpatient stay with no bleeding or VTE
Marshall et al, 2012[18]	Canada	$12,958 CDN	Acute inpatient stay only
Higashi and Barendregt, 2011[12]	Australia	$13,640 AUD	

AUD, Australian dollar; CDN, Canadian dollar; VTE, venous thromboembolism.
[a]All costs are in US dollars unless otherwise indicated.

impedes gait.[6] Ultimately, the decision for either TAA or AF should be made by the treating physician and patient after appropriate consultation, and according to the results of this analysis, cost should not be a deciding factor.

Cost analysis is challenging to perform, as the real cost of any procedure is difficult to define within a given hospital and health care system. Depending on the health system, country, and funding model, how cost is defined varies. In some systems, a billed cost to a provider may be considered the true cost of the procedure. However, the billed cost may not reflect the actual cost and, rather, may reflect what the payer or insurance company is (or is not) willing to pay. This method of cost analysis may be relevant to other health care systems with large patient populations, such as the National Health Service in the United Kingdom, provincial health care service plans in Canada, and similar systems in the United States such as the Department of Veterans Affairs or some health maintenance organizations. Within these systems, defining cost is still important, since access to care may be limited by the cost of procedures, equipment costs, or surgeon training and availability of expertise. For example, under the payment system in the current study, the cost of the prosthesis for TAA is not supported, resulting in TAA not being available to a patient population that has ready access to THA and TKA.

This study has other limitations. First, hospital admission times may not reflect current standards. Length of stay data are from 2006 and reflect standards of care in a teaching hospital serving a large geographic area, in which discharge from the hospital for inpatient procedures can be slow. Hospital stays today may be shorter than those during the study period,[20] and the comparative costs may not be relevant for all hospital systems and environments. However, the cost comparison should provide a framework for the cost of care across different procedures performed at the same hospital. Second, the cohorts were small, limiting the generalizability of the results. Finally, this study did not consider nonhospital costs (eg, physiotherapy, rehabilitation, home care, time off work) or implant longevity or survivorship.

Summary

The cost of TAA was similar to THA and TKA. Total ankle arthroplasty should not be denied based on prosthetic cost alone, as the total cost of the procedure is equivalent to THA and TKA. Ankle fusion is a less expensive and sometimes preferable alternative for some patient groups.

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Declaration of Conflicting Interests

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References

1. Birkmeyer JD, Gust C, Dimick JB, Birkmeyer NJ, Skinner JS. Hospital quality and the cost of inpatient surgery in the United States. *Ann Surg*. 2012;255:1-5.
2. Centers for Disease Control and Prevention. Prevalence of doctor-diagnosed arthritis and arthritis-attributable activity limitation—United States, 2007-2009. *Morb Mortal Wkly Rep*. 2010;59:1261-1265.
3. Coester LM, Saltzman CL, Leupold J, Pontarelli W. Long-term results following ankle arthrodesis for post-traumatic arthritis. *J Bone Joint Surg Am*. 2001;83A:219-228.
4. Courville XF, Hecht PJ, Tosteson AN. Is total ankle arthroplasty a cost-effective alternative to ankle fusion? *Clin Orthop Relat Res*. 2011;469:1721-1727.
5. Cushnaghan J, Dieppe P. Study of 500 patients with limb joint osteoarthritis, I: analysis by age, sex, and distribution of symptomatic joint sites. *Ann Rheum Dis*. 1991;50:8-13.
6. Daniels TR, Younger AS, Penner MJ, et al. Intermediate-term results of total ankle replacement and ankle arthrodesis: a COFAS multicenter study. *J Bone Joint Surg Am*. 2014;96:135-142.
7. Doman DM, Gerlinger TL. Total joint arthroplasty cost savings with a rapid recovery protocol in a military medical center. *Mil Med*. 2012;177:64-69.
8. 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 Relat Res*. 2011;469:48-54.
9. Glazebrook M, Daniels T, Younger A, et al. Comparison of health-related quality of life between patients with end-stage ankle and hip arthrosis. *J Bone Joint Surg Am*. 2008;90:499-505.
10. Gougoulias N, Khanna A, Maffulli N. How successful are current ankle replacements? A systematic review of the literature. *Clin Orthop Relat Res*. 2010;468:199-208.
11. Health Canada. *Arthritis in Canada: An Ongoing Challenge*. Ottawa: Health Canada; 2003.
12. Higashi H, Barendregt JJ. Cost-effectiveness of total hip and knee replacements for the Australian population with osteoarthritis: discrete-event simulation model. *PLoS One*. 2011;6:e25403.
13. Jimenez-Garcia R, Villanueva-Martinez M, Fernandez-de-Las-Penas C, et al. Trends in primary total hip arthroplasty in Spain from 2001 to 2008: evaluating changes in demographics, comorbidity, incidence rates, length of stay, costs and mortality. *BMC Musculoskelet Disord*. 2011;12:43.
14. Krause FG, Windolf M, Bora B, et al. Impact of complications in total ankle replacement and ankle arthrodesis analyzed with a validated outcome measurement. *J Bone Joint Surg Am*. 2011;93:830-839.
15. Lavernia CJ, Alcerro JC. Quality of life and cost-effectiveness 1 year after total hip arthroplasty. *J Arthroplasty*. 2011;26:705-709.
16. Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. *Lancet*. 2007;370:1508-1519.
17. Lernout T, Labalette C, Sedel L, et al. Cost analysis in total hip arthroplasty: experience of a teaching medical center located in Paris. *Orthop Traumatol Surg Res*. 2010;96:113-123.
18. Marshall DA, Wasylak T, Khong H, et al. Measuring the value of total hip and knee arthroplasty: considering costs over the continuum of care. *Clin Orthop Relat Res*. 2012;470:1065-1072.
19. Norman-Taylor FH, Palmer CR, Villar RN. Quality-of-life improvement compared after hip and knee replacement. *J Bone Joint Surg Br*. 1996;78:74-77.
20. Pugely AJ, Lu X, Amendola A, et al. Trends in the use of total ankle replacement and ankle arthrodesis in the United States Medicare population. *Foot Ankle Int*. 2014;35(3):207-215.
21. Rana AJ, Iorio R, Healy WL. Hospital economics of primary THA decreasing reimbursement and increasing cost, 1990 to 2008. *Clin Orthop Relat Res*. 2011;469:355-361.
22. Rissanen P, Aro S, Sintonen H, Slatis P, Paavolainen P. Quality of life and functional ability in hip and knee replacements: a prospective study. *Qual Life Res*. 1996;5:56-64.
23. Rissanen P, Aro S, Slatis P, Sintonen H, Paavolainen P. Health and quality of life before and after hip or knee arthroplasty. *J Arthroplasty*. 1995;10:169-175.
24. Robinson JC, Pozen A, Tseng S, Bozic KJ. Variability in costs associated with total hip and knee replacement implants. *J Bone Joint Surg Am*. 2012;94:1693-1698.
25. Sanchez-Sotelo J, Haidukewych GJ, Boberg CJ. Hospital cost of dislocation after primary total hip arthroplasty. *J Bone Joint Surg Am*. 2006;88:290-294.
26. Singer S, Klejman S, Pinsker E, Houck JR, Daniels T. Ankle arthroplasty and ankle arthrodesis: gait analysis compared with normal controls. *J Bone Joint Surg Am*. 2013;95:e191(1-10).
27. Stundner O, Kirksey M, Chiu YL, et al. Demographics and perioperative outcome in patients with depression and anxiety undergoing total joint arthroplasty: a population-based study. *Psychosomatics*. 2013;54:149-157.
28. Terrell RD, Montgomery SR, Pannell WC, et al. Comparison of practice patterns in total ankle replacement and ankle fusion in the United States. *Foot Ankle Int*. 2013;34(11):1486-1492.
29. Vekeman F, LaMori JC, Laliberte F, et al. In-hospital risk of venous thromboembolism and bleeding and associated costs for patients undergoing total hip or knee arthroplasty. *J Med Econ*. 2012;15:644-653.