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Systemic lupus erythematosus is not a risk factor for poor outcomes after total hip and total knee arthroplasty

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Abstract

Objectives—Historically, arthroplasty in systemic lupus erythematosus (SLE) patients has been less successful than for patients with osteoarthritis. It is not known if SLE remains an independent risk factor for poor arthroplasty outcomes or if other factors, such as avascular necrosis (AVN), continue to play a role.

Methods—A case-control study using data from a single institution arthroplasty registry compared SLE total hip arthroplasty (THA) and total knee arthroplasty (TKA) with OA controls matched by age, gender and presence of AVN. Baseline, 2-year administrative and self-report data, and diagnosis leading to arthroplasty were evaluated.

Results—54 primary SLE THA and 45 primary SLE TKA were identified from May 2007 through June 2011. AVN was present in 32% of SLE THA and no TKA. SLE THA had worse pre-op WOMAC pain (42.5 vs. 52.7; $p=0.01$) and function (38.8 vs. 48.0; $p=0.05$) compared with OA. However, at 2 years there was no difference in WOMAC pain (91.1 vs. 92.1; $p=0.77$) or WOMAC function (86.4 vs. 90.8; $p=0.28$). SLE TKA were similar to OA in both pre-op pain (42.6 vs. 48.4; $p=0.14$) and function (42.1 vs. 46.8; $p=0.30$) and 2-year pain (85.7 vs. 88.6; $p=0.50$) and function (83.7 vs. 85.1; $p=0.23$). Compared to OA, SLE THA and TKA patients had more renal failure (14% vs. 1%; $p=0.007$) and hypertension (52% vs. 29%; $p=0.009$). In a multivariate linear regression, SLE was not predictive of either poor pain or poor function.

Conclusions—While SLE patients have more comorbidities than OA, and SLE THA have worse pre-operative pain and function compared with OA controls, SLE was not an independent risk factor for poor short term pain or function after either hip or knee arthroplasty.

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CONFLICT OF INTEREST STATEMENT:

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Keywords

systemic lupus erythematosus; musculoskeletal; cardiovascular disease

INTRODUCTION

Systemic Lupus Erythematosus (SLE) is a multisystem autoimmune disease. While arthritis is the most common manifestation of SLE and is present in over 90% of patients, the primary arthritis in SLE is not typically described as destructive or erosive [1]. Nonetheless, patients with SLE undergo joint arthroplasty; rates of arthroplasty in SLE patients have been increasing [2]. Historically, while 50% of THA in patients with SLE have been for avascular necrosis (AVN), a common concurrent condition associated with corticosteroid therapy, recent reports note lower rates of arthroplasty for AVN [3, 4]. Other reasons reported for joint replacement in patients with SLE are rheumatoid arthritis overlap syndrome, infection, fracture, and OA [4].

SLE patients have been reported to have THA results similar to patients with inflammatory arthritis, but to have worse outcomes compared to patients with OA [5, 6]. Older literature suggests poor outcomes after THA in SLE patients with AVN [7], although SLE patients have fewer revision surgeries when compared with other patients undergoing THA for AVN [8]. For SLE patients with AVN of the knee, poorer clinical outcomes are reported after TKA when compared to TKA patients with other etiologies for AVN [9]. However, a recent retrospective study of SLE patients undergoing THA for both AVN and OA does not report a difference in outcomes when these patients are compared to those without SLE who have AVN [10].

Over the past decades there have been tremendous advances in the medical care of SLE patients, specifically a decreased reliance on corticosteroids and an increased use of steroid-sparing medications. In addition, there have been significant improvements in both anesthesia and arthroplasty techniques. Moreover, as fewer patients with SLE undergo arthroplasty for AVN, quality of life outcomes after arthroplasty may differ from the outcomes reported for AVN. We hypothesize that SLE itself is no longer an independent risk factor for poor pain and function after arthroplasty. The objective of this study is to evaluate SLE patients undergoing THA and TKA and determine their pain and function outcomes using prospectively gathered patient-reported quality of life outcome measures and comparing them to controls matched for confounders such as age, gender, and the presence of AVN.

METHODS

Patients were eligible for this study if they had a primary THA or TKA enrolled in the Hospital for Special Surgery (HSS) Total Joint Replacement Registry between May 2007 and June 2011. This is a prospective, single-institution arthroplasty registry that enrolled approximately 80% of all patients and contains administrative data as well as pre-operative and 2-year self-report data.

Patients with ICD-9 code for SLE (710.0) were identified. Charts were reviewed, and the diagnosis of SLE was validated if the patient had 3 out of 11 ACR SLE criteria documented [11, 12], the patient was on immunosuppressant therapy other than prednisone, or if the diagnosis of SLE was independently confirmed by his or her consulting rheumatologist. This method of case validation was chosen because, as a tertiary referral center, most SLE cases were from other centers. We therefore did not have access to detailed rheumatology records. It has been shown that rheumatologist confirmation increases the accuracy of the diagnosis [13]. Diagnosis codes in selected populations have a high positive predictive value for SLE as do diagnosis made on more than one encounter [14]. In addition, the accuracy of the diagnosis of rheumatoid arthritis based on ICD-9 code was shown to increase if evidence of DMARD use was also obtained and included in the diagnostic algorithm [15]. Therefore, after identification of the ICD-9 code of SLE, we included documentation of at least three SLE ACR criteria, use of immunosuppressive medications, and diagnosis by a rheumatologist to increase the specificity of the diagnosis of SLE.

Two OA cases were matched to each validated SLE case on age \pm 2.5 years, sex, procedure type and presence of AVN. Matching was implemented to reduce confounding, and it allowed us to assess the relationship between SLE and clinical outcomes having already taken these confounding factors into account. AVN was confirmed in cases and controls if present on the pre-operative radiograph or MRI or if AVN was identified on the post-surgical pathology specimen report. For pathologic specimens, the Ficat and Arlet classification scheme was used to classify the different stages of AVN [16]. OA was confirmed by the pre-operative radiograph or the pathology specimen report.

All cases and controls with an ICD-9 code for other autoimmune diseases, inflammatory arthritis, or fracture were excluded.

All registry patients completed baseline questionnaires regarding demographic and self-reported health, function and quality of life outcomes pre-operatively and again at 2 years. These included the HSS Total Hip or Knee Expectations Survey (at baseline only), which is a 19-item questionnaire covering different aspects of surgical recovery including pain relief and ability to complete different activities. Scores are reported on a scale of 1–100; higher scores indicate higher expectations [17, 18]. The Western Ontario McMaster University Osteoarthritis (WOMAC) survey is a lower extremity specific patient-reported measure used to assess arthritis pain, stiffness and function; lower scores indicate worse status. The survey has been validated for total hip and total knee arthroplasty and is derived from the HOOS and KOOS surveys, which are completed by patients at baseline and 2 years [19]. A difference of 10 points is considered a clinically meaningful change [20]. The Short Form-36 (SF-36) Physical Component Summary Score (PCS) and Mental Component Summary Score (MCS) are two composite subscales of the generic validated patient-reported measure of general health and well-being, with higher scores indicating better status. A difference of 5 points is considered clinically meaningful [21]. The Euro-Qol 5D (EQ-5D) assesses the subjective value placed on one's health, with a score of 1 indicating perfect health and zero indicating death [22]. The Lower Extremity Activity Scale (LEAS) is a validated scale comprised of 12 questions assessing different levels of activity [23]. Using

ICD-9 codes, the Elixhauser Co-morbidity measures were obtained from the hospital administrative database for each patient.

Analysis

Total knee and total hip replacements were analyzed separately. Variables used for matching were compared between the cases and controls to evaluate the quality of matching. Descriptive statistics were generated for patient demographics, self-reported outcomes, and co-morbidities. Characteristics in the SLE cases and OA controls were compared using Chi-square or Fisher exact tests for categorical variables and two-sample Student's t-test for continuous variables. Multiple linear regression models were performed comparing outcomes at 2 years between SLE cases and OA controls. The models included main effects for SLE and OA, pre-operative pain or function, and patient characteristics which were found to be significant in univariate analyses. Prior to performing the multivariate analysis, we also examined the relationship between SLE and clinical outcomes using simple linear regression (unadjusted) and the matched cohort. No statistically significant relationship between SLE and outcomes were found in either unadjusted or adjusted analysis; and therefore, only results from the multivariate analyses were reported. Matching on age \pm 2.5 years, sex, procedure type and presence of AVN allowed us to assess the relationship between SLE and clinical outcomes having already taken these confounding factors into account. In order to minimize residual confounding, matching variables which were not evenly distributed between the two groups (i.e. the presence of AVN) were included in the models to account for the imbalance between groups. Differences between patients with and without 2-year data were evaluated to identify potential biases and were not found to be significant. If patients had more than 1 surgery, the latest procedure with follow-up data was included. Multicollinearity diagnostics were conducted for each analysis by assessing the Variance Inflation Factor (VIF) for each independent variable. No VIF values exceeded 2.5, and therefore no significant multicollinearity was presented among the independent variables.

All analyses were performed using SAS for Windows 9.3 (Cary, NC). All tests were 2-sided with a critical p-value of 0.05 regarded as statistically significant.

This study was approved by our Institutional Ethical Review Board.

RESULTS

183 THA and TKA patients with ICD-9 code 710.0 (SLE) were identified, and the diagnosis was validated in 99 patients after chart review. 54 of the SLE patients had undergone primary total hip arthroplasty, of whom 17 had evidence of AVN (32%). In contrast, of the 45 SLE patients who had undergone TKA, none had AVN. These 99 cases were matched to 198 OA controls (Table 1). Pre-operative self-report data were available on 60/99 SLE cases (61%) and 135/198 OA (68%); 2-year self-report data were available on 45/99 SLE (46%) and 103/198 OA (52%). Although questionnaire response rate was poor at 2 years, there was no difference between patients with or without responses in age (58.0 years vs. 57.8 years; p-value=0.90) or BMI (28.7 vs. 29.5; p-value=0.38). Patients with higher education levels were more likely to complete the follow-up surveys. There was no difference in the

expectations score between those with or without 2-year responses (81.6 vs. 85.6, p-value=0.14).

Total Hip Arthroplasty

Among THA (Table 1), the average age at time of surgery was 54 years. There was no significant difference in BMI (27.6 vs. 27.1; p-value=0.69) between SLE and OA patients. As shown in Table 1, 74% of SLE patients were on immunosuppressive medications: 70% were on hydroxychloroquine, 20% were on mycophenolate mofetil, 16% on prednisone, 11% on azathioprine and 9% on methotrexate. As depicted in Table 2, SLE THA patients had statistically significantly higher prevalence of renal failure (7 (14%) vs. 2 (1%); p-value=0.01), HTN (28 (52%) vs. 32 (29%); p-value=0.01), pulmonary circulatory disease (3 (5%) vs. 0; p-value =0.04), and valvular disease (10 (18%) vs. 2 (3%); p-value=0.003) compared to the matched OA controls.

There was no difference in the expectation of outcome (83.2 vs. 87.5; p-value=0.22) between SLE and OA cases. SLE THA patients had significantly worse pre-operative WOMAC pain (42.5 vs. 52.7; p-value=0.01 compared to matched OA controls), while WOMAC function (38.8 vs. 48.0; p-value=0.05) was similar (Table 3). At 2 years, SLE patients had marked improvement with no clinically or statistically significant difference in WOMAC pain (91.1 vs. 92.1; p-value=0.77) or function (86.4 vs. 90.8; p-value=0.28) compared with OA. SLE patients also had statistically and clinically significantly lower pre-operative SF-36 PCS scores compared to OA controls (25.0 vs. 31.7; p-value=0.0001) and, despite significant improvement in WOMAC scores, their SF-36 PCS scores remained significantly lower 2 years post THA (40.5 vs. 48.7; p-value=0.01). There was no statistically significant difference in pre-operative or post-operative SF-36 MCS scores (45.2 vs. 46.2; p-value=0.71, 51.4 vs. 50.7; p-value=0.80, respectively). There was no difference in pre-operative EQ-5D scores (0.5 vs. 0.6; p-value=0.16) or 2-year post-operative EQ-5D scores (0.8 vs. 0.9; p-value=0.17).

Baseline activity levels measured with the LEAS were statistically significantly lower for SLE patients (LEAS score of 8: able to walk several blocks without assistance) compared to OA (LEAS score 9: can walk outside home without restrictions); p-value =0.03. Two years post-THA, SLE patients' activity scores improved to 11 (able to work outside home with moderately active job) vs. OA 13 (engages in moderately active exercises without difficulty), a difference which was statistically significant (p-value=0.02).

Total Knee Arthroplasty

The mean age of SLE and OA TKA patients at the time of surgery was 62 years (Table 1). There was no significant difference in mean BMI (31.5 vs. 31.5; p-value=0.98). Among SLE TKA patients, 76% were on immunosuppressive medications: 62% were on hydroxychloroquine, 11% were on mycophenolate mofetil, 7% were on prednisone, 9% were on azathioprine and 9% were on methotrexate. SLE TKA had a statistically significantly higher prevalence of renal failure (5 (11%) vs. 2 (2%); p-value=0.04) and coagulation disorders (3 (7%) vs. 0; p-value=0.04) as compared to matched OA undergoing TKA (Table 2).

SLE patients had the same expectations of outcome prior to TKA as patients with OA (79.2 vs. 80.6; p-value=0.77). SLE patients undergoing TKA had no significant difference in pre-operative WOMAC pain (42.6 vs. 48.4, p-value =0.14) or function (42.1 vs.46.8, p-value =0.30) compared to OA TKA (Table 3). Both OA and SLE TKA subjects had improvement in WOMAC pain (85.7 vs. 88.6; p-value=0.50) and function scores (83.7 vs. 85.1; p-value=0.77) at 2 years, with no significant difference between groups. SLE TKA had statistically and clinically significantly lower pre-operative SF-36 PCS scores compared to OA (27.3 vs. 33.4; p-value=0.001) and, despite improvement in scores at 2 years, their SF-36 PCS scores remained statistically and clinically significantly lower (40.2 vs. 47.2; p-value=0.02). There was no clinically or statistically significant difference in pre-operative SF-36 MCS scores as compared to OA (48.1 vs. 48.7; p-value=0.83), which improved for both groups at 2 years (54.5 vs. 55.3; p-value=0.62) (Table 3). There was no significant difference in EQ 5D scores pre-operatively (0.6 vs. 0.6; p-value=0.30) and at 2 years post-operatively (0.8 vs. 0.9; p-value=0.60). Baseline activity levels measured with the LEAS were comparable at baseline (8.4 (SLE) vs. 9.4 (OA); p-value=0.14) and increased at 2 years (10.4 (SLE) vs. 11.0; p-value=0.42) with no significant differences between groups.

Multivariate linear regression

For THA, a multivariate linear regression (Table 4) was performed to determine predictors of pain and function at 2 years after controlling for baseline SF-36 MCS, PCS, AVN status, and WOMAC pain or function. Although a matching variable, AVN status was included in the regression model to account for the slight imbalance between groups. SLE was not an independent predictor of poor WOMAC pain (point estimate 3.95; 95% CI -2.47, 10.4; p-value=0.23) or function (point estimate 2.66; 95% CI -4.9, 10.2; p-value=0.49). Pre-operative PCS (point estimate 0.46; 95% CI 0.03, 0.9; p-value=0.02) and MCS scores (point estimate 0.24; 95% CI 0.02, 0.46; p-value=0.03) were significant predictors of WOMAC pain scores at 2 years, but were not clinically significant. For WOMAC function, baseline WOMAC function (point estimate 0.32; 95% CI 0.10, 0.54; p-value=0.01) and baseline MCS (point estimate 0.35; 95% CI 0.10, 0.60; p-value=0.01) were strong predictors of outcome.

For TKA patients, in a multivariate linear regression (Table 5) performed to determine predictors of poor pain and function outcomes controlling for SF-36 MCS and PCS and baseline pain or function, SLE was not an independent predictor of poor WOMAC pain (point estimate 0.69; 95% CI -7.86, 9.24; p-value=0.87) or function (point estimate 3.11; 95%CI -5.18, 11.4; p-value=0.46) at 2 years.

DISCUSSION

In this analysis, after controlling for important potential confounders, the diagnosis of SLE was not associated with poor pain or function after THA or TKA. Surprisingly, there were multiple differences between SLE THA patients and SLE TKA patients at the preoperative baseline evaluation. SLE TKA patients were older, had higher BMI's and had no evidence of AVN, in contrast with the younger THA patients in whom 32% had AVN. The low overall prevalence of AVN in these patients may reflect less reliance on high dose

corticosteroids for disease control compared with earlier SLE cohorts. In addition, prior to surgery, SLE patients undergoing THA had worse pain and function, quality of life, and lower activity levels than OA patients, while SLE patients undergoing TKA were similar to the OA patients in these measures. However, there was little difference in pre-operative pain and function between SLE patients undergoing TKA when compared with SLE patients undergoing THA. Interestingly, expectations of arthroplasty outcomes were comparable for all groups, despite the increased burden of co-morbidities in SLE.

At 2 years, pain and function for both THA and TKA were comparable between SLE patients and OA patients. While previous series have reported quality of life outcomes for THA in SLE [5, 7], this has not been reported for SLE TKA patients, where reports have focused on infection and revision [9, 24].

The striking differences between our TKA and THA cohorts in age, BMI, and prevalence of AVN were consistent with our previous large population-based study, which reported that SLE undergoing TKA were almost 10 years older than SLE THA [2]. Only 17% of the overall SLE arthroplasty cases had AVN, similar to the low prevalence of AVN reported in our population-based study, where 24% of SLE THA cases were performed for AVN [2]. However, as neither co-morbidities nor medication use were significantly different between the SLE THA and TKA in this cohort, it is tempting to speculate that the older SLE TKA patients analyzed here represent a cohort of SLE long-term survivors [25, 26] for whom aging might contribute to the development of OA and who have chosen to undergo TKA [27]. This may also reflect improvements in surgical and anesthetic techniques, which permit safe elective surgeries in patients with SLE [10] given their high prevalence of co-morbidities. SLE TKA patients appear to be more like their OA counterparts, which is underscored by the fact that SLE TKA patients and OA TKA patients have similar BMI, as well as similar pre- and post-operative pain, function, activity levels and mental health. A similar age difference is also seen in our registry among OA patients, where the mean age for OA patients undergoing TKA is 67.2 and the mean age of OA patients undergoing THA is 62.8 [28, 29]. However, SLE TKA patients have worse pre-operative and 2-year SF-36 PCS scores, consistent with having chronic disease with a high burden of co-morbidities. This contrasts with SLE THA patients, who differ from OA THA patients in many measures, such as pre-operative pain and function, both pre- and post-operative activity levels, and SF-36 PCS.

These observations need to be considered in the face of specific limitations. The diagnosis of SLE was validated via chart review, not patient interview and examination, and, therefore, there could have been potential misclassification. However, use of ICD-9 codes on multiple visits, expert opinion, and use of specific therapy have all been shown to improve diagnostic specificity and would decrease the risk of bias introduced via misclassification [14, 15]. Responses to the 2-year surveys were low; only 61% of SLE and 68% of OA returned questionnaires at 2 years, yielding limited 2-year self-report data for our analysis. Patients with poor outcomes and patients with chronic diseases are less likely to respond to questionnaires [30, 31], creating significant challenges in studying chronically ill SLE patients. This would favor patients with better outcomes returning the surveys, creating the potential for selection bias due to differential non-response. However, it is important to note

that baseline characteristics were similar between those with 2-year follow-up and those without. Alternatively, there may be bias introduced when patients with a chronic disease are more careful in answering medical questions than healthy controls, creating the potential for response bias. Although we matched on age, sex, procedure and presence of AVN, there may be other confounders present that we did not analyze, such as medication use or comorbidities, which could have introduced another potential source of bias. We lacked specific SLE measures of disease activity as well as SLE serologies. In addition, all surgeries were performed in a high volume tertiary referral orthopedic hospital, so the results may not be generalizable, as most arthroplasties are performed in community hospitals [32, 33].

Strengths of our study include a large validated cohort of SLE patients with radiographic or pathologic validation of AVN. While previous retrospective series have reported benefits to health related quality of life (HRQOL) and improved function for SLE patients after THA [5, 34], our series of SLE patients analyzes prospectively gathered data for both THA and TKA, using appropriately matched contemporaneous surgical controls undergoing the same operation.

In summary, the results of this study suggest that patients with SLE have marked improvements in pain and function after THA and TKA and that SLE itself is not associated with worse short term post-operative pain or function. Although significant differences between the SLE THA and TKA patients were observed, outcomes between the groups were similarly excellent. This is important information to consider when counseling SLE patients contemplating arthroplasty.

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Table 1

Patient Characteristics

	THA			TKA		
	SLE N = 54	OA N = 108	P-Value	SLE N = 45	OA N = 90	P-Value
Age	54.4 ± 14.4	54.4 ± 14.2	0.99	62.4 ± 10.1	62.7 ± 9.4	0.89
Female	48 (89%)	93 (88%)	0.62	42 (93%)	84 (93%)	0.99
AVN	17 (32%)	34 (30%)	0.99	0	0	0.99
BMI	27.6 ± 6.9	27.1 ± 6.3	0.69	31.5 ± 8.0	31.5 ± 6.9	0.98
Caucasian	41 (76%)	82 (77%)	0.84	31 (71%)	73 (81%)	0.17
On Immunosuppressive Drugs	40 (74%)			34 (76%)		
Current Steroid Use	8 (15%)			3 (7%)		
Knee Surgery Expectation	83.2 ± 15.0	87.5 ± 14.6	0.22	79.2 ± 16.2	80.6 ± 17.8	0.77

Table 2
Differences in Co-morbidities^a between SLE and OA Receiving THA and TKA

	THA			TKA		
	SLE N = 54	OA N = 108	P-Value	SLE N = 45	OA N = 90	P-Value
Congestive heart failure	2 (4%)	---	0.11	1 (2%)	2 (2%)	0.99
Valvular disease	10 (18%)	2 (3%)	0.0003*	4 (9%)	3 (3%)	0.22
Pulmonary circulation disease	3 (5%)	---	0.04*	---	---	---
Peripheral vascular disease	1 (2%)	1 (1%)	0.99	---	---	---
Paralysis	2 (4%)	1 (1%)	0.26	1 (2%)	---	0.33
Other neurological disorders	1 (2%)	10 (7%)	0.10	2 (4%)	6 (7%)	0.72
Chronic pulmonary disease	16 (29%)	17 (20%)	0.06	6 (13%)	6 (8%)	0.21
Hypothyroidism	8 (16%)	15 (15%)	0.99	12 (27%)	16 (18%)	0.26
Renal failure	7 (14%)	2 (1%)	0.007*	5 (11%)	2 (2%)	0.04*
Liver disease	---	1 (3%)	0.99	1 (2%)	---	0.33
Coagulopathy	1 (2%)	1 (2%)	0.99	3 (7%)	---	0.035*
Obesity	9 (16%)	23 (20%)	0.54	14 (31%)	26 (29%)	0.84
Depression	7 (14%)	17 (14%)	0.82	10 (22%)	21 (22%)	0.99
Hypertension	28 (52%)	32 (29%)	0.009*	25 (56%)	53 (60%)	0.72

* Statistically significant

^a Elixhauser Co-morbidity Measures

Table 3

Health-Related Quality of Life Assessment Outcomes

	THA			TKA		
	SLE N = 54	OA N = 108	P-Value	SLE N = 45	OA N = 90	P-Value
Pre-operative WOMAC Pain ^b	42.5 ± 19.9	52.7 ± 17.3	0.01*	42.6 ± 17.3	48.4 ± 15.9	0.14
Two-Year WOMAC ^b Pain	91.1 ± 12.4	92.1 ± 14.7	0.77	85.7 ± 14.6	88.6 ± 15.4	0.50
Pre-operative WOMAC Function ^b	38.8 ± 21.0	48.0 ± 19.2	0.045*	42.1 ± 17.0	46.8 ± 18.0	0.30
Two-Year WOMAC Function ^b	86.4 ± 17.4	90.8 ± 15.4	0.30	83.7 ± 16.3	85.1 ± 17.4	0.77
Pre-operative LEAS ^c	8.0 ± 3.0	9.4 ± 3.0	0.03	8.4 ± 2.3	9.4 ± 3.1	0.14
Two-Year LEAS ^c	10.8 ± 3.6	12.7 ± 3.1	0.02	10.4 ± 2.5	11.0 ± 3.1	0.42
Pre-Operative EQ-5D ^d	0.5 ± 0.2	0.6 ± 0.2	0.16	0.6 ± 0.2	0.6 ± 0.2	0.30
Two-Year EQ-5D ^d	0.8 ± 0.2	0.9 ± 0.2	0.17	0.8 ± 0.1	0.9 ± 0.2	0.59
Pre-operative SF-36 PCS ^e	25.0 ± 6.4	31.7 ± 8.6	0.0001*	27.3 ± 6.7	33.4 ± 8.1	0.001*
Two-Year SF-36 PCS ^e	40.5 ± 12.1	48.7 ± 10.6	0.01*	40.2 ± 7.1	47.2 ± 10.7	0.02*
Pre-operative SF-36 MCS ^e	45.2 ± 9.4	46.2 ± 13.6	0.71	48.1 ± 13.3	48.7 ± 11.6	0.83
Two-Year SF-36 MCS ^e	51.4 ± 9.9	50.7 ± 11.5	0.80	54.5 ± 10.2	53.3 ± 7.8	0.62

* Statistically significant

^b Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), scale of 1–100 with a difference of 10 considered a clinically meaningful change in arthritis pain, stiffness, and function^c Lower Extremity Activity Scale (LEAS), comprised of 12 questions assessing different levels of activity^d Euro-QoL 5D (EQ-5D), assesses the subjective value placed on one's health with a score of 1 indicating perfect health and 0 indicating death^e Short Form-36 (SF-36) Physical Component Summary Score (PCS) and Mental Component Summary Score (MCS), composite subscales of the generic validated patient-reported measure of general health and well-being, a difference of 5 points is considered clinically meaningful

Table 4
Multivariate Linear Regression Analysis of Risk Factors for WOMAC Pain and Function Outcomes after THA*

Parameter	Estimate	Standard Error	95% Confidence Intervals	P-value	
WOMAC pain at 2 years					
SLE vs. OA	3.95	3.28	-2.47	10.4	0.23
WOMAC Pain at Baseline	0.14	0.09	-0.04	0.32	0.12
PCS at Baseline	0.46	0.22	0.03	0.90	0.04
MCS at Baseline	0.24	0.11	0.02	0.46	0.03
WOMAC Function at 2 years					
SLE vs. OA	2.66	3.85	-4.90	10.2	0.49
WOMAC Function at Baseline	0.32	0.11	0.10	0.54	0.01
PCS at Baseline	0.15	0.31	-0.45	0.75	0.62
MCS at Baseline	0.35	0.13	0.10	0.60	0.01

* Multivariate linear regression controlling for diagnosis, baseline WOMAC pain and function, and baseline MCS and PCS.
Bolding indicates a statistically significant value.

Table 5
 Multivariate Linear Regression Analysis of Risk Factors for WOMAC Pain and Function Outcomes after TKA*

	Parameter	Estimate	Standard Error	95% Confidence Intervals	P-value
WOMAC pain at 2 years	SLE vs. OA	0.69	4.36	-7.86 9.24	0.87
	WOMAC Pain at Baseline	0.10	0.14	-0.17 0.36	0.48
	PCS at Baseline	0.39	0.26	-0.12 0.90	0.13
	MCS at Baseline	0.19	0.16	-0.12 0.51	0.23
WOMAC Function at 2 years	SLE vs. OA	3.11	4.23	-5.18 11.4	0.50
	WOMAC Function at Baseline	0.05	0.13	-0.21 0.32	0.70
	PCS at Baseline	0.47	0.30	-0.11 1.06	0.11
	MCS at Baseline	0.30	0.15	0.00 0.60	0.05

* Multivariate linear regression controlling for diagnosis, baseline WOMAC pain and function, and baseline MCS and PCS.