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History of COVID-19 Was Not Associated With Length of Stay or In-Hospital Complications After Elective Lower Extremity Joint Replacement

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ABSTRACT

Background: The impact of previous SARS-CoV-2 infection on the morbidity of elective total joint arthroplasty (TJA) is not fully understood. This study reports on the association between previous COVID-19 disease, hospital length of stay (LOS), and in-hospital complications after elective primary TJA.
Methods: Demographics, comorbidities, LOS, and in-hospital complications of consecutive 340 patients with a history of COVID-19 were compared with those of 5014 patients without a history of COVID-19 undergoing TJA. History of COVID-19 was defined as a positive IgG antibody test for SARS-CoV-2 before surgery. All patients were given both antibody and polymerase chain reaction tests before surgery.
Results: Patients with a history of COVID-19 were more likely to be obese (43.8% vs 32.4%, $P < .001$), Black (15.6% vs 6.8%, $P < .001$), or Hispanic (8.5% vs 5.4%, $P = .028$) than patients without a history of COVID-19. COVID-19 treatment was reported by 6.8% of patients with a history of COVID-19. Patients with a history of COVID-19 did not have a significantly longer median LOS after controlling for other factors (for hip replacements, median 2.9 h longer, 95% confidence interval = −2.0 to 7.8, $P = .240$; for knee replacements, median 4.1 h longer, 95% confidence interval = −2.4 to 10.5, $P = .214$), but a higher percentage were discharged to a post–acute care facility (4.7% vs 1.9%, $P = .001$). There was no significant difference in in-hospital complication rates between the 2 groups (0/340 = 0.0% vs 22/5014 = 0.44%, $P = .221$).
Conclusions: We do not find differences in LOS or in-hospital complications between the 2 groups. However, more work is needed to confirm these findings, particularly for patients with a history of more severe COVID-19.
Level of evidence: II.

Introduction

The novel coronavirus, SARS-CoV-2, has caused millions of deaths worldwide as part of a global pandemic; the impact of persistent health effects among survivors of COVID-19 remains under evaluation [1,2]. Beyond upper and lower respiratory symptoms commonly reported in COVID-19, systemic effects including thrombophilia [3], myocarditis [4,5], and neuropathy [6,7] have been reported. Other symptoms including fatigue and malaise [8] can persist months after resolution of primary illness. Furthermore, active COVID-19 illness has been shown to be associated with an increased risk for perioperative complications, including sepsis, shock, cardiac arrest, pneumonia, respiratory failure, acute respiratory distress syndrome, acute kidney injury, and mortality in patients undergoing emergency procedures [9].

The impact of prior infection with SARS-CoV-2 on the outcomes of elective surgical procedures is an important, unanswered clinical issue.

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As rates of COVID-19 illness fell in New York City, elective surgical procedures at our high-volume specialty musculoskeletal center resumed. Presurgical screening was adjusted to test for serum antibodies to SARS-CoV-2 [10]. In addition, all patients underwent nasopharyngeal polymerase chain reaction (PCR) screening within 3 days before admission, and elective surgery on PCR-positive patients was postponed in accordance with regulatory guidance.

The impact of previous SARS-CoV-2 infection on the morbidity of patients undergoing elective total joint replacement has not yet been carefully assessed. We hypothesized that morbidity after joint replacement would be increased among those who had a history of COVID-19, even if symptoms were resolved [11].

The current study reports how demographics, comorbidities, hospital course (including length of stay [LOS]), and in-hospital complications among consecutive patients undergoing elective arthroplasty at our large orthopaedic hospital differed between patients with and without a history of COVID-19.

Material and methods

After obtaining institutional review board approval, we queried our institution's data warehouse for patients undergoing elective primary total hip arthroplasty (THA) or total knee arthroplasty (TKA) between 5/6/2020 and 1/5/2021. Inclusion criteria were based on International Classification of Diseases-10 codes from the Centers for Medicare and Medicaid Elective Primary THA/TKA Complication Measure. Exclusion criteria included indications for pelvic or lower limb fracture; concurrent partial hip or knee arthroplasty; concurrent revision, resurfacing, or implanted device/prosthesis removal procedure; indications for mechanical complication; and/or indications for malignant neoplasms [12].

Our institution's presurgical screening for elective surgery was modified to account for the ongoing COVID-19 pandemic. These changes included the following:

1. All patients received a SARS-CoV-2 RNA qualitative real-time (RT)-PCR test within 3 days of the scheduled surgery;
   a. Cepheid Xpert Xpress SARS-CoV-2 (Sunnyvale, CA; positive percent agreement 98%, negative percent agreement 96%) [13] or
   b. Biomerieux Biofire Respiratory Panel 2.1 (Salt Lake City, UT; positive percent agreement 98% and negative percent agreement 100%) [14]
2. A screening questionnaire to determine
   a. If the patient had experienced any symptoms related to COVID-19 within the last 2 weeks;
   b. If the patient had traveled to a foreign country or US state outside of our regional catchment area in the last 2 weeks;
   c. If the patient had recent exposure to someone with suspected or confirmed COVID-19;
3. SARS-CoV-2 IgG serological testing (Abbott Architect, IgG sensitivity 100%, specificity 99%; Abbott Park, IL) within 4 weeks of surgery at the time of preoperative medical clearance [15];
4. Pulse oximetry (performed at the time of RT-PCR);
5. Two-view chest radiography.

The cohort was then divided into 2 groups based on evidence of a history of COVID-19 at the time of presurgical screening. Because this study was fairly early in the COVID-19 pandemic, and because any patient with a positive COVID-19 PCR would not have qualified for elective arthroplasty, patients in the history of COVID-19 group were defined as those with a positive IgG serology test for SARS-CoV-2 before surgery. All remaining patients were classified as lacking a history of COVID-19. Chart review of the COVID-19 group was done to collect further data on their symptom history and degree of illness (Fig. 1) and included questions about presence, start and duration of symptoms, prior COVID-19–related hospitalizations, and pharmacological and respiratory treatments for COVID-19. For the majority of patients in the COVID-19 group, who were never PCR-tested and were pauci-symptomatic, the date of COVID-19 infection and its relationship with the date of surgery was unknown.

Patient demographics (including age, sex, race, ethnicity, and body mass index [BMI]), the American Society of Anesthesiologists classification [16], the Elixhauser Comorbidity Index (ECI) [17,18], and comorbidities were compared between patients with and without a history of COVID-19. We also compared information from patients' presurgical screening including vital signs (pulse, respiration rate, SpO_2), blood type, antibody test results, PCR test results, self-report of recent travel, self-report of recent COVID-19 exposure, and self-report of recent COVID-19 symptoms, as well as surgery details (hip or knee replacement, inpatient or ambulatory, type of anesthesia), discharge disposition (home or not), LOS, and in-hospital complication rate (which included 8 specific complications from the Centers for Medicare and Medicaid Elective Primary THA/TKA Complication Measure, but was limited to complications that occurred during the index hospital admission and were not present on admission).

Continuous variables with normal distribution were presented as mean (standard deviation [SD]) and compared by Student's t test; non-normal variables were reported as median (interquartile range [IQR]) and compared by the Wilcoxon Mann-Whitney U test. Categorical variables were presented as frequencies and percentages and compared using the chi-square test or the Fisher exact test, when appropriate. Multivariable quantile regressions were used to analyze the association between median LOS and history of COVID-19, controlling for age, BMI, sex, race, and ECI (separately for TKA and THA cohorts).

All tests were 2-sided. Significance was defined as $P < .05$. Statistical analyses were performed using R, version 4.0.3. (R Foundation for Statistical Computing, Vienna, Austria, https://www.R-project.org/) and SAS, version 9.4 (SAS Institute Inc., Cary, NC).

Before our analysis, we conducted power calculations for LOS and in-hospital complications. For LOS, this was estimated using a nonparametric Mann-Whitney method. We estimated our sample size would achieve 90% power to detect noninferiority at a 5% significance level, with the margin of equivalence set to a third of a day and the true difference assumed to be 3 hours. For in-hospital complications, we used an equivalence test for difference between 2 independent proportions. We estimated our sample size would achieve 45% power to detect equivalence at a 5% significance level, assuming 0.5% of patients with no history of COVID-19 would have an in-hospital complication, the actual difference in in-hospital complication rates between groups is 0.5%, and the margin of equivalence, given in terms of difference, is [−0.5%, 1.5%]. Given low expected power, we view the in-hospital complication analysis as preliminary. We report the results here given the importance of the underlying questions and in the hopes of spurring further work on this topic.

Results

Demographics, comorbidities, and history of COVID-19

We identified 5354 patients who underwent a primary elective THA or TKA, among whom 3083 (57.6%) were female, 4458 (83.3%) were White or Caucasian, 394 (7.4%) were Black or African American, and 301 (5.6%) were Hispanic or Latino. The mean age was 64.8 (SD = 10.2) years, and the mean BMI was 30.5 (SD = 6.4) (Table 1).

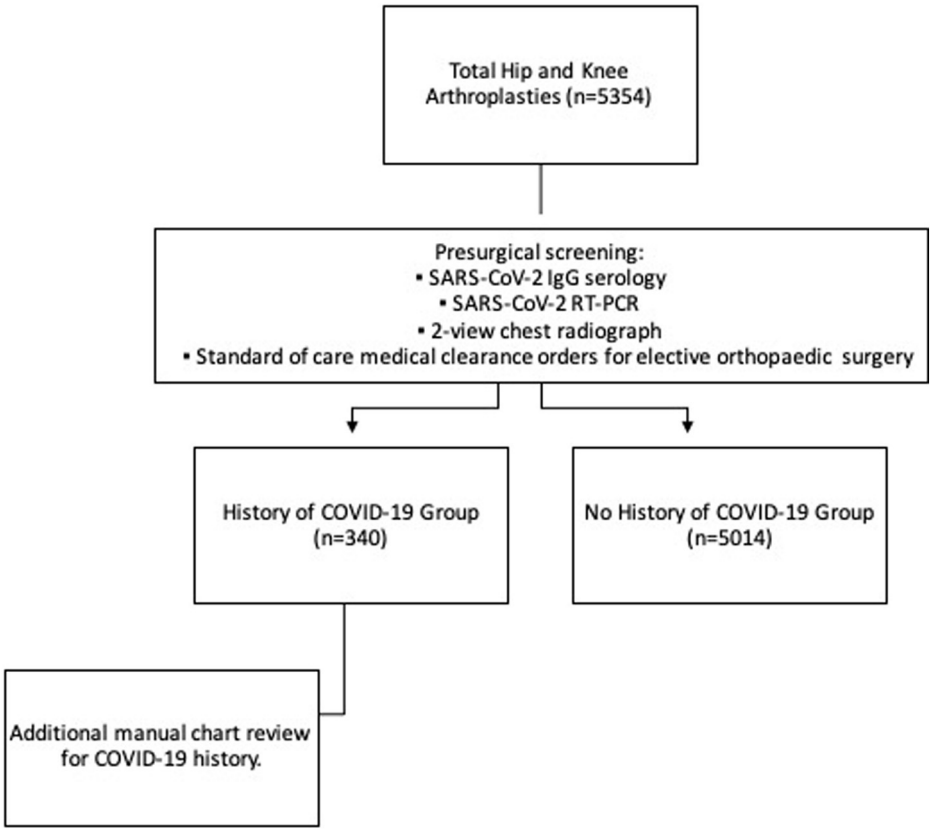

Figure 1. Chart review of the 2 groups.

The history of the COVID-19 group consisted of 340 (6.3%) patients, 3 of whom (0.9%) had a positive RT-PCR for SARS-CoV-2 at the time of presurgical screening; surgeries of those 3 patients were initially postponed for at least 4 weeks, and these patients were later included in the cohort; 145 of 340 (42.6%) reported experiencing COVID-19 symptoms, 29 of 340 (8.5%) reported pneumonia, 23 of 340 (6.8%) were admitted to a hospital for COVID-19 treatment, and 2 of 340 (0.6%) were transferred to the ICU for treatment of severe COVID-19 disease. The mean time to surgery from disease onset was 168 (SD = 71) days.

A higher proportion of patients with a history of COVID-19 were Black or African American (15.6% vs 6.8%, $P < .001$) and Hispanic or Latino (8.5% vs 5.4%, $P = .028$). Also, a higher proportion of patients with a history of COVID-19 were obese (43.8% vs 32.4%, $P < .001$) and anemic (defined as hemoglobin <12 g/deciliters [dL] in female and <13.3 g/dL in male patients) (7.6% vs 4.0%, $P = .002$), and a lower proportion had rheumatoid arthritis (1.8% vs 3.9%, $P = .048$). There were no significant differences with respect to mean age, sex, American Society of Anesthesiologists classification, or ECI (Table 1).

Presurgical screening

During presurgical screening, 22 (6.5%) patients with a history of COVID-19 reported recent exposure to a suspected or confirmed case of COVID-19; only 78 (1.6%) in the no history of COVID-19 group reported recent exposure ($P < .001$) (Table 2). There were no differences in patient-reported recent symptoms of COVID-19 ($P = .218$) or recent foreign or domestic travel ($P = .773$) between groups. For vitals taken during presurgical screening, there were no differences in mean SpO_2, respiration rate, or pulse. The history of the COVID-19 group had a higher proportion of A (44.4% vs 40.3%) and B (17.6% vs 14.0%) blood types ($P = .012$).

Surgery details, discharge disposition, LOS, and in-hospital complications

There was no difference in the percentage of ambulatory (vs inpatient) surgeries (11.8% vs 11.3%, $P = .797$) or regional anesthesia use (97.1% vs 97.8%, $P = .136$). However, a lower proportion of patients in the history of COVID-19 group were discharged home (95.3% vs 98.1%, $P < .001$) (Table 3). The median length of inpatient stay was 53 hours (IQR = 33-76) among the history of COVID-19 group and 50 hours (IQR = 31-60) in the no history of COVID-19 group ($P = .001$). However, our multivariable quantile regression controlling for confounders found that history of COVID-19 was not significantly associated with median inpatient LOS for hip replacements (2.9 hours longer, 95% confidence interval = −2.0 to 7.8, $P = .240$) and knee replacements (4.1 hours longer, 95% confidence interval = −2.4 to 10.5, $P = .214$) (Table 4).

The overall in-hospital complication rate was 0.4%, with no significant differences between the history of COVID-19 group and the no history of COVID-19 group. There were zero complications in the history of COVID-19 group (0/340 = 0.0% vs 22/501 = 0.44%, $P = .221$) (Table 3).

Discussion

This study reports on the largest known cohort of patients undergoing elective TJA operated on during the COVID-19 pandemic and compares 340 patients with evidence of a history of COVID-19 with 5014 contemporaneous patients without evidence of a history of COVID-19. Patients in the history of COVID-19 group were more

Table 1
Patient characteristics by history of COVID-19.

Demographics	Overall	History of COVID-19	No history of COVID-19	*P*-value
Total	5354	340	5014	
Age, mean (SD)	64.8 (10.2)	63.4 (10.22)	64.9 (10.19)	.533
BMI, mean (SD)	30.5 (64.2)	31 (5.71)	30.4 (66.31)	.533
Female (%)	3083 (57.6)	180 (52.9)	2903 (57.9)	.074
Race (%)				<.0001
White or Caucasian	4458 (83.3)	248 (72.9)	4210 (84)	
Black or African American	394 (7.4)	53 (15.6)	341 (6.8)	
Other	502 (9.4)	39 (11.5)	463 (9.2)	
Ethnicity (%)				.028
Hispanic or Latino	301 (5.6)	29 (8.5)	272 (5.4)	
Not Hispanic or Latino	4912 (91.7)	299 (87.9)	4613 (92)	
Other	141 (2.6)	12 (3.5)	129 (2.6)	
ASA (%)				.22
1	197 (3.7)	15 (4.4)	182 (3.6)	
2	4304 (80.4)	261 (76.8)	4043 (80.6)	
3+	853 (15.9)	64 (18.8)	789 (15.7)	
Elixhauser Comorbidity Index (%)				.565
0	1839 (34.3)	106 (31.2)	1733 (34.6)	
1	1281 (23.9)	87 (25.6)	1194 (23.8)	
2	1192 (22.3)	75 (22.1)	1117 (22.3)	
3+	1042 (19.5)	72 (21.2)	970 (19.3)	
Comorbidities				
Congestive heart failure (%)	41 (0.8)	3 (0.9)	38 (0.8)	.7989
Valvular disease (%)	171 (3.2)	9 (2.6)	162 (3.2)	.5535
Pulmonary hypertension (%)	3 (0.1)	1 (0.3)	2 (0)	.0552
Peripheral vascular disease (%)	66 (1.2)	3 (0.9)	63 (1.3)	.5452
Hypertension (%)	2144 (40)	147 (43.2)	1997 (39.8)	.2147
Neurological disease (%)	118 (2.2)	8 (2.4)	110 (2.2)	.8467
Pulmonary disease (%)	539 (10.1)	30 (8.8)	509 (10.2)	.4309
Diabetes (%)	301 (5.6)	24 (7.1)	277 (5.5)	.2346
Diabetes with complications (%)	97 (1.8)	6 (1.8)	91 (1.8)	.9464
Hypothyroid disease (%)	665 (12.4)	35 (10.3)	630 (12.6)	.2193
Renal disease (%)	186 (3.5)	9 (2.6)	177 (3.5)	.3895
Liver disease (%)	44 (0.8)	2 (0.6)	42 (0.8)	.622
Peptic ulcer disease (%)	10 (0.2)	0 (0)	10 (0.2)	.4098
HIV (%)	2 (0)	0 (0)	2 (0)	.7126
Lymphoma (%)	13 (0.2)	0 (0)	13 (0.3)	.3472
Metastatic cancer (%)	3 (0.1)	0 (0)	3 (0.1)	.6519
Solid tumor cancer (%)	36 (0.7)	4 (1.2)	32 (0.6)	.2399
Rheumatic disease (%)	200 (3.7)	6 (1.8)	194 (3.9)	.0477
Coagulopathy (%)	109 (2)	9 (2.6)	100 (2)	.4096
Obesity (%)	1772 (33.1)	149 (43.8)	1623 (32.4)	<.0001
Anemia (%)	229 (4.3)	26 (7.6)	203 (4)	.0015
Alcohol abuse (%)	13 (0.2)	0 (0)	13 (0.3)	.3472
Drug or substance abuse (%)	5 (0.1)	1 (0.3)	4 (0.1)	.2105
Psychoses (%)	51 (1)	6 (1.8)	45 (0.9)	.1111
Depression (%)	481 (9)	27 (7.9)	454 (9.1)	.4872

likely to be obese and more likely to be part of an ethnic/racial minority. These findings are consistent with the literature. In a study by Gu et al, obesity was associated with a higher risk of having positive COVID-19 test results among African American patients [19]. Unfortunately, a greater risk of severe COVID-19 disease has been described in African American, Asian, and minority ethnic populations in a study by Raisi-Estabragh et al [20]. In New York City, more cases and deaths of COVID-19 of Black and Latino individuals were recorded than white individuals [21]. Potential reasons underlying why minorities have been more affected are lack of ability to socially distance at work and in multigenerational homes, mistrust of healthcare systems resulting from historical mistreatment, lack of access to quality medical care, and personal experience of discriminatory treatment [22].

Published data on the safety of elective surgery in COVID-19–recovered patients have been limited to smaller cohorts and some recent population-level studies. Among smaller cohorts, Lei et al reported a death rate of 20.6% in 34 patients who developed COVID-19 during a hospitalization for an elective procedure [11]; Aminian et al reported a mortality rate of 75% among 4 patients with active COVID-19 undergoing elective surgery [23]; and in a study by Shrikhande et al, none of the 6 patients undergoing oncologic surgery who tested positive for COVID-19 required intensive care [24]. Other specific surgical subdisciplines have reported that elective surgeries during COVID-19 can be of low risk [24-26]. Kaye et al assume elective plastic surgery could be safe among COVID-19–negative patients, given the relatively short duration of surgery and good underlying health of the plastic surgery patient population. On the other hand, data suggest that surgeries with longer durations and higher severity levels among COVID-19–positive patients may be associated with negative outcomes [27]. In a multidisciplinary ambulatory surgery center setting, 300 elective surgeries in patients without COVID-19 symptoms 7 days before their surgery were safely performed between March and April 2020 with no noted COVID-19–related illnesses or complications [28]. The International Consensus Group recommends elective orthopaedic surgery only among COVID-19–negative patients, preoperative screening for SARS-CoV-2, and minimizing risk of pathogen transfer, as well as hygiene measurements and personal protection equipment [29]. Optimal timing for emergency surgery is still debated, although severe COVID-19 has been described as a

Table 2
Presurgical screening results by history of COVID-19.

Demographics	Overall	History of COVID-19	No history of COVID-19	*P*-value
Preoperative vitals, mean (SD)				
Pulse	72 (12.2)	71 (12.6)	72 (12.2)	.614
Respiration rate	16 (2.2)	17 (4.7)	16 (1.9)	.195
SpO_2	98 (1.3)	98 (1.2)	98 (1.3)	.431
Blood type, count (%)				.012
A	2171 (40.5)	151 (44.4)	2020 (40.3)	
B	764 (14.3)	60 (17.6)	704 (14)	
N	52 (1)	0 (0)	52 (1)	
O	2367 (44.2)	129 (37.9)	2238 (44.6)	
COVID-19 screening				
SARS-CoV-2 antibody positive (%)	340 (6.4)	340 (100)	0 (0)	<.0001
SARS-CoV-2 RT-PCR positive (%)	3 (0.1)	3 (0.9)	0 (0)	<.0001
Patient-reported recent foreign or domestic travel[a] (%)	185 (3.5)	11 (3.2)	174 (3.5)	.773
Patient-reported recent exposure to COVID-19[b] (%)	100 (1.9)	22 (6.5)	78 (1.6)	<.0001
Patient reported recent COVID-19 symptoms[c] (%)	299 (5.6)	15 (4.4)	284 (5.7)	.218

[a] Patients were asked at presurgical screening if they had recently traveled outside of the country or outside of the NY, NJ, CT, and/or PA area within the past 2 weeks.
[b] Patients were asked at presurgical screening if they had been exposed to a suspected or confirmed COVID-19 case within the past 2 weeks.
[c] Patients were asked at presurgical screening if they had experienced any COVID-19–related symptoms within the past 2 weeks.

relative contraindication and critical COVID-19 as an absolute contraindication for emergency orthopaedic surgery [30].

On the other hand, among surgical patients with symptomatic COVID-19, risks may abound. An international multicenter cohort of 1128 patients undergoing surgery with perioperative COVID-19 infection found a mortality rate of 18.9% among patients undergoing elective surgery and 25.6% among patients undergoing emergency surgery [31]. Because of this risk, preoperative assessment for the presence of SARS-CoV-2 remains important, particularly in populations where the pandemic persists and vaccination is not widespread.

In a recent and more rigorous epidemiologic analysis, among 140,231 patients undergoing surgery in 116 countries, 3127 had a history of COVID-19. Mortality in this cohort was significantly lower among patients who had completely resolved symptoms and delayed surgery >7 weeks after COVID-19 was diagnosed [32].

In our study of patients undergoing elective primary joint arthroplasty, no significant differences in LOS or complication rates during hospitalization were detected. Patients with COVID-19 were somewhat more likely to be discharged to a post–acute care facility. Although the current study is not well powered to detect differences for in-hospital complications (especially for rarer complications such as pulmonary emboli), our preliminary findings suggest that, at least with respect to in-hospital complications, elective joint replacement surgery is safe in patients with a history of COVID-19. However, more research is needed in larger samples to confirm the robustness of this finding, as well as to investigate longer term outcomes. Future research in broader patient samples, including patients recovering from more severe COVID-19 disease, is also important.

Table 3
Surgery details and index admission outcomes by history of COVID-19.

Demographics	Total	History of COVID-19	No history of COVID-19	*P*-value
Joint (%)				.24
Hip	2732 (51)	163 (47.9)	2569 (51.2)	
Knee	2622 (49)	177 (52.1)	2445 (48.8)	
Admission type (%)				.797
Ambulatory[a]	607 (11.3)	40 (11.8)	567 (11.3)	
Inpatient	4747 (88.7)	300 (88.2)	4447 (88.7)	
Type of anesthesia (%)				.136
General	110 (2.1)	8 (2.4)	102 (2)	
Regional	5235 (97.8)	330 (97.1)	4905 (97.8)	
Other	9 (0.2)	2 (0.6)	7 (0.1)	
Discharge status (%)				.0004
Home	5244 (97.9)	324 (95.3)	4920 (98.1)	
Not home	110 (2.1)	16 (4.7)	94 (1.9)	
Length of stay (h), median (IQR)				
Ambulatory, hip and knee[a]	10 (9, 11)	11 (9, 11)	10 (9, 11)	.5669
Ambulatory, hip	11 (10, 12)	11 (11, 12)	11 (10, 12)	.2843
Ambulatory, knee	10 (9, 11)	10 (9, 11)	10 (8.5, 11)	.7163
Inpatient, hip and knee	50 (31, 61)	53 (33, 76)	50 (31, 60)	.0005
Inpatient, hip	35 (30, 56)	50 (31, 57)	35 (30, 56)	.0536
Inpatient, knee	53 (32, 77)	55.5 (39, 81)	53 (32, 77)	.0051
Index admission complications (%)				
All complications	22 (0.4)	0 (0)	22 (0.4)	.221
Acute myocardial infarction	0 (0)	0 (0)	0 (0)	–
Mechanical complications	1 (0)	0 (0)	1 (0)	.7945
Pulmonary embolism	6 (0.1)	0 (0)	6 (0.1)	.5233
Prosthetic joint/wound infection	0 (0)	0 (0)	0 (0)	–
Pneumonia	8 (0.1)	0 (0)	8 (0.2)	.4611
Sepsis	0 (0)	0 (0)	0 (0)	–
Surgical site bleeding	7 (0.1)	0 (0)	7 (0.1)	.4906

[a] Ambulatory was defined as discharge on the same day.

Table 4
Quantile regression analysis of inpatient length of stay (in h).

Demographics	Hip (n = 2446)	*P*	Knee (n = 2294)	*P*
Intercept	26.08 (19.65 to 32.51)	<.0001	22.47 (15.04 to 29.9)	<.0001
History of COVID-19	2.93 (−1.96 to 7.82)	.24	4.08 (−2.35 to 10.51)	.214
Age (year)	0.13 (0.04 to 0.22)	.004	0.21 (0.1 to 0.31)	0
BMI (kg/m^2)	0.06 (−0.08 to 0.2)	.388	−0.005 (−0.12 to 0.11)	.937
Male (v female)	−6.23 (−7.95 to 4.51)	<.0001	−5.01 (−6.57 to 3.45)	<.0001
Race				
Black or African American (v White)	13.01 (7.13 to 18.89)	<.0001	7.8 (1.24 to 14.35)	.02
Other (v White)	2.27 (−1.42 to 5.95)	.228	2.91 (−0.78 to 6.61)	.122
Elixhauser Comorbidity Index				
1 (v 0)	3.09 (1.21 to 4.97)	.001	17.98 (15.64 to 20.31)	<.0001
2 (v 0)	7.01 (2.91 to 11.12)	.001	19.04 (16.85 to 21.24)	<.0001
3+ (v 0)	19.53 (17.35 to 21.72)	<.0001	22.22 (19.69 to 24.74)	<.0001

Point estimates and 95% confidence intervals.

The current study has several limitations: (1) patients with a history COVID-19 in our cohort may have self-selected into surgery and thus may not represent the true spectrum of disease among all COVID-19 survivors who need a joint replacement (eg, some sicker patients likely did not receive medical clearance for elective surgery or may have self-selected not to undergo surgery this year). In addition, the antibody response to COVID-19 in patients with immune issues is likely not be the same as in healthier patients, which may have led us to miscategorize some unknown proportion of previously infected, anergic patients; (2) we did not assess complications after hospital discharge; (3) despite the fact that this cohort represents the largest group of elective surgical patients in the COVID-19 era, our study is likely underpowered to detect increased risks for relatively rare outcomes such as in-hospital complications; and (4) COVID-19 is not randomly assigned, so all analyses, particularly with respect to any differences we found, must be viewed as associations (ie, are not necessarily causal).

Conclusions

While patients undergoing elective joint arthroplasty with a history of COVID-19 (compared with patients without a history of COVID-19) differed in terms of race, ethnicity, and prevalence of obesity, there were not significant differences in median LOS (after controlling for measured confounding variables), nor in-hospital complication rates between groups. Our findings suggest that a history of mild or asymptomatic SARS-CoV-2 infection is not a risk factor for perioperative adverse events after elective primary joint replacement. Further surveillance and research are needed to evaluate the impact of COVID-19 on posthospitalization complications and patients with a history of moderate and severe COVID-19.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Friedrich Boettner receives compensation from Orthodevelopment, Smith&Nephew, Depuy, and Medtronic and royalties from Smith & Nephew and Orthodevelopment, outside the submitted work; Stephen Lyman reports receiving personal fees from Japanese Orthopaedic Society of Knee Arthroscopy, outside the submitted work, and is the Statistics Editor of the JBJS, the Statistics Editor of the HSS Journal, the editor of the Journal of ISAKOS Statistics, and the Editor of the Journal of Social Media; the other authors declare no potential conflicts of interest.

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References

[1] Debeaumont D, Boujibar F, Ferrand-Devouge E, et al. Cardiopulmonary exercise testing to assess persistent symptoms at 6 months in people with COVID-19 who survived hospitalization - a pilot study. Phys Ther 2021;101(6):pzab099.
[2] De Biase S, Cook L, Skelton DA, Witham M, Ten Hove R. The COVID-19 rehabilitation pandemic. Age Ageing 2020;49(5):696.
[3] Waleed RM, Sehar I, Iftikhar W, Khan HS. Hematologic parameters in coronavirus infection (COVID-19) and their clinical implications. Discoveries (Craiova) 2020;8(4):e117.
[4] Magadum A, Kishore R. Cardiovascular manifestations of COVID-19 infection. Cells 2020;9(11):2508.
[5] Nishiga M, Wang DW, Han Y, Lewis DB, Wu JC. COVID-19 and cardiovascular disease: from basic mechanisms to clinical perspectives. Nat Rev Cardiol 2020;17(9):543.
[6] Ellul MA, Benjamin L, Singh B, et al. Neurological associations of COVID-19. Lancet Neurol 2020;19(9):767.
[7] Sharifian-Dorche M, Huot P, Osherov M, et al. Neurological complications of coronavirus infection; a comparative review and lessons learned during the COVID-19 pandemic. J Neurol Sci 2020;417:117085.
[8] Yang W, Cao Q, Qin L, et al. Clinical characteristics and imaging manifestations of the 2019 novel coronavirus disease (COVID-19): a multi-center study in Wenzhou city, Zhejiang, China. J Infect 2020;80(4):388.
[9] Knisely A, Zhou ZN, Wu J, et al. Perioperative morbidity and mortality of patients with COVID-19 who undergo urgent and emergent surgical procedures. Ann Surg 2021;273(1):34.
[10] Boettner F, Bostrom MP, Figgie M, et al. Timeline and procedures on restarting non-emergent arthroplasty care in the US epicenter of the COVID-19 pandemic. HSS J 2020;6(Suppl 1):1.
[11] Lei S, Jiang F, Su W, et al. Clinical characteristics and outcomes of patients undergoing surgeries during the incubation period of COVID-19 infection. EClinicalMedicine 2020;21:100331.
[12] De Buhr J, McDowell K, Grady J. Condition specific measures updates and specifications report hospital-level 30 day risk-standardized readmission measures: elective primary total hip arthroplasty (THA) and/or total knee arthroplasty (TKA) - version 9.0. CMS; 2020.
[13] Cepheid. Xpert Xpress SARS-CoV-2/Flu/RSV Instructions for Use. https://www.fda.gov/media/142438/download. [accessed 02.01.21].
[14] Biomerieaux. Biomerieaux diagnostics respiratory panel 2.1 (technical details). https://www.biomerieux-diagnostics.com/filmarrayr-respiratory-panel. [accessed 02.01.21].
[15] Abbott Architect SARS-CoV-2 IgG. https://www.fda.gov/medical-devices/coronavirus-disease-2019-covid-19-emergency-use-authorizations-medical-devices/eua-authorized-serology-test-performance. [accessed 04.08.20].
[16] Dripps RD, Lamont A, Eckenhoff JE. The role of anesthesia in surgical mortality. JAMA 1961;178:261.
[17] Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care 1998;36(1):8.
[18] Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care 2005;43(11):1130.
[19] Gu T, Mack JA, Salvatore M, et al. Characteristics associated with racial/ethnic disparities in COVID-19 outcomes in an academic health care system. JAMA Netw Open 2020;3(10):e2025197.
[20] Raisi-Estabragh Z, McCracken C, Bethell MS, et al. Greater risk of severe COVID-19 in Black, Asian and Minority Ethnic populations is not explained by cardiometabolic, socioeconomic or behavioural factors, or by 25(OH)-vitamin D status: study of 1326 cases from the UK Biobank. J Public Health (Oxf) 2020;42(3):451.
[21] Grigsby-Toussaint DS, Shin JC, Jones A, Grigsby-Toussaint DS. Disparities in the distribution of COVID-19 testing sites in black and Latino areas in New York City. Prev Med 2021;147:106463.

[22] Buikema AR, Buzinec P, Paudel ML, et al. Racial and ethnic disparity in clinical outcomes among patients with confirmed COVID-19 infection in a large US electronic health record database. EClinicalMedicine 2021;39:101075.
[23] Aminian A, Safari S, Razeghian-Jahromi A, Ghorbani M, Delaney CP. COVID-19 outbreak and surgical practice: unexpected fatality in perioperative period. Ann Surg 2020;272(1):e27.
[24] Shrikhande SV, Pai PS, Bhandare MS, et al. Outcomes of elective major cancer surgery during COVID 19 at Tata Memorial Centre: implications for cancer care policy. Ann Surg 2020;272(3):e249.
[25] Teitelbaum S, Diaz J, Singer R. Outpatient plastic surgery is safe during the COVID-19 pandemic: results of a July 2020 Los Angeles Survey and Literature Review. Aesthet Surg J 2021;41:98.
[26] Hoyos Mejía L, Romero Román A, Gil Barturen M, et al. Thoracic surgery during the coronavirus disease 2019 (COVID-19) pandemic in Madrid, Spain: single-centre report. Eur J Cardiothorac Surg 2020;58(5):991.
[27] Kaye K, Paprottka F, Escudero R, et al. Elective, non-urgent procedures and aesthetic surgery in the wake of SARS-COVID-19: considerations regarding safety, feasibility and impact on clinical management. Aesthetic Plast Surg 2020;44:1014.
[28] Couto RA, Wiener TC, Adams WP. Evaluating postoperative outcomes of patients undergoing elective procedures in an ambulatory surgery center during the COVID-19 pandemic. Aesthet Surg J 2020;41(2):250.
[29] Parvizi J, Gehrke T, Krueger CA, et al. Resuming elective orthopaedic surgery during the COVID-19 pandemic: guidelines developed by the International Consensus Group (ICM). J Bone Joint Surg Am 2020;102(14):1205.
[30] Wang Y, Zeng L, Yao S, et al. Recommendations of protective measures for orthopedic surgeons during COVID-19 pandemic. Knee Surg Sports Traumatol Arthrosc 2020;28(7):2027.
[31] Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. Lancet 2020;396(10243):27.
[32] Collaborative C, Collaborative G. Timing of surgery following SARS-CoV-2 infection: an international prospective cohort study. Anaesthesia 2021;76(6):748.