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Which Factors Are Considered by Patients When Considering Total Joint Arthroplasty? A Discrete-choice Experiment

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Abstract

Background TKA and THA are major surgical procedures, and they are associated with the potential for serious, even life-threatening complications. Patients must weigh the risks of these complications against the benefits of surgery. However, little is known about the relative importance patients place on the potential complications of surgery compared with any potential benefit the procedures may achieve. Furthermore, patient preferences may often be discordant with surgeon preferences regarding the treatment decision-making process. A discrete-choice experiment (DCE) is a quantitative survey technique designed to elicit patient preferences by presenting patients with two or more hypothetical scenarios. Each scenario is composed of several attributes or factors, and the relative extent to which respondents prioritize these attributes can be quantified to assess preferences when making a decision, such as whether to pursue lower extremity arthroplasty.

Questions/purposes In this DCE, we asked: (1) Which patient-related factors (such as pain and functional level) and surgery-related factors (such as the risk of infection, revision, or death) are influential in patients' decisions about whether to undergo lower extremity arthroplasty? (2) Which of these factors do patients emphasize the most when making this decision?

Methods A DCE was designed with the following attributes: pain; physical function; return to work; and infection risks, reoperation, implant failure leading to premature revision, deep vein thrombosis, and mortality. From October 2021 to March 2022, we recruited all new patients to two arthroplasty surgeons' clinics who were older than 18 years and scheduled for a consultation for knee- or hip-related complaints who had no previous history of a primary TKA or THA. A total of 56% (292 of 517) of new patients met the inclusion criteria and were approached with the opportunity to complete the DCE. Among the cohort, 51% (150 of 292) of patients completed the DCE. Patients were administered the DCE, which consisted of 10 hypothetical scenarios that had the patient decide between a surgical and nonsurgical outcome, each consisting of varying levels of eight attributes (such as infection, reoperation, and ability to return to work). A subsequent demographic questionnaire followed this assessment. To answer our first research question about the patient-related and surgery-related factors that most

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influence patients' decisions to undergo lower extremity arthroplasty, we used a conditional logit regression to control for potentially confounding attributes from within the DCE and determine which variables shifted a patient's determination to pursue surgery. To answer our second question, about which of these factors received the greatest priority by patients, we compared the relevant importance of each factor, as determined by each factor's beta coefficient, against each other influential factor. A larger absolute value of beta coefficient reflects a relatively higher degree of importance placed on a variable compared with other variables within our study. Of the respondents, 57% (85 of 150) were women, and the mean age at the time of participation was 64 ± 10 years. Most respondents (95% [143 of 150]) were White. Regarding surgery, 38% (57 of 150) were considering THA, 59% (88 of 150) were considering TKA, and 3% (5 of 150) were considering both. Among the cohort, 49% (74 of 150) of patients reported their average pain level as severe, or 7 to 10 on a scale from 0 to 10, and 47% (71 of 150) reported having 50% of full physical function.

Results Variables that were influential to respondents when deciding on lower extremity total joint arthroplasty were improvement from severe pain to minimal pain (β coefficient: -0.59 [95% CI -0.72 to -0.46]; $p < 0.01$), improvement in physical function level from 50% to 100% (β: -0.80 [95% CI -0.9 to -0.7]; $p < 0.01$), ability to return to work versus inability to return (β: -0.38 [95% CI -0.48 to -0.28]; $p < 0.01$), and the surgery-related factor of risk of infection (β: -0.22 [95% CI -0.30 to -0.14]; $p < 0.01$). Improvement in physical function from 50% to 100% was the most important for patients making this decision because it had the largest absolute coefficient value of -0.80. To improve physical function from 50% to 100% and reduce pain from severe to minimal because of total joint arthroplasty, patients were willing to accept a hypothetical absolute (and not merely an incrementally increased) 37% and 27% risk of infection, respectively. When we stratified our analysis by respondents' preoperative pain levels, we identified that only patients with severe pain at the time of their appointment found the risk of infection influential in their decision-making process (β: -0.27 [95% CI -0.37 to -0.17]; $p = 0.01$) and were willing to accept a 24% risk of infection to improve their physical functioning from 50% to 100%.

Conclusion Our study revealed that patients consider pain alleviation, physical function improvement, and infection risk to be the most important attributes when considering total joint arthroplasty. Patients with severe baseline pain demonstrated a willingness to take on a hypothetically high infection risk as a tradeoff for improved physical function or pain relief. Because patients seemed to prioritize postoperative physical function so highly in our study, it is especially important that surgeons customize their presentations about the likelihood an individual patient will achieve a substantial functional improvement as part of any office visit where arthroplasty is discussed. Future studies should focus on quantitatively assessing patients' understanding of surgical risks after a surgical consultation, especially in patients who may be the most risk tolerant.

Clinical Relevance Surgeons should be aware that patients with the most limited physical function and the highest baseline pain levels are more willing to accept the more potentially life-threatening and devastating risks that accompany total joint arthroplasty, specifically infection. The degree to which patients seemed to undervalue the harms of infection (based on our knowledge and perception of those harms) suggests that surgeons need to take particular care in explaining the degree to which a prosthetic joint infection can harm or kill patients who develop one.

Introduction

TKA and THA are major surgical procedures, and they are associated with the potential for serious, even devastating complications. Patients must weigh the risks of these complications against the potential benefits before deciding to undergo these procedures. Qualitative studies have identified length of stay, complication risk, and pain improvement, among other factors, as involved in the patient's decision-making process to undergo total joint arthroplasty (TJA); however, this type of analysis is limited in its scope and depth [8, 36]. Accordingly, the orthopaedic surgeon is tasked with the responsibility of explaining these risks in their entirety. For example, although the incidence of periprosthetic joint infection (PJI) is low, patients who do develop PJI postoperatively should be aware of the significant psychological and physical consequences that lead to a lower quality of life, which may persist for years even after successful surgical treatment of the infection [23, 42]. Furthermore, there is a financial burden for patients and the healthcare system, with the projected cost of treating PJI estimated to be $1.85 billion by 2030 [28]. Although most potential complications are communicated by the surgeon to the patient during preoperative consultations, research across various surgical fields has revealed that patient preferences are often discordant with surgeon preferences regarding the treatment decision-making process [11, 17, 32, 40]. Moreover, previous studies have shown that verbal descriptions of the risks of orthopaedic surgery, which are commonplace in clinical practice, may be inadequate for patient comprehension when compared with written and video modalities [15, 21]. This poses a serious concern in the decision-making model as patients may not understand the risks associated with TJA because the explanation provided by the surgeon may not be sufficient.

A discrete-choice experiment (DCE) is a quantitative technique widely used in healthcare to elicit patient preferences [5, 6, 35]. In this technique, two or more hypothetical scenarios are presented to patients and they are asked to choose the one they prefer. A DCE is based on the economic theory that any complex decision can be simplified to its core attributes, and the relative extent to which individuals prioritize these attributes guides their decision-making process [31]. Regarding the decision to proceed with lower extremity TJA, patients have the difficult task of weighing numerous potential risks and benefits. Unfortunately, to our knowledge, no data currently exist that quantitively assess the relative importance to patients of different attributes when deciding whether to undergo TJA. Understanding patient preferences and risk tolerance can provide valuable information to healthcare providers responsible for counseling patients, and this may ultimately better align goals and expectations and lead to improved satisfaction.

Therefore, we performed a DCE in which we asked: (1) Which patient-related factors (such as pain and functional level) and surgery-related factors (such as the risk of infection, revision, or death) are influential in patients' decisions about whether to undergo lower extremity arthroplasty? (2) Which of these factors do patients emphasize the most when making this decision?

Patients and Methods

Study Design, Setting, and Patients

This DCE was performed at a 300-bed community, suburban hospital and a 999-bed urban tertiary-care hospital in Massachusetts, USA. From October 2021 to March 2022, we recruited all new patients in two arthroplasty surgeons' clinics (CMM, HSB) who were older than 18 years, who were scheduled for a consultation for knee- or hip-related complaints, and who had no previous history of a primary TKA or THA. We sent a targeted research announcement email to each possible new patient meeting the inclusion criteria within 24 hours before their scheduled appointment; this email informed the patients about a research opportunity that could be discussed in person before their appointment. Patients could select to decline the targeted research announcement, excluding them from participating in the study. To include all potential qualifying patients, we also approached all new patients who did not decline the targeted research announcement in the waiting room of the clinics. These patients had not yet discussed the risks or benefits of TJA with their surgeon nor had they consented to the procedure. A study staff member met interested patients immediately before their surgical consultation visit in person to obtain verbal consent.

Patients were included if they were older than 18 years, were scheduled for a consultation for knee- or hip-related complaints, and spoke English. Patients were excluded if they had a history of THA or TKA, had surgery within 1 year of scheduled TJA, or did not speak English. Throughout the recruitment period of our study, 56% (292 of 517) of new patients met the inclusion criteria and were approached with the opportunity to participate in this study. Approximately 51% (150 of 292) of eligible patients who were approached to participate in the study fully completed the DCE. Based on an a priori power analysis, study recruitment was halted once 150 patients had been recruited.

In an empty examination room, survey administrators obtained verbal consent from patients and provided patients with an informational fact sheet (Supplementary Fig. 1; http://links.lww.com/CORR/A907) and DCE instructions (Supplementary Fig. 2; http://links.lww.com/CORR/A908), which were thoroughly reviewed with patients. All questions were addressed before beginning the surveys. After completing the DCE, patients completed a demographic questionnaire (Supplementary Fig. 3; http://links.lww.com/CORR/A909).

The attributes and levels of the DCE were chosen through a combination of reviewing previous studies and the expert opinion of three fellowship-trained orthopaedic surgeons (CMM, MH, HSB), an approach consistent with published DCE methods [8, 27, 39, 43]. From this comprehensive process, seven attributes with three levels each and one attribute with seven levels were selected for the final DCE (Supplementary Table 1; http://links.lww.com/CORR/A910). Pain level; physical function level; return to work; and the risks of infection, reoperation, implant failure leading to premature revision, deep vein thrombosis (DVT), and mortality were selected as the eight attributes. The levels for pain were minimal, moderate, and severe, with the choice set indicating that these levels corresponded to 0 to 2, 3 to 6, and 7 to 10, respectively, on a scale of 10. For physical function, the levels were either 50%, 75%, or 100% of complete, normal functioning for that respondent. The return-to-work attribute had three levels, each pertaining to a varying time increment to return to work after the procedure: 1 week, 3 months, or no return to work. The attributes pertaining to the risks of infection, reoperation, implant failure leading to premature revision, and DVT each had three levels: 1%, 10%, and 20%. The risk of mortality attribute had seven levels: 0.3%, 1%, 1.5%, 5%, 10%, 15%, and 20%. Although many of the risks presented in our DCE are purposely exaggerated compared with standard risks, these numbers are used to establish granularity, which can then allow for detection of nuanced preferences that may not be evident when asking patients about complications at their true rates of occurrence. However, our use of exaggerated risks introduces a

hypothetical bias, which is a known phenomenon inherent to DCEs stating that patient preferences in a DCE may not be reflective of reality [29].

Using these attributes, we created different scenarios (choice sets) for patients to consider; the choice was between undergoing surgical or nonsurgical treatment for arthritis, given the assigned attribute levels (Supplementary Fig. 4; http://links.lww.com/CORR/A911). These specific combinations of attributes and levels resulted in 6561 unique iterations of outcomes using a full factorial design; all of these iterations could not be feasibly presented to each patient because of respondent fatigue [13]. To address this limitation, we used a technique commonly used in DCE studies known as fractional factorial design to select a representative subset of all possible scenarios to administer to participants. Using this method, we reduced the number of choice sets to 30, each reviewed for plausibility by each team member. The use of 30 unique choice sets (none containing identical attribute levels) is consistent with DCE practice, in which eight attributes require that a minimum of 27 choice sets be used [18]. Alternatives for each choice set were chosen based on a rotating design that limits level overlap and orthogonality [20]. Enrolled patients were randomly assigned 10 of these 30 choice sets. Each choice set consisted of two options, labeled as surgery and no surgery. Given the inclusion of a no-surgery option, no opt-out choice was provided. Each patient was required to select one of the two options until all 10 choice sets had been answered (Supplementary Fig. 4; http://links.lww.com/CORR/A911).

Study recruitment was concluded when 150 complete response sets were recorded. These 150 respondents provided 3000 observations (150 x 20) for analysis.

Participants' Demographic Data

Of the 150 respondents, 57% (85 of 150) were women, the mean age at the time of participation was 64 ± 10 years, and most (95% [143 of 150]) respondents were White. All respondent race/ethnicity categories were derived from patient self-report and were accessed via our institution's electronic health record. The demographic profiles of respondents and nonrespondents (those who declined participation in the study) were not statistically different (Table 1). More than 50% of our patient respondents had completed a bachelor's degree or higher level of education at the time of their appointment (Table 2). In our respondent cohort, 53% (79 of 150) of respondents were currently employed and 41% (61 of 150) were retired. Regarding surgery, 38% (57 of 150) were considering THA, 59% (88 of 150) were considering TKA, and 3% (5 of 150) were considering both. Regarding the respondent's baseline clinical status, 49% (74 of 150) reported their average pain level to be severe, or 7 to 10 on a scale from 0 to 10, and 47% (71 of 150) reported to be at 50% of full physical function.

Study Size

With a significance level set at less than 0.05, and given our number of choice tasks (n = 10), alternatives (n = 1), and the largest number of levels for any attribute (n = 7), our minimum required sample size was 100 patients to ensure 80% power for an effect size of 20% and endpoint of each attribute coefficient to be equal to 0 [3]. This is considered to be a small effect size, and it should be interpreted as if the difference between two groups' means is smaller than 0.2 SDs, which means the

Table 1. Demographics of respondents and nonrespondents

Variable	Nonrespondents (n = 142)	Respondents (n = 150)	p value
Age in years at the time of scheduled appointment	66 ± 11	64 ± 10	0.07
Gender	50 (71)	57 (85)	0.25
Women			
BMI in kg/m^2	28.87 ± 6.20	29.46 ± 6.18	0.42
Race or ethnicity			
White	92 (130)	95 (143)	0.19
Hispanic	5 (7)	2 (3)	0.17
Asian	3 (4)	0 (1)	0.16
Black	0 (1)	1 (2)	0.59
Native American or Alaskan Native	0 (0)	0 (1)	> 0.99
Preferred language			
English	99 (141)	100 (150)	> 0.99

Data presented as mean ± SD or % (n).

Table 2. Respondent demographic information (n = 150)

Parameter	Total
Education level	
Less than a high school diploma	3 (4)
High school diploma or GRE	13 (20)
Associates degree	2 (22)
Bachelor's degree	32 (48)
Master's degree	29 (43)
Advanced professional degree	9 (13)
Joint	
Hip	38 (57)
Knee	59 (88)
Both hip and knee	3 (5)
Employment status	
Employed	53 (79)
Unemployed	7 (10)
Retired	41 (61)
Average pain level on a scale of 0 (no pain) to 10 (worst possible pain)	
Minimal (0-2)	11 (16)
Moderate (3-6)	40 (60)
Severe (7-10)	49 (74)
Current level of physical functioning	
Completely disabled	3 (4)
25% of full physical function	15 (22)
50% of full physical function	47 (71)
75% of full physical function	33 (50)
100% of full physical function	2 (3)

Data presented as % (n); GRE = Graduate Record Examinations standardized test.

difference is negligible regardless of statistical significance [9]. We recruited 150 patients to potentially increase the power of subgroup analyses.

Experimental Overview

DCEs allow researchers to discern how changes in attribute levels impact a respondent's decision-making process. This idea is based on consumer theory, in which respondents always desire to maximize their utility or satisfaction when making any decision [31]. All attributes are assumed to have an independent impact on a respondent's preference, and the combination of these attributes and their corresponding levels helps respondents make decisions. For this study, patients had the choice to pursue a surgical or nonsurgical option when considering treatment for hip or knee osteoarthritis. Therefore, they needed to assess each of the 10 scenarios, analyze the eight attributes and their corresponding levels, and make an informed decision that maximized their utility or overall satisfaction with their choice in each scenario.

Modeling the DCE

Each respondent's preference could be modeled by the weight they placed on each attribute presented to them. All attributes were assumed to have an independent impact on a respondent's preference, which could be modeled for this specific study by the function below:

$$U = \beta_0 + \beta_1 \text{PAINmoderate} + \beta_2 \text{PAINsevere} + \beta_3 50\text{PHYSICAL\_FUNCTION} + \beta_4 75\text{PHYSICAL\_FUNCTION} + \beta_5 \text{INFECTION} + \beta_6 \text{REOPERATION} + \beta_7 \text{IMPLANTFAILURE} + \beta_8 \text{DVT} + \beta_9 \text{MORTALITY} + \beta_{10} \text{RTWthreemonths} + \beta_{11} \text{RTWnoreturn}$$

In this function, U signifies the utility patients received from the treatment of arthritis, β_0 is a constant that represents the respondents' preferences for surgical treatment for their arthritis versus nonsurgical treatment, and β_1 through β_{11} represent coefficients or preference weights that signify the relative weight or importance of its corresponding attribute. U in isolation possesses no inherent meaning. However, respondents attempt to maximize U in the choices they make. The magnitude of the coefficients also has no intrinsic meaning, but these coefficients can be compared with one another to observe how respondents value each attribute, with relatively higher values indicating greater importance placed on that attribute when making a decision. Similarly, lower values indicate lower importance. The sign of a coefficient indicates whether that attribute contributes positively or negatively to U. If a coefficient for an attribute was statistically significant ($p < 0.05$), we interpreted the attribute as being potentially important to the respondent's decision. Tradeoffs between the attributes were determined by comparing the ratios of two attributes' coefficients. This value signified the marginal rate of substitution, which in the setting of our DCE, is the rate at which a patient is willing to experience one outcome to achieve another. As an example, β_8/β_2 represents how much of an increased risk of DVT a patient was willing to accept to have a decrease in pain from severe to minimal when considering treatment for arthritis. These tradeoffs or marginal rates of substitution allowed us to quantify how patients value attributes with respect to one another in their decision-making process.

Primary and Secondary Study Outcomes

To answer our first research question about the patient-related and surgery-related factors that most influence patients' decisions about whether to undergo lower

extremity arthroplasty, we used the data obtained from the DCE to perform a conditional logit regression, which provided absolute coefficients that indicated the relative weight patients placed on each attribute and could indicate whether patients deemed those attributes influential.

To answer our second question about which of those factors patients prioritized the most, we compared the coefficients of influential variables to determine the relative importance of these variables compared with one another.

Ethical Approval

This study was approved by our institutional review board.

Statistical Analysis

We analyzed responses following parameters outlined by the Good Research Practices Task Force [12]. We used a conditional logit regression analysis to analyze response; this is consistent with the random utility theory, which determines that the utility of each choice is a function of its attribute levels [4, 12, 24, 26, 33, 41]. Each answer chosen by each participant and each alternative they do not choose was considered an independent observation in this model. A DCE analysis was performed using methods described by Aizaki and Nishimura [1]. The variables input into the conditional logit regression were patient-assessed attributes. Pain level, physical function level, and return to work were coded with dummy variables, with minimal pain, 100% of complete physical function, and return in 1 week as the omitted reference groups (Supplementary Table 1; http://links.lww.com/CORR/A910). The pain level was presented to respondents in a categorical fashion, in that patients selected among minimal, moderate, and severe levels of pain, corresponding to levels of 0 to 2, 3 to 6, and 7 to 10, respectively, on a scale of 10. The physical function level was also interpreted as a categorical variable. Return to work was coded with a dummy variable because it was also a categorical variable with no continuous interpretation, with return to work 1 week after treatment as the reference. The remaining variables were coded as continuous variables. Responses were reviewed to ensure respondents did not answer all of one option because such patterns could indicate respondent inattention [19]. A calculated β coefficient (preference weight), standard error, and the p value are reported for each attribute. There was a demonstrated statistical difference when the confidence intervals (CIs) for a single attribute's β coefficient did not overlap. A two-tailed p value < 0.05 was considered to indicate statistical significance. To account for potential demographic confounders, we repeated analyses after stratification of the study sample by joint, gender, baseline respondent pain level, and employment status. All statistical analyses were performed using R (The R Foundation) and RStudio (RStudio).

Results

Patient-related and Surgery-related Factors That Influenced the Decision to Have Surgery

We found that patients were willing to take on a hypothetically increased PJI risk after their TJA in exchange for a perceived pain reduction, improved physical function, and the ability to return to work postoperatively.

Respondents preferred surgery resulting in pain reduction from severe pain (β coefficient: -0.59 [95% CI -0.72 to -0.46]; $p < 0.01$) to minimal pain (Table 3). For the return-to-work variable, only the change from no return to work to return in 1 week was prioritized by patients when considering surgery (β: -0.38 [95% CI -0.48 to -0.28]; $p < 0.01$). Improvement in physical function was also important to patients; respondents desired to improve from 50% (β: -0.80 [95% CI -0.9 to -0.7]; $p < 0.01$) and 75% (β: -0.44 [95% CI -0.55 to -0.33]; $p < 0.011$) of complete physical function to 100% when considering surgery. Infection risk was the only procedure-level variable identified as influential to patients when deciding to undergo TJA (β: -0.22 [95% CI -0.30 to -0.14]; $p < 0.01$). Patients did not find the risks of reoperation (β: -0.05 [95% CI -0.12 to 0.3]; $p = 0.51$), implant failure leading to premature revision (β: -0.14 [95% CI -0.23 to -0.05]; $p = 0.10$), DVT (β: 0.07 [95% CI -0.01 to 0.15]; $p = 0.40$), or mortality (β: -0.04 [95% CI -0.12 to 0.04]; $p = 0.66$) to be influential (point of discussion) when considering lower extremity arthroplasty.

The β coefficients for the severe pain, 50% physical function, and 75% physical function attributes were negative, indicating that these variables contributed adversely to respondent desire (utility). This indicates that patients consider living with severe pain and 50% and 75% of complete physical function to be undesirable. The β coefficients for infection risk and no-return-to-work variables were also negative and thus contributed negatively to utility and were undesired by respondents. The signs for these coefficients were as expected, with respondents preferring increased physical function, reduced pain level, reduced infection risk, and reduced likelihood of never returning to work. In addition, a positive constant term indicated that in the absence of the influence of the studied attributes, respondents preferred surgery to no surgery.

Table 3. Conditional logit model results for all patients

Variable	Description	β coefficient	Standard error	p value
Constant		0.17	0.20	0.40
Pain level	Minimal (0-2 of 10)		Constrained to be 0	
	Moderate (3-6 of 10)	0.19	0.13	0.15
	Severe (7-10 of 10)	-0.59	0.13	< 0.01
Physical function level	100% of complete physical function		Constrained to be 0	
	75% of complete physical function	-0.44	0.11	< 0.01
	50% of complete physical function	-0.80	0.10	< 0.01
Risk of infection (per 10% increase)		-0.22	0.07	< 0.01
Risk of reoperation (per 10% increase)		-0.05	0.07	0.51
Risk of implant failure leading to premature revision (per 10% increase)		-0.14	0.09	0.10
Risk of DVT (per 10% increase)		0.07	0.08	0.40
Risk of mortality (per 10% increase)		-0.04	0.08	0.66
Return to work	Return in 1 week		Constrained to be 0	
	Return in 3 months	-0.20	0.12	0.09
	No return to work	-0.38	0.10	< 0.01

The β coefficient, or preference weights, signify the relative weight or importance of a corresponding attribute for participants deciding between surgical treatment for their arthritis as opposed to nonoperative treatment. The magnitude of the coefficients also has no intrinsic meaning, but these coefficients can be compared with one another to observe how respondents value each attribute, with relatively higher absolute values indicating greater importance placed on that attribute during decision-making. The sign (+/-) of a coefficient indicates whether that attribute contributes positively or negatively to the collective participants' utility, or overall benefit gained as a result of choosing surgical treatment for arthritis as opposed to nonoperative treatment.

Which Factors Do Patients Emphasize the Most When Making Surgical Decisions?

Of the attributes deemed important by respondents, improving from 50% physical function to 100% physical function and pain alleviation from severe to minimal were the most influential attributes because they had the largest absolute β coefficient values of -0.80 (95% CI -0.9 to -0.7; $p < 0.01$) and -0.59 (95% CI -0.72 to -0.46; $p < 0.01$), respectively. Patients deemed improvement in physical function from 75% to 100% to be the next most influential attribute, with a β coefficient of -0.44 (95% CI -0.55 to -0.33; $p < 0.01$).

The factors with the least amount of influence on patients' decision-making during the DCE were going from no return to work to return in 1 week, with a β coefficient of -0.38 (95% CI -0.48 to -0.28; $p < 0.01$), followed by infection risk, with a β coefficient of -0.22 (95% CI -0.29 to -0.15; $p < 0.01$).

Regarding potential complications, respondents believed that a change from 50% to 100% physical function was the most important attribute, followed by pain reduction from severe to minimal because they were willing to accept the greatest risk of an infectious complication to achieve these outcomes. Specifically, patients were willing to accept an absolute (and not merely an incrementally increased) 37% infection risk to go from 50% to 100% physical function and an absolute (not an incremental increase) 27% infection risk to go from severe to minimal pain (Supplementary Table 2; http://links.lww.com/CORR/A912). Returning to work was heavily prioritized by respondents as well. We found that patients were willing to accept an 18% infection risk to return to work as opposed to being unable to return to work (Supplementary Table 2; http://links.lww.com/CORR/A912).

Subanalysis Stratified by Joint, Employment Status, Gender, and Preoperative Pain Level

We chose to stratify our analysis by joint, employment status, gender, and the respondent's subjective preoperative pain level (severe versus mild or moderate). When we stratified our analysis by joint, we found differences between the two cohorts. For patients considering THA, we found that pain reduction from severe pain to minimal was the most influential factor, with a β coefficient of -1.04 (95% CI -1.28 to -0.80; $p < 0.01$), followed by improvement in physical function from 50% to 100%, with a β coefficient of -0.86 (95% CI -1.03 to -0.69; $p < 0.01$) (Supplementary Table 3; http://links.lww.com/CORR/A913). For patients considering TKA, improvement in physical function from 50% to 100% (β: -0.83 [95% CI -0.96 to -0.70]; $p < 0.01$) and 75% to

100% (β: -0.44 [95% CI -0.58 to -0.30]; p < 0.01) were the most influential factors, followed by reduction in pain from severe to minimal (β: -0.37 [95% CI -0.51 to -0.21]; p = 0.02) (Supplementary Table 4; http://links.lww.com/CORR/A914).

When we stratified our analysis by employment status (employed versus unemployed and retired), the most notable difference compared with the overall cohort was observed in the second and third most influential variables; employed patients valued improvement in physical function from 75% to 100% (β: -0.62 [95% CI -0.77 to -0.45]; p < 0.01), followed by reduction in pain from severe to minimal (β: -0.59 [95% CI -1.14 to -0.04]; p < 0.01) (Supplementary Table 5; http://links.lww.com/CORR/A915). For unemployed patients, the trends in influential variables were the same as those in the overall cohort, except patients in this subgroup did not appear to place importance on improvement in physical function from 75% to 100% (β: -0.27 [95% CI -43 to -0.11]; p = 0.11) (Supplementary Table 6; http://links.lww.com/CORR/A916).

Stratification by gender revealed that women had a similar pattern of decision-making to the overall cohort (Supplementary Table 7; http://links.lww.com/CORR/A917), whereas men did not appear to consider an improvement in physical function from 75% to 100% as an important factor when deciding to undergo TJA (β: -0.28 [95% CI -0.45 to -0.11]; p = 0.09) (Supplementary Table 8; http://links.lww.com/CORR/A918).

Finally, we identified that only patients with severe pain at the time of their appointment found infection risk influential in their decision-making process (β: -0.27 [95% CI -0.37 to -0.17]; p = 0.01) (Supplementary Table 9; http://links.lww.com/CORR/A919). These patients were willing to accept an absolute (and not merely an incrementally increased) 24% risk of infection to improve their physical functioning from 50% to 100%. Conversely, patients with only mild-to-moderate pain at their appointments were unwilling to take on a hypothetically high infection risk as a tradeoff for improvement in physical function or pain relief (Supplementary Table 10; http://links.lww.com/CORR/A920).

Discussion

TJA is associated with great benefit but potentially severe complications; however, patients' understanding and tolerance of these risks need to be better characterized. This study aimed to determine how patients quantify and weigh these benefits and risks relative to one another when considering whether to undergo TJA. In order of relative importance, we found that patients considered physical function, pain level, returning to work, and infection influential when deciding to pursue TJA. Despite taking numerous steps to aid patients in understanding TJA complications and their sequalae, we were surprised that patients were willing to take on concerningly high infection risks for pain relief and physical function improvement. We theorize that patients may not appreciate the potentially devastating complications of PJI as much as their surgeons. Interestingly, respondents did not appear to find the risk of death influential when considering surgery. Based on these findings, we suggest that surgeons need to do two things with particular care: (1) We need to individualize our counseling of patients and focus on each individual patient's likelihood of achieving a functional result that is in range with that patient's own desires (not all patients are equally likely to achieve full function after TJA, but the desire to achieve full or near-full function was strongly valued by our study's participants), and (2) we need to counsel patients to ensure that they know just how devastating periprosthetic joint infections really are.

Limitations

Our study has several important limitations. Only including one urban and one suburban hospital in our study may limit the generalizability of our findings to similar healthcare systems. In addition, although our study's population consisted of predominantly White patients, it reflects known racial and ethnic disparities in patients considering lower extremity TJA [2, 34]. Regarding the use of a DCE in our study, an inherent limitation is an inability to control for potential confounders in the regression analysis. However, we performed stratified analyses of possible confounding variables such as gender, joint, employment status, and baseline pain level. In addition, although we included exaggerated risks for TJA outcomes, this is a standard practice in DCE study design that can lead to hypothetical bias or differences in participant response in reality compared with responses within the DCE. To address the concern of nonresponse bias in our study, we examined the demographics of the 142 patients who met the inclusion criteria but ultimately did not complete the survey [22]. We were unable to find any differences between the nonrespondents and respondents (Table 1). A different composition of respondents may result in different valuations of attributes and tradeoffs.

Furthermore, it is not practical to list every attribute that might influence a patient's decision to pursue TJA. Through a comprehensive review, we were forced to omit several factors that have been shown to influence patient preferences, including surgeon experience and out-of-pocket cost [16, 30]. Considering this, we believe our selected variables represent the most commonly discussed topics during patient discussions with orthopaedic surgeons. Although our subanalyses may have been underpowered,

they highlighted some interesting findings and were therefore included. Future studies with larger patient cohorts could examine the preferences of men and women when deciding whether to undergo TJA to provide better patient-centered counseling.

Patients were aware that they were answering hypothetical scenarios in the DCE, and this could have affected their decision-making compared with a nonhypothetical scenario. However, patients were explicitly advised to answer each choice scenario as they would in reality, thus limiting this concern. Recognizing that patients may have undergone nonoperative treatments before their orthopaedic consultation, we placed an emphasis on interpreting the variables in the DCE as valid, despite any previous experience with nonoperative management.

Another potential concern is varying levels of patient appreciation for the ramifications of certain complications, such as infection, when answering the DCE. To mitigate such concerns, the survey administrators provided and thoroughly reviewed an informational sheet with the patients that intentionally had much more detailed descriptions of complications such as infection than of the easily interpretable complications of death and return to work. Study coordinators were also present to clarify any questions or confusion regarding the DCE and informational sheet if needed. Thus, we believe that our findings, such as patients being willing to take on a higher infection risk to achieve improvements in physical function and pain, may reflect a lack of appreciation for the full range of PJI sequelae, although efforts were made to educate patients as much as reasonably possible.

Of note, the rates of complications presented to patients were intentionally many times higher than their true rates of occurrence in practice. This study design could also draw concerns that patient preferences may deviate if presented with true complication rates. However, this practice is consistently performed throughout studies using DCE and is required especially when rare complications are used as attributes, such that subtle differences in preferences can be perceived and quantified.

Discussion of Key Findings

Our study found that patients prioritize pain reduction, improvement in physical function, infection risk, and the ability to return to work as the most important when considering lower extremity arthroplasty. These variables were not of equal importance in the decision-making process, with considerably more weight placed on pain reduction and improvement in physical function as opposed to infection risk, as evidenced by their larger β coefficients. Furthermore, our study suggested that patients who present to their consultation with higher baseline pain levels are more willing to accept an increased infection risk to improve physical function and ameliorate their pain. Thus, it is apparent that there is a discrepancy between the patient's understanding of the risks and complications following infection compared with those of the surgeon, which warrants further targeted intervention. Specifically, verbal explanation may not be sufficient, as evidenced by our results, and additional education using a multimodal (video and written) instructional seminar preoperatively with opportunities for patient teach-back may be most effective [36, 38]. This may help patients better understand the gravity of PJI complications and the almost inevitable risk of reoperation(s). In addition, early identification of patients with higher baseline pain levels may streamline a surgical consultation so a larger emphasis can be placed on addressing the seriousness of potential surgical complications.

Our findings are generally supportive of earlier DCEs in arthroplasty [16, 37], but ours extends knowledge in several important ways by stratifying TJA complications in the DCE, which highlighted a potential lack of appreciation for postoperative complications, namely infection. One notable study performed by Hutyra et al. [16] used a DCE to examine patient preferences when considering TKA or unicompartmental knee arthroplasty. Patients in that study were divided into one of two groups depending on their preoperative functional ability based on the Oxford Knee Score. In both groups, patients prioritized serious complications and the risk of revision over functional ability. There is a possibility as to why our study results are different from those of Hutyra et al.'s [16]. We asked patients to decide between a definitive surgical treatment (TKA or THA) or nonoperative management for their joint pain, whereas Hutyra et al. [16] asked patients to choose between unicompartmental knee arthroplasty and TKA. Patients in our study, especially those with severe baseline pain levels who may have tried nonoperative options in the past, might have believed that any benefits in physical function or pain relief from the nonoperative option would ultimately be less effective than TJA, even if the choice presented in the DCE demonstrated some benefit to the nonoperative management option. Although Hutyra et al. [16] listed an overall complication rate for their DCE, we further stratified complications into more granular components, which allowed us to discern differences in the prioritization of various complications. Certainly, not all complications bear the same consequences for patients, such as postoperative DVT versus infection. Furthermore, we chose to examine return to work as an attribute that influenced patients' decision-making processes.

By including these additional attributes, we could discern that although patients consider life-threatening complications—namely infection—to be important, they

place more value on factors such as pain reduction, physical function level, and returning to work.

Recent studies have found that reoperation risk is a factor in patients' decision-making process about TKA and the type of revision surgery for the management of periprosthetic joint infections [7, 16]. It is worth noting that prior studies did not include the diversity of patient-related or surgery-related attributes that we did, and we believe this helped us to discern some subtle yet important preferences. In our study, reoperation risk did not influence our respondents' decision-making processes. We believe that when requiring a choice between unlikely complications, such as reoperation or infection, and an attribute that would affect an individual's everyday quality of life, such as pain, patients choose to prioritize the latter. This may especially be the case when a patient may have limited understanding of the full range of consequences for complications such as those following a PJI, further underscoring the need for more effective patient education by surgeons.

Conclusion

Overall, our findings revealed that in patients considering TJA, alleviation of pain and improvement in physical function were relatively more important attributes in the decision-making process than risk of infection. This suggests that patients may not recognize the very serious and potentially life-threatening consequences of a PJI. In addition, patients presenting with severe baseline pain may be more willing than patients with mild-to-moderate pain to accept an infection risk after TJA to improve physical function and decrease pain. Because preoperative expectations about TJA have a high correlation with postoperative functional outcomes, orthopaedic surgeons should prioritize patient education with respect to these attributes, such that patients understand the implicit risks and benefits of TJA [10, 14, 25]. Future studies should investigate the effect of targeted, multimodal counseling on infection risk and the effectiveness of teach-back in patients who may be the most risk-tolerant, such as those with higher baseline pain levels.

References

1. Aizaki H, Nishimura K. Design and analysis of choice experiments using r: a brief introduction. *Agricultural Information Research*. 2008;17:86-94.
2. Basu J, Mobley LR. Trends in racial disparities among the elderly for selected procedures. *Med Care Res Rev*. 2008;65:617-637.
3. de Bekker-Grob EW, Donkers B, Jonker MF, Stolk EA. Sample size requirements for discrete-choice experiments in healthcare: a practical guide. *Patient*. 2015;8:373-384.
4. de Bekker-Grob EW, Essink-Bot ML, Meerding WJ, Pols HAP, Koes BW, Steyerberg EW. Patients' preferences for osteoporosis drug treatment: a discrete choice experiment. *Osteoporos Int*. 2008;19:1029-1037.
5. de Bekker-Grob EW, Niers EJ, van Lanschot JJB, Steyerberg EW, Wijnhoven BPL. Patients' preferences for surgical management of esophageal cancer: a discrete choice experiment. *World J Surg*. 2015;39:2492-2499.
6. Bunge EM, de Bekker-Grob EW, van Biezen FC, Essink-Bot M-L, de Koning HJ. Patients' preferences for scoliosis brace treatment: a discrete choice experiment. *Spine*. 2010;35:57-63.
7. Carroll FE, Gooberman-Hill R, Strange S, Blom AW, Moore AJ. What are patients' preferences for revision surgery after periprosthetic joint infection? A discrete choice experiment. *BMJ Open*. 2020;10:e031645.
8. Coast J, Al-Janabi H, Sutton EJ, et al. Using qualitative methods for attribute development for discrete choice experiments: issues and recommendations. *Health Economics*. 2012;21:730-741.
9. Fritz CO, Morris PE, Richler JJ. Effect size estimates: current use, calculations, and interpretation. *J Exp Psychol Gen*. 2012;141:2-18.
10. Harris IA, Harris AM, Naylor JM, Adie S, Mittal R, Dao AT. Discordance between patient and surgeon satisfaction after total joint arthroplasty. *J Arthroplasty*. 2013;28:722-727.
11. Harrison JD, Solomon MJ, Young JM, et al. Patient and physician preferences for surgical and adjuvant treatment options for rectal cancer. *Arch Surg*. 2008;143:389-394.
12. Hauber AB, González JM, Groothuis-Oudshoorn CGM, et al. Statistical methods for the analysis of discrete choice experiments: a report of the ISPOR Conjoint Analysis Good Research Practices Task Force. *Value Health*. 2016;19:300-315.
13. Hess S, Hensher DA, Daly A. Not bored yet – revisiting respondent fatigue in stated choice experiments. *Transportation Research Part A: Policy and Practice*. 2012;46:626-644.
14. Husain A, Lee G-C. Establishing realistic patient expectations following total knee arthroplasty. *J Am Acad Orthop Surg*. 2015;23:707-713.
15. Hutson MM, Blaha JD. Patients' recall of preoperative instruction for informed consent for an operation. *J Bone Joint Surg Am*. 1991;73:160-162.
16. Hutyra CA, Gonzalez JM, Yang J-C, et al. Patient preferences for surgical treatment of knee osteoarthritis: a discrete-choice experiment evaluating total and unicompartmental knee arthroplasty. *J Bone Joint Surg Am*. 2020;102:2022-2031.
17. Janz NK, Wren PA, Copeland LA, Lowery JC, Goldfarb SL, Wilkins EG. Patient-physician concordance: preferences, perceptions, and factors influencing the breast cancer surgical decision. *J Clin Oncol*. 2004;22:3091-3098.
18. Jaynes J, Wong W-K, Xu H. Using blocked fractional factorial designs to construct discrete choice experiments for healthcare studies. *Stat Med*. 2016;35:2543-2560.
19. Johnson FR, Kanninen B, Bingham M, Özdemir S. Experimental design for stated-choice studies. In: Kanninen BJ, ed. *Valuing Environmental Amenities Using Stated Choice Studies: A Common Sense Approach to Theory and Practice. The Economics of Non-Market Goods and Resources*. Springer Netherlands; 2007:159-202.
20. Johnson FR, Yang J-C, Reed SD. The internal validity of discrete choice experiment data: a testing tool for quantitative assessments. *Value Health*. 2019;22:157-160.
21. Johnson MR, Singh JA, Stewart T, Gioe TJ. Patient understanding and satisfaction in informed consent for total knee arthroplasty: a randomized study. *Arthritis Care Res (Hoboken)*. 2011;63:1048-1054.
22. Johnson TP, Wislar JS. Response rates and nonresponse errors in surveys. *JAMA*. 2012;307:1805-1806.

23. Kurtz SM, Lau E, Schmier J, Ong KL, Zhao K, Parvizi J. Infection burden for hip and knee arthroplasty in the United States. *J Arthroplasty*. 2008;23:984-991.
24. Louviere JJ, Hensher DA, Swait JD. *Stated Choice Methods: Analysis and Applications*. Cambridge University Press; 2000.
25. Mahomed NN, Liang MH, Cook EF, et al. The importance of patient expectations in predicting functional outcomes after total joint arthroplasty. *J Rheumatol*. 2002;29:1273-1279.
26. Mazzanti M. Discrete choice models and valuation experiments. *Journal of Economic Studies*. 2003;30:584-604.
27. Mühlbacher A, Johnson FR. Choice experiments to quantify preferences for health and healthcare: state of the practice. *Appl Health Econ Health Policy*. 2016;14:253-266.
28. Premkumar A, Kolin DA, Farley KX, et al. Projected economic burden of periprosthetic joint infection of the hip and knee in the United States. *J Arthroplasty*. 2021;36:1484-1489.e3.
29. Quaife M, Terris-Prestholt F, Di Tanna GL, Vickerman P. How well do discrete choice experiments predict health choices? A systematic review and meta-analysis of external validity. *Eur J Health Econ*. 2018;19:1053-1066.
30. Reuter JM, Hutyra CA, Politzer CS, et al. Characterizing patient preferences surrounding total knee arthroplasty. *JBJS Open Access*. 2018;3:e0017.
31. Ryan M, Bate A, Eastmond C, Ludbrook A. Use of discrete choice experiments to elicit preferences. *Qual Health Care*. 2001;10:i55-i60.
32. Sepucha K, Bedair H, Yu L, et al. Decision support strategies for hip and knee osteoarthritis: less is more: a randomized comparative effectiveness trial (DECIDE-OA Study). *J Bone Joint Surg Am*. 2019;101:1645-1653.
33. Shah KK, Tsuchiya A, Wailoo AJ. Valuing health at the end of life: a stated preference discrete choice experiment. *Soc Sci Med*. 2015;124:48-56.
34. Shahid H, Singh JA. Racial/ethnic disparity in rates and outcomes of total joint arthroplasty. *Curr Rheumatol Rep*. 2016; 18:20.
35. Shanahan M, Larance B, Nielsen S, Cohen M, Schaffer M, Campbell G. A protocol for a discrete choice experiment: understanding patient medicine preferences for managing chronic non-cancer pain. *BMJ Open*. 2019;9:e027153.
36. Shersher V, Haines TP, Sturgiss L, Weller C, Williams C. Definitions and use of the teach-back method in healthcare consultations with patients: a systematic review and thematic synthesis. *Patient Educ Couns*. 2021;104:118-129.
37. Szawlowski S, Choong PFM, Li J, et al. How do surgeons' trade-off between patient outcomes and risk of complications in total knee arthroplasty? A discrete choice experiment in Australia. *BMJ Open*. 2019;9:e029406.
38. Talevski J, Shee AW, Rasmussen B, Kemp G, Beauchamp A. Teach-back: a systematic review of implementation and impacts. *PLoS ONE*. 2020;15:e0231350.
39. Telser H, Zweifel P. Validity of discrete-choice experiments evidence for health risk reduction. *Applied Economics*. 2007;39: 69-78.
40. Thrumurthy SG, Morris JJA, Mughal MM, Ward JB. Discrete-choice preference comparison between patients and doctors for the surgical management of oesophagogastric cancer. *Br J Surg*. 2011;98:1124-1131
41. Vass C, Rigby D, Tate K, Stewart A, Payne K. An exploratory application of eye-tracking methods in a discrete choice experiment. *Med Decis Making*. 2018;38:658-672.
42. Walter N, Rupp M, Hierl K, et al. Long-term patient-related quality of life after knee periprosthetic joint infection. *J Clin Med*. 2021;10:907.
43. Wright JG, Santaguida PL, Young N, Hawker GA, Schemitsch E, Owen JL. Patient preferences before and after total knee arthroplasty. *J Clin Epidemiol*. 2010;63:774-782.