

IMPACT OF COST REDUCTION PROGRAMS ON SHORT-TERM PATIENT OUTCOME AND HOSPITAL COST OF TOTAL KNEE ARTHROPLASTY

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Background: During the 1990s, cost reduction programs were developed to decrease the hospital cost of total knee arthroplasty. The purpose of this study was to evaluate the impact of hospital cost reduction programs for total knee arthroplasty on patient outcome at our hospital.

Methods: We evaluated 159 patients who had undergone unilateral primary total knee arthroplasty for the treatment of osteoarthritis at the Lahey Clinic. The results of fifty-six knee replacements performed in 1992 without a clinical pathway or a knee-implant standardization program (the control group) were compared with the results of 103 knee replacements performed in 1995 with a clinical pathway and a knee-implant standardization program (the study group). Before the operation, the two patient populations were similar in terms of age, pain score on a visual analog scale, and clinical knee scores; the groups were also similar with regard to the surgical approach and the time in the operating room. The minimum duration of follow-up was eight years for the control group and five years for the study group.

Results: All patients in both groups had excellent relief of pain and improvement in function. There were no differences in clinical outcome between the patient groups. The rate of patient satisfaction was 98% in the control group and 99% in the study group. Implementation of the clinical pathway was associated with a reduction in the average length of the stay in the hospital from 6.79 days in 1992 to 4.16 days in 1995. Implementation of the knee-implant standardization program was associated with increased use of all-polyethylene tibial components in 1995. Hospital cost adjusted for medical inflation was reduced 19% with the implementation of the clinical pathway and the knee-implant standardization program.

Conclusions: The clinical pathway and the knee-implant standardization program reduced resource utilization and hospital cost for total knee arthroplasty without affecting short-term patient outcome in our hospital. Orthopaedic surgeons should carefully evaluate cost reduction programs, which may affect their patients, in order to maintain high-quality orthopaedic care and consistently successful patient outcomes.

Total knee arthroplasty is an expensive operation with a high cost per case and a high volume of cases in this country. The Medicare program has realized unprecedented increases in expenditures for total knee arthroplasty, and this operation has been targeted for cost control by the Centers for Medicare and Medicaid Services (CMS). Proposed methods for control of CMS cost and hospital cost for knee replacement operations include reducing the volume of knee replacements performed, reducing the use of services and supplies for each operation, and reducing the unit cost of

services and supplies for each operation.

Use of services and supplies has been reduced through utilization review and clinical pathways¹⁻⁵. A clinical pathway in health care is a protocol or algorithm that standardizes patient care from the initial diagnosis to the hospital discharge or the expected patient outcome. The goal of a clinical pathway is to improve clinical efficiency, cost-effectiveness, and quality of care. The Mayo Clinic implemented a clinical pathway for knee replacement and reported a reduction in hospital charges and the length of the hospital stay without an increase in complications^{1,2}. One of us (W.L.H.) and Finn demonstrated that utilization review substantially decreased the length of the hospital stay and the use of supplies for total knee arthroplasty⁶.

TABLE I Preoperative Comparison of Cohorts

	1992	1995	P Value for Difference Between Groups
No. of patients	56	103	
Mean age (range) (yr)	70.66 (45-88)	69.53 (46-91)	0.4453
Mean weight (range) (kg)	80.7 (49.0-121.6)	86.5 (54.4-136.1)	0.0242†
Mean pain score (range) on visual analog scale*	7.13 (4-10)	6.89 (0-10)	0.4890
Mean Knee Society knee score (range) (points)	43.61 (8-69)	51.58 (0-93)	0.0015†
Mean Knee Society function score (range) (points)	45.18 (0-80)	49.90 (0-100)	0.0797
Mean Hospital for Special Surgery knee score (range) (points)	57.68 (36-80)	60.64 (24-84)	0.8982
Mean arc of maximum flexion-maximum extension (range) (points)	97.59 (40-125)	92.44 (55-120)	0.0312†

*The scale ranged from 0 (no pain) to 10 (severe pain). †Significant.

The cost of joint implants for hip or knee replacements is the largest single unit cost in the hospital cost of total joint arthroplasty^{4,6,7}. The American Academy of Orthopaedic Surgeons^{8,9} estimated that joint implants can account for as much as 40% to 50% of the Medicare DRG (diagnosis-related-group) 209 hospital payment for total joint arthroplasty. The Academy and *The Journal of Bone and Joint Surgery* have encouraged surgeons to help their hospitals to control the costs of implants for joint replacement operations⁸⁻¹⁰.

In an effort to control the hospital cost of knee replacement at the Lahey Clinic, two cost reduction programs were implemented: a clinical pathway and a knee-implant standardization program. The clinical pathway for knee replacement was designed to standardize and improve care, reduce the length of the hospital stay, and reduce hospital cost. The knee-implant standardization program was designed to reduce variation in knee-implant selection and reduce the cost of knee implants for the hospital.

Controlling hospital costs is necessary in the health-care economy of 2002, but orthopaedic surgeons are first and foremost patient advocates. Surgeons must ensure that implementation of hospital cost reduction programs has no adverse effect on clinical results of treatment or patient outcome. This study was performed to evaluate the impact of a clinical pathway and a knee-implant standardization program on the short-term clinical and functional outcomes of total knee arthroplasty.

Materials and Methods

The Lahey Clinic clinical pathway for total knee arthroplasty was developed by a multidisciplinary committee of orthopaedic surgeons, internists, physician's assistants, nurse practitioners, nurses from the inpatient and ambulatory services, physical and occupational therapists, social workers/case managers, and hospital administrators. The clinical pathway begins when the decision is made to perform a knee re-

placement operation, continues throughout the acute-care hospitalization, and includes a post-acute-care pathway for rehabilitation and physical therapy¹¹.

The Lahey Clinic knee-implant standardization program was developed to assist surgeons in knee implant selection, to reduce variation in implant selection, and to reduce knee implant cost for the hospital. This program, which was developed by orthopaedic surgeons, is based on a patient-type scoring system that is used to evaluate the expected demand that patients will place on their knee implants after the replacement. This score includes five objective patient variables related to demand: age, weight, expected activity after the replacement, general health, and bone stock (see Appendix). On the basis of the patient-type scores, patients were assigned to one of four demand categories by the operating surgeon (see Appendix). The designers of this program did not make assumptions about the effectiveness of different designs and materials of the various implants. The knee-implant standardization program permitted maximum flexibility in implant choice for patients in high-demand categories, and it recommended specific, less expensive implants (with well-documented surgical results¹²⁻¹⁴) for patients in lower-demand categories¹⁵. The orthopaedic surgeons at the Lahey Clinic complied with the knee-implant standardization program for the vast majority of their patients. However, they were allowed to choose any nonconforming knee implant for their patient if they had compelling reasons to do so.

The clinical pathway and the knee-implant standardization program were developed and implemented at the Lahey Clinic by the orthopaedic surgeons. The impact of these programs was evaluated in 159 patients who had a unilateral total knee replacement (CPT [current procedural terminology] code 27447) for osteoarthritis of the knee (ICD-9 [International Classification of Diseases—Ninth Revision] code 715.96). Fifty-six consecutive patients who had a knee replacement in 1992 were compared with 103 consecutive patients who had a

knee replacement in 1995. Patients operated on in 1992 were not treated with a clinical pathway or a knee-implant standardization program. Patients operated on in 1995 were treated with a clinical pathway and knee-implant standardization program.

Preoperatively, the patient cohorts were similar with regard to age, pain score on a visual analog scale, Knee Society function score¹⁶, and The Hospital for Special Surgery knee score¹⁷, but the patients treated in 1995 (the study group) were significantly heavier, had a significantly higher Knee Society knee score, and had significantly less preoperative motion of the knee than did the patients treated in 1992 (the control group) (Table I).

All patients were treated through a midline approach and with a quadriceps-splitting anteromedial arthrotomy. The two groups of patients spent a similar amount of time in the operating room. In 1992, most patients (91%) were treated with a posterior cruciate ligament-retaining implant; in 1995, fifty-five patients (53%) were treated with a posterior cruciate ligament-retaining implant and forty-eight (47%) were treated with a posterior cruciate ligament-sacrificing or substituting implant ($p < 0.0001$). This difference was the result of a change in the implant preference of one surgeon. In 1992, none of the fifty-six patients were treated with an all-polyethylene tibial implant. In 1995, fourteen (14%) of the 103 patients were treated with an all-polyethylene tibial implant ($p = 0.0023$).

TABLE II Comparison of Outcome Before (1992) and After (1995) Implementation of Cost Reduction Program

	1992	1995	P Value for Difference Between Groups
No. of patients	56	103	
No. responding	47	95	
No. of deaths	9	8	
Minimum duration of follow-up (yr)	8	5	
Mean pain score (range) on visual analog scale*	0.94 (0-5)	0.86 (0-10)	<0.400
Mean Knee Society knee score (range) (points)	90.75 (45-100)	92.11 (60-100)	>0.500
Mean Knee Society function score (range) (points)	74.69 (0-100)	75.11 (20-100)	>0.500
Mean Hospital for Special Surgery knee score (range) (points)	86.92 (56-98)	88.06 (61-98)	>0.500
Mean arc of maximum flexion-maximum extension (range) (points)	110.00 (90-125)	113.24 (75-130)	<0.200
Satisfied with total knee arthroplasty (no. of patients)			1.0000
Yes	46 (98%)	94 (99%)	
No	1 (2%)	1 (1%)	
Disposition (no. of patients)			<0.0001†
Home	34 (61%)	1 (1%)	
Post-acute-care facility	22 (39%)	102 (99%)	
Readmission within 4 mo. after operation (no. of patients)	3	4	0.7000
Reoperation (no. of patients)			0.2143
Manipulation under anesthesia	2	4	0.9999
Revision	2	0	0.1283
Average length of hospital stay (range) (day)	6.79 (3-19)	4.16 (3-9)	<0.0001†
Mean actual hospital cost (range) (dollars)	10,043.11 (7331-19,980)	8747.18 (6254-15,225)	<0.0001†
Mean inflation-adjusted hospital cost (range) (1995 dollars)	10,804.98 (7961-21,698)	8747.18 (6254-15,225)	<0.0001†

*The scale ranged from 0 (no pain) to 10 (severe pain). †Significant.

This difference was due to the knee-implant standardization program (see Appendix).

The minimum follow-up period for the control group was eight years; the minimum follow-up period for the study group was five years.

The impact of the clinical pathway and knee-implant standardization program was evaluated on the basis of a pain score on a 10-point visual analog scale (0 indicates no pain, and 10 indicates severe pain), three clinical knee scores (Knee Society knee score, Knee Society function score, and The Hospital for Special Surgery knee score), range of motion, patient outcome data, patient satisfaction, disposition after acute hospitalization, need for hospital readmission, need for manipulation under anesthesia, need for a revision operation, length of hospital stay, implant cost, and hospital cost. The database for the study, which was developed in conjunction with Summit Medical (Minneapolis, Minnesota)¹⁸, has several modules: preoperative data, surgical data, hospital utilization data, clinical follow-up data, outcome data, and financial data. All clinical and outcome data were collected prospectively. Outcome information was collected with use of a patient questionnaire that was distributed by the nursing staff and was completed by patients. The 1992 hospital costs were determined by conversion of hospital charges with use of cost-to-charge ratios that are government-mandated and department-specific. The 1995 hospital costs were determined by a resource-based cost accounting system developed by Transition Systems (TSI) (Boston, Massachusetts). Hospital costs were compared in terms of actual dollars and inflation-adjusted dollars.

Statistical analyses included the Student *t* test for continuous variables. Contingency tables were analyzed with use of the chi-square test and the Fisher exact test, when indicated. All probability values were two-tailed, with $p < 0.05$ regarded as significant.

Results

As assessed at the minimum eight and five-year follow-up evaluations, the total knee arthroplasties were successful in relieving pain and improving function, without a significant difference between the two groups. The three clinical knee scores (the Knee Society knee score, Knee Society function score, and The Hospital for Special Surgery knee score) improved in both groups, with no significant difference between groups. The range of motion also improved in both groups, again with no difference between groups (Table II).

Considerable improvement was documented with regard to such patient outcomes as activity, stair-walking, need for walking support, and distance that the patient could walk, and there was no difference in the improvement between groups. Outcome questions also documented improvement regarding sleep, function in activities of daily living, enjoyment of recreation, decrease in knee pain, and decrease in use of medications for knee pain. Ninety-eight percent of the controls and 99% of the study patients were satisfied with the results of the knee replacement (Table II).

Patient disposition following hospital discharge differed

between the two groups because of implementation of the clinical pathway. In the 1992 control group, thirty-four patients (61%) were discharged to home and twenty-two patients (39%) were discharged to a rehabilitation hospital or skilled nursing facility. In the 1995 study group, one patient (1%) was discharged to home and 102 patients (99%) were discharged to a rehabilitation hospital or skilled nursing facility. This difference was significant ($p < 0.0001$).

Three patients were readmitted to the hospital and there was a total of four readmissions (three for manipulation under anesthesia and one for evacuation of a hematoma) within four months after the operation in the control group. In the study group, four patients were each readmitted to the hospital once (for manipulation under anesthesia) within four months after the operation. The hospital readmission rates did not differ significantly between the two groups ($p = 0.7000$) (Table II).

In the 1992 control group, two knees (3.6%) were manipulated a total of three times, at an average of 5.3 weeks following the operation or the previous manipulation. In the 1995 study group, four knees (3.9%) required manipulation at an average of 8.3 weeks following the total knee arthroplasty. The difference in the prevalence of manipulation was not significant ($p = 0.9999$) (Table II).

At the time of follow-up, at a minimum of eight years postoperatively, two patients (4%) in the 1992 control group had required revision surgery: one had an isolated femoral revision at 4.7 years, and one had an isolated tibial revision at 2.0 years. At the time of follow-up, at a minimum of five years, no patient in the 1995 study group had required revision surgery. This difference in the prevalence of revision operations was not significant ($p = 0.1283$).

There was a significant difference in the average length of the hospital stay between the two study groups ($p < 0.0001$). In 1992 the average length of the stay was 6.79 days, whereas in 1995 it was 4.16 days. This difference is related to the clinical pathway and the higher number of patients discharged to post-acute-care facilities in 1995.

From 1992 to 1995, the cost of knee implants (a cemented condylar femoral component, a cemented modular tibial base-plate, a polyethylene tibial insert, and a cemented all-polyethylene patellar component) decreased 34.9% at the Lahey Clinic. The cost of knee implants was gradually reduced by negotiated vendor discount, knee-implant standardization, and a competitive-bid implant-purchasing program¹⁹. (We cannot disclose specific prices paid to implant manufacturers.) The impact of the knee-implant standardization program on the average implant cost can be measured by quantifying the dollar value of a change in implant selection due to the standardization program. From 1992 to 1995, we increased our use of all-polyethylene tibial implants from 0% (of fifty-six) to 14% (fourteen of 103). In 1995, the use of an all-polyethylene tibial implant reduced the average cost of knee implants for total knee arthroplasty by 24.7%.

The clinical pathway and knee-implant standardization program were associated with reduced hospital cost for total

knee arthroplasty (Table II). The actual average hospital cost was reduced by \$1295.93, which is 12.9% per admission ($p < 0.0001$). The inflation-adjusted average hospital cost was reduced by \$2057.80, which is 19.0% per admission ($p < 0.0001$). This reduction in hospital cost was due to the reduced length of the hospital stay and reduction in the cost of knee implants.

Discussion

The popularity of total knee arthroplasty can be attributed to its success in relieving pain, correcting deformity, and improving function for patients with arthritic knees. There were 335,176 knee replacement operations in the United States in 2000, which represents an increase of 22.5% from the number in 1999²⁰. As the population of the United States increases and grows older, it is likely that more patients will seek knee replacement as a means of treating painful arthritic knees. It is also likely that the total cost for knee replacements in this country will increase during the next decade. The Medicare program provides hospital payment for approximately two-thirds of the knee replacements in the United States through the diagnosis-related-group (DRG) payment program, and the federal government is concerned about the increasing prevalence and cost of total knee arthroplasties. In general, hospital reimbursement for knee replacement operations in 2002 is based on case-price payment, which is adjusted annually. All expenses related to the hospital care must be deducted from a fixed amount of payment dollars. On October 1, 2001, Medicare decreased payment to hospitals for joint replacement operations by 1.8%²¹.

In response to the economic reality of joint replacement surgery, the Department of Orthopaedic Surgery at the Lahey Clinic implemented a clinical pathway and a knee-implant standardization program in order to control the hospital cost of knee replacement without compromising our commitment to quality patient care. The surgeons were motivated to reduce costs because the Lahey Clinic Group Practice owns the Lahey Clinic hospital.

The results of this study showed that cost reduction programs can reduce the hospital cost of total knee arthroplasty while maintaining high-quality care. Patients in the control group and in the study group reported reduced pain and improved function. The short-term outcomes were not significantly different for patients treated with or without the cost reduction programs, but the length of the hospital stay, implant cost, and hospital cost were significantly reduced. The results of this study are similar to those of our previous study of the impact of cost reduction programs for total hip arthroplasty²². While these cost reduction programs for hip and knee replacement operations were clinically and economically successful at the Lahey Clinic, and they could be successful at any hospital, this study does not prove that they would succeed at all hospitals.

The implementation of the clinical pathway at the Lahey Clinic was associated with a change in the disposition of patients at the time of discharge from the acute-care hospital. In 1992, 39% of the patients were discharged to a post-acute-care facility. In 1995, 99% of the patients were discharged to such a

facility. This change in practice was due to the clinical pathway. The practice of early discharge to a post-acute-care facility such as a rehabilitation hospital or skilled nursing facility allows patients to leave the acute-care hospital earlier than they could if they were discharged to home. When patients were discharged to a post-acute-care facility, the acute-care hospital collected the full case price payment for service and reduced their expenses for service. This practice has been called cost-shifting because while the acute-care hospital realizes a benefit, the patient generates new expenses at the post-acute-care facility for the payer, health plan, or insurance company. Medicare has attempted to discourage this practice with the Transfer Rule in the Balanced Budget Act of 1997. The Transfer Rule provides less reimbursement to hospitals for joint replacements when patients are transferred to post-acute-care facilities earlier than the average length of stay for DRG 209. In 2000, the average length of the stay for knee replacement in our acute-care hospital was four days; 27% of the patients were discharged to home, and 73% were discharged to a post-acute-care facility.

The implementation of the knee-implant standardization program at the Lahey Clinic was associated with a reduction in the average cost of knee implants in 1995 primarily because of the use of all-polyethylene tibial components when recommended by the standardization program. All-polyethylene tibial implants have demonstrated predictably successful outcomes¹²⁻¹⁴, and knee surgeons in our department are equally skilled in implanting modular tibial components and all-polyethylene tibial components. This may not be true in all practices or at all hospitals. In 2002, we utilize a single price/case price purchasing program for buying knee implants. This program is more effective than knee implant standardization for reducing implant cost. It simplifies implant selection for surgeons and implant purchasing for hospitals, and it does not ask surgeons to use techniques or implants that they may not prefer¹⁹.

The ultimate measure of successful cost-containment in total joint arthroplasty should include the costs of hospital readmission and revision surgery. The rate of hospital readmission was not different between the two groups of patients in our study; however, eight and five years are short-term periods of follow-up. We will continue to observe these patients prospectively to determine intermediate and long-term rates of revision. The impact of cost reduction programs for knee replacement should be reevaluated at regular intervals.

More than 90% of patients with total knee arthroplasty are expected to have a good or excellent result for ten years or more. In this study, both groups had low pain scores, high clinical scores, and a high rate of patient satisfaction at eight and five years postoperatively. The clinical pathway and knee-implant standardization program were associated with reduced costs and maintenance of excellent patient outcomes. As the health-care economy evolves, orthopaedic surgeons will be asked to participate in programs to increase revenues and decrease expenses for the hospitals and health-care systems with which they work. Orthopaedic surgeons should carefully evaluate these programs and ensure that patient care is not compro-

mised in the interest of economics. Patient care and excellent patient outcomes must always be the highest priority for orthopaedic surgeons, especially in a difficult health-care economy.

Appendix

eA The Lahey Clinic knee-implant standardization program, including the patient-type scoring and the demand categories for implant selection, and a comparison of the operative techniques and types of implants in the two cohorts of patients, presented in tabular form, are available with the electronic versions of this article, on our web site at www.jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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