

Research Article

Elective joint surgeries were safe and effective during the COVID-19 pandemic: a retrospective cohort study in Washington State

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Introduction

The cancelation of elective joint procedures left patients affected with debilitating osteoarthritis unsure of when their joint replacement operation would take place. Our primary aim in this study was to assess the safety of total hip and knee arthroplasty (THA, TKA) during an active pandemic and to determine if patient outcomes changed after a State of Emergency declaration.

Methods

This retrospective cohort study evaluated the outcomes of patients who received a THA or TKA in Yakima County, a region in Washington State which had the most COVID-19 infections per capita at the time of the initial surge in 2020. Patients were stratified between a control group and COVID-19 group depending on if their surgery was before or

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after the cancellation of all elective surgeries on March 19th, 2020. Demographics, surgical notes, COVID-19 test status, functional outcomes, and adverse events were collected. Chi-square and t-tests were utilized to analyze differences between categorical and continuous variables, respectively.

Results

Inclusion criteria was met for 90 patients for the control group and 490 patients for the COVID-19 group. There were no differences between the cohorts in age, BMI, ethnicity, Charlson Comorbidity Index scores, insurance status, or procedure type. There were four recorded COVID-19 infections from patients in the COVID-19 group ($p=0.39$); zero of which had complications related to their postoperative care. In comparing our control group to COVID-19 group, no significant differences were observed in postoperative emergency room visits (2.2% vs 6.3% respectively ($p=0.126$)), hospital readmissions (2.2% vs 3.9% respectively ($p=0.447$)), or any adverse events (5.6% vs 7.3% respectively ($p=0.073$)). Visual analogue pain scores, Lower Extremity Functional scores, and range of motion at one week and three months postoperative were not significantly different between either group.

Discussion

Our comparison between these patient cohorts showed no significant differences in the rate of postoperative adverse events, functional outcome scores, or complications from COVID-19 infections. Thus, with the proper precautions, elective joint replacement surgery may be done safely during a State of Emergency declaration for an active pandemic.

INTRODUCTION

The majority of total joint arthroplasty (TJA) procedures in the United States are considered elective surgeries. As domestic COVID-19 cases escalated in March and April of 2020, hospitals and clinics made complicated decisions regarding the cancelation or postponement of these surgeries with the aim of limiting viral transmission and preserving personal protective equipment (PPE). After the announcement of these mandates in March of 2020, an estimated 250,000 patients scheduled for total joint hip and knee replacements (THA, TKA) had their operations canceled or postponed (Bedard, Elkins, and Brown 2020; COVIDSurg Collaborative 2020). This left patients to continue dealing with the debilitating effects of osteoarthritis while waiting for an unknown period of time for their surgery to be rescheduled.

At a national level, current estimates of the total scale and number of canceled surgeries in the months that followed the COVID-19 elective surgery mandates are still widely unknown. Currently, TJAs and other elective orthopedic procedures have well been reintroduced into the normal flow of hospital operations and the backlog of patients waiting for their surgeries has shrunk; however, an estimated backlog of 1 million patients in the US are still wait-

ing for their elective joint or spine operations (The Lancet Rheumatology 2021). Moreover, the impact of these cancellations may have been magnified for various racially and ethnically diverse populations in terms of access to care and insurance coverage for surgery (Kang, Sims, and Day, n.d.; Glance et al. 2022). The subsequent effect of these mandates on individuals' longevity may not be understood for years to come.

If a similar pandemic of equal magnitude took place in the future, would the current health care system in this country be prepared with safety protocols to ensure patient, provider, and healthcare staff safety with continuation of elective joint replacements? As COVID-19 cases oscillate and with the likely chance of another global pandemic in the future, the previous question emphasizes the importance of adapting models of care to avoid delays in surgery as this has a tangible effect on patients' health outcomes.

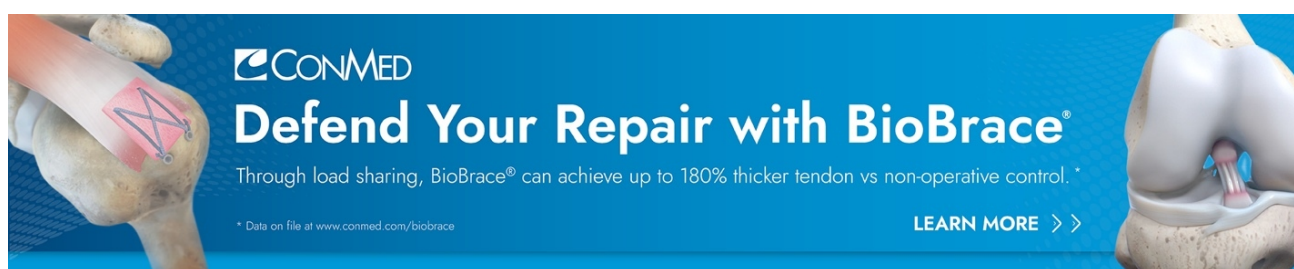
The primary aim of this study was to determine the safety of undergoing total hip and knee arthroplasty (THA, TKA) procedures during an active pandemic. We hypothesized that there would not be a significant difference between clinical outcomes and the rate of adverse events between patients receiving surgery during the COVID-19 pandemic compared to patients in a pre-pandemic time frame.



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METHODS

This study retrospectively evaluated the outcomes of adult patients who received THA or TKA in Yakima County, Washington, during the initial surge of COVID-19 in 2020. Patients who underwent surgery between January 2020 and December 31st, 2021, and had at least six months of post-operative follow-up were included. COVID-19 vaccinated patients were not excluded.

Our study stratified patients who had their procedure before and after March 19th, 2020—when the proclamation of a State of Emergency by the governor of Washington State restricted non-urgent medical procedures. Patients who had surgery between January 1st and March 19th, 2020, were labeled as our control group while patients who had surgery between March 20th, 2020, and December 31st, 2021, represented our COVID-19 group. These time periods were chosen to reflect how COVID-19 protocols and added institutional policies at the state level in regard to elective joint replacements impacted patient postoperative care.

All patients underwent a COVID-19 test before surgery, and CDC-recommended practices (masking, social distancing, limiting visitors, and additional sanitization of hospital equipment to minimize possible COVID exposures to the patients undergoing the surgical procedures) were followed to minimize COVID-19 exposure during hospitalization. The study also evaluated the frequency of patients exposed to the virus during their hospital stay through a postoperative visit within a week of discharge.

Patient demographics, procedure type, Charlson Comorbidity Index (CCI) score, surgical notes, length of stay (LOS), COVID-19 test status, emergency room visits, hospital readmissions, functional outcomes, and any adverse events were collected from the electronic health records of a single institution. Physical therapy notes including range of motion (ROM) records were recorded if available. Lower extremity functional scale (LEFS) scores and visual analog scale (VAS) pain scores were assessed at one week and three months postoperatively.

This study was deemed exempt by the Washington State University Institutional Review Board based on the notion that patient health information was blinded and anonymized. Being retrospective, patients were not recruited for this study and were only chosen for review if they met the study inclusion and exclusion criteria.

In comparing cohorts, descriptive statistics were used to assess the patients' demographics and comorbidities. To examine the associations between two or more qualitative variables we used a Chi-square test and Fisher's Exact test, when appropriate for small sample size variables, whereas an unpaired t-test was utilized to analyze continuous variables. Multivariate analysis was performed to evaluate the association between COVID period procedures and adverse events after discharge. Logistic regression models were used to estimate odds ratios and 95% Confidence Intervals. Adjusted estimates were produced using our variables of interest. Frequency, percentage, mean, and standard deviation were used to report as appropriate for categorical and continuous values. We used a p-values of ≤ 0.05 when considering the significance of our results. All statistical analyses were done using statistical packages SPSS 28.0 (IBM SPSS Statistics for Mac, Version 28.0).

RESULTS

Of the 580 patients included in the study, there were a total of 90 patients in the control group and 490 patients in the COVID-19 group. The average age of the patients at the time of surgery was 67.7, and the average BMI was 31.0; there was no difference in preoperative demographics between groups ([Table 1](#)). A total of 211 (43.1%) patients had THAs and 268 (54.7%) had TKAs in the COVID-19 group; in the control group, there were 32 (35.6%) patients who had THAs and 58 (64.4%) patients who had TKAs ([Table 2](#)). The primary indication for surgery in the patient cohorts was osteoarthritis (94.8%). The majority of patients had Charleston-Comorbidity Index scores of <5 in both patient groups ($p = 0.165$). Fifty-two surgeries in the COVID-19 group were recorded as being cancelled due to COVID-19 mandates. There were four recorded COVID-19 infections from patients in the COVID-19 group ($p = 0.39$), of which zero had complications related to their postoperative care ([Table 1](#)).

No differences were noted between groups in regard to TONNIS and Kellgren-Lawrence scores ($p = 0.051$, 0.804 respectively) ([Table 2](#)). In terms of inpatient and outpatient, 25.9% of patients recovered in an inpatient setting, and 73.8% recovered in an outpatient setting; this was not statistically significant between the groups ($p = 0.346$). Of the patients recovering in an inpatient setting, the average LOS in the control group was 0.5 days and 0.2 days in the

Table 1. Demographics of patients undergoing Total Knee or Hip Arthroplasty

Descriptive	Total	Pre COVID-19	During COVID-19	p-value
Age (years: mean, SD)	67.7 (9.8)	68.2 (8.4)	67.6 (10.1)	0.602*
BMI (kg/m2: mean, SD)	31.0 (5.6)	31.1 (5.6)	31.0 (5.6)	0.864*
Ethnicity (n, %)				0.677***
White	490 (84.5)	75 (83.3)	415 (84.7)	
Hispanic/ Latino	65 (11.2)	10 (11.1)	55 (11.2)	
African American	14 (2.4)	2 (2.2)	12 (2.4)	
American Indian	10 (1.7)	3 (3.3)	7 (1.4)	
Asian/ Pacific Islander	1 (0.2)	0 (0.0)	1 (0.2)	
CCI Grade (n, %)				0.165**
≤4	525 (90.5)	85 (94.4)	440 (89.8)	
≥5	55 (9.5)	5 (5.6)	50 (10.2)	
Surgery Indication (n, %)				0.331***
Osteoarthritis	550 (94.8)	88 (97.7)	462 (94.3)	
Avascular necrosis	9 (1.6)	0 (0)	9 (1.8)	
Infection	7 (1.2)	0 (0)	7 (1.4)	
Other	14 (2.4)	2 (2.2)	12 (2.4)	
Insurance (n, %)				0.744**
Medicare/Medicaid	326 (56.2)	52 (57.8)	274 (55.9)	
Other	254 (43.8)	38 (42.2)	216 (44.1)	
Canceled Surgery (due to COVID-19) (n, %)				0.012**
No	526 (90.7)	88 (97.8)	438 (89.4)	
Yes	54 (9.3)	2 (2.2)	52 (10.6)	
COVID-19 Infection (n, %)				0.508***
Yes	4 (0.7)	0(0)	4 (0.8)	
No	576 (99.3)	90(100)	486 (99.2)	

Our two groups are stratified based on their surgery dates: Patients having surgery before and after March 19th, 2020. The two groups are labeled as Pre COVID-19 and During COVID-19.

BMI, body mass index; CCI, Charlson Comorbidity Index

*Unpaired Student T-test

**Chi-Square Test

***Fisher-Freeman-Halton Exact Test or Fisher's Exact Test

Table 2. Operative Demographics

Descriptive	Total	Pre COVID-19	During COVID-19	p-value*
Procedure (n, %)				0.228
THA	243 (41.9)	32 (35.6)	211 (43.1)	
TKA	326 (56.2)	58 (64.4)	268 (54.7)	
THA Revision	5 (0.9)	0 (0)	5 (1.0)	
TKA Revision	6 (1.0)	0 (0)	6 (1.2)	
TONNIS (n, %)				0.051
2	5 (4.3)	0 (0)	5 (4.4)	
3	84 (71.8)	1 (25)	83 (73.5)	
4	28 (23.9)	3 (75)	25 (22.1)	
KL Grade (n, %)				0.804
3	17 (12.3)	3 (3.3)	14 (7.0)	
4	221 (87.7)	34 (37.8)	187 (93.0)	
Surgery location (n, %)				0.346
Inpatient	152 (25.9)	22 (24.4)	130 (26.5)	
Outpatient	428 (73.8)	68 (75.6)	360 (73.5)	
Anesthesia (n, %)				<0.001
General	576 (99.3)	87 (96.7)	489 (99.8)	
Spinal	4 (0.7)	3 (3.3)	1 (0.2)	
Blood loss (ml, mean SD)	327.4 (161.2)	314.2 (113.1)	329.6 (167.9)	0.303
Surgery Time (hours, mean, SD)	2.4 (0.4)	2.3 (0.2)	2.4 (0.4)	0.073
Length of Stay (days: median)	0.4 (0.9)	0.5 (1.0)	0.2 (0.4)	<0.001

KL, Kellgren Lawrence;

Table 3. Postoperative adverse events

<i>Descriptive</i>	<i>Total</i>	<i>Pre COVID-19</i>	<i>During COVID-19</i>	<i>P value</i>
ER visit (n, %)				
Yes	33 (5.7)	2 (2.2)	31 (6.3)	0.126
No	547 (94.3)	88 (96.8)	459 (93.7)	
Hospital Readmission (n, %)				0.447
Yes	21 (3.6)	2 (2.2)	19 (3.9)	
No	559 (96.4)	88 (97.8)	471 (96.1)	
Infection (n, %)				0.256
Yes	7 (1.2)	0 (0)	7 (1.4)	
No	573 (98.8)	90 (100.0)	483 (98.6)	
DVT (n, %)				0.935
Yes	7 (1.2)	1 (1.1)	6 (1.2)	
No	573 (98.8)	89 (97.9)	484 (98.8)	
Incontinence (n, %)				0.294
Yes	6 (1.0)	0 (0)	6 (1.2)	
No	574 (99.0)	90 (100)	484 (98.8)	
Fall (n, %)				0.692
Yes	31 (5.3)	4 (4.4)	27 (5.5)	
No	549 (94.7)	86 (94.6)	463 (94.5)	
Adverse Events (n, %)				0.342
Yes	41 (7.1)	5 (5.6)	36 (7.3)	
No	539 (92.9)	85 (94.4)	454 (92.7)	

ER, emergency room ; DVT, deep venous thrombosis

Table 4. Postoperative functional and clinical outcomes

<i>Descriptive</i>	<i>Total</i>	<i>Pre COVID-19</i>	<i>During COVID-19</i>	<i>P value</i>
LEFS (n, %)				
1 week PO	10.6 (6.1)	10.09 (3.5)	10.7 (6.4)	0.500
3 months PO	46.5 (13.7)	48.5 (14.1)	46.3 (13.7)	0.588
VAS pain (n, %)				
1 week PO	3.5 (2.4)	3.5 (2.4)	3.5 (2.4)	0.883
3 months PO	1.6 (2.2)	1.5 (2.2)	1.6 (2.2)	0.817
ROM Flexion* (n, %)				
1 week PO	86.6 (10.7)	84.5 (8.3)	86.9 (11.0)	0.141
3 months PO	120.0 (12.2)	120.4 (7.4)	119.6 (12.7)	0.740
ROM Extension* (n, %)				
1 week PO	-3.3 (8.5)	-3.5 (5.3)	-3.3 (8.9)	0.843
3 months PO	-0.0 (1.4)	0.32 (2.5)	-0.1 (1.2)	0.200

LEFS, lower extremity functional score; VAS, visual analogue score; ROM, range of motion

COVID-19 group ($p < 0.01$). There were no differences in blood loss and surgery time ($p = 0.303$, 0.073 respectively).

Comparing our control group and COVID-10 group, no significant differences were observed in postoperative emergency room visits (2.2% vs 6.3% respectively, $p = 0.126$), hospital readmissions (2.2% vs 3.9% respectively, $p = 0.447$), or any adverse events (5.6% vs 7.3% respectively, $p = 0.342$) (Table 3). VAS pain scores, LEFS scores, ROM flexion, and extension at one week and three months postoperatively were not significantly different between either group (Table 4). After accounting for potential confounders, having TKA/THA during the COVID period was not found to have a significant association with adverse events after discharge when comparing patients that underwent the procedures before the Covid period and those who had their procedure during the Covid period (5 [5.6%] vs. 36 [7.3%]; odds ratio, 3.081; 95% confidence interval, 0.720-13.178; $p = 0.13$) (Table 5).

DISCUSSION

This study contributes to the expanding body of literature that suggests that elective joint procedures during a State of Emergency declaration due to the COVID-19 pandemic are safe and do not have an impact on patient's operative outcomes. Our retrospective comparison revealed no significant differences in the rate of postoperative adverse events, readmission rates, postoperative emergency room visits, functional outcome scores, or complications from COVID-19 infections. A notable strength of this study pertains to the region in Washington State where these patients were disproportionately affected by high rates of viral transmission when compared to the rest of the state and country at the beginning of the pandemic (Disease Control and Health Statistics 2022; Seattle Times 2020). Therefore, the demographic observed from this region provides impor-

Table 5. Predictors of adverse events after discharge

	Unadjusted				Adjusted			
	OR	95% CI (Lower)	95% CI (Upper)	P-value	OR	95% CI (Lower)	95% CI (Upper)	P-value
Age (Ref: 64 or younger) 65 or older	0.986	0.493	1.972	0.968	1.10	0.479	2.522	0.823
Gender (Ref: Female) Male	0.984	0.509	1.901	0.961	1.131	0.573	2.231	0.723
BMI (Ref: Under 30) Greater than 30	1.480	0.749	2.923	0.259	1.468	0.729	2.955	0.282
CCI Grade (Ref: 4 or less) 5 or greater	1.879	0.749	4.715	0.179	1.595	0.594	4.279	0.354
Insurance (Ref: Medicare/Medicaid) Non Medicare/Medicaid	1.177	0.609	2.275	0.628	1.451	0.663	3.178	0.352
Procedure (Ref: TKA) THA	2.418	1.224	4.778	0.011	2.372	1.188	4.736	0.014
Setting (Ref: Outpatient) Inpatient	1.530	0.761	3.073	0.232	1.401	0.682	2.877	0.358
Time of Procedure(Ref: Before COVID) During the COVID Period	3.457	0.817	14.624	0.092	3.081	0.72	13.178	0.129

Ref, reference; OR, odds ratio; CI, confidence interval; CCI, Charlson Comorbidity Index; TKA, Total Knee Arthroplasty; THA, Total Hip Arthroplasty.

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tant information regarding the effectiveness of surgical and clinical pandemic protocols as they relate to elective orthopedic surgery during COVID-19.

The COVID-19 pandemic significantly impacted hospitals and clinics in performing elective procedures. Many surgeries were cancelled or postponed to preserve resources and minimize the risks to patients and healthcare personnel. A Surgeon General advisory on March 16th, 2020, recommended states to postpone elective surgeries, resulting in an estimated 28 million canceled surgeries during the 12-week peak of the pandemic from March to May of 2020 (Sarac et al. 2020). Out of these surgeries, 244,121 were orthopedic-related, the highest proportion among all specialties (COVIDSurg Collaborative 2020). The consequences of delaying elective surgical care for these patients may not be fully understood for years to come (Masroor 2020).

Certainly, the cancellation of elective surgeries was made in good faith to protect patients and providers, preserve inpatient hospital beds, and conserve a short supply

of medical equipment. As detailed by Zhou et al. very early on in the COVID-19 outbreak in China, 44% of 179 COVID-19 patients in the hospital had nosocomial acquired infections which affected postoperative recovery (Zhou et al. 2020). Fortunately, rates of nosocomial infections have decreased, but still remain a serious public health issue (Barranco, Vallega Bernucci Du Tremoul, and Ventura 2021). Therefore, these cancellations were deemed necessary during a time in which hospitals and public health officials were uncertain about the trajectory of the pandemic. However, the post-pandemic evaluation and planning for the possibility of future outbreaks should incorporate a contingency plan to continue surgical services to avoid collateral health disparities (Maringe et al. 2020).

Similar to our present study, Wang et al. compared patients who underwent elective adult spinal deformity surgery prior to COVID-19 to patients who had their surgery after the reinstatement of elective surgery (Wang et al. 2021). No differences between groups in terms of

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readmission rates, ER visits, adverse events, or reoperations were observed. Similar to our findings, the patients who had their operation during the pandemic had a decreased LOS when compared to the pre-pandemic cohort ($p = 0.015$). Decreased LOS for elective procedures especially in the midst of a pandemic has positive implications for patient satisfaction, lowering healthcare costs, and possibly decreasing patients' reluctance of getting surgery in fear of spending more time in the hospital.

A multicenter study by Brown et al. ($n = 2135$) found that the most anxiety-provoking thought for patients who had their joint replacement surgery canceled was the uncertainty of if, or when their procedure will be rescheduled (Brown et al. 2021, 2020). They polled patients and found almost 90% planned to reschedule as soon as possible (Brown et al. 2020). Another study polled patients regarding their canceled surgeries and 78% believed their surgery was justified and therefore should not be categorized as 'elective' due to the daily affliction their pathologies presented with (Dittman, Johnson, and Trousdale 2021).

One potential solution for continuing elective procedures during a pandemic is to shift outpatient elective procedures to ambulatory surgical centers (ASCs), which have fewer medically complex patients and lower patient volumes (Jabbouri et al., n.d.; DePhillipo et al. 2020). This could theoretically reduce viral transmission and preserve hospital resources. Our previous study on early discharge after total joint arthroplasty through ASC utilization in the COVID-19 pandemic showed a high satisfaction score and no instances of viral transmission (Jabbouri et al., n.d.). However, adequate personnel and PPE supplies are necessary (Ranney, Griffeth, and Jha 2020). Challenges include the risk of using up limited resources and presenting risks to providers and patients (Søreide et al. 2020). Proper planning and utilization of pandemic-era safety protocols, such as symptom attestations, social distancing, and preoperative testing, can help avoid COVID-19 outbreaks and related surgical complications (Brat et al. 2020; Aminian et al. 2020; Knisely et al. 2021).

It is important to consider the limitations of our study when interpreting our findings. As a retrospective study, we did not perform a power analysis, and our cohorts were underpowered, which may limit our ability to detect important differences between patient groups and overall generalizability. For example, although 2.2% of patients in the pre-COVID group and 6.3% of patients in the COVID group had ER visits, which is clinically significant, this difference

did not reach statistical significance likely due to underpowered cohorts.

Moreover, misclassification bias may have occurred due to the potential for some patients to have been asymptomatic during the postoperative period and not proactive in testing themselves. Additionally, since many state and national policies were changed, and advancements of care adapted over time between the initial shutdown of elective procedures in Washington State on March 19, 2020 and the end of December 2021, our comparisons between a pre- and post-State of Emergency declaration could have been biased and may have affected our results. We also did not investigate the pandemic's effect on hospital or clinic staff, which could have had downstream effects on patient pre and postoperative care. Lastly, since this is a single-center study, our conclusions may not be generalizable to other areas.

Despite these limitations, our findings provide valuable insights into the potential impact of the COVID-19 pandemic on postoperative outcomes. Therefore, we suggest that our findings should still be considered as part of the broader discussion on the impact of the COVID-19 pandemic on surgical care.

A significant challenge in applying the lessons learned from the COVID-19 pandemic to clinical care is the presumption that future pandemics will behave similarly. Given the unpredictability of such events, healthcare providers, clinics, and hospitals must incorporate the insights gained from the COVID-19 pandemic and prepare for the next potential natural disaster of this kind. The ultimate goal is to protect patients' well-being while also ensuring that surgical procedures are carried out efficiently, so patients do not have to suffer from debilitating joint diseases for prolonged periods without proper care.

The postponement and cancellation of elective surgeries posed challenges for both patients and providers. Based on our study of a limited group of patients undergoing joint replacement surgery, it suggests that performing elective joint replacement during a viral outbreak can be safe and effective, provided that appropriate restrictions, testing, and precautions are in place. However, to confidently conclude the safety and efficacy of joint surgeries during an active pandemic, further research with larger sample sizes comparing outpatient vs inpatient joint replacement outcomes is necessary.

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