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Original Research

Who is Completing Patient-Reported Outcome Measures following Total Hip Arthroplasty? An Investigation of Completion Characteristics to Inform the Age of Mandatory Reporting Rates

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ABSTRACT

Background: The Centers for Medicare and Medicaid Services has mandated at least 50% institutional compliance of patient-reported outcome–based performance measures (PRO-PMs) for Medicare fee-for-service patients undergoing inpatient, elective total joint arthroplasty. The purpose of this study was to evaluate characteristics of patients undergoing primary total hip arthroplasty to identify risk factors for patient-reported outcome measures (PROMs) noncompletion using the Hip Dysfunction and Osteoarthritis Joint Replacement Outcome Score as a marker PROM.

Methods: A retrospective review was performed of patients undergoing primary total hip arthroplasty at a single large academic center between January 2013 and August 2020. Demographics, operative variables, hospital outcomes, and PROMs were compared between patients achieving and not achieving PRO-PM requirements and multivariable analysis was performed.

Results: A total of 5691 patients were included; 2547 patients did not complete either PROM, 2201 completed the preoperative PROM within 90 days of surgery, and 943 completed the PROM preoperatively and at 365 ± 60 days postoperatively. Demographics and outcomes between groups varied; patients not completing the PROM more often had a length of stay >48 hours ($P < .001$) and any complication ($q = 0.07$); these associations remained significant with adjusted multivariable analyses.

Conclusions: PRO-PM completion is necessary for compliance with the new Centers for Medicare and Medicaid Services mandate. We report on the characteristics of patients completing and not completing a marker PROM as well as risk factors for noncompletion from the era before this mandate, before substantial efforts were undertaken to increase response rate, to provide an organic overview of the patients at risk for noncompletion to guide further initiatives.

Introduction

In response to continuously increasing health-care spending within the United States, within the field of orthopaedic surgery there has been a shift to value-based health-care models to prioritize quality, value, and patient-centric outcomes. These models promote care standardization and aspire to offer health-care savings, incentivizing institutions to deliver successful outcomes in a cost-efficient manner. Total hip (THA) and knee arthroplasty (TKA) have been consistently identified by policymakers as key targets for cost-attenuation—and as such, participation in these programs—due to their expanding prevalence and associated proportion of Medicare and Medicaid expenditure. One initiative currently underway is the Centers for Medicare and Medicaid Services (CMS) patient-reported outcome-based performance measure (PRO-PM) for Medicare patients 65 years of age or older undergoing inpatient THA or TKA, which went into effect on July 1, 2024. [1,2] The THA and TKA PRO-PM requires reporting of a set of patient-reported outcome measures (PROMs) collected within 90 days preoperatively and 365 ± 60 days postoperatively. The PRO-

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PM is then utilized to calculate the proportion of THA or TKA patients meeting or exceeding the substantial clinic benefit threshold. [1,3,4] While this now-implemented CMS proposal will not reward high performing systems, it will penalize institutions that do not report complete PRO-PMs for 50% of all Medicare fee-for-service patients undergoing inpatient, elective total joint arthroplasty (TJA). Financial penalty for noncompliance is significant, as hospitals will suffer a 25% reduction in their Annual Payment Update on all Fee for Service Medicare Payments, including those outside of TJA and orthopaedic surgery. This payment update will apply to hospital payment determinations starting fiscal year 2028.

Such policy changes have brought renewed attention to PROMs, as compliance with CMS policy is essential to avoid the significant associated financial ramifications. PROMs offer a compelling way to involve each patient in their care, standardize outcome data, and compare different health systems in their respective delivery of care, yet integrating the large-scale collection of this survey data into the workflow of orthopaedic practice poses logistical challenges and postulates the patients vulnerable to being left behind in PROMs completion may be those already facing barriers and inequity in arthroplasty care. Prior studies have identified low socioeconomic status, [5-7] older age, [8-10] Black race, [11-15] and non-English primary language [16,17] as factors associated with poor outcomes following TJA, and recent work suggests that these factors are also associated with PROMs noncompletion. [17-20] Complications following TJA, such as infections, thromboembolic events, and mechanical issues, have been shown to significantly impact patient satisfaction and perceived success of the surgery, [21] yet any impact of such events on PROMs completion has yet to be studied. To the best of our knowledge, we are the first to investigate whether operative, hospital, and outcome variables impact PROMs completion. It becomes essential to identify characteristics associated with PROMs completion as well as risk factors for noncompletion in order to maximize compliance with the CMS mandate, as well as to ensure such policies are not exacerbating existing health-care access inequities within the field of arthroplasty.

Material and Methods

Data collection

Patients undergoing primary THA between January 1, 2013, and August 31, 2020 at a single large academic center in a rural state were included in this retrospective review. Institutional review board approval was obtained. Patients received surgery using the anterior-based muscle sparing approach [22] by 1 of 3 fellowship-trained arthroplasty surgeons. Compliance was defined as completion of the Hip Dysfunction and Osteoarthritis Joint Replacement Outcome Score (HOOS JR) PROM in the preoperative window (within 90 days before surgery) and the 1-year postoperative window (at 365 ± 60 days following index surgery). This particular PROM was selected as a marker for PROMs completion due to its central role in the PRO-PM and use in the substantial clinical benefit calculation. [1,2] Count was recorded for patients who did not complete either PROM ("neither PROM"), patients who completed only the preoperative PROM ("preoperative PROM only"), and patients who completed only the 1-year postoperative PROM ("preoperative and postoperative PROM"). Evidence indicates that the collection of postoperative PROMs is more challenging than the collection of preoperative PROMs due to lower completion rates and various patient and logistical factors, and it was for this reason (and our interest in evaluating postoperative PROMs between analysis groups) that we structured the patient cohorts in this way. [23,24] Of note, patients who completed postoperative PROMs at 6 weeks, 3 months, or 6 months without completion of 1-year PROMs were still analyzed within the "preoperative PROM only" cohort based on this classification system. Loss to follow-up was calculated based on institutional electronic medical record (EMR) patient portal status; patients who deactivated their patient portal (where PROMs questionnaires were delivered) between date of surgery and 425 days following surgery who were not seen in office were considered lost to follow-up. Exclusion criteria then included patients less than 18 years of age at time of surgery, those with a history of septic arthritis, and those discharged to a psychiatric hospital.

The primary outcomes of interest were evaluated by patient groups: "neither PROM", "preoperative PROM only", and "preoperative and postoperative PROM". Demographic, operative, hospital, and complication data were obtained from the institutional EMR, including sex (male or female, as recorded in the EMR), age at time of surgery, body mass index (BMI) and BMI category (underweight, healthy weight, overweight, and obese), self-reported race, self-reported ethnicity, American Society of Anesthesiologists (ASA) score, and indication for surgery (degenerative joint disease/ osteoarthritis, osteonecrosis, or fracture). Insurance type was collected under the categories of private, government, workers' compensation, Department of Veterans' Affairs, and Other/Unknown. The category of 'private' included all private insurance plans within the dataset, the category of 'government' included Medicare, Medicaid, Medicare Replacement, Medicaid Replacement, Tricare, and Prison Health plans. Whether the patient's home address came from an area designated as rural was also recorded. Comorbid conditions contributing to the Charlson Comorbidity Index (CCI) [25] and updated CCI [26] were collected, including myocardial infarction (MI), congestive heart failure, peripheral vascular disease, cerebrovascular disease, chronic obstructive pulmonary disease, dementia, peptic ulcer disease, rheumatic disease, liver disease, diabetes, renal disease, hemiplegia or paraplegia, malignancy, metastatic solid tumor, and HIV. Operative variables collected included arthroplasty fixation (press fit or cemented), procedure duration, anesthesia type (spinal or general), anesthesia time, length of stay, need for transfusion, and occurrence of an intraoperative complication). Hospital-reported outcomes included discharge disposition (home, home with health-care services, rehabilitation facility, or skilled nursing facility) as well as occurrence of any postoperative complication, emergency department visit (within 30 days), and readmission (within 90 days). Complications evaluated included MI or pneumonia (within 7 days), surgical site complication, pulmonary embolism, death (within 30 days), fracture, dislocation, mechanical complication, joint infection, or wound infection (within 90 days). PROMs were recorded preoperatively (within 90 days before surgery) and at 6 weeks, 6 months, and 1 year (365 ± 60 days) following index surgery. These included the visual analog scale, HOOS JR, Single Assessment Numeric Evaluation, University of California, Los Angeles, and Patient-Reported Outcomes Measurement Information System (PROMIS) mental/physical scores, and were collected from an in-house database. Satisfaction scores evaluating functional improvement, pain relief, procedure meeting expectations, and surgeon were collected for all postoperative time points.

Data analyses

To assess the relationship between PROM completion and outcomes of interest, all demographic, patient-reported, and hospital-reported variables were analyzed with respect to this characteristic. For normally distributed categorical variables

Pearson's Chi-square test was used. For nonnormally distributed categorical variables and continuous variables, Fisher's exact test or the Wilcoxon rank sum test were used. Q-values were reported in outcomes tables to correct for the False Discovery Rate for multiple testing. Univariate regression models were created to analyze the relationship between patient- and hospital-reported outcomes and all covariates. Linear and logistic regression approaches were used according to the respective outcome (linear for continuous outcomes, logistic for binary outcomes). The final linear and logistic multivariable regression models were created using a combination of purposeful selection ($P < .2$) and clinical expertise with respect to each individual outcome. Analysis was performed using R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Patient completion of PRO-PM

From 2013 to 2020, 2547 of 5691 total patients did not complete the HOOS JR PROM at either the preoperative nor 1-year postoperative time point. A total of 3144 (55.2%) of patients completed the preoperative PROM within 90 days of surgery, and 943 of these patients completed both the preoperative and 1-year postoperative PROM at 365 ± 60 days (30.0%) (Table 1). Across the study period, 106 (1.9%) patients were lost to follow-up (Table 1).

Demographics

From January 1, 2013, to August 31, 2020, a total of 5691 patients underwent primary THA and met the inclusion criteria. Of this patient population, 3119 were female (55%). The average age of patients was 65 (±10) years, and the average BMI was 29.3 (±6.0). A total of 99% of patients were of White or Caucasian race. All other racial demographics (American Indian or Alaska Native, Black or African American, Multiracial, and Native Hawaiian and Other Pacific Islander) represented less than 1% of the study population. Less than 1% of the study population self-reported Hispanic/Latino ethnicity.

Preoperative diagnosis was overwhelmingly degenerative joint disease/osteoarthritis (97%) across the patient population, with a greater percentage of patients in the "neither PROM" group undergoing THA for fracture (3.5%) than the "preoperative PROM only" (0.3%) and "preoperative and postoperative PROM" (0%) groups ($P < .001$). Demographic differences between the PROM completion groups included a variation in BMI; patients in the "neither PROM" group had a BMI of 29.1 (±6.2), slightly different ($P = .021$) than patients in the "preoperative PROM only" and "preoperative and postoperative PROM" group, with average BMI of 29.5 (±5.9) and 29.3 (±5.8), respectfully, which appears driven by a BMI distribution that skewed to a higher percentage (43%) of obese patients ($P = .004$) in the "preoperative PROM only" group. ASA score varied slightly between groups ($P < .001$)—higher at 2.20 (±0.54) in the "preoperative PROM only" group than both the "neither PROM" group at 2.10 (±0.53) and the "preoperative and postoperative PROM" group at 2.15 (±0.53)—yet CCI did not. Supplementary Table 1 shows diagnoses contributing the CCI; the prevalence of most comorbidities did not vary significantly based on PRO-PM completion status.

Insurance type was variable among groups: government insurance predominated among the cohorts (3086 (54%) of all patients), followed by private insurance (2533 (45%) of all patients). The distribution of patients on government insurance was higher (56%) and private insurance lower (43%) among the "preoperative PROM only" group ($P < .001$). Across the patient population, nearly half (47%) came from a rural location. Table 2 summarizes the baseline and perioperative characteristics of the study cohort.

Operative, hospital, and outcome variables

Surgical variables differed between PROM completion groups (Table 3). Anesthesia type varied ($P < .001$), with general anesthesia predominating (99%) for "neither PROM" patients, compared to "preoperative PROM only" (96%) and "preoperative and postoperative PROM" (93%) patients. Average anesthesia time varied as well ($P < .001$), lengthier at 113 minutes (±24) in the "neither PROM" group than the "preoperative PROM only" (103 minutes ± 17) and "preoperative and postoperative PROM" (107 minutes ± 18) groups. Similar trends in room ($P < .001$) and procedure ($P < .001$) duration were observed between groups. Length of stay did not vary significantly between groups, but the "neither PROM" group had a greater proportion of patients staying 48 hours or longer (17%) than the "preoperative PROM only" (13%) and "preoperative and postoperative PROM" (11%) groups ($P < .001$). Discharge disposition also varied between groups ($P < .001$), yet most patients in all groups discharged to home/self-care (60%) or home with home health services (33%). The "neither PROM" group had a greater percentage of patients discharging to a skilled nursing facility (6.8%) and rehab facility (2.4%) when compared to the other groups. Postsurgical events were rare; only 77 (1.4%) of 5691 total patients were affected by any complication (Table 4). However, most complications (47/77) occurred within the "neither PROM" ($q = 0.007$). There were no differences between incidence of individual complications—myocardial infarction, pulmonary embolism, fracture, infection) that remained statistically significant once corrected for multiple tests. There were no differences observed in incidence of emergency department visit within 30 days or readmission within 90 days (Table 4).

Table 1
Distribution of THA patients by eligibility for study inclusion based on completion status of the HOOS JR per study year.

Number	2013	2014	2015	2016	2017	2018	2019	2020	Total
Number of eligible primary THA	619	731	377	705	907	926	910	516	5691
HOOS JR Completion									
Number (% of total) of THA who completed preoperative HOOS	0 (0.0%)	0 (0.0%)	2 (0.5%)	484 (68.7%)	811 (89.4%)	841 (90.8%)	754 (82.9%)	252 (48.8%)	3144 (55.2%)
Number (% of those who completed preoperative) of THA who completed pre and 1-year postoperative HOOS	0 (0.0%)	0 (0.0%)	1 (50%)	285 (58.9%)	106 (13.1%)	393 (46.7%)	155 (20.6%)	3 (1.2%)	943 (30.0%)
Practice Follow-Up									
Number (% of total) of were lost to follow up before 1 year	5 (0.8%)	11 (1.5%)	9 (2.4%)	9 (1.3%)	15 (1.7%)	17 (1.8%)	17 (1.9%)	23 (4.5%)	106 (1.9%)

Completion of HOOS JR in the preoperative window occurred within 90 days before surgery. Completion of PROMs 1 year postoperatively occurred within the window of 365 ± 60 days following index surgery.

Table 2
Demographic information stratified by PROM completion status.

Characteristic	Overall N = 5,691[a]	Neither PROM[c] N = 2,547[a]	Preoperative PROM only[d] N = 2,201[a]	Preoperative and postoperative PROM[e] N = 943[a]	*P* value[b]
Procedure Type (Primary)	5637 (99%)	2518 (99%)	2184 (99%)	935 (99%)	.4
Laterality (Right)	3036 (53%)	1370 (54%)	1166 (53%)	500 (53%)	.8
Sex (Female)	3119 (55%)	1408 (55%)	1210 (55%)	501 (53%)	.5
Age (Y) at Discharge	65 (10)	65 (11)	66 (10)	66 (10)	**.004**
Race					.5
American Indian and Alaska Native	10 (0.2%)	4 (0.2%)	5 (0.2%)	1 (0.1%)	
Asian	12 (0.2%)	4 (0.2%)	5 (0.2%)	3 (0.3%)	
Black or African American	17 (0.3%)	7 (0.3%)	9 (0.4%)	1 (0.1%)	
Multiracial	6 (0.1%)	1 (<0.1%)	3 (0.1%)	2 (0.2%)	
Native Hawaiian and Other Pacific Islander	2 (<0.1%)	2 (<0.1%)	0 (0%)	0 (0%)	
White or Caucasian	5622 (99%)	2513 (99%)	2176 (99%)	933 (99%)	
Declined, Other, Unknown	22 (0.4%)	16 (0.6%)	3 (0.1%)	3 (0.3%)	
Ethnicity					.9
Hispanic	19 (0.3%)	11 (0.4%)	6 (0.3%)	2 (0.2%)	
Non-Hispanic	5618 (99%)	2513 (99%)	2173 (99%)	932 (99%)	
Declined, Unknown	54 (0.9%)	23 (0.9%)	22 (1.0%)	9 (1.0%)	
BMI	29.3 (6.0)	29.1 (6.2)	29.5 (5.9)	29.3 (5.8)	**.013**
BMI Category					**.004**
Healthy Weight (18.5-24.9)	1351 (24%)	631 (25%)	521 (24%)	199 (21%)	
Underweight (<18.5)	61 (1.1%)	35 (1.4%)	17 (0.8%)	9 (1.0%)	
Overweight (25-29.9)	2010 (35%)	914 (36%)	733 (33%)	363 (38%)	
Obese (>30)	2269 (40%)	967 (38%)	930 (42%)	372 (39%)	
CCI	0.65 (1.17)	0.65 (1.18)	0.67 (1.18)	0.61 (1.11)	.4
ASA Rating	2.14 (0.53)	2.10 (0.53)	2.20 (0.54)	2.15 (0.53)	**<.001**
Preoperative Diagnosis					**<.001**
DJD/OA	5511 (97%)	2414 (95%)	2163 (98%)	934 (99%)	
ON	85 (1.5%)	44 (1.7%)	32 (1.5%)	9 (1.0%)	
Fracture	95 (1.7%)	89 (3.5%)	6 (0.3%)	0 (0%)	
Insurance Type					**<.001**
Private	2533 (45%)	1170 (46%)	949 (43%)	414 (44%)	
Government	3086 (54%)	1343 (53%)	1231 (56%)	512 (54%)	
Veterans' Affairs	36 (0.6%)	8 (0.3%)	16 (0.7%)	12 (1.3%)	
Workers' Compensation	18 (0.3%)	9 (0.4%)	4 (0.2%)	5 (0.5%)	
Other, Unknown	18 (0.3%)	17 (0.7%)	1 (<0.1%)	0 (0%)	
Percentage rural	2549 (47%)	1126 (47%)	1000 (48%)	423 (48%)	.9

DJD/OA, degenerative joint disease/osteoarthritis; ON, osteonecrosis.
Bolded *P* values indicate statistical significance ($P < .05$).
[a] N (%); Mean (SD).
[b] Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test.
[c] "Neither PROM" group defined as neither completion of the HOOS JR PROM in the preoperative window nor at 1 year.
[d] "Preoperative PROM only" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery *without* completion of 1-year HOOS JR PROM.
[e] "Preoperative and postoperative PROM" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery and completion of HOOS JR PROM 1-year postoperatively that occurred within the window of 365 ± 60 days following index surgery.

PROMs

Analysis of the available PROMs data—while recognizing that study of the 1-year postoperative time period was inherently deficient—revealed differences in PROMs at each time point after correcting for the False Discovery Rate for multiple testing (Table 5). Such differences are most notable at the preoperative time point, as "neither PROM" patients had scores consistent with worse function and higher pain across all surveys measured, including higher visual analog scale (6.1 ± 2.20, q < 0.001) and lower Single Assessment Numeric Evaluation (38.8 ± 21.34, q = 0.026), University of California, Los Angeles (4.2 ± 1.86, q = 0.003), PROMIS mental (49.8 ± 7.39, q = 0.045) and PROMIS physical (39.5 ± 5.13, q = 0.010) (Table 5).

Multivariable analysis

Multivariable logistic regression analysis was performed to identify patient risk factors associated with noncompletion of preoperative and 1-year postoperative PROM (evaluating the "neither PROM" group) and noncompletion of 1-year postoperative PROM (evaluating the "preoperative PROM only" group) in reference to the PROM completion group (preoperative and postoperative PROM). Adjusted odds ratios (ORs) were determined from a multivariable logistic regression that accounted for age at time of surgery, sex, and BMI. Among risk factors evaluated, including obesity (BMI >30), ASA rating ≥3, CCI score ≥3, any complication, length of stay >48 hours, and government insurance, only "any complication" was significantly associated with noncompletion of 1-year postoperative PROM (OR 0.11, 95% confidence interval (CI) [0.01-0.54], $P = .003$) (Table 6). Both "any complication" (OR 0.09, 95% CI [0.01-0.42], $P < .001$) and length of stay >48 hours (OR 0.69, 95% CI [0.52-0.92], $P = .010$) were significant risk factors for noncompletion of preoperative and 1-year postoperative PROM (Table 7).

Discussion

The purpose of this study was to evaluate demographics, operative variables, hospital outcomes, and PROMs among

Table 3
Surgical variables and disposition stratified by PROM completion status.

Characteristic	Overall N = 5,691[a]	Neither PROM[c] N = 2,547[a]	Preoperative PROM only[d] N = 2,201[a]	Preoperative and postoperative PROM[e] N = 943[a]	*P* value[b]
Anesthesia Type (General)	5504 (97%)	2515 (99%)	2111 (96%)	878 (93%)	**<.001**
Anesthesia Time (Min)	108 (21)	113 (24)	103 (17)	107 (18)	**<.001**
Room Duration (min)	101 (21)	106 (24)	96 (16)	100 (18)	**<.001**
Length of stay (h)	34 (20)	35 (22)	33 (20)	33 (17)	.4
Cemented (Yes)	223 (3.9%)	162 (6.4%)	49 (2.2%)	12 (1.3%)	**<.001**
EBL (mL)	221 (79)	241 (82)	202 (72)	204 (69)	**<.001**
Blood Transfusion (Yes)	51 (0.9%)	27 (1.1%)	19 (0.9%)	5 (0.5%)	.3
Intraoperative Complication (Yes)	18 (0.3%)	7 (0.3%)	5 (0.2%)	6 (0.6%)	.2
Procedure Duration (Min)	65 (19)	70 (21)	61 (14)	64 (16)	**<.001**
Procedure Duration (Min)					**<.001**
Greater than 100	331 (5.8%)	267 (10%)	45 (2.0%)	19 (2.0%)	
Less than or equal to 100	5360 (94%)	2280 (90%)	2156 (98%)	924 (98%)	
Length of Stay (h)					**<.001**
Greater than 48	815 (14%)	421 (17%)	287 (13%)	107 (11%)	
Less than or equal to 48	4876 (86%)	2126 (83%)	1914 (87%)	836 (89%)	
Discharge Disposition					**<.001**
Home or Self Care	3401 (60%)	1262 (50%)	1527 (69%)	612 (65%)	
Home Health Care	1865 (33%)	1052 (41%)	547 (25%)	266 (28%)	
Skilled Nursing Facility	348 (6.1%)	172 (6.8%)	114 (5.2%)	62 (6.6%)	
Rehab Facility	77 (1.4%)	61 (2.4%)	13 (0.6%)	3 (0.3%)	

EBL, estimated blood loss.
Bolded *P* values indicate statistical significance ($P < .05$).
[a] N (%); Mean (SD).
[b] Wilcoxon rank sum test; Pearson's Chi-square test.
[c] "Neither PROM" group defined as neither completion of the HOOS JR PROM in the preoperative window nor at 1-year.
[d] "Preoperative PROM only" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery *without* completion of 1-year HOOS JR PROM.
[e] "Preoperative and postoperative PROM" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery and completion of HOOS JR PROM 1-year postoperatively that occurred within the window of 365 ± 60 days following index surgery.

patients following THA to determine if there were characteristics associated with noncompletion of a marker PROM (the HOOS JR survey) that may be helpful to identify care gaps or disparities that can be addressed to facilitate compliance with the new CMS-mandated PRO-PM requirements.

Demographics

Overall, PRO-PM compliance, defined within our model as completion of both the preoperative and 1-year postoperative HOOS JR PROM, was 16.6% (N = 943 of 5691) among all eligible

Table 4
Postoperative variables stratified by PROM completion status.

Characteristic	Overall N = 5,691[a]	Neither PROM[d] N = 2,547[a]	Preoperative PROM only[e] N = 2,201[a]	Preoperative and postoperative PROM[f] N = 943[a]	*P* value[b]	q value[c]
ED Visit within 30 d	104 (1.8%)	47 (1.8%)	42 (1.9%)	15 (1.6%)	.8	>0.9
Average days after surgery for ED visit	8 (4, 15)	8 (4, 15)	8 (4, 14)	8 (3, 23)	>.9	>0.9
Readmission within 90 d	175 (3.1%)	94 (3.7%)	61 (2.8%)	20 (2.1%)	.033	0.14
Average days after surgery for readmission	32 (13, 59)	28 (10, 56)	28 (12, 62)	38 (34, 68)	.086	0.3
Surgical or Medical complication (Surgical)	55 (71%)	32 (68%)	22 (76%)	1 (100%)	.7	>0.9
Readmission Unplanned or Unplanned Prior	175 (3.1%)	94 (3.7%)	61 (2.8%)	20 (2.1%)	.033	0.14
Any Complication	77 (1.4%)	47 (1.8%)	29 (1.3%)	1 (0.1%)	**<.001**	0.007
Myocardial Infarction within 7 d	5 (<0.1%)	4 (0.2%)	1 (<0.1%)	0 (0%)	.4	0.8
Pneumonia within 7 d	3 (<0.1%)	1 (<0.1%)	2 (<0.1%)	0 (0%)	.8	>0.9
Surgical Site Complication within 30 d	3 (<0.1%)	2 (<0.1%)	1 (<0.1%)	0 (0%)	>.9	>0.9
Pulmonary Embolism within 30 d	4 (<0.1%)	2 (<0.1%)	2 (<0.1%)	0 (0%)	>.9	>0.9
Death within 30 d	2 (<0.1%)	2 (<0.1%)	0 (0%)	0 (0%)	.7	>0.9
Fracture within 90 d	24 (0.4%)	15 (0.6%)	9 (0.4%)	0 (0%)	.031	0.12
Dislocation within 90 d	10 (0.2%)	6 (0.2%)	3 (0.1%)	1 (0.1%)	.7	>0.9
Mechanical Complication within 90 d	4 (<0.1%)	4 (0.2%)	0 (0%)	0 (0%)	.2	0.5
Joint Infection within 90 d	12 (0.2%)	6 (0.2%)	6 (0.3%)	0 (0%)	.3	0.8
Wound Infection within 90 d	10 (0.2%)	5 (0.2%)	5 (0.2%)	0 (0%)	.4	0.8

ED, emergency department. Bolded P values indicate statistical significance ($P < .05$).
[a] N (%); for data points involving days, mean (Q1, Q3).
[b] Pearson's Chi-square test; Wilcoxon rank sum test; Fisher's exact test.
[c] False discovery rate correction for multiple testing.
[d] "Neither PROM" group defined as neither completion of the HOOS JR PROM in the preoperative window nor at 1 year.
[e] "Preoperative PROM only" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery *without* completion of 1-year HOOS JR PROM.
[f] "Preoperative and postoperative PROM" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery and completion of HOOS JR PROM 1-year postoperatively that occurred within the window of 365 ± 60 days following index surgery.

Table 5
PROMs stratified by PROM completion status.

Characteristic	N	Overall N = 5,691[a]	Neither PROM[d] N = 2,547[a]	Preoperative PROM only[e] N = 2,201[a]	Preoperative and postoperative PROM[f] N = 943[a]	*P* value[b]	q value[c]
Preoperative							
VAS	3673	5.6 (2.21)	6.1 (2.20)	5.5 (2.22)	5.4 (2.13)	**<.001**	<0.001
SANE	3314	42.0 (21.35)	38.8 (21.34)	42.4 (21.44)	42.4 (21.03)	**.005**	0.026
HOOS	3144	41.0 (15.47)	NA (NA)	40.7 (15.41)	41.6 (15.61)	.3	0.5
UCLA	4061	4.3 (1.82)	4.2 (1.86)	4.3 (1.81)	4.5 (1.81)	**<.001**	0.003
PROMIS Mental	3597	50.4 (7.41)	49.8 (7.39)	50.3 (7.47)	50.9 (7.24)	.011	0.045
PROMIS Physical	3597	39.9 (5.25)	39.5 (5.13)	39.7 (5.24)	40.4 (5.31)	**.002**	0.010
6-wk Postoperative							
VAS	3311	1.6 (1.70)	1.6 (1.70)	1.6 (1.76)	1.4 (1.54)	.2	0.5
UCLA	3313	4.9 (1.40)	4.9 (1.40)	4.8 (1.38)	4.9 (1.44)	.4	0.6
HOOS	2977	76.4 (13.07)	76.9 (13.69)	76.0 (13.27)	76.8 (12.35)	.3	0.5
PROMIS Physical	3266	44.9 (5.51)	45.3 (5.73)	44.7 (5.52)	45.2 (5.32)	.024	0.084
PROMIS Mental	3266	51.5 (7.05)	50.9 (7.03)	51.5 (7.17)	52.1 (6.77)	**.009**	0.043
SANE	3050	76.7 (18.00)	79.1 (18.67)	76.1 (18.25)	76.6 (16.88)	**<.001**	0.002
Satisfaction Pain Relief	2882	8.9 (1.75)	8.9 (1.73)	8.8 (1.83)	9.0 (1.56)	.7	0.8
Satisfaction Functional Improvement	2860	8.6 (1.70)	8.7 (1.71)	8.6 (1.75)	8.7 (1.59)	.5	0.7
Satisfaction Procedure Expectations	2860	9.0 (1.68)	9.0 (1.65)	9.0 (1.72)	9.1 (1.60)	.7	0.8
Satisfaction Surgeon	2884	9.8 (0.72)	9.9 (0.66)	9.8 (0.78)	9.8 (0.62)	.11	0.3
3-mo Postoperative							
VAS	231	1.1 (1.40)	1.0 (1.29)	1.2 (1.54)	1.5 (1.63)	.2	0.5
UCLA	228	5.6 (1.76)	5.6 (1.85)	5.8 (1.45)	5.5 (1.98)	.7	0.8
HOOS	84	83.5 (13.73)	83.4 (16.10)	82.5 (13.41)	84.5 (12.91)	.8	0.8
PROMIS Physical	145	45.4 (5.78)	44.9 (5.91)	45.8 (5.45)	46.3 (5.84)	.4	0.6
PROMIS Mental	145	50.6 (6.74)	49.7 (6.58)	50.9 (6.62)	52.2 (7.09)	.3	0.6
SANE	208	85.6 (16.86)	86.2 (16.56)	85.2 (15.71)	83.9 (20.83)	.8	0.8
Satisfaction Pain Relief	88	9.2 (1.42)	9.1 (1.66)	9.3 (1.15)	9.8 (0.46)	.5	0.7
Satisfaction Functional Improvement	89	9.1 (1.26)	9.1 (1.33)	9.0 (1.29)	9.4 (0.74)	.8	0.8
Satisfaction Procedure Expectations	88	9.3 (1.41)	9.3 (1.42)	9.2 (1.55)	9.8 (0.46)	.7	0.8
Satisfaction Surgeon	89	9.6 (1.35)	9.5 (1.29)	9.6 (1.60)	10.0 (0.00)	.3	0.5
6-mo Postoperative							
VAS	697	0.9 (1.60)	1.0 (1.50)	0.8 (1.69)	2.2 (2.39)	**<.001**	0.004
UCLA	678	6.1 (1.90)	5.9 (1.92)	6.4 (1.86)	7.2 (1.48)	**.001**	0.009
HOOS	407	86.7 (15.29)	84.5 (16.16)	87.2 (15.11)	80.8 (14.38)	.3	0.5
PROMIS Physical	652	46.7 (6.22)	46.3 (6.11)	47.1 (6.32)	44.6 (2.83)	.15	0.4
PROMIS Mental	652	51.1 (6.93)	50.0 (6.66)	52.2 (6.98)	51.5 (14.99)	**.001**	0.008
SANE	613	89.8 (15.35)	89.6 (15.97)	90.1 (14.63)	75.0 (25.00)	.4	0.6
Satisfaction Pain Relief	375	9.4 (1.33)	9.4 (1.29)	9.4 (1.34)	NA (NA)	.6	0.8
Satisfaction Functional Improvement	373	9.3 (1.42)	9.3 (1.37)	9.3 (1.44)	NA (NA)	.8	0.8
Satisfaction Procedure Expectations	373	9.4 (1.48)	9.3 (1.56)	9.4 (1.46)	NA (NA)	.5	0.7
Satisfaction Surgeon	373	9.9 (0.60)	9.9 (0.56)	9.9 (0.61)	NA (NA)	.8	0.8
1-y Postoperative							
VAS	1545	NA (NA)	NA (NA)	NA (NA)	0.7 (1.45)	NA	NA
UCLA	1505	NA (NA)	NA (NA)	NA (NA)	6.5 (1.91)	NA	NA
HOOS	943	NA (NA)	NA (NA)	NA (NA)	87.8 (14.16)	NA	NA
PROMIS Physical	1551	NA (NA)	NA (NA)	NA (NA)	47.4 (6.33)	NA	NA
PROMIS Mental	1551	NA (NA)	NA (NA)	NA (NA)	52.6 (7.34)	NA	NA
SANE	1405	NA (NA)	NA (NA)	NA (NA)	90.5 (15.07)	NA	NA
Satisfaction Pain Relief	1050	NA (NA)	NA (NA)	NA (NA)	9.5 (1.18)	NA	NA
Satisfaction Functional Improvement	1059	NA (NA)	NA (NA)	NA (NA)	9.4 (1.20)	NA	NA
Satisfaction Procedure Expectations	1056	NA (NA)	NA (NA)	NA (NA)	9.5 (1.32)	NA	NA
Satisfaction Surgeon	1053	NA (NA)	NA (NA)	NA (NA)	9.9 (0.64)	NA	NA

VAS, Visual Analog Score; SANE, Single Assessment Numeric Evaluation; SD, standard deviation; UCLA, University of California Los Angeles.
Bolded *P* values indicate statistical significance ($P < .05$).

[a] N (%); Mean (SD).

[b] Pearson's Chi-square test; Wilcoxon rank sum test; Fisher's exact test.

[c] False discovery rate correction for multiple testing.

[d] "Neither PROM" group defined as neither completion of the HOOS JR PROM in the preoperative window nor at 1-year.

[e] "Preoperative PROM only" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery *without* completion of 1-year HOOS JR PROM.

[f] "Preoperative and postoperative PROM" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery and completion of HOOS JR PROM 1-year postoperatively that occurred within the window of 365 ± 60 days following index surgery.

primary THA patients from 2013-2020, well below the 50% completion rate required for all Medicare fee-for-service patients undergoing inpatient, elective TJA. During the study period, 3144 total patients (55.2%) completed the preoperative PROM within 90 days of surgery, and 2201 of these patients (38.7%) did not go on to complete the 1-year postoperative (365 ± 60 days) PROM. A total of 106 patients (1.9%) were lost to follow-up between surgery and the 1-year postoperative period across the study. The distribution of completion fluctuated over the course of the study, supporting that results provide insight into an era before the current period of intense prioritization of increasing PROMs acquisition. There were differences in demographics between patient groups, notable for variation in BMI and insurance payor category, yet neither remained significant on multivariable analysis. These results are reassuring that obesity, a known risk factor for complications, infections, and revisions following THA [27,28], is not the sole driver

Table 6
Results of multivariate analyses for outcomes between "preoperative and postoperative PROM"* and "preoperative PROM only"* patient cohorts.

Characteristic	Odds ratio	95% CI	*P* value
Obesity (BMI >30)	0.87	0.71, 1.07	.2
ASA Rating ≥3	0.80	0.61, 1.03	.086
CCI Score ≥3	0.99	0.66, 1.48	>.9
Any complication	0.11	0.01, 0.54	**.003**
Length of Stay >48 h	0.85	0.62, 1.16	.3
Government Insurance	0.82	0.61, 1.10	.2

Odds ratios indicate the relative odds of each postsurgical event in "preoperative and postoperative PROM" * relative to "preoperative PROM only"* patients. Unadjusted odds ratios were determined from univariate logistic regression. Adjusted odds ratios were determined from a multivariable logistic regression that accounts for age at time of surgery, sex, and body mass index. For all analyses, significant values in bold and defined as $P < .05$.
*"Preoperative and postoperative PROM" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery and completion of HOOS JR PROM 1 year postoperatively that occurred within the window of 365 ± 60 days following index surgery. *"Preoperative PROM only" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery *without* completion of 1-year HOOS JR PROM.

of PROMs noncompletion. Between groups, the average ASA varied, yet the clinical significance of this small difference is unclear, as ASA score is notable for high variability and its potential for poor inter-rater agreement/reliability based on patient and evaluator factors. [29,30] On adjusted analysis, neither CCI greater than 3 nor ASA greater than 3 were significantly associated with PROMs noncompletion, suggesting that poorer patient health status is not the primary driver of PROMs noncompletion. It was notable that fracture as an indication for THA was more prevalent in the patients in the "neither PROM" group, and suggests an area for quality improvement for our practice to ensure that fracture patients are able to access PROM surveys while awaiting surgery.

Operative, hospital, and outcome variables

Complications following TJA, including thromboembolic events, infections, and mechanical issues, have been shown to significantly impact patient satisfaction and perceived success of the surgery, yet work has not been completed to address the impact of these events on PROMs completion. [21] We found that length of stay (LOS) >48 hours was associated with noncompletion of the preoperative and 1-year PROM, and "any complication" was associated with noncompletion of the preoperative and 1-year PROM and of the 1-year PROM among patients who completed the preoperative PROM; such associations remained significant on multivariable analysis. Patients with an extended LOS (≥2 days) after THA have been shown to be at notably higher risk for complications, readmissions, and other adverse outcomes. [31] Florance et al. found that patients with a LOS ≥2 days had higher incidences of surgical site infections, hospital readmissions, and revision surgeries within 30 days compared to those with a shorter LOS, suggesting extended LOS is a marker of increased postoperative morbidity even outside of the hospital stay window. [31] Our results support such conclusions— patients in the "neither PROM" and "preoperative PROM only" groups experienced a higher rate of complications—though when stratified by individual complication (MI within 7 days, pneumonia within 7 days, pulmonary embolism within 30 days, death within 30 days, etc.), none were significant after correcting for the False Discovery Rate for multiple testing (Table 4), indicating this occurrence was not driven by one complication. Though rare, the most frequent complications occurring in this study were fracture within 90 days (n = 24; 0.4%), joint infection within 90 days (n = 12, 0.2%), and wound infection within 90 days (n = 10, 0.2%). Experiencing any complication following primary THA can increased morbidity and mortality from the procedure, and as such, ensuring these patients receive attentive follow-up care is necessary for managing complications and preserving outcomes.

Table 7
Results of multivariate analyses for outcomes between "preoperative and postoperative PROM"* and "neither PROM"* patient cohorts.

Characteristic	Odds ratio	95% CI	*P* value
Obesity (BMI >30)	1.15	0.95, 1.40	.2
ASA Rating ≥3	1.07	0.84, 1.37	.6
CCI Score ≥3	1.08	0.73, 1.56	.7
Any complication	0.09	0.01, 0.42	**<.001**
Length of Stay >48 h	0.69	0.52, 0.92	**.010**
Government Insurance	0.88	0.68, 1.14	.3

Odds ratios indicate the relative odds of each postsurgical event in "preoperative and postoperative PROM" * relative to "neither PROM"* patients. Unadjusted odds ratios were determined from univariate logistic regression. Adjusted odds ratios were determined from a multivariable logistic regression that accounts for age at time of surgery, sex, and body mass index. For all analyses, significant values in bold and defined as $P < .05$.
*"Preoperative and postoperative PROM" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery and completion of HOOS JR PROM 1 year postoperatively that occurred within the window of 365 ± 60 days following index surgery. *"Neither PROM" group defined as neither completion of the HOOS JR PROM in the preoperative window nor at 1-year.

PROMs

PROMs were essentially equivalent between groups at all postoperative time points, with no differences reaching minimal clinically important differences. [32,33] However, preoperatively, "neither PROM" patients experienced significantly greater pain and lower functioning across all survey measures when compared to "preoperative and postoperative PROM" patients. Our finding supports the work of Rullán et al, who found that patients with lower preoperative scores for pain, function, and mental health were more likely to be lost to follow-up (and not complete PROMs) following TJA. [34] Similarly, Kadiyala et al reported that higher preoperative pain, as measured by the PROMIS pain interference domain, was associated with significantly lower survey completion rates 2 years postoperatively in knee surgery patients. [35] Loss to follow-up for our population was recorded at only 1.9% across the study period, which is reassuring that PROMs noncompleters are a group of patients distinct from lost to follow-up. Results from PROMs taken at 6 weeks, 3 months, and 6 months postoperatively are reassuring that it is not poor function and inadequate satisfaction driving inadequate PROMs completion 1-year postoperatively.

Limitations

Several potential limitations are notable. This study was retrospective in design, and the data collected pertain to patients with varying insurance coverage, not just patients covered by Medicare. Due to awareness of the coming CMS PRO-PM mandate, in recent years arthroplasty practices across the country have devoted significant resources to increasing PROMs collection, including our practice. Overall preoperative and 1-year postoperative PROM completion (a model for PRO-PM compliance) among all primary THA patients at our institution was 30.0% across this study period (2013-2020), and through collection restructuring and the addition of iterative messaging protocols, the most recent preoperative PROMs completion rate was 86.5% (467 of 540) over the 3-month period following official implementation.

While we feel that this is a unique strength of our data—they are representative of PROMs completion characteristics and trends independent of the extensive and nonstandardized external forces since applied to increase adherence—it is possible that, had current strategies been applied, many of these patients would have been in compliance. Additionally, the past few years have witnessed an accelerated shift from inpatient to outpatient primary THA among Medicare patients, driven by both the removal of THA from the Medicare inpatient-only list and the pressures of the COVID-19 pandemic. [36,37] There exists the possibility than many of the patients included here would receive outpatient surgery and therefore the new CMS mandate would not apply. Furthermore, included data came from only 3 surgeons at a single institution, and the study population was racially and ethnically homogenous, limiting generalizability. Non-White race and Hispanic/Latino ethnicity have been associated with underutilization of TJA, higher complication and readmission rates, and poorer PROMs related to systemic racism. [11-15] Our study was underpowered to detect any of these important differences and therefore cannot address these disparities, and many additional possible contributors to PROMs noncompletion, such as visual acuity and digital literacy, were not measured nor addressed. Just under half of our patient population was from a rural location, a patient characteristic associated disparities in access to care often underrepresented in medical research, [38] and we can add to the body of literature that rural status was not associated with PROM noncompletion. Complications in general were infrequent, making it challenging to identify and statistically account for the differences seen between groups. This study domain can benefit from future prospective studies discerning reasons for noncompletion and addressing both barriers and facilitators to PROMs survey completion.

Conclusions

CMS implementation of a mandatory PROMs reporting initiative tied to hospital payment determinations has pushed the optimization of PROMs collection the forefront of the field of arthroplasty, as practices around the country are struggling to meet the basic PRO-PM collection compliance threshold. Understanding the characteristics of THA patients completing—and not completing—now compulsory PROMs at 1 year can help surgeons meet PRO-PM collection compliance rates. Our findings suggest certain operative, hospital, and outcome characteristics may hinder successful PROMs completion; including length of stay >48 hours and any complication; these associations remained significant with adjusted multivariable analyses. The body of evidence demonstrating potential for health inequity in PROMs completion continues to grow, and we suggest that if PROMs are to be used to allocate resources and establish performance benchmarks, further investigation is needed. New policy changes enacted on CMS TJA procedures are likely a bellwether of similar programs ahead for a wider range of orthopaedic procedures as well as medical care in general; this work provides additional understanding of PROMs completion patterns, which will likely play a central role.

CRediT authorship contribution statement

Catherine M. Call: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Zoë A. Walsh:** Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – review & editing. **Aliyah A. Olaniyan:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis, Data curation. **George Babikian:** Writing – review & editing, Writing – original draft, Project administration, Data curation. **Brian J. McGrory:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Conceptualization. **Adam J. Rana:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization.

Conflicts of interest

George Babikian receives royalties from, is on the speakers bureau/paid presentations for, and is a paid consultant for Smith & Nephew.

Brian J. McGrory is on the speakers bureau/paid presentations for Smith & Nephew; receives royalties from Innomed, Inc. and Smith & Nephew, Inc.; receives institutional research support from Smith & Nephew, Inc.; Zimmer Biomet, Inc.; receives Royalties, financial or material support from Springer, Inc.; and is an emeritus at Arthroplasty Today (AAHKS).

Adam J. Rana receives royalties from, is on the speakers bureau/paid presentations for, and is a paid consultant for Smith & Nephew; receives research support from Zimmer; and is a board member/committee appointments for a society for Eastern Orthopedics Association and AAHKS.

The other authors declare there are no conflicts of interest.

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Supplemental Table 1
CCU stratified by PROM completion status.

Characteristic	Overall N = 5,691[a]	Neither PROM[c] N = 2,547[a]	Preoperative PROM only[d] N = 2,201[a]	Preoperative and postoperative PROM[e] N = 943[a]	*P* value[b]
CCI	0.65 (1.17)	0.65 (1.18)	0.67 (1.18)	0.61 (1.11)	.4
Updated CCI	0.46 (0.97)	0.47 (0.99)	0.46 (0.96)	0.45 (0.94)	>.9
Myocardial Infarction	216 (3.8%)	98 (3.8%)	78 (3.5%)	40 (4.2%)	.6
Congestive Heart Failure	239 (4.2%)	103 (4.0%)	94 (4.3%)	42 (4.5%)	.8
Peripheral Vascular Disease	139 (2.4%)	54 (2.1%)	65 (3.0%)	20 (2.1%)	.14
Cerebrovascular Disease	79 (1.4%)	30 (1.2%)	36 (1.6%)	13 (1.4%)	.4
Dementia	84 (1.5%)	49 (1.9%)	22 (1.0%)	13 (1.4%)	**.030**
Chronic Pulmonary Disease	875 (15%)	382 (15%)	353 (16%)	140 (15%)	.5
Rheumatic Disease	168 (3.0%)	76 (3.0%)	60 (2.7%)	32 (3.4%)	.6
Peptic Ulcer Disease	15 (0.3%)	2 (<0.1%)	9 (0.4%)	4 (0.4%)	**.031**
Mild Liver Disease	91 (1.6%)	37 (1.5%)	36 (1.6%)	18 (1.9%)	.6
Moderate/Severe Liver Disease	0 (0%)		0 (0%)	0 (0%)	>.9
Diabetes without Complications	583 (10%)	267 (10%)	237 (11%)	79 (8.4%)	.11
Diabetes with Complications	163 (2.9%)	63 (2.5%)	79 (3.6%)	21 (2.2%)	**.031**
Hemiplegia or Paraplegia	19 (0.3%)	4 (0.2%)	9 (0.4%)	6 (0.6%)	.053
Renal Disease Moderate/Severe	278 (4.9%)	126 (4.9%)	108 (4.9%)	44 (4.7%)	>.9
Any Malignancy	62 (1.1%)	36 (1.4%)	17 (0.8%)	9 (1.0%)	.10
Metastatic Solid Tumor	12 (0.2%)	7 (0.3%)	5 (0.2%)	0 (0%)	.3
AIDS/HIV	2 (<0.1%)	0 (0%)	1 (<0.1%)	1 (0.1%)	.2

[a] n (%); Mean (standard deviation).
[b] Wilcoxon rank sum test; "Pearson's Chi-squared test"; Fisher's exact test.
[c] "Neither PROM" group defined as neither completion of the HOOS JR PROM in the preoperative window nor at 1-year.
[d] "Preoperative PROM only" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery *without* completion of 1-year HOOS JR PROM.
[e] "Preoperative and postoperative PROM" group defined as completion of HOOS JR PROM in the preoperative window occurring within 90 days before surgery and completion of HOOS JR PROM 1-year postoperatively that occurred within the window of 365 ± 60 days following index surgery.