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Original Research

Examining the Relationship Between Value and Patient Satisfaction With Treatment in Total Joint Arthroplasty

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ABSTRACT

Background: A shift toward performance, cost, outcomes, and patient satisfaction has occurred with healthcare reform promoting value-based programs. The purpose of this study was to evaluate the relationship between patient satisfaction and value with treatment in a cohort of patients undergoing total knee arthroplasty (TKA) and total hip arthroplasty (THA).
Methods: Value was determined by the relationship of treatment outcome with episodic cost. Measurements included both clinical outcomes and patient-reported outcomes. Participating surgeons took part in the modified Delphi method resulting in an algorithm measuring patient value. Treatment outcome, cost, and resultant value (outcome/cost) of both TKA and THA were evaluated using binomial logistic regression by adjusting for age, gender, body mass index, Charlson comorbidity index, tobacco, education, and income with patient-reported satisfaction as the outcome.
Results: This study had a total of 909 patients (TKA n = 438; THA n = 471), with an average age of 67 (TKA) and 65 (THA) years. Patient satisfaction shared a significant positive relationship with treatment outcome for TKA (odds ratio [OR] = 1.53, confidence interval [CI] = 1.35-1.73, $P < .001$) and THA (OR = 1.93, CI = 1.62-2.29, $P < .001$). Higher value was associated with a significantly higher odds of patient satisfaction for both TKA (OR = 1.39, CI = 1.25-1.54, $P < .001$) and THA (OR = 1.70, CI = 1.47-1.97, $P < .001$).
Conclusions: This study showed a positive relationship between treatment outcome but not cost with subsequent value and patient satisfaction. This method provides a promising approach to comprehensively evaluate outcomes, cost, and value of total joint arthroplasty procedures. This approach can help predict the probability of value-driven patient satisfaction.

Introduction

Healthcare spending in the United States is significant compared to other industrialized countries. In 2015, Americans spent $3.2 trillion on health care, accounting for 17.8% of the gross domestic product, with projections reaching 20.1% of the gross domestic product in 2025 [1]. In the United States, over 1 million total joint arthroplasty (TJA) procedures are performed each year [2]. The Medicare system is the primary payor for over 60% of TJA procedures [3], accounting for more Medicare spending than for any other medical procedure. Estimates predict that up to 1.5 million TJAs will be performed annually by 2030 [4]. As both the cost and number of procedures continue to increase, the question of whether healthcare delivery is both efficient and effective arises, shifting focus to both patient-centered outcomes and clinical outcomes [1,5,6].

In the past decade, the Centers for Medicare and Medicaid Services' (CMS) promotion of value-based programs (VBPs) has shifted health care away from a fee-for-service system toward one in which reimbursement is based on quality-of-care, commonly

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known as "volume to value" [7]. This shift toward value-based-care is perhaps best exemplified with the passage of the Medicare Access and CHIP Reauthorization ACT in 2015. With this, future payments follow 2 payment tracks: The Merit-Based Incentive Program and the Alternative Payments Model [7]. Here, we are focused on Merit-Based Incentive Program, a fee-for-service model with the addition of a value-based component dependent on quality parameters [7]. This is also known as "pay for performance," in which providers are reimbursed for meeting predefined quality metrics [7]. Quality is determined by both clinical and patient-reported outcomes. Value is typically defined using Porter's framework of outcomes per dollar spent [8,9].

Put simply, this newly evolving value-based care paradigm is focused on improving quality of health care by providing higher outcomes of care at a lower cost to patients [10]. In this new model, health care and provider compensation are more closely tied to value-specific metrics rather than total services provided [7,11,12]. Embracing this new value-based approach requires establishing a formal definition of value and capturing data associated with outcomes and cost at the patient, provider, and system levels. These data can then be utilized to identify levers of change, ultimately leading to improved healthcare quality and care efficiencies.

In line with CMS recommendations, cost and outcome metrics need to be compared in the context of patient-reported satisfaction with treatment. So far, there are no universally agreed upon metrics to capture value after TJA. The purpose of this study was to evaluate the relationship of patient satisfaction with cost, outcome, and value in a cohort of patients undergoing total knee arthroplasty (TKA) and total hip arthroplasty (THA) [10]. We use a value dashboard previously established at our institution where value is determined by patient health outcomes per dollar spent on health services [8,9]. This definition of value is in line with Porter's framework [8,9]. Outcomes include both patient- and physician-reported outcomes, which are reliant on physician performance and thus quality of care. Examples of these outcomes are patient-reported health outcomes (PROMIS-10 global physical functioning measure [PROMIS]) and Knee or Hip Injury and Osteoarthritis Outcome Scores (KOOS Jr./HOOS Jr.) We hypothesize that patient satisfaction with operative treatment will share a significant and positive relationship with outcomes and value across TKA and THA procedures.

Materials and methods

All patients treated in the Department of Orthopaedics at a rural, tertiary, academic medical center were included. Approval was granted by the institutional review board. Patient value was defined in previous work as outcomes divided by direct cost, which included all costs directly tied to the TJA [13,14]. Cost accounting methodology was applied to arrive at specific dollar amounts throughout the care of patients and included both technical and professional aspects of care. The Epic billing system was the data source, which is the origin of all standard Diagnosis-Related Group codes and International Classification of Diseases codes that are tied to individual patients [8]. A customized arthroplasty database geared toward analyzing patient-specific economic impact was used to further extrapolate raw accounting data. Individual patient direct cost was benchmarked against the institutional average direct cost across all TJA-treated patients. Treatment outcome included both clinical and patient-reported health outcomes [PROMIS-10 global physical functioning measure (PROMIS) [13,15], Knee or Hip Injury and Osteoarthritis Outcome Scores (KOOS Jr./HOOS Jr.) [15], modified Single Assessment Numeric Evaluation measure [16,17], 90-day complication, primary joint infection (PJI), and readmission [Eq. (B.1)]. To determine the appropriate weighting for each outcome measure, surgeons who performed THA or TKA at the participating institution were selected as panelists for the modified Delphi method [18]. This resulted in an algorithm to measure patient value [Eq. (B.1)]. Using this methodology, 6 surgeons were selected to survey on TKA, and 5 were selected to survey on THA. All survey rounds were anonymous, and the panelists were explicitly instructed not to discuss their responses. There were multiple survey rounds. After each of the survey rounds, data were analyzed and presented to all panelists, who were then resurveyed and given the opportunity to provide anonymous feedback on the collective responses. After multiple rounds, consensus was reached on the relative weighting of the following variables: PROMIS 10 PCS, HOOS Jr./KOOS Jr., Single Assessment Numeric Evaluation, PJI, readmission, and inpatient complication. There were no significant differences in value analysis between surgeons after the consensus was reached. Weightings from the first survey round did not change significantly from the first to the final survey round and no surgeons held significantly different opinions initially, indicating that at our institution, surgeons held similar beliefs regarding the factors that delivered the greatest value to patients. Eq. (B.1) weightings were 0.12 for PROMIS 10 PCS, 0.19 for HOOS Jr./KOOS Jr., 0.13 for Single Assessment Numeric Evaluation, 0.19 for PJI, 0.20 for readmission, and 0.17 for inpatient complication.

Satisfaction was measured at 9 and 25 months after surgery with the question "How would you rate your satisfaction with the treatments you have been given for your condition thus far?" including 4 response options (unsatisfied, somewhat unsatisfied, somewhat satisfied, satisfied). Considering the skewed response toward satisfied, unsatisfied and somewhat unsatisfied were combined into a single "unsatisfied" category, and somewhat satisfied and satisfied were merged into a single "satisfied" category, resulting in 2 binary outcomes for primary analysis. We believe grouping these into a binary response (satisfied or unsatisfied) did not lead to any loss in our conclusions and likely are more representative of how patients would respond after their joint replacement. Though the authors believe that grouping patient responses into binary categories for analysis is reasonable in this case, it does represent a methodological change and a possible source of error. All relationships were evaluated using binomial logistic regression with patient reported satisfaction (unsatisfied/satisfied) as the outcome; the aforementioned calculations controlled for age, gender, body mass index (BMI), tobacco (yes, quit, no), Charlson comorbidity index (CCI 0, 1, 2+) [19], education (some college, college graduate, college post-graduate), and income (less than 25k, 25k-50k, 50k-75k, 75k+, unknown). Given our sample size, further classification into CI3 and CI4 categories was not included as there were too few data points with which to base a meaningful conclusion. Given that at least 45% of our cohort was CCI 2+, future studies that include more data points are warranted. With more data points, further classification of the CCI will yield a more accurate effect size estimate. Any missing data was accounted for through the use of multiple imputation by chained equations, an informative approach for handling missing data in data set that employs an iterative process of predictive models to impute missing data [20]. Data are displayed as the odds ratio (OR) of patient satisfaction given independent variables of age, gender, BMI, CCI category, tobacco, education level, income, value, outcome, and cost.

Results

Table 1 shows demographics of both TKA and THA patients. For both TKA and THA, the majority of patients were Caucasian. The

Table 1
Sample demographic characteristics.

Demographic	TKA	THA
n	438	471
Age (mean [SD])	66.72 (9.70)	64.87 (10.99)
Gender = Male (%)	190 (43.4)	208 (44.2)
BMI (mean (SD))	31.87 (6.44)	29.83 (6.16)
BMI category (%)		
Underweight (<18.5)	2 (0.5)	2 (0.4)
Normal weight (18.5-24.9)	62 (14.2)	105 (22.3)
Overweight (25.0-29.9)	123 (28.1)	160 (34.0)
Class I obesity (30.0-34.9)	116 (26.5)	95 (20.2)
Class II obesity (35.0-39.9)	87 (19.9)	84 (17.8)
Class III obesity (≥40.0)	48 (11.0)	25 (5.3)
CCI[a] (mean [SD])	1.79 (2.08)	1.67 (2.18)
CCI category (%)		
0	180 (41.1)	229 (48.6)
1	40 (9.1)	29 (6.2)
2+	218 (49.8)	213 (45.2)
Race (%)		
Non-White[b]	8 (1.9)	10 (2.1)
White	425 (97.0)	454 (96.4)
Unknown	5 (1.1)	7 (1.5)

[a] Charlson comorbidity index.
[b] Non-White represented by American Indian/Alaska Native, Asian, and Black or African American individuals.

mode BMI of patients in both THA and TKA had a BMI classification of "overweight."

Six surgeons were included in the analysis of TKA, with a total of 438 patients. The average follow-up was 446 days. The average age for TKA was 67 years, and 43% of this patient population was male (Table 1). Patient satisfaction shared a significant relationship with better treatment outcomes (OR: 1.53, $P < .001$), and advancing age (1.06, $P < .001$) (Table 2). Patient satisfaction was not significantly correlated with gender ($P = .65$), BMI ($P = .133$), CCI = 1 ($P = .737$), CCI = 2 ($P = .072$), tobacco (quit: $P = .866$; yes: $P = .182$), education (some college: $P = .288$; college graduation: $P = .934$; college postgraduation: $P = .757$), income (25-50K: $P = .276$; 50-75k: $P = .374$; 75K+: $P = .171$; Unknown: $P = .873$), or cost ($P = .934$) (Table 2). Patient satisfaction showed a significantly positive relationship with value for TKA (OR = 1.39, $P < .001$) (Table 3).

Table 2
Binary logistic regression predicting patient satisfaction with TKA cost and treatment outcome.

	DV: Satisfaction = *Yes*			
	OR	SE	*P*	95% Confidence interval
(Intercept)	3.85	0.48		1.49-9.94
Age	1.06	0.01	<.001	1.03-1.09
Gender				
Male	1.13	0.27	.650	0.66-1.94
BMI	1.03	0.02	.133	0.99-1.08
CCI category[a]				
1	1.17	0.46	.737	0.47-2.87
2+	0.60	0.29	.072	0.34-1.05
Tobacco[b]				
Quit	1.05	0.28	.866	0.60-1.82
Yes	1.99	0.52	.182	0.72-5.48
Education[c]				
Some college	0.62	0.44	.288	0.26-1.49
College grad	1.04	0.48	.934	0.41-2.67
College postgrad	0.84	0.56	.757	0.28-2.52
Income[d]				
$25-50,000	1.63	0.45	.276	0.67-3.94
$50-75,000	0.64	0.49	.374	0.24-1.70
$75,000+	1.98	0.50	.171	0.74-5.30
Unknown	1.08	0.48	.873	0.42-2.76
Cost	1.01	0.08	.934	0.86-1.18
Treatment outcome	1.53	0.06	<.001	1.35-1.73

[a] Referent: 0.
[b] Referent: No.
[c] Referent: High School.
[d] Referent: Less than $25,000.

Five surgeons were included in the analysis of THA, with a total of 471 patients. Average follow up was 432 days. The average age for THA was 65 years, and 44% of this patient population was male (Table 1). Patient satisfaction shared a significant positive relationship with treatment outcome (OR = 1.92, $P < .001$), advancing age (OR = 1.05, $P = .002$), and income above $75,000/year (as compared to less than $25,000/year, OR = 4.02, $P = .017$) (Table 4). BMI had a significant negative relationship with satisfaction (OR = 0.05, $P = .034$). Patient satisfaction for THA was not significantly associated with gender ($P = 1.62$), CCI (CCI 1: $P = .152$; CCI 2+: $P = .068$), Tobacco (quit: $P = .125$; yes: $P = .062$), education (some college: $P = .063$; graduation: $P = .445$, post graduation: $P = .802$), or income either <75K or unknown (25K-50K: $P = .323$; 50k-75k: $P = .188$; unknown: $P = .143$) (Table 4). Patient satisfaction showed a significantly positive relationship with THA value (OR = 1.70, $P < .001$) (Table 5).

Discussion

Defining value with respect to specific outcome metrics is controversial. The Porter and Tiesberg approach to value-based healthcare states that the main goal of healthcare delivery must be one that achieves high value for patients, with value and outcomes always being defined around the patient [9]. With this method, value is defined as the health outcomes achieved per dollar spent [21]. This ideology demands that patients determine value via health outcomes that directly benefit patients, as defined by patients. Using this approach, the way to transform health care is to realign care toward the greatest value for patients [21]. As such, diligent measurement and improvement of value is the best way to drive system progress [9]. However, to achieve value improvement, specific measurements of patient-centered value must be identified. Once these variables are identified, specific and measurable targets will foster competition. This will drive innovation toward patient-centered value improvement which will ultimately benefit patients, payers, providers, and suppliers, increasing the economic sustainability of the healthcare system [9].

Our study examined the relationship between value, determined by treatment outcome and episodic cost, and patient satisfaction with operative treatment in THA and TKA. These data suggest that for patients undergoing primary THA or TKA, patient satisfaction is positively correlated with value. Importantly, the increased satisfaction was tied to improved outcomes and not cost in our cohorts of patients. This algorithm reveals tangible and quantitative components pertinent to CMS' VBP's that can be targeted as areas of improvement for surgeons in order to maximize value and thus patient satisfaction. Surgeons can better understand their value delivery by collecting PROMs and assessing episodic cost of care. The quantification of value via the assessment of clinical and patient-reported outcomes and direct cost for THA and TKA enables calculation of patient-reported satisfaction for both THA and TKA.

TKA and THA procedures are elective procedures aimed at improving a patient's quality of life. These procedures are costly and are some of the most commonly performed surgeries in the United States, thus they were felt to be good examples to test this model [2,3]. Furthermore, PROM collection after these procedures is increasing and the available literature supporting its collection is robust [22]. CMS VBP links outcomes and costs with the goal of improving value delivery for patients. Value-based care has many

Table 3
Binary logistic regression predicting patient satisfaction with TKA for value.

	DV: Satisfaction = *Yes*			
	OR	SE	*P*	95% Confidence interval
(Intercept)	2.90	0.46		1.18-7.15
Age	1.05	0.01	.001	1.02-1.07
Gender				
Male	1.06	0.27	.828	0.62-1.80
BMI	1.03	0.02	.109	0.99-1.08
CCI Category[a]				
1	1.12	0.45	.795	0.46-2.73
2+	0.62	0.28	.093	0.36-1.08
Tobacco[b]				
Quit	1.04	0.28	.889	0.60-1.79
Yes	1.53	0.49	.387	0.58-4.03
Education[c]				
Some college	0.73	0.43	.463	0.31-1.71
College grad	1.32	0.46	.551	0.53-3.26
College postgrad	0.94	0.55	.917	0.32-2.78
Income[d]				
$25-50,000	1.58	0.44	.300	0.66-3.75
$50-75,000	0.64	0.48	.360	0.25-1.66
$75,000+	1.96	0.50	.178	0.74-5.20
Unknown	1.17	0.47	.740	0.47-2.93
Value	1.39	0.05	<.001	1.25-1.54

[a] Referent: 0.
[b] Referent: No.
[c] Referent: High School.
[d] Referent: Less than $25,000.

proposed system-wide benefits. The goal of this care model is to provide a higher value of care, creating better patient outcomes, higher patient satisfaction rates and care efficiencies, and stronger cost controls [7,11,12]. However, in order to achieve this, the CMS VBP metrics must be measurable. Our study relies on a novel, previously reported approach utilizing commonly obtained metrics to measure value and establishes a model to measure patient satisfaction in both THA and TKA using directly measured cost, outcome, and calculated value.

Table 4
Binary logistic regression predicting patient satisfaction with THA cost and treatment outcome.

	DV: Satisfaction = *Yes*			
	OR	SE	*P*	95% Confidence interval
(Intercept)	8.10	0.55		2.76-23.71
Age	1.05	0.02	.002	1.02-1.08
Gender				
Male	1.52	0.30	.162	0.84-2.75
BMI	0.95	0.03	.034	0.90-1.00
CCI Category[a]				
1	3.55	0.88	.152	0.63-20.17
2+	0.55	0.33	.068	0.29-1.05
Tobacco[b]				
Quit	0.60	0.33	.125	0.31-1.15
Yes	0.41	0.48	.062	0.16-1.05
Education[c]				
Some college	0.36	0.55	.063	0.12-1.06
College grad	0.65	0.57	.445	0.21-1.98
College postgrad	0.86	0.62	.802	0.25-2.92
Income[d]				
$25-50,000	1.71	0.54	.323	0.59-4.96
$50-75,000	2.16	0.58	.188	0.69-6.78
$75,000+	4.02	0.58	.017	1.28-12.61
Unknown	2.22	0.54	.143	0.76-6.45
Cost	0.88	0.13	.355	0.68-1.15
Treatment outcome	1.93	0.09	<.001	1.62-2.29

[a] Referent: 0.
[b] Referent: No.
[c] Referent: High School.
[d] Referent: Less than $25,000.

Table 5
Binary logistic regression predicting patient satisfaction with THA value.

	DV: Satisfaction = *Yes*			
	OR	SE	*P*	95% Confidence interval
(Intercept)	5.65	0.51		2.06-15.52
Age	1.04	0.01	.013	1.01-1.07
Gender				
Male	1.43	0.29	.220	0.81-2.54
BMI	0.96	0.02	.142	0.92-1.01
CCI Category[a]				
1	3.68	0.86	.131	0.68-19.98
2+	0.58	0.32	.091	0.31-1.09
Tobacco[b]				
Quit	0.63	0.33	.161	0.33-1.20
Yes	0.44	0.47	.082	0.18-1.11
Education[c]				
Some college	0.46	0.52	.142	0.17-1.30
College grad	0.80	0.54	.678	0.27-2.32
College postgrad	1.02	0.60	.980	0.31-3.31
Income[d]				
$25-50,000	1.62	0.53	.364	0.57-4.61
$50-75,000	2.21	0.57	.164	0.72-6.72
$75,000+	3.46	0.55	.026	1.17-10.24
Unknown	2.21	0.53	.135	0.78-6.26
Value	1.70	0.07	<.001	1.47-1.97

[a] Referent: 0.
[b] Referent: No.
[c] Referent: High School.
[d] Referent: Less than $25,000.

We found that overall, patients receiving higher value were more likely to be satisfied and less likely to be unsatisfied for both TKA and THA. For both TKA and THA, as outcome and age increased, the odds of patient satisfaction increased, and this is consistent with previous reports of lower satisfaction with health care in younger patient populations [22–28]. For THA, as patient economic indices increased, the odds of patient-reported satisfaction also increased, consistent with current literature reporting higher likelihood of poor satisfaction in patients with lower socioeconomic status [22,29]. BMI was significantly associated with a lower likelihood of satisfaction for THA, but not TKA. Previous studies have shown mixed results on whether BMI affects patient satisfaction in TJA, with some showing obesity to be significantly associated with dissatisfaction after TKA procedures [30–32], and some showing obesity as not a significant factor in patient satisfaction after TKA [33] or THA [34,35] Of note, obesity has been shown to be an independent risk factor for increased postoperative complications, with complications for THA being more profound than TKA [36].

Recent research by Kohring, et al [37] examined the association between patient satisfaction as measured by Press-Ganey score and patient-reported outcome scores in the domains of physical function, mental health, physical health, and pain in the TJA population. The authors reported improvement in preoperative vs postoperative patient-reported outcome scores, suggesting a positive outcome response to surgical intervention. However, little, if any, correlation between patient satisfaction was noted [37]. Patient satisfaction was quantified using Press-Ganey questions which are more focused on satisfaction with provider interaction and communication measuring patient satisfaction for healthcare *delivery*. In the current study, we specifically asked about satisfaction with respect to the *treatments* given. Satisfaction was influenced by the outcome of care which took into consideration PROMs, but did not solely rely on this as the outcome of interest, as we included readily available clinical outcomes as well. This may contribute to our more favorable satisfaction outcomes. Although patient satisfaction is likely linked to both provider interactions and treatments, it's important to consider how patient satisfaction was measured when comparing outcomes. Our findings that TJA leads to overall positive outcomes is in agreement with Kohring et al's study and further links patient outcome with patient satisfaction.

The current study demonstrated an insignificant relationship between cost and satisfaction in both the THA cohort and TKA cohort. In our center, we employ a standardized care pathway for TJA and have utilized a sole-vendor supply chain strategy for our implants. Nonimplant costs such as cement, operative time, and length of stay are less controllable and standardized. Measuring cost in health care can be challenging. We utilized lean baseline methodology which we believe strengthens our analysis and further supports outcome as a main determinant of value and thus patient satisfaction. One survey showed that two-thirds of patients said cost strongly influences satisfaction with their hospital or physician, and 60% of health systems failed to discuss costs with patients [38]. Although an interesting finding, the survey did not ask about satisfaction as it relates to the intervention received. Our data did not suggest that cost is a significant factor in determining patient satisfaction. Furthermore, patients seek surgical treatment with the goal of improved quality of life which is affected by both physical and mental health and not typically driven by cost of care. Patients may have preoperative difficulty with mobility, ability for self-care, and the ability to perform usual activities. It's logical to hypothesize that surgical interventions which improve outcomes related to physical health, subsequent mental health, and ultimately overall quality of life will result in improved patient satisfaction. This theory is supported by a recent study by Ray et al [39], citing positive changes in health-related quality of life associated with patient satisfaction of life before and after THA.

Our study has several limitations. First, it is important to note that our patient population was predominately Caucasian and from one academic medical center, which is not representative of the US population as a whole. Second, THA procedure results should be interpreted with caution as the clear majority of patients endorsed being satisfied with treatment at our institution, which may not be the case at all institutions or for all procedures. Weightings for outcome measures, as determined by surgeons at our institution using the modified Delphi method, may vary between surgeons at other institutions. Additionally, there are limitations within the multiple imputation by chained equation approach used to address the missing data. While multiple imputation by chained equation is a more flexible approach compared to other methods, like regression modeling, for handling missing data, it lacks the theoretical underpinning that some other approaches have. It is possible that a joint model like a multivariate normal approach would have produced more accurate results in this scenario. Methods for addressing multilevel missing data are an area of ongoing research [20].

As stated previously, our standardized approach to care may not be representative of all organizations and could make it difficult to measure differences in satisfaction related to cost. Future studies should align outcome measures with aspects of care that hold particular value for patients, include data from multiple institutions, and include outcome data from a diverse patient population.

Conclusions

Our investigation reveals that better patient outcomes create higher value and has a positive relationship with patient satisfaction. This study establishes a promising and novel approach to determining value as well as its relationship with patient satisfaction. This methodology provides an approach to comprehensively evaluate the 3 characteristics of value-based programs as defined by CMS, which can then be used to compare and improve patient-reported satisfaction with respect to value.

Conflicts of interest

David S. Jevsevar reports being a part of AAOS: Chair, Council on Research and Quality and AAHKS: Chair, Evidence-based Medicine Committee. Wayne Moschetti reports being a part of PJI CPG committee AAOS; is a paid consultant and a part of speakers bureau for Depuy, Smith and Nephew; and has received research support from Depuy, OREF, Microgen, and PCORI. All other authors declare no potential conflicts of interest

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CRediT authorship contribution statement

Mackenzie B. Norman: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Paul M. Werth:** Data curation, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **Benjamin A. Levy:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. **Wayne E. Moschetti:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. **Samuel T. Kunkel:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **David S. Jevsevar:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Appendix 1. Value equation

Equation 1: Patient value

$$P_{Value}=\frac{Wt\left(\frac{\Delta P_{PROMIS}}{I\overline{x}(\Delta P_{PROMIS})}\right)+Wt\left(\frac{\Delta P_{KOOS/HOOS}}{I\overline{x}\left(\Delta P_{KOOS/HOOS}\right)}\right)Wt\left(\frac{\Delta P_{M-SANE}}{I\overline{x}(\Delta P_{M-SANE})}\right)+Wt(P_{Comp})+Wt(P_{PJI})+Wt(P_{Readmit})}{\left(\frac{P_{Cost}}{I\overline{x}(P_{Cost})}\right)}$$

Note: Where *Wt* is the modified Delphi Method defined weight, *P* represented individual patient scores, and $I\overline{x}$ represents institutional average scores. ΔP is the change in PROM scores from preoperation to postoperation. *Comp* is 90-day complication, *PJI* is 90-day primary joint infection, and *Readmit* is 90-day readmission. Note, the modified Single Assessment Numeric Evaluation measure and Patient Reported Outcomes Measurement Information System Global Functioning measure scales are rescaled to a range of 0-100.

Appendix 2
Results of the Delphi process.

Outcome	Surgeon A	Surgeon B	Surgeon C	Surgeon D	Surgeon E	Surgeon F	Average
Round one result of the Delphi method							
PROMIS	25%	15%	9%	10%	10%	15%	14%
HOOS/KOOS	20%	30%	15%	20%	10%	10%	18%
M-SANE	15%	25%	1%	10%	10%	15%	13%
PJI	5%	5%	25%	30%	30%	20%	19%
Readmission	20%	20%	25%	20%	20%	20%	21%
Complication	15%	5%	25%	10%	20%	20%	16%
Total	100%	100%	100%	100%	100%	100%	100%
Round 2 result of the Delphi method							
PROMIS	10%	15%	10%	10%	10%	15%	12%
HOOS/KOOS	20%	25%	25%	20%	15%	10%	19%
M-SANE	10%	25%	10%	10%	10%	15%	13%
PJI	20%	5%	10%	25%	30%	25%	19%
Readmission	20%	20%	20%	20%	20%	20%	20%
Complication	20%	10%	25%	15%	15%	15%	17%
Total	100%	100%	100%	100%	100%	100%	100%

M-SANE, modified Single Assessment Numeric Evaluation measure.

Appendix 3
Procedure complications.

Procedure 90-d complications			
Diagnosis description	Procedure	ICD-10	Count
Postoperative anemia due to acute blood loss	THA	D62	18
Acute UTI (urinary tract infection)	THA	N39.0	7
Dislocation of hip prosthesis	THA	T84.020	6
Postoperative anemia due to acute blood loss	TKA	D62	9
Pulmonary embolism	TKA	I26.99	2
Acute UTI (urinary tract infection)	TKA	N39.0	4
Failed total knee replacement	TKA	T84.0	2

ICD-10, International Classification of Diseases, Tenth Revision.