The Effect of Surgical Duration on Complications and Patient Reported Outcomes in Total Hip Replacement as Evaluated Through Multi-Surgeon Pooled FORCE Registry Data from a Tertiary Care Referral Total Joint Center

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ABSTRACT

BACKGROUND: The relationship between operative times and patient outcomes in total hip arthroplasty (THA) has not been well defined.

METHODS: From January 2016 to December 2019, data were prospectively collected for THA patients in the *FORCE-TJR* registry and hospital EMR of an academic total-joint center.

RESULTS: 1,123 patients were included. Operative times ranged from 36 to 366 minutes, with a mean operative time of 111.26+/–31.37 minutes. Unadjusted GLM showed HOOS pain, ADL, and QoL scores differed across operative times, with patients who had operative times between 106 and 120 minutes having significantly lower pain, higher function, and better quality of life at 12 months, especially compared to patients with operative times < 90 minutes. Patients who had operative times between 106 and 120 minutes had significantly better VR-12 PCS and MCS at 12 months. Although statistically significant, differences were small and did not persist after controlling for within-surgeon effects, patient socio-demographics and baseline patient-reported outcomes, suggesting that patient characteristics or within-surgeon effects may play a more significant role in these patient-reported outcomes than operative time.

CONCLUSION: This study showed that among THA patients, operative times were significantly associated with patient-reported outcomes at 12 months post-operatively, but is one of many surgeon and patient-related factors with effect on THA outcome.

KEYWORDS: Total Hip Arthroplasty, THA, Operative Time, PROM, FORCE-TJR

INTRODUCTION

Shorter surgical times have been reported to be associated with a variety of better outcomes,[1-4] and could be assumed to decrease cost due to the high expense of operating room time.[5] It may appear that decreasing time of an operation will confer better result to the patient and be more cost effective, but this may be true only up to a point. We would propose that expert surgeons should be efficient and perform required steps of the operation in a timely manner while also avoiding rushing and errors, with the goal of the best long-term result for the patient. Furthermore, with the transition to shared-responsibility payer programs, including bundled care,[6] value is assigned to long-term successful outcomes and avoiding complication and reoperation. This idea of valuing quality over speed is a well-understood concept expressed commonly in familiar phrases such as *haste makes waste, and slow is smooth and smooth is fast*.

The purpose of this study was to define the relationship between operative times and patient outcomes in total hip arthroplasty patients, drawing from the *Function and Outcomes Research for Comparative Effectiveness in Total Joint Replacement (FORCE-TJR) data registry of the Miriam Hospital Total Joint Center, Providence, RI.* The primary aim was to examine the relationship between operative times and patient-reported outcome measures 12 months postoperatively, and the secondary aim was to understand the relationship between operative time, length of hospital stay, and 90-day all-cause-readmissions.

METHODS

This study was approved by the Lifespan Institutional Review Board.

Data Source

Deidentified clinical data from patients undergoing total hip replacements were obtained from the *Function and Outcomes Research for Comparative Effectiveness in Total Joint Replacement (FORCE-TJR) data registry of the Miriam Hospital Total Joint Center.* This is a retrospective review of registry data from January 2016 to December 2019. The FORCE-TJR maintains outcome data on primary THR and TKR using validated patient reported outcome (PRO) instruments including, but not limited to, the hip disability and osteoarthritis outcome score (HOOS). This study uses the HOOS subscales of pain, activities of daily living (ADL), and quality of life (QOL), as well as the Veteran's Rand 12-item (VR-12) health survey instrument with 2 outcome domains (physical health and mental health). PROs were collected preoperatively and 12 months postoperatively. The FORCE-TJR also contains data on patient socio-demographics, including age, gender, race, educational level, marital status, insurance status, body mass index, smoking status, diabetes, Charlson comorbidity index, and Oswestry low back score, all of which are included in this study. Additional data on length of hospital stay and 90-day-readmissions were obtained from the Miriam Hospital EPIC electronic medical record (EMR). Surgical time was defined as the difference between the timepoints logged in the EMR by the circulating nurse from "surgery start" to "surgery end." Clinically, these timepoints correspond to surgical incision to closure complete.

Outcomes Measures

The primary study outcomes were the HOOS pain, ADL, and QoL outcome scores and secondary outcomes included the VR-12 physical component (PCS) and mental component (MCS) outcome scores. The HOOS is a validated patient-reported-outcome-measure (PROM)[7] with 2 domains relevant to THA (pain and ADL function), and a QoL subscale, with scores ranging from 1 to 100 with higher scores associated with better outcomes. The VR-12 is a validated PROM[8] with two domains (MCS and PCS), scores range from 0 to 80 where 50 is the general population mean, and higher scores are best. These measures were chosen as they represent different domains of recovery. Additional secondary study outcomes were length of hospital stay and 90-day all-cause readmissions.

Independent Variables

The primary independent variable was operative time in minutes. For analysis purposes, operative time was examined as a categorical variable based on observed quintiles: <90 minutes, 90 to 105 minutes, 106 to 120 minutes, 121 to 135 minutes, and >135 minutes. The preoperative model covariates considered in this study were age, gender, race, educational level, marital status, insurance status, body mass index, smoking status, diabetes, Charlson comorbidity index, and Oswestry low back score.

Power Analysis and Sample Size Justification

Power was estimated with intent to determine the difference between operative time quintiles that could be detected at 80% power with an estimated sample size of 1100 total hip arthroplasty cases, while accommodating the Bonferroni adjusted per-comparison alpha ($p<0.005$) necessary to maintain an overall two-tailed alpha of 0.05 across the hypotheses we tested. A Bonferroni adjustment was chosen for the purposes of power analysis because it is highly conservative and the Holm test, which was used in all analyses, is based on the empirical p-value attained at the time of data analysis which was unavailable. Given these parameters, a sample size of 1100 at the time of analysis maintained a power of approximately 80% to detect a difference of 3 points in the PROMS, a 0.22-day difference in hospital length of stay, and an 8% difference in 90-day all-cause readmission rates between operative time quintiles.

Statistical Methods

Data was imported into SAS version 9.4 (SAS Institute Inc., Cary, NC) for data management and statistical analysis. Descriptive statistics for the sample socio-demographics and baseline patient reported outcomes were obtained for the overall sample and by operative time. Mean and standard deviation were reported for the continuous variables while frequency and percentage were reported for the categorical variables. Analysis of variance (continuous variables) and Chi-square test (categorical variables) were used to compare the patient socio-demographics and baseline patient reported outcomes across operative time. Generalized linear models (GLM) were used to assess the unadjusted association between study outcomes and operative times. Generalized estimating equations (GEE) were used to evaluate association between study outcomes and operative times, after accounting for study covariates and possible within-surgeon effects. Classical sandwich estimators were used to protect against possible model misspecification. Post-hoc pairwise comparisons between operative time quintiles were conducted within the regression model via orthogonal contrasts. The Holm test was used to correct for multiple comparisons where appropriate in order to maintain a two-tailed familywise alpha at 0.05. A p-value < 0.05 was used to determine statistical significance.

RESULTS

Cohort Baseline Characteristics

There were 1,123 total hip arthroplasty patients available for analysis between January 2016 and December 2019 (mean Age=65.5 years, 41% male). Operative times ranged from 36 minutes to 366 minutes, with a mean operative time of 111.26 minutes (SD=31.37). **Table 1** presents the patient socio-demographics and baseline patient reported outcome measures. Several patient characteristics significantly differ across operative times, including age, gender, insurance status, education level, body mass index, Oswestry back pain score, baseline VR-12 mental component score, baseline HOOS pain score, and baseline HOOS activities of daily living score ($p<0.05$). (See **Table 2:** Comparisons of patient characteristics across time groups.) Patient age decreases across operative times, with a mean of 67.7 years for operative times <90 minutes and a mean of 64.1 years for operative times >135 minutes ($p=0.006$). The percentage of males, privately insured patients, and patients with a college degree increases with increasing operative times ($p<0.0001$, $p=0.01$, $p=0.04$ respectively). Similarly, body mass index and HOOS outcome scores increase with increasing operative times.

Outcome Assessments

Table 3 shows the distribution of patient reported outcome scores at 12 months postoperative, as well as the distribution of length of hospital and 90-day all-cause readmissions.

12-Months Patient-Reported Outcomes

Unadjusted GLM showed that HOOS pain scores 12-months post-operatively differed across operative times, with patients who had operative times of 106 to 120 minutes (M=89.04, p<0.0001 and p<0.0001 respectively), 121 to 135 minutes (M=88.75, p=0.0003 and p<0.0001 respectively), and >135 minutes (M=88.57, p=0.01 and p=0.002, respectively) having significantly lower pain at 3 months than patients with operative times <90 minutes (M=86.27) and between 90 and 105 minutes (M=87.35). Patients with operative times between 90 and 105 minutes had significantly lower pain than patients with operative times <90 minutes (p=0.01). There were no statistically significant differences in HOOS pain scores at 12-months post-operatively between patients with operative times >105 minutes (all p>0.05) (**Table 4**).

HOOS ADL scores at 12-months post-surgery significantly differed across operative times in unadjusted GLM. Patients who had operative times between 106 and 120 minutes (M=89.36), between 121 and 135 minutes (M=88.83) and >135 minutes (M=89.40) had significantly fewer difficulties with activities of daily living than patients who had operative times <90 minutes (M=86.87, all p<0.0001) and between 90 and 105 minutes (M=87.87, p<0.0001, p=0.02, p<0.0001 respectively). Similarly, patients who had operative times between 90 and 105 minutes had significantly fewer difficulties with activities of daily living than patients who had operative times <90 minutes (p=0.02). There were no statistically significant differences in HOOS ADL scores among patients with operative times >105 minutes (all p>0.05) (**Table 4**).

HOOS QoL scores at 12-months post-surgery significantly differed across operative times in the unadjusted GLM. Patients with operative times between 106 and 120 minutes had significantly better quality of life at 12 months (i.e., higher QoL scores) (M=83.62) than patients with operative times <90 minutes (M=80.93, p<0.0001), between 90 and 105 minutes (M=80.61, p<0.0001), between 121 and 135 minutes (M=80.22, p<0.0001), and >135 minutes (M=80.93, p<0.0001). None of the other pairwise comparisons yielded statistically significant findings (**Table 4**).

VR-12 PCS at 12 months significantly differed across operative times in unadjusted GLM. Patients who had operative times between 106 and 120 minutes had significantly better physical functioning at 12 months (i.e., higher PCS scores) than patients who had operative times <90 minutes (M=47.53 vs. M=45.17, p<0.0001). Similarly, patients who had operative times >135 minutes had significantly better physical functioning at 12 months than patients who had operative times <90 minutes (M=45.17, p=0.001). There were no other statistically significant pairwise comparisons (**Table 4**).

VR-12 MCS scores at 12-months post-surgery significantly differed across operative times in the unadjusted GLM. Patients with operative times between 106 and 120 minutes had significantly better mental health at 12 months (i.e., higher MCS scores) (M=56.71) than patients with operative times <90 minutes (M=54.06, p<0.0001) and between 90 and 105 minutes (M=54.64, p=0.0003). Similarly, patients with operative times between 121 and 135 minutes (M=55.51) and >135 minutes (M=55.69) had significantly better mental health than patients with operative times <90 minutes (p=0.04 and p=0.01 respectively). Mental health at 12-months postoperative did not differ among patients who had operative times between 106 and 120 minutes and patients with operative times between 121 and 135 minutes (p=0.10) and >135 minutes (p=0.21). Similarly, mental health at 12-months postoperative did not significantly differ

Table 1. Sample Demographics and Baseline Patient Reported Outcomes

Characteristic	N	%
Male	459	41.28
BMI Category		
<25	230	21.12
25-30	398	36.55
30-35	293	26.91
35-40	137	12.58
>40	31	2.85
Race		
White	1042	94.73
Black or African American	27	2.45
Asian	4	0.36
Native American or Alaska Native	3	0.27
Native Hawaiian or Other Pacific Islander	1	0.09
Other	15	1.36
Refused	8	0.73
Married	712	64.26
Health Insurance Type		
Private	479	44.68
Medicaid	29	2.71
Medicare	520	48.51
Other	44	4.10
Cigarette smoker	65	5.88
Diabetes	108	9.91
Age, Mean ± SD	65.49 ± 10.04	
BMI, Mean ± SD	29.39 ± 5.33	
OSWE Pain Intensity, Mean ± SD	2.00 ± 1.07	
Charlson Comorbidity Index Count, Mean ± SD	0.40 ± 0.78	
Baseline VR12 PCS, Mean ± SD	31.30 ± 9.59	
Baseline VR12 MCS, Mean ± SD	54.89 ± 10.98	
Baseline HOOS Pain, Mean ± SD	40.97 ± 17.56	
Baseline HOOS ADL, Mean ± SD	46.47 ± 19.86	
Baseline HOOS QoL, Mean ± SD	31.21 ± 17.97	

Table 2. Comparisons of patient characteristics across time groups

	<90 min	91–105 min	106–120 min	121–135 min	>135 min	P
Age	67.7 (10.2)	66.5 (10.8)	65.1 (9.7)	64.5 (9.2)	64.1 (10.1)	0.006
BMI	29.1 (5.4)	28.0 (4.8)	29.1 (5.1)	30.4 (5.7)	30.5 (5.3)	<0.0001
OWSE pain	2.3 (1.2)	2.0 (1.1)	1.8 (1.0)	2.0 (1.0)	1.9 (1.0)	<0.0001
CCI count	0.48 (0.90)	0.36 (0.62)	0.36 (0.85)	0.36 (0.85)	0.39 (0.71)	0.44
Pre PCS	31.2 (9.9)	30.7 (9.3)	31.6 (9.5)	31.6 (9.5)	31.2 (9.8)	0.78
Pre Pain	38.1 (18.2)	39.8 (17.2)	42.4 (18.1)	42.4 (18.1)	42.3 (16.3)	0.02
Pre MCS	52.7 (11.2)	55.1 (11.3)	56.6 (10.6)	56.6 (10.6)	55.5 (10.6)	0.002
Pre ADL	42.6 (20.5)	46.3 (19.1)	46.8 (20.3)	46.8 (20.3)	49.9 (18.9)	0.003
Male	71 (30.3%)	81 (39.1%)	109 (41.4%)	87 (43.1%)	110 (54.5%)	<0.0001
Race						0.29
Asian	0 (0%)	1 (0.5%)	2 (0.8%)	0 (0%)	1 (0.5%)	
Black	6 (2.6%)	5 (2.5%)	2 (0.8%)	3 (1.5%)	10 (5.1%)	
Native Am.	2 (0.9%)	0 (0%)	0 (0%)	0 (0%)	1 (0.5%)	
Native HI	0 (0%)	0 (0%)	1 (0.4%)	0 (0%)	0 (0%)	
Other	3 (1.3%)	5 (2.5%)	2 (0.8%)	2 (1%)	3 (1.5%)	
Refused	3 (1.3%)	0 (0%)	3 (1.2%)	1 (0.5%)	1 (0.5%)	
White	219 (94%)	191 (94.6%)	252 (96.2%)	196 (97%)	181 (91.9%)	
Married	140 (60.1%)	138 (67.3%)	175 (66.8%)	124 (61.1%)	133 (66.2%)	0.34
Insurance						0.01
Medicaid	13 (5.7%)	3 (1.5%)	3 (1.2%)	5 (2.5%)	4 (2.1%)	
Medicare	130 (56.8%)	95 (48.7%)	117 (46.3%)	93 (47%)	83 (43%)	
Other	8 (3.5%)	9 (4.6%)	9 (3.6%)	8 (4%)	10 (5.3%)	
Private	78 (34.1%)	88 (45.1%)	124 (49%)	92 (46.5%)	96 (49.7%)	
Smoker	17 (7.3%)	12 (5.9%)	18 (6.8%)	8 (4.0%)	10 (5.0%)	0.58
Diabetes	23 (10.2%)	20 (9.8%)	22 (8.4%)	23 (11.7%)	19 (9.6%)	0.85
School completed						0.04
<HS	11 (4.7%)	7 (3.4%)	8 (3.1%)	5 (2.5%)	3 (1.5%)	
≥ College Grad	81 (34.5%)	100 (49.0%)	127 (48.5%)	97 (48.0%)	106 (53.0%)	
HS/Some College	138 (58.7%)	92 (45.1%)	121 (46.2%)	97 (48.0%)	89 (44.5%)	
Other	5 (2.1%)	5 (2.5%)	6 (2.3%)	3 (1.5%)	2 (1.0%)	

Table 4. 12-month HOOS and VR-12 patient reported outcomes by operative times

Patient Reported Outcome	Operative Time				
	<90 minutes Mean (95% CI)	90–105 minutes Mean (95% CI)	106–120 minutes Mean (95% CI)	121–135 minutes Mean (95% CI)	>135 minutes Mean (95% CI)
HOOS					
Pain	86.27 (85.78–86.74)	87.35 (86.85–87.83) †	89.04 (88.62–89.45) £†	88.75 (88.28–89.21) £†	88.57 (88.09–89.03) £†
ADL	86.87 (86.39–87.34)	87.87 (87.38–88.34) †	89.36 (88.94–89.77) †£	88.83 (88.36–89.29) †£	89.40 (88.93–89.86) †£
QoL	80.93 (80.26–81.58)	80.61 (89.90–81.29)	83.62 (83.07–84.16) †£	80.22 (79.53–80.89)*	80.13 (79.39–80.84)*
VR–12					
PCS	46.26 (45.52–46.99)	47.53 (46.88–48.19)	46.34 (45.60–47.07) †	47.16 (46.43–47.89)	45.17 (44.48–45.87) †
MCS	54.06 (53.36–54.76)	54.64 (53.90–55.37)	56.71 (56.06–57.36) †£	55.51 (54.77–56.24) †	55.69 (54.95–56.42) †

† p<0.05 for comparisons to <90 minutes
£ p<0.05 for comparisons to 90–105 minutes
* p<0.05 for comparisons to 106–120 minutes

Table 3. Descriptive Statistics for Study Outcome Measures

Measure	Mean	SD
12-month PROMS		
HOOS Pain	88.13	15.60
HOOS ADL	88.46	14.96
HOOS QoL	81.27	19.53
VR-12 PCS	46.59	10.09
VR-12 MCS	55.37	9.74
Length of Hospital Stay, in days	1.77	0.90
90-day All Cause Readmissions	366	32.59
90-day All Cause Inpatient Readmissions	51	4.54

among patients with operative times <90 minutes and between 90 and 105 minutes (p=0.54) or among patients with operative times between 90 and 105 minutes and between 121 and 135 minutes (p=0.30) or >135 minutes (p=0.21) (**Table 4**).

There were no statistically significant differences in patient-reported outcomes at 12 months after controlling for within-surgeon effects, patient socio-demographics and baseline patient reported outcomes in the GEE, suggesting that patient characteristics or within-surgeon effects may play a more significant role in these patient-reported-outcomes than operative time.

Length of Hospital Stay

There were no statistically significant differences in length of hospital stays between operative times.

90-Day All-Cause Readmissions

90-day-all-cause-readmissions significantly differed across operative times. (See **Table 5a,b**: Readmission rates by procedure time.) Patients who had

Table 5a. Readmission rates by procedure time

	<90 minutes % (95% CI)	90–105 minutes % (95% CI)	106–120 minutes % (95% CI)	121–135 minutes % (95% CI)	>135 minutes % (95% CI)
Readmission Rate	30% (24.5–36.1%)	34.3% (28.2–41.0%)	25.2% (20.3–30.8%)	33.0% (26.9–39.7%)	41.8% (24.5–36.1%)*

* p<0.05 for comparisons to 106–120 minutes

Table 5b. P-values for the above comparisons

Comparison	P-value
<90 minutes to	
90–105 minutes	0.99
106–120 minutes	0.91
121–135 minutes	0.99
> 135 minutes	0.09
90–105 minutes to	
106–120 minutes	0.25
121–135 minutes	0.99
> 135 minutes	0.59
106–120 minutes to	
121–135 minutes	0.44
> 135 minutes	0.002
121–135 minutes to	
>135 minutes	0.44

an operative time between 106 and 120 minutes had a significantly lower likelihood of 90-day all-cause readmission than patients who had an operative time >135 minutes (25.2% vs. 41.8%, p=0.002). There were no other statistically significant pairwise comparisons.

DISCUSSION

This paper sought to determine the relationship between operative times and patient-reported outcomes, length of hospital stay, and 90-day all-cause readmissions among total hip arthroplasty patients. Analysis showed that among total hip arthroplasty patients, operative times were significantly associated with patient-reported outcomes 12 months post-operatively and 90-day all-cause readmissions but not with length of hospital stay. Further, the study indicated that this relationship between operative times and patient-reported outcomes and 90-day all-cause readmissions was not linear, suggesting an optimal operative time between 106 and 120 minutes.

Differences in the outcome measures, while statistically significant were very small, and the clinical significance of these small differences should be considered. The definition of a Minimal Clinically Important Change in HOOS score varies across publications,[9-11] but is reported at 6 to 33 depending on study and calculation methods.

Furthermore, these differences in patient-reported outcomes in relation to operative time, after controlling for within-surgeon effects, patient's socio-demographics and baseline patient reported outcomes became insignificant. This emphasizes that time in the operating room alone is not the only factor in the success of surgery, but instead this suggests that patient selection, and what is done in the operating room by the surgeon in the time they have may be more important factors influencing patient outcome.

It is important to note that the optimal operative time range we have determined in this study is slightly greater than a previous study using the ACS National Surgical Quality Improvement Program (NSQIP) database, which reported optimal THA operative time at approximately 80 minutes.[12] A THA operative time cutoff of greater than 150 minutes is suggested to prevent a significant but slight increase in revision rates using the Norwegian Arthroplasty Registry.[13] Historical average THA operative times reported in previous studies had been shown to decrease from 171.0 to 142.5 minutes from 1997–2004, using Medicare data,[14] but more recently, average THA operative times in NSQIP patient sample has remained relatively uniform from 2008–2018[15] with median time reported as 87 minutes.

The current study has several limitations that warrant consideration. First, this study is a retrospective study of registry data; therefore, the findings cannot establish a causal relationship between operative times and patient outcomes. However, the study does suggest associations between operative times and several patient-related measures of outcome. A randomized controlled study of surgical times is very unlikely to be done for pragmatic and ethical reasons. Second, the clinical significances of the observed differences in patient-reported outcome measures are unknown. It may be postulated that, if these differences were of greater magnitude or the measured operative times were more extreme, clinical significances could be established. In this context, the study suggests a larger, prospective study of operative times on patient-reported outcomes.

Prolonged duration of surgery due to surgeon or operating room inefficiencies or errors should be avoided as this results in increased anesthesia time, cost, and risks associated with over-exposure of the surgical site without any benefit. Quick surgery resulting from skipped steps, less careful or rushed technique, similarly should be avoided as the slightly decreased cost of the diminished operative time could be outweighed by potential increased risk of complication, re-operation, and worse long-term outcome for the patient. We propose that surgeons should operate efficiently and not waste time, but this should not come at the expense of rushing and compromising outcomes. Spending time to do the best job initially should be emphasized to prevent complications and revision surgery, which ultimately add more cost to the episode of care than what is saved by slightly decreased operative time.

Other stakeholders will also find this information useful. Defining surgery-time ranges resulting in optimal outcomes can help hospitals to provide adequate resources and block time, and payers to allocate appropriate value for the time of the team performing an operation. The results reported in this study help us understand surgical-time-outcome-quality relationship for total hip replacement in more quantitative terms.

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