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Comparison of total joint arthroplasty care patterns prior to the Covid-19 pandemic and after resumption of elective surgery during the Covid-19 Outbreak: A retrospective, large urban academic center study

Kush C. Shah [a], Jashvant Poeran [a], Nicole Zubizarreta [a], Ken McCardle [b], Jebakaran Jebakumar [a], Calin S. Moucha [a], Brett L. Hayden [a,*]

[a] Department of Orthopedic Surgery, The Mount Sinai Hospital, Icahn School of Medicine at Mount Sinai, New York, NY, USA
[b] Department of Clinical Operations, Mount Sinai Health System, USA

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ABSTRACT

Background: After the suspension of elective surgeries was lifted in June 2020 in New York State, challenges remained regarding coordination of total joint arthroplasty (TJA) cases. Using the experience from a high-volume health system in New York City, we aimed to describe patterns of care after resumption of elective TJA.
Methods: We retrospectively assessed 7,699 TJAs performed before and during the COVID-19 pandemic. Perioperative characteristics and clinical outcomes were compared between TJAs based on time period of performance: 1) pre-pandemic (PP, June 8th–December 8th, 2019), 2) initial period post-resumption of elective surgeries (IR, June 8th–September 8th, 2020), and 3) later period post-resumption (LR, September 9th–December 8th, 2020).
Results: LOS > 2 days (83%, 67%, 70% for PP, IR, LR periods respectively) and discharge rates to post-acute care (PAC) facilities were lower during the pandemic periods ($OR_{IR\ vs.\ PP}$: 0.48, 95% CI: 0.40–0.59, $p < 0.001$; $OR_{LR\ vs.\ PP}$: 0.63, 95% CI: 0.53–0.75, $p < 0.001$). Compared to the pre-pandemic period, the risk for 30-day readmission was lower during the IR period (OR: 0.62, 95% CI: 0.40–0.98, $p = 0.041$) and similar during the LR period (OR: 0.96, 95% CI: 0.65–1.41, $p = 0.832$).
Conclusions: Despite decreased LOS and discharge to PAC for TJAs performed during the pandemic, 30-day readmissions did not increase. Given the increased costs and lack of superior functional outcomes associated with discharge to PAC, these findings suggest that discharge to PAC facilities need not return to pre-pandemic levels.

1. Introduction

Formally declared a pandemic on March 11, 2020 by the World Health Organization, COVID-19 has contributed to over 212 million confirmed cases and 4.4 million deaths worldwide as of August 25, 2021 [1,2]. Within the months of March and

* Corresponding author at: Department of Orthopedic Surgery, Icahn School of Medicine at Mount Sinai Complex, Primary, & Revision Total Joint Replacement and Musculoskeletal Oncology, 5 East 98th St, New York, NY 10029, USA.
E-mail address: brett.hayden@mountsinai.org (B.L. Hayden).

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April 2020, New York State, and New York City in particular, quickly became an epicenter for the COVID-19 outbreak [3,4]. Recommendations to cancel elective procedures were soon issued by the United States Surgeon General and American Association of Hip and Knee Surgeons (AAHKS) [5]. Total hip and knee joint arthroplasty (TJA), two of the most common orthopedic elective procedures, were among the cohort of elective surgeries that were suspended in mid-March 2020 across New York State [6,7].

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are widely regarded as highly successful procedures, as numerous studies have outlined both their cost-effectiveness and societal benefits [8,9]. With cancellations of elective TJA across the country, researchers have estimated that over 300,000 TJA procedures were delayed through June 2020 [6]. For New York City in particular, elective surgeries did not resume until June 8th, 2020 [10]. Given that about 1.4 million TJA procedures were projected to be performed in 2020, the suspension and resulting delay of these procedures is suspected to cause severe financial strain for hospital systems across the country [11]. Additionally, the backlog in TJA procedures poses specific challenges regarding triaging surgical cases, coordinating with institutional post-acute care, and evaluating effects on provider reimbursement. Thus, the purpose of this study is to characterize and compare patterns of care for TJA after the resumption of elective surgery.

2. Materials and methods

This study was approved by the Institutional Review Board. A retrospective medical record review was performed to determine the two study populations of interest: 1) patients who underwent total joint arthroplasty (TJA) between June 8th–December 8th 2019, and 2) June 8th–December 8th 2020. TJA was defined as the sum of total knee arthroplasty (TKA) and total hip arthroplasty (THA) cases performed during these selected time periods. Patients who underwent TKA and patients who underwent THA across an urban, academic health system were identified. Additional inclusion criteria included age greater than or equal to 18 years, elective surgery, and inpatient surgery. Patients who died during hospitalization or underwent nonelective procedures were excluded. Out of 11,459 TJA patients, 7,699 patients met our inclusion and exclusion criteria for this study.

TJA cases were divided into three groups based on time period of performance: 1) pre-pandemic (PP; procedures performed from June 8th–December 8th, 2019), 2) initial-resumption (IR; procedures performed during the pandemic directly after the resumption of elective surgery in NYC, June 8th–September 8th, 2020), and later-resumption (LR; procedures that occurred greater than 3 months after the resumption of elective surgery in NYC, September 9th–December 8th, 2020). Covariates pertaining to patient characteristics were collected for each group: age (median, <65, ≥ 65), sex (% male), BMI (<18, 18–29, ≥ 30), race (white, non-white), location (patient residence in NYC, patient residence not in NYC), Charlson Comorbidity Index (CCI) (0, 1, ≥ 2), American Society of Anesthesiologists (ASA) score (1, 2, ≥ 3) [12]. Surgical care patterns were also collected for each group: anesthesia type (regional, general), operative time, length of stay (LOS; median, ≤ 2 days, > 2 days), frequency of blood transfusion, readmission rate within 30 days, and discharge patterns (home, institutional post-acute care [PAC]).

Univariable associations were assessed using standardized differences instead of p-values given the large sample size. A standardized difference (STD) of 0.1 (or 10%) has been previously proposed to indicate a meaningful difference between groups, and was thus used [13]. For each variable, comparisons were made between the following cohorts: 1) pre-pandemic & initial-resumption, 2) pre-pandemic & later-resumption, 3) initial-resumption & later-resumption. Multivariable logistic regression models controlling for age, sex, race, BMI, anesthesia type, CCI, ASA score, and TJA type (THA or TKA) were used to assess associations between TJA time periods and the following outcomes: length of stay > 2 days, discharge to institutional post-acute care, and 30-day readmissions. All of these analyses were performed in SAS v9.4 statistical software (SAS Institute, Cary, NC).

3. Results

A summary of patient characteristics is provided in Table 1. A total of 7,699 patients who underwent TJA (THA or TKA) were included in this study, with 4,221 procedures performed in the pre-pandemic period, 1,629 procedures performed between in the initial resumption period, and 1,849 procedures performed in the period following initial resumption. The median age of TJA patients was highest in the pre-pandemic period (66.56 years), as the median ages were 65.14 years (STD = 0.180) and 64.97 years (STD = 0.125) during the initial resumption and later-resumption periods respectively. The percentage of male TJA patients was greater during the initial resumption period, as males accounted for 32.62% of cases prior to the pandemic and 39.29% in the initial resumption period (STD = 0.139).

There was a nearly significant difference in patient race between the pre-pandemic (% of non-white patients: 58.42%) and initial resumption periods (% of non-white patients: 53.53%) (STD = 0.099). There was no significant difference in patient race between the pre-pandemic and later-resumption periods (% of non-white patients: 58.73%) (STD = 0.006). There was a significant difference in patient race between the initial-resumption (% of non-white patients: 53.53%) and later-resumption time (% of non-white patients: 58.73%) periods (STD = 0.105). While there was no difference in median BMI across the three time periods (none of the standardized differences are > 0.1), fewer patients with BMI < 18 were operated on during the

Table 1
Patient Characteristics.

Variables	Pre-Pandemic TJAs (n = 4,221)	Initial Resumption TJAs (n = 1,629)	Later Resumption TJAs (n = 1,849)	Standardized Difference (PP vs. IR)	Standardized Difference (PP vs. LR)	Standardized Difference (IR vs. LR)
Age						
Median (years)	66.56 (59.51–73.88)	65.14 (58.60–72.02)	64.97 (59.22–72.13)	0.180	0.125	0.058
Categorical				0.105	0.115	0.012
≥65	2345 (55.56%)	820 (50.34%)	921 (49.81%)			
<65	1876 (44.44%)	809 (49.66%)	928 (50.19%)			
Sex- Male				0.139	0.059	0.080
Yes	1377 (32.62%)	640 (39.29%)	655 (35.42%)			
No	2844 (67.38%)	989 (60.71%)	1194 (64.58%)			
BMI						
Medians	30.11 (26.37–34.46)	30.27 (26.13–34.78)	29.95 (26.07–34.67)	0.034	0.013	0.047
Categorical				0.193	0.289	0.145
<18	174 (4.12%)	12 (0.74%)	6 (0.32%)			
18–30	1982 (46.96%)	780 (47.88%)	922 (49.86%)			
>30	2065 (48.92%)	837 (51.38%)	921 (49.81%)			
Race				0.099	0.006	0.105
White	1755 (41.58%)	757 (46.47%)	763 (41.27%)			
Non-White	2466 (58.42%)	872 (53.53%)	1086 (58.73%)			
Location				0.082	0.117	0.035
NYC residence	2866 (67.9%)	1043 (64.03%)	1153 (62.36%)			
non-NYC residence	1355 (32.1%)	586 (35.97%)	696 (37.64%)			
CCI				0.082	0.054	0.048
0	2321 (54.99%)	957 (58.75%)	1052 (56.9%)			
1	1106 (26.2%)	383 (23.51%)	473 (25.58%)			
≥2	792 (18.76%)	289 (17.74%)	324 (17.52%)			
Unknown	2 (0.05%)	0 (0.00%)	0 (0.00%)			
ASA				0.122	0.175	0.089
1	56 (1.35%)	14 (0.89%)	30 (1.73%)			
2	2164 (52.36%)	918 (58.43%)	1022 (58.9%)			
≥3	1913 (46.29%)	639 (40.67%)	683 (39.37%)			
Unknown	88	58	114			

COVID-19 pandemic (% of BMI < 18 patients: pre-pandemic = 4.12%, initial-resumption = 0.74% (STD = 0.193), later-resumption = 0.32% (STD = 0.289)).

There was no significant difference in Charlson Comorbidity Index scores between patients in all three cohorts (none of the standardized differences are > 0.1). ASA scores were lower for patients whose TJAs were performed during the pandemic, as the percentage of patients with ASA $\geq$ 3 was 46.29% prior to the pandemic, 40.67% in the initial resumption period (STD = 0.122), and 39.37% in the later-resumption period (STD = 0.175). There was no significant difference in ASA scores between the initial-resumption and later-resumption cohorts (STD = 0.089).

A summary of surgical care pattern data is provided in Table 2. There was no difference in OR time, blood transfusions, and type of anesthesia used for cases performed prior to and during the pandemic (none of the standardized differences are > 0.1). Patients who underwent TJAs during the pandemic had shorter LOS, as the median LOS was 2.35 days prior to the pandemic, 2.26 days in the initial period (STD = 0.233), and 2.25 days in the later period (STD = 0.190). There was no difference in median LOS between the initial resumption and later-resumption periods (STD = 0.039). On categorical analysis, 82.50% of patients had a LOS > 2 days during the pre-pandemic period, while only 67.1% of patients in the initial-resumption period (STD = 0.360) and 70.4% of patients in the later-resumption period (STD = 0.288) had a LOS > 2 days.

The 30-day readmission rate was nearly significantly lower in the initial-resumption cohort when compared to the pre-pandemic cohort (1.47% vs. 2.76%, STD = 0.09), but there was no significant difference in readmission rates between the pre-pandemic and later-resumption (30-day readmissions rate: 2.44%) cohort (STD = 0.02). During the pandemic, fewer patients were discharged to institutional post-acute care, as the rates were 19.90%, 9.39% (STD = 0.301), and 11.79% (STD = 0.224) for the pre-pandemic, initial resumption cohort, and later-resumption cohort respectively. Discharges to institutional post-acute care remained low during the later-resumption period, as there was no significant difference between the initial-resumption and later-resumption cohorts (STD = 0.078).

Multivariable logistic regression analysis for prolonged LOS, discharge to institutional post-acute care, and 30-day readmissions is summarized in Table 3. Compared to pre-pandemic TJA cases, patients were less likely to have a LOS $\geq$ 2 days during the initial-resumption (OR: 0.47, 95% CI: 0.41–0.54, $p < 0.0001$) and later-resumption (OR: 0.55, 95% CI: 0.48–0.63, $p < 0.0001$) time periods. Patients were also less likely to be discharged to an institutional post-acute care facility in the initial-resumption (OR: 0.48, 95% CI: 0.40–0.59, $p < 0.0001$) and later-resumption (OR: 0.63, 95% CI: 0.53–0.75, $p < 0.0001$) cohorts compared to patients who underwent TJA prior to the COVID-19 pandemic. Patients who underwent TJA during the initial resumption period were significantly less likely to be readmitted within 30-days compared to pre-

Table 2
Surgical Care Patterns.

	Pre-Pandemic TJAs (n = 4,221)	Initial Resumption TJAs (n = 1,629)	Later Resumption TJAs (n = 1,849)	Standardized Difference (PP vs. IR)	Standardized Difference (PP vs. LR)	Standardized Difference (IR vs. LR)
Anesthesia				0.028	0.043	0.071
Regional	3928 (93.06%)	1504 (92.33%)	1740 (94.1%)			
General	293 (6.94%)	125 (7.67%)	109 (5.9%)			
L.O.S. median (days)	2.35 (2.16–3.28)	2.26 (1.40–3.11)	2.25 (1.46–3.04)	0.233	0.190	0.039
L.O.S categorical				0.360	0.288	0.071
≤2 days	740 (17.50%)	536 (32.9%)	548 (29.6%)			
>2 days	3481 (82.50%)	1093 (67.1%)	1301 (70.4%)			
OR time median (minutes)	166 (146–189)	164 (147–183)	167 (148–188)	0.077	0.036	0.049
Blood Transfusion (%)	102 (2.42%)	32 (1.96%)	61 (3.30%)	0.031	0.053	0.084
Readmission within 30 days	116 (2.76%)	24 (1.47%)	45 (2.44%)	0.09	0.02	0.07
Discharge to Institutional Post-Acute Care?				0.301	0.224	0.078
Yes	840 (19.9%)	153 (9.39%)	218 (11.79%)			
No	3381 (80.1%)	1476 (90.61%)	1631 (88.21%)			

Table 3
Multivariable Logistic Regression Models Assessing Impact of TJA Time Period on Prolonged Length of Stay, Discharge to Institutional Post-Acute Care, and 30-Day Readmissions.

		Prolonged LOS		Discharge to Institutional Post-Acute Care		30-Day Readmissions	
		OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
TIME PERIOD							
	Pre-pandemic	*					
	initial-resumption	0.47 (0.41–0.54)	<0.0001	0.48 (0.40–0.59)	<0.0001	0.62 (0.40–0.98)	0.0412
	later-resumption	0.55 (0.48–0.63)	<0.0001	0.63 (0.53–0.75)	<0.0001	0.96 (0.65–1.41)	0.8317

*indicates reference category.

pandemic patients (OR: 0.62, 95% CI: 0.40–0.98, $p = 0.0412$), however there was no difference in 30-day readmission likelihood when comparing pre-pandemic and later-resumption patients (OR: 0.96, 95% CI: 0.65–1.41, $p = 0.8317$).

4. Discussion

The COVID-19 pandemic, which has caused over 4.1 million deaths worldwide as of July 2021, resulted in significant delays in access to medical and surgical care, particularly in the year 2020 [6]. As New York City quickly became a pandemic epicenter in March and April 2020, elective surgical procedures were quickly halted and not resumed until June 8, 2020 [3,5,7]. Among the most common orthopedic procedures, THAs and TKAs made up a significant proportion of the delayed surgeries. The goal of this study was to assess the effect of the pandemic on TJA care patterns through an evaluation of patient characteristics, surgical characteristics, and postoperative outcomes.

There were significant differences in several key patient characteristics when comparing TJAs performed prior to the pandemic and post-resumption of elective surgery during the pandemic. During the pandemic period, especially during the initial resumption period, patients who underwent TJAs were younger, had healthier physical status scores, and had fewer risk factors for adverse outcomes than patients who underwent TJAs prior to the pandemic. Patients ≥ 65 years of age made up over 55% of the total pre-pandemic TJA cohort, while patients ≥ 65 years of age only made up around 50% of the total TJAs during the initial resumption period (June 8, 2020–September 8, 2020) and later-resumption period (September 9, 2020–December 8, 2020).

The proportion of underweight patients was significantly smaller during the pandemic than prior to it, as the percent of TJAs performed on patients with BMI < 18 decreased from 4.12% pre-pandemic to 0.74% and 0.32% during the initial resumption and later-resumption periods respectively. Prior studies have identified an association between low BMI and increased LOS, increased mortality, as well as increased risk for adverse outcomes such as postoperative anemia and deep vein thrombosis in TJA [14,15]. Patients who underwent TJA during both pandemic periods also had lower ASA scores, as patients with ASA ≥ 3 accounted for 46% of cases pre-pandemic, 41% during the initial resumption period, and 39% during the later-resumption period. Prior studies have identified the association between higher ASA scores and increased complications, readmissions, and mortality [16,17]. In a study of 14,185 patients who underwent TJA, Gronbeck et al. determined that the ASA score was a better risk stratification tool for TJA patients than the CCI, and that higher ASA scores were risk factors for medical complications, surgical complications, 30-day readmission, and mortality [17].

Differences in proportion of patients by race were also noticed across the three time periods. While non-white patients made up 58% of total TJA cases prior to the pandemic, nonwhite patients only accounted for 53.5% of cases during the 3-month period immediately following the resumption of elective surgery in New York City (STD = 0.099). In the subsequent 3 months (September 9–December 8, 2020), levels of nonwhite patients (59%) returned to pre-pandemic levels (STD comparing pre-pandemic and later-resumption cohorts: 0.006, STD comparing initial-resumption and later-resumption cohorts: 0.105). This data underscores decreased access to care for nonwhite patients in the period immediately following resumption of elective surgery in New York City, and unfortunately reflects healthcare disparities that minorities have faced throughout the COVID-19 pandemic [18,19].

Decreased length of stay for TJA patients was noted during the pandemic, as LOS > 2 days dropped from 83% prior to the pandemic to 67% in the initial resumption period and 70% in the later-resumption period. Decreased LOS was in fact independently associated with TJAs performed during the two pandemic periods, initial-resumption (OR: 0.47, 95% CI: 0.41–0.54, $p < 0.0001$) and later-resumption (OR: 0.55, 95% CI: 0.48–0.63, $p < 0.0001$). Despite decreases in hospital LOS for patients, we did not see an increase in 30-day readmissions during the two pandemic periods. In fact, patients were less likely to be readmitted during the initial resumption period (OR: 0.62, 95% CI: 0.40–0.98, $p = 0.0412$) and not more likely to be readmitted during the later-resumption period (OR: 0.96, 95% CI: 0.65–1.41, $p = 0.8317$) when compared to pre-pandemic TJAs. Similarly, in a study analyzing 172,760 patients who underwent TJA over a 15-year period, Kirkland et al. found that increased index length of stay was associated with increased risk of readmission [20]. Altogether, decreased LOS is not associated with increased readmissions in TJA.

Additionally, we found a highly significant decrease in discharge to institutional post-acute for patients who underwent TJA during either of the pandemic periods. Non-home discharge rates dropped from 19.90% of cases pre-pandemic to 9.39% (STD = 0.301) and 11.79% (STD = 0.224) for patients who underwent surgery during the pandemic between June 8–September 8, 2020 and September 9–December 8, 2020 respectively. Lower odds of discharge to institutional post-acute care during the initial-resumption (OR: 0.48, 95% CI: 0.40–0.59, $p < 0.0001$) and later-resumption (OR: 0.63, 95% CI: 0.53–0.75, $p < 0.0001$) time periods were also supported by multivariate analysis. Post-acute care facilities were especially at-risk environments for COVID-19 transmission and infection, and this explains the significant drop in discharge to these facilities post-TJA during the two pandemic time periods. As of November 2020, Skilled Nursing Facilities had accounted for around 40% of all COVID-related mortality in the United States [21,22]. Despite decreased discharge to institutional post-acute care facilities, we noticed no increase in readmissions for patients who underwent TJA during the pandemic periods. Thirty-day readmission rates were in fact lower during the initial-resumption time period (OR: 0.62, 95% CI: 0.40–0.98, $p = 0.0412$) and not higher during the later-resumption time period (OR: 0.96, 95% CI: 0.65–1.41, $p = 0.8317$) compared to the pre-pandemic period. This was the case when controlling for factors that typically influence discharge destination such as comorbidity burden, physical status, BMI, and age. This data suggests that discharge to post-acute care facilities need not be as frequent as it was prior to the pandemic. Post-TJA discharge to post-acute care facilities have been associated with increased costs, frequency of adverse events, decreased patient satisfaction, and similar functional outcomes when compared to home discharge [23–26].

5. Conclusions

Altogether, patients who underwent TJA during the pandemic were younger and had healthier physical status scores. Non-white patients were at a disadvantage when it came to access to TJA in the period immediately following resumption of elective surgery in NYC. Hospital LOS and discharge to institutional post-acute care were both lower throughout the pandemic. 30-day readmissions did not increase throughout the pandemic, and in fact readmissions were significantly lower in the 3-month period following resumption of elective surgery than in the pre-pandemic period, suggesting that discharge to post-acute care facilities need not return to the higher pre-pandemic level for TJA cases.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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