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VALUE-BASED SHOULDER/ELBOW HEALTHCARE

Preparing for the bundled-payment initiative: the cost and clinical outcomes of total shoulder arthroplasty for the surgical treatment of glenohumeral arthritis at an average 4-year follow-up

Nazeem A. Virani, MD, MPH[a], Christopher D. Williams, BS[b], Rachel Clark, BA, CCRC[a], John Polikandriotis, PhD, MBA, MPH[a], Katheryne L. Downes, MPH[c], Mark A. Frankle, MD[d,*]

[a]*Clinical Research Department, Foundation for Orthopaedic Research and Education, Tampa, FL, USA*
[b]*Medical College, Lake Erie College of Osteopathic Medicine–Bradenton, Bradenton, FL, USA*
[c]*Office of Research, University of South Florida, Tampa, FL, USA*
[d]*Shoulder & Elbow Division, Florida Orthopaedic Institute, Tampa, FL, USA*

Background: The purpose of this study is to report on cost, outcomes, reliability, and safety of total shoulder arthroplasty (TSA) in patients with symptomatic glenohumeral joint arthritis.
Materials and methods: Eighty-three primary TSA patients operated on at a single institution by a single surgeon were prospectively studied for a mean of 48 months (range, 32-69 months). For each patient, validated subjective and independently evaluated objective outcome measures were collected to determine clinical reliability of TSA. In addition, safety—defined as the lack of major complications—and direct costs specific to each patient were collected and analyzed.
Results: There were significant improvements ($P < .01$) in all clinical measures with the exception of the general health component of the Short Form 36 version 2. In addition, the majority of the patients met the criteria set forth for clinical reliability (76 of 83 [92%]) and safety (80 of 83 [96%]). The mean 4-year cost was $17,587, with the hospitalization accounting for 88% of this cost. Fiscal year was found to be responsible for the greatest fluctuation in total cost ($P < .001$). In addition, greater improvements in American Shoulder and Elbow Surgeons function scores ($P = .022$), higher preoperative social functioning scores on the Short Form 36 version 2 ($P < .001$), and female gender ($P = .001$) were correlated with lower cost.
Conclusion: Before operative treatment, patients had moderate to severe shoulder pain and were limited in performing their activities. The mean 4-year cost of $17,587 allowed the purchase of treatment with TSA, leading to a greater than 5-fold reduction in pain and a nearly double improvement in shoulder function with a small risk of harm.

This study was approved by the Western Institutional Review Board (study No. 1098441).

*Reprint requests: Mark A. Frankle, MD, Shoulder & Elbow Division, Florida Orthopaedic Institute, 13020 N Telecom Pkwy, Tampa, FL 33637, USA.
E-mail address: mfrankle@floridaortho.com (M.A. Frankle).

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Keywords: Total shoulder arthroplasty; cost; accountable care organizations; glenohumeral arthritis; safety; reliability

With the continuous rise in health care costs in the face of limited resources, there has been an increasing interest in analyzing the costs and benefits for various elective orthopaedic procedures such as spinal fusion for scoliosis[8] and total hip arthroplasty for osteoarthritis.[2] However, a recently published literature review noted inadequate quality and quantity of publications on the economics of shoulder care.[12]

Primarily in response to an unsustainable rise in health care costs,[1] along with major gaps in insurance coverage, the 111th Congress of the United States enacted the Patient Protection and Affordable Care Act.[17] Accountable care organizations were introduced as part of the bundled-payment initiative under the Medicare Shared Savings Program (Section 3022 of the Patient Protection and Affordable Care Act). Under the bundled-payment initiative, the Centers for Medicare & Medicaid Services would link payments for multiple services that patients receive during an episode of care. One entity (or provider) would be paid a bundled fee and subsequently pay the other components of the fee from this amount. For example, instead of a surgical procedure such as total shoulder arthroplasty (TSA) generating multiple claims from multiple providers, the entire team is compensated with a ‘‘bundled’’ payment that provides incentives to deliver health care services more efficiently while maintaining or improving quality of care and therefore increasing the value. The length of an episode of care for shoulder arthroplasty has not yet been determined nor have the services that will be bundled, with the Centers for Medicare & Medicaid Services currently field testing various bundled-payment models.

The purpose of this study is to analyze the costs and benefits of TSA from the preoperative assessment to the minimum 2-year postoperative clinic visit. We hypothesize that TSA is a reliable and safe procedure for the surgical management of shoulder arthritis as assessed by the likelihood of a patient improving from intervention using both patient-derived and independent third-party objective observer outcome measures (reliability) or having a major complication (safety). The secondary aim is to break down costs into subunits based on the timing (ie, preoperative/intraoperative/postoperative) and nature of the cost (eg, laboratory, implant, and therapy) to identify areas of high cost and variability. Finally, we hypothesize that identifiable patient factors can predict total cost. Ultimately, this information will provide orthopaedic surgeons a mechanism to understand the episode-of-care costs associated with TSA and prepare for the bundled-payment initiative.

Materials and methods

Between April 2004 and May 2006, 179 shoulders underwent primary anatomic TSA at a single institution by the senior author. Indications for surgery were moderate to severe shoulder pain, reduced ability to perform daily function, physical examination that showed consistent reduction of shoulder motion, evidence of glenohumeral arthritis on imaging studies,[21] and failed nonoperative management (including medical management, physical therapy, and cortisone injections). These patients were part of a prior prospective cohort study investigating objectively measured improvements in shoulder function after shoulder arthroplasty.[18]

All patients gave their informed consent to be included in the study. However, to be included, patients had to complete both preoperative and minimum 2-year postoperative independent third-party isometric strength testing as described later. Only the most recent shoulder replacement was included for patients with available strength data who underwent bilateral TSAs.

Of 179 primary TSAs, 83 shoulders in 83 patients met the inclusion criteria for the study. Preoperatively, these patients had symptoms for a mean of 5.7 years (range, 0.3-30.5 years). There were various reasons for nonparticipation in the study (Table I), which required a special visit to be made for detailed isometric strength measurements in the method outlined later. The most common reason was failure to locate (41 of 96), despite multiple attempts including numerous phone calls to all available numbers, requests to follow-up sent by certified mail, and the use of people finder services.

The 83 participating primary TSAs were followed up for a mean of 48 months (range, 32-69 months). Table II summarizes their demographic variables. Of the 96 nonparticipating primary TSAs, 51 had available minimum 2-year clinical follow-up (mean, 53 months; range, 24-89 months), which was compared with the 83 participating TSAs. Clinical follow-up data for the remaining 45 of 96 nonparticipants without minimum 2-year follow-up were also reported but were not statistically compared with participating TSAs because of the short follow-up time, which would not allow for a balanced comparison to be made.

Clinical analysis

We performed an evaluation of prospectively collected subjective and objective clinical data. Subjective data were collected from patient forms preoperatively and at minimum 2-year follow-up. These data included a standardized list of comorbidities (collected preoperatively); the visual analog scale pain score[6,22] ranging from 0 to 10, where 0 is ‘‘no pain at all’’ and 10 is ‘‘pain as bad as it can be’’; the American Shoulder and Elbow Surgeons (ASES) score[15,20]; the Short Form 36 version 2 (SF-36v2) score[14,16,24]; and a patient satisfaction rating on a scale from 0 to 10, where 0 is unsatisfied and 10 is very satisfied.

Table I Reasons for nonparticipation

	No. of shoulders
Unable to locate	39
Poor health/unable to travel	27
Deceased (unrelated to shoulder surgery)	14
Unsatisfied/no longer desire to participate	15
Bilateral TSA (only most recent shoulder included)	1
Total No. of nonparticipating shoulders	96

Similar to the prior study,[18] objective shoulder-specific data collected preoperatively and at minimum 2-year follow-up included isometric shoulder strength measurements performed by an independent physical therapist blinded to the purpose of the study using a Biodex System II dynamometer (Biodex Medical Systems, Shirley, NY, USA). Measurements were obtained in 6 shoulder positions (forward flexion at 0°, 30°, 60°, and 90° and internal rotation and external rotation at 0° of abduction). Patients performed three 5-second trials, advancing to maximal isometric exertion at each position. The highest score obtained was recorded. In addition, shoulder range of motion was videotaped in 4 different ranges and later measured with a digital goniometer according to a previously published protocol.[3]

To derive a summary score indicative of overall shoulder function, defined as the objective outcome summary score (OOSS), the strength and range-of-motion data were combined using a modification of the Florida impairment guidelines[4] as published previously.[18] The response rate for all data is summarized in Table III.

Hospital and clinic charts were reviewed for complications that occurred during the study period. These complications were stratified into major and minor. A major complication included any that required reoperation, readmission, or extensive evaluation and treatment lasting greater than 1 month. Complications not meeting these criteria were considered minor. Finally, any reason for readmission to the hospital (such as the need for rehabilitation) during the study period was also recorded.

Safety was defined by the number of major complications related to the procedure during the entire study period. Reliability was defined by the number of patients who had a clinically significant improvement as defined by either a minimum 15-point improvement on the ASES score[23] or any improvement in the OOSS combined with a satisfaction rating of 9 or 10.

Cost analysis

The period of cost collection mirrored the length of clinical data collection for this study. Cost accumulation began at the preoperative orthopaedic clinic visit. The endpoint was the last follow-up clinic visit recorded in the study (mean, 48 months; range, 32-69 months). Three periods were defined: (1) the prehospitalization period, which included any costs incurred before the day of surgery (mean, 5 days; range, 3-6 days); (2) the hospitalization period, which included costs incurred on the day of surgery and during the patients' hospital stay after surgery (mean length of stay, 2.28 days; range, 0-4 days); and (3) the posthospitalization period, which included costs incurred after the patient was discharged up to the last follow-up visit recorded in the study (mean, 48 months; range, 32-69 months).

The acquisition of cost data for each patient was performed by recording the location and cost of each service. Costs that accrued in the hospital system were provided for each patient by the Decision Support Department of the hospital as direct allocated costs specific to the fiscal year, which included the cost of materials, personnel, resource utilization, rent, and other factors necessary to perform a specific aspect of patient care. Costs that accrued outside the hospital system were defined for each patient by the year-specific regional Medicare reimbursement during the study period. Figures 1, 2, and 3 list the goods and services provided during each of the 3 periods defined, along with the number of patients who received these goods and services. Appendix 1 (available on the journal's website at www.jshoulderelbow.org) provides further details on the goods and services, including the Medicare codes used to derive costs outside the hospital system. Only direct costs related to the TSA procedure were considered. Indirect costs such as the cost of lost wages and productivity were not considered.

The cost of additional treatment for all complications that occurred during the study period was recorded and calculated as stated earlier. The costs of major complications and readmission to the hospital for any reason were reported separately, whereas minor complications were included in the 4-year cost.

Statistical analysis

The Shapiro-Wilk test was used to assess the normality of clinical data. Univariate comparisons were conducted between the preoperative and postoperative time frames by use of the Wilcoxon signed rank test, whereas all other group comparisons were conducted with the *t* test, Mann-Whitney *U* test, or Kruskal-Wallis test where appropriate. Correlations were performed with the Pearson *r* and Spearman ρ where appropriate. Variables were then evaluated individually in the regression model, and significant terms were selected as candidates for the final model. Forward stepwise multivariable analysis was used to investigate the independent effect of the demographic variables, the fiscal year in which the patient underwent treatment, and clinical outcomes on the dependent variable total cost. Observations where $P < .05$ were considered significant.

Results

Clinical analysis

There was a significant improvement in the visual analog scale pain score, the ASES scores, the OOSS, and the SF-36v2 component and summary scores with the exception of the general health component (Table IV). There were no significant differences found between the 83 participants and 51 nonparticipants with available minimum 2-year follow-up in terms of total ASES score and patient satisfaction (Appendix 2, available on the journal's website at www.jshoulderelbow.org). In addition, there were 3 major complications and 2 readmissions for inpatient rehabilitation among the participants compared with 3 major complications and 1 readmission among the nonparticipants.

Table II Demographic variables for study participants

	Data	Additional information
No.	83	
Gender (No.)		
Male	45	
Female	38	
Mean age (y)	66 (range, 35-89)	
Race (No.)		
White	68	
Native American	6	
African American	4	
Hispanic	2	
Other	2	
No response	1	
Hand dominance (No.)		42 with surgery on nondominant side and 41 with surgery on dominant side
Right handed	71	
Left handed	12	
Surgical side (No.)		
Left	46	
Right	37	
Mean No. of comorbidities	4 (range, 0-11)	
Indications (No.)		Samilson arthritis grade[21]:Severe in 78/83 (94%) Moderate in 3/83 (4%) Mild in 1/83 (1%) Not available in 1/83 (1%)
Osteoarthritis	70	
Rheumatoid arthritis	6	
Post-traumatic arthritis	3	
Unspecified DJD	4	
Follow-up	48 mo (range, 32-69 mo)	24-36 mo in 6 patients 36-48 mo in 33 patients 48-60 mo in 34 patients >60 mo in 10 patients

DJD, Degenerative joint disease.

As shown in Table V, major complications occurred in 3 of 83 patients (4%). One patient had a postoperative cellulitis that was successfully treated with re-hospitalization for intravenous antibiotics. The second patient had a postoperative brachial plexus palsy that resolved over a period of 25 to 32 months with observation and outpatient physical/occupational therapy. This patient did not require any further procedures. The third patient had a postoperative reflex sympathetic dystrophy that was treated unsuccessfully with home physical/occupational therapy. On the basis of these patients' satisfaction rating, as well as the change in total ASES score and OOSS, only 1 of the 3 patients with major complications met the defined criteria for clinical reliability. There was another patient who had a humeral shaft nonunion stabilized at the same time as the shoulder arthroplasty and required reoperation for the nonunion without any revision of the TSA implants. This patient was not listed as having a major complication because the revision procedure was performed for the nonunion and was not related to the TSA procedure.

Of the 83 patients, 9 (11%) had minor complications including hypokalemia (3), superficial skin tears (3), urinary tract infection (1), temporary left hemidiaphragm paralysis from a postoperative paracervical nerve block (2), acute bronchitis (1), and postoperative ileus (1). Of the 83 patients, 80 (96%) met the defined criteria for safety of the TSA procedure, whereas 76 of 83 (92%) met the defined criteria for reliability of the TSA procedure.

Cost analysis

The mean total 4-year cost of TSA was $17,587 (SD, $1,711; range, $14,713-$26,434) and is stratified into the various subgroups based on the timing and nature of the cost (Figs. 1-3). Goods and services provided by the hospital cost a mean of $13,383 (SD, $1,691; range, $10,737-$22,411), whereas goods and services not provided by the hospital cost $4,204 (SD, $192; range, $3,756-4,853).

The pre-hospitalization, hospitalization, and post-hospitalization periods accounted for 3.5%, 88.4%, and

Table III Data availability for preoperative versus postoperative clinical variables measured in study

	Preoperative	Postoperative	Both preoperative and postoperative
VAS pain score	77 (93%)	83 (100%)	77 (93%)
ASES score			
Pain	77 (93%)	83 (100%)	77 (93%)
Function	76 (92%)	82 (99%)	76 (92%)
Total	76 (92%)	82 (99%)	76 (92%)
SF-36v2			
Physical functioning	76 (92%)	80 (96%)	74 (89%)
Role-physical	74 (89%)	80 (96%)	72 (87%)
Bodily pain	74 (89%)	79 (95%)	71 (86%)
General health	73 (88%)	79 (95%)	70 (84%)
Physical component summary	69 (83%)	78 (94%)	66 (80%)
Vitality	73 (88%)	79 (95%)	70 (84%)
Social functioning	75 (90%)	79 (95%)	72 (87%)
Role-emotional	73 (88%)	80 (96%)	71 (86%)
Mental health	74 (89%)	79 (95%)	71 (86%)
Mental component summary	69 (83%)	78 (94%)	66 (80%)
OOSS	83 (100%)	83 (100%)	83 (100%)
Patient satisfaction rating	NA	82 (99%)	NA

NA, Not applicable; *VAS*, visual analog scale.
All percentages are derived by dividing the number of responders by the total number of patients included in this study (N = 83).

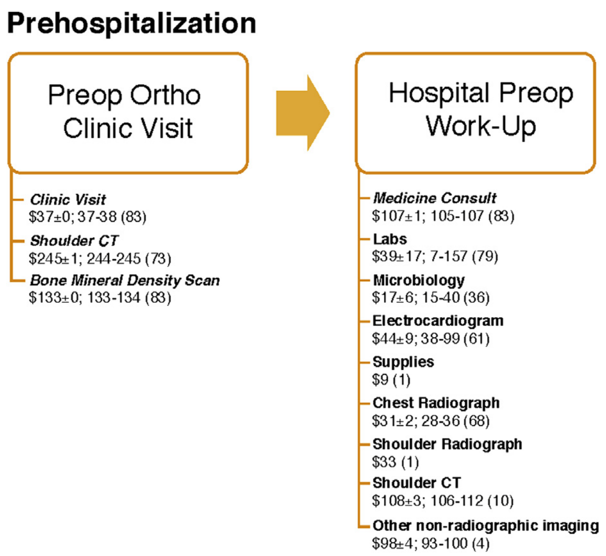

Figure 1 Cost of various aspects of care during pre-hospitalization period. Costs are represented as mean ± standard deviation and range, with the number of patients to whom the cost was attributed in parentheses. Costs provided by the hospital are in normal font, whereas non-hospital costs are in italics. *CT*, Computed tomography; *Ortho*, orthopaedic; *Preop*, preoperative.

8.1% of the 4-year total cost of TSA, respectively. Within the pre-hospitalization period, the shoulder computed tomography scan was the most expensive component of care (37% of pre-hospitalization cost). During the hospitalization period, as well as during the entire 4-year study period, the operating room was the most expensive area (81% of hospitalization cost and 71% of total cost). Within the operating room, the implants were the single most expensive component of care (43% of hospitalization cost and 38% of total cost). The surgeon's fee was $1,470 and was responsible for 8% of total cost. In the post-hospitalization period, home health care was the most expensive component of care (70% of post-hospitalization cost).

The greatest variations of cost seen in the pre-hospitalization, hospitalization, and post-hospitalization periods, respectively, were as follows: the laboratory category, with the SD being 44% of pre-hospitalization cost; the respiratory services category, with the SD being 135% of hospitalization cost; and the follow-up clinic visit and shoulder radiograph cost, with the SD being 42% of the mean cost.

As stated earlier, 3 patients had major complications. One of the patients was readmitted for intravenous antibiotics for postoperative cellulitis. The cost associated with this readmission was $14,647 (Table V). The postoperative brachial plexus palsy required additional care costing $6,089. The third patient, who had unsuccessfully treated reflex sympathetic dystrophy, required additional care costing $24,417.

Two patients were readmitted immediately after the index TSA procedure for inpatient rehabilitation. One patient was readmitted for 32 days at a cost of $17,596, whereas the other patient was readmitted for 8 days at a cost of $6,017.

Relationship of cost to demographic variables and clinical measures of general health and shoulder pain/function

Tables VI and VII show the results of the univariate analysis looking at the effect of demographic variables, fiscal year, and

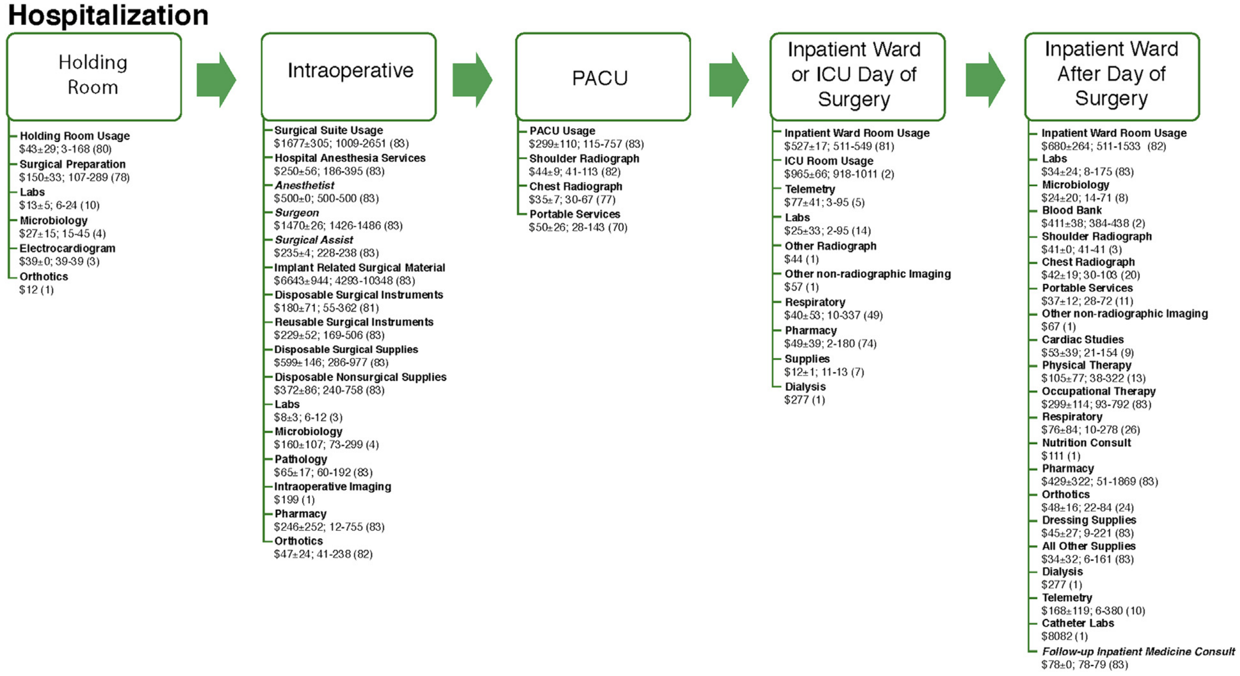

Figure 2 Cost of various aspects of care during hospitalization period. Costs are represented as mean ± standard deviation and range, with the number of patients to whom the cost was attributed in parentheses. Costs provided by the hospital are in normal font, whereas non-hospital costs are in italics. *ICU*, Intensive care unit; *PACU*, postanesthesia care unit.

clinical measures on total cost. Univariate analysis identified fiscal year ($P < .001$) and the preoperative to postoperative difference in the ASES function score ($P = .022$; greater improvements cost less) as variables that had a significant correlation with total cost. Multivariable regression analysis showed that hospital fiscal year ($P = .001$), gender ($P = .001$; female patients cost less), and the social functioning domain of the SF-36v2 ($P < .001$; higher scores cost less) were significant predictors of lower cost.

Discussion

The annual number of shoulder arthroplasties increased 2.5-fold between 2000 and 2008.[10] The number of patients of all ages who underwent total shoulder replacement in 2004, 2005, and 2006 was 15,400, 16,500, and 18,300, respectively, with forecasts that, because of the baby boomer population, this number will increase to around 63,500 by the end of 2020.[7] The federal government has introduced the opportunity to participate in the bundled-payment concept where 1 entity (or provider) would be paid a bundled fee and pay the other components from this amount.[17] Even though the specific methods of treatment selected by the individual surgeon in this study may vary among practitioners, this is the first study to provide orthopaedic surgeons a method of obtaining information that would allow them to manage the episodes of care related to TSA.

In addition, the literature clearly indicates that TSA improves patient outcomes in terms of reducing pain and

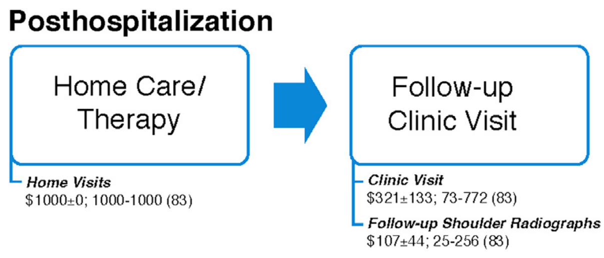

Figure 3 Cost of various aspects of care during post-hospitalization period. Costs are represented as mean ± standard deviation and range, with the number of patients to whom the cost was attributed in parentheses. Costs for the post-hospitalization period were outside the hospital system and are in italics.

improving functionality.[5] By using independent video and strength measurements, this study validates these findings by reporting that 92% of TSA patients met the defined criteria for reliability, with 4% of patients having major complications related to the treatment. However, the cost for this improvement in outcome is not well understood.

A previous shoulder arthroplasty cost study in the literature used a Markov decision analysis model to compare the cost per quality-adjusted life-year for TSA versus hemiarthroplasty.[13] The study found improved cost-effectiveness for TSA in the treatment of glenohumeral arthritis. Our study takes a different approach to analyzing costs of shoulder arthroplasty by looking at costs and outcomes from the point of view of a consumer of health care or from the perspective of an orthopaedic surgeon involved in setting up an accountable care organization.

Table IV Preoperative versus postoperative comparison of subjective and objective outcome measures for patients in study by use of Wilcoxon signed rank test

	Preoperative	Postoperative	*P* value
VAS pain score	6.56	1.25	<.001
ASES score			
Pain	17	44	<.001
Function	22	39	<.001
Total	39	82	<.001
SF-36v2			
PF	37	41	<.001
RP	27	43	<.001
BP	34	45	<.001
GH	48	49	.144
PCS	33	42	<.001
VT	45	50	<.001
SF	42	48	<.001
RE	37	48	<.001
MH	46	51	.001
MCS	45	52	.001
OOSS	36	17	<.001
Patient satisfaction rating		9	

BP, Bodily pain; *GH*, general health; *MCS*, mental component summary; *MH*, mental health; *PCS*, physical component summary; *PF*, physical functioning; *RE*, role-emotional; *RP*, role-physical; *SF*, social functioning; *VAS*, visual analog scale; *VT*, vitality.

The cost data obtained in this study represent the most complete set of direct cost data on shoulder arthroplasty in the literature. The total 4-year cost of TSA was $17,587, with $13,383 attributable to hospital services and $4,204 attributable to other components of care. It was expectedly noted that the operating room was the single most expensive area where costs were incurred. Within the operating room, the implant and related material were the most expensive factors accounting for the cost of care and had a nearly 4 times higher cost compared with the next most expensive factor—surgical suite use. During the prehospitalization period, the shoulder computed tomography scan was the most expensive component of care, accounting for 37% of the cost of care for that period. Removing this test would result in a savings of only 1.29% off the 4-year total cost of TSA. During the posthospitalization period, home health care was the most expensive portion of care, accounting for 70% of the cost of care during that period. Removing this from the postoperative care of patients after TSA would result in a cost savings of 6% from the 4-year total cost of TSA.

The univariate analysis found fiscal year and the preoperative to postoperative difference in ASES function score to be significantly correlated with total cost. The fiscal year at the hospital in this study went from October through September and was found to be responsible for the greatest fluctuation in the total cost of care. Depending on the fiscal year, the total cost went from $688 below to $1,468 above the mean total cost. The reason for these differences in cost is multifactorial and specific to individual line item costs, which may fluctuate depending on material/labor costs, changes in overhead costs, and adjustments for inflation. In addition, the correlation between total cost and the preoperative to postoperative difference in ASES function scores indicates that patients with greater improvements in their shoulder function cost less. The reason for this may be related to the increased need for care after surgery in patients with low functional improvement (more clinic visits and so on).

Because the fiscal year was a large confounding variable, multivariable regression analysis was performed and fiscal year, gender, and the preoperative social functioning domain of the SF-36v2 were ultimately found to have a significant correlation with total cost. Gender has not been previously associated with total cost after shoulder surgery, and the reasons for this association need to be studied further. In our study, the regression model indicated that female patients cost roughly $670 less than male patients. Prior studies have noted differences between men and women in other areas such as reported disability both before and after rotator cuff surgery.[19] Finally, the correlation of the preoperative social functioning domain of the SF-36v2 was an interesting finding that questions the role a patient's mental health has in affecting total cost. For each 1-point improvement in the social functioning domain of the SF-36v2, there was a $34 decrease in total cost. The relationship of mental health to cost has been noted in a prior study, which found that psychiatric comorbidity increased the cost of care in patients undergoing lumbar and cervical disc surgery.[11]

Prior cost studies on TSA focused on the cost of the hospitalization and the surgeon fee based on Medicare reimbursement without considering all the costs associated with clinic visits, other specialties involved, home health care/therapy, and other costs that accrue over the years.[13] Unfortunately, Medicare reimbursement is not necessarily reflective of the actual cost of care but is commonly used in many orthopaedic cost-analysis studies because of the ease of access of these data compared with actual cost calculation using resource utilization techniques.[9] Although Medicare data were used for some components of cost calculation in this study, the hospital cost, which is the largest share of the total cost of shoulder arthroplasty, was determined in conjunction with the Decision Support Department of the hospital. Not all patients in this study were Medicare patients, and this may have overestimated or underestimated the cost calculation for those portions of the study in which Medicare reimbursement data were used. Moreover, regional Medicare reimbursement data as opposed to national averages were used in this study to keep the cost calculation more specific to these patients.

There were a large number of nonparticipants (96 of 179 primary TSAs), which increases the possibility of selection bias. Although we were able to secure some type of follow-

Table V Details on 3 patients who had major complications in study, including cost of treatment

Patient initials	Complication	Time to diagnosis	Readmission/reoperation	Evaluation/treatment	Cost	Outcomes	Reliable?
D.A.	Cellulitis	11 d after surgery	Yes	Inpatient intravenous antibiotics	Hospital: $14,647 Total cost: $14,647	Cellulitis resolved 41-mo follow-up: Total ASES score, 13-point increase OOSS, 5-point decrease* Satisfaction, 9	Yes
C.L.	Brachial plexus palsy	11 d after surgery	No	Observation Outpatient PT Outpatient OT EMG/NCV study	Aquatic therapy, 21 visits: $1,890 PT, 1 episode with 6 visits: $3,240 OT, 2 episodes with 18 visits/episode: $540 EMG/NCV study: $419 Total cost: $6,089	Brachial plexus palsy resolved over period of 25-32 mo 63 mo follow-up: Total ASES score, 27-point decrease OOSS, 3-point decrease* Satisfaction, 4	No
O.W.	Reflex sympathetic dystrophy	1 mo after surgery	No	Observation Home PT Home OT EMG/NCV study MRI of cervical spine	PT, 7 episodes with 18-27 visits/episode: $14,625 OT, 3 episodes with 18-27 visits/episode: $7,875 EMG/NCV study $\times$ 2: $834 MRI: $1,083 Total cost: $24,417	Reflex sympathetic dystrophy unresolved 47 mo follow-up: Total ASES score, 5-point increase OOSS, 12-point increase* Satisfaction, 4	No

EMG, Electromyography; *MRI*, magnetic resonance imaging; *NCV*, nerve conduction velocity; *OT*, occupational therapy; *PT*, physical therapy.

* It should be noted that a decrease in OOSS equals an improvement in objectively measured function (combination of strength and range of motion), whereas an increase in OOSS equals diminished objectively measured function.

Table VI Univariate analysis correlating demographic variables and fiscal year to cost

	Univariate analysis results
Gender	
Female (n = 38)	Mean, $17,525 (SD, $2,140; 95% CI, $16,822-$18,228)
Male (n = 45)	Mean, $17,640 (SD, $1,265; 95% CI, $17,260-$18,020)
P value	.246 (Mann-Whitney)
Age (mean, 66 y; range, 35-89 y)	Correlation coefficient, 0.122
P value	.270
Race	
White (n = 68)	Mean, $17,506 (SD, $1,784; 95% CI, $17,074-$17,937)
Other (n = 15)	Mean, $17,957 (SD, $1,320; 95% CI, $17,226-$18,688)
P value	.121 (Mann-Whitney)
Surgery on dominant side	
No (n = 42)	Mean, $17,639 (SD, $2,167; 95% CI, $16,964-$18,314)
Yes (n = 41)	Mean, $17,534 (SD, $1,088; 95% CI, $17,191-$17,877)
P value	.495 (Mann-Whitney)
Comorbidities (mean, 4; range, 0-11)	Correlation coefficient, 0.094
P value	.398
Fiscal year	
1 (n = 13)	Mean, $18,827 (SD, $847; 95% CI, $18,315-$19,339)
2 (n = 43)	Mean, $17,072 (SD, $1,551; 95% CI, $16,595-$17,549)
3 (n = 27)	Mean, $17,811 (SD, $1,939; 95% CI, $17,044-$18,578)
P value	<.001 (Kruskal-Wallis)

CI, Confidence interval.

Table VII Univariate analysis correlating total cost to shoulder-specific and general health clinical measures

	Preoperative		Postoperative		Preoperative to postoperative difference	
	Correlation coefficient	*P* value	Correlation coefficient	*P* value	Correlation coefficient	*P* value
VAS pain score	0.073	.525	0.044	.692	0.103	.374
ASES score						
Pain	−0.073	.525	−0.044	.692	−0.103	.374
Function	0.220	.057	−0.214	.054	−0.262	.022
Total	0.143	.216	−0.164	.141	−0.279	.105
SF-36v2						
PF	0.024	.839	−0.071	.533	−0.105	.375
RP	0.045	.704	−0.010	.932	−0.211	.075
BP	0.083	.481	−0.038	.739	−0.165	.168
GH	−0.116	.329	0.063	.580	0.038	.754
PCS	0.089	.466	−0.043	.707	−0.185	.137
VT	0.036	.765	−0.041	.719	−0.172	.156
SF	−0.135	.249	−0.072	.526	−0.089	.458
RE	0.071	.550	0.112	.321	−0.093	.442
MH	−0.051	.666	0.040	.726	−0.062	.609
MCS	−0.047	.702	0.038	.740	−0.038	.764
OOSS	−0.074	.509	0.082	.463	0.145	.192
Patient satisfaction rating			0.015	.891		

BP, Bodily pain; *GH*, general health; *MCS*, mental component summary; *MH*, mental health; *PCS*, physical component summary; *PF*, physical functioning; *RE*, role-emotional; *RP*, role-physical; *SF*, social functioning; *VAS*, visual analog scale; *VT*, vitality.

up in these patients (eg, subjective data obtained over the phone), it was difficult to get some of these patients, many of whom were out-of-town referrals, to return to the clinic for the time-consuming objective range-of-motion and strength assessments. Importantly, there were no differences between the participating and nonparticipating groups with minimum 2-year data in either total ASES score or satisfaction rating (Appendix 2, available on the journal's website at www.jshoulderelbow.org), which provides some evidence that selection bias was minimized.

However, a large number of nonparticipating shoulders (45 of 96) did not have minimum 2-year clinical follow-up and may be a source of selection bias, potentially overstating the improvements in patients who benefited from surgery.

Finally, our results cannot be generalized to all TSA patients, especially in low-volume hospitals. The senior author received fellowship training and had 15 years of prior experience in a high-volume shoulder replacement practice at a single institution, which may represent an idealized environment. Regional differences and differences in practice type and individual surgeon preference also make it difficult to generalize the results of this study. A multicenter cost/outcome collection study would be helpful in overcoming some of the previously mentioned study weaknesses. This study is a first step in that direction that shows one methodology of cost/outcome collection that can potentially be used on a larger scale.

Conclusion

In the current health care climate of continuously increasing cost in the face of limited resources, policymakers and private insurance companies often cut reimbursement for elective orthopaedic procedures across the board. Unfortunately, these cuts are often made without regard to the time and material resources required. Part of the problem is the lack of studies that accurately reflect costs of orthopaedic procedures and clinical benefits that accompany the economic burden. In the case of primary shoulder arthroplasty, the 4-year cost of $17,587 may be a reasonable expense, considering significant improvements in both subjective and objective outcome measures at a mean 4-year follow-up with the majority of patients meeting the criteria for reliability and safety. Therefore, potential consumers of health care with daily pain and reduced function from glenohumeral osteoarthritis, which diminish their quality of life, would have to consider whether the same amount of money could provide similar or better value if spent on other forms of medical care for their shoulder.

Disclaimer

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Supplementary data

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