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Primary Hip

Impact of COVID-19 Protocols on Primary and Revision Total Hip Arthroplasty

Michael Sybert, MD, Christian T. Oakley, BS, Thomas Christensen, BS, Joseph Bosco, MD, Ran Schwarzkopf, MD, MSc, James Slover, MD, MS *

Department of Orthopedic Surgery, NYU Langone Health, New York, New York

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ABSTRACT

Background: Surgical site infection (SSI) after total hip arthroplasty (THA) is associated with increased morbidity, mortality, and healthcare expenditures. Our institution intensified hygiene standards during the COVID-19 pandemic; hospital staff exercised greater hand hygiene, glove use, and mask compliance. We examined the effect of these factors on SSI rates for primary THA (pTHA) and revision THA (rTHA).

Methods: A retrospective review was performed identifying THA from January 2019 to June 2021 at a single institution. Baseline characteristics and outcomes were compared before (January 2019 to February 2020) and during (May 2020 to June 2021) the COVID-19 pandemic and during the first (May 2020 to November 2020) and second (December 2020 to June 2021) periods of the pandemic. Cohorts were compared using the Chi-squared test and independent samples *t*-test.

Results: A total of 2,682 pTHA (prepandemic: 1,549 [57.8%]; pandemic: 1,133 [42.2%]) and 402 rTHA (prepandemic: 216 [53.7%]; Pandemic: 186 [46.2%]) were included. For primary and revision cases, superficial and deep SSI rates were similar before and during COVID-19. During COVID-19, the incidence of all (−0.43%, $P = .029$) and deep (−0.36%, $P = .049$) SSIs decreased between the first and second periods for rTHA. pTHA patients had longer operative times ($P < .001$) and shorter length of stay ($P = .006$) during COVID-19. Revision cases had longer operative times ($P = .004$) and length of stay ($P = .046$). Both pTHA and rTHA were discharged to skilled nursing facilities less frequently during COVID-19.

Conclusion: During COVID-19, operative times were longer in both pTHA and rTHA and patients were less likely to be discharged to a skilled nursing facility. Although intensified hygienic standards may lower SSI rates, infection rates did not significantly differ after our hospital implemented personal protective guidelines and a mask mandate.

The COVID-19 pandemic has been a global healthcare crisis that is unprecedented in recent times [1,2]. The effects of the pandemic have shown to be far-reaching within our healthcare system, with impacts on elective surgery including total hip arthroplasty (THA) [3–5]. During the initial stage of the pandemic in March 2020, elective THA volumes saw a steep decline of 92% after the American College of Surgeons and Centers for Medicare and Medicaid Services recommended postponing elective procedures [3,6,7].

Upon resuming elective THA cases during the COVID-19 pandemic, institutional protocols intensified hygiene standards in an attempt to curb the spread of the virus. Increased hand hygiene, limited visitations, and strict mask compliance in all areas of the hospital were employed to contribute to the effort. The positive effect of masks on the spread of bioaerosols has been shown in the literature [8,9]. This protection has also been shown beneficial in the transmission of the COVID-19 virus [10,11].

The benefit of increased hygiene and masks as it relates to surgical site infection (SSI) in the general surgical population is unclear with mixed results in the literature [12–19]. To our knowledge, the effect of continuous mask use throughout the hospital and perioperative area on THA outcomes remains unknown. Given this, the objective of this study was to quantify changes in SSI and other

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* Address correspondence to: James D. Slover, MD, MS, Division of Adult Reconstruction, Department of Orthopedic Surgery, NYU Langone Health 301 East 17th Street, New York, NY 10003.

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perioperative metrics of primary and revision THA after the implementation of hospital-wide COVID protocols, including frequent hand washing and continuous mask use.

Materials and Methods

This retrospective study examined all patients aged more than 18 years who underwent primary or revision THA (pTHA and rTHA) between January 2019 and June 2021 at a single academic orthopedic specialty hospital. Exclusion criteria included THA for fracture, oncologic indications, and bilateral THA. Patients were separated into 2 cohorts based on the date of surgery: the prepandemic group (January 2019 to February 2020) and the pandemic group (May 2020 to June 2021). We have excluded the months of March and April 2020 because our institution suspended elective surgeries and only performed emergent cases from March 15 through May 4, 2020. The pandemic group was further stratified into 2 time periods: period 1 (May 2020 to November 2020) and period 2 (December 2020 to June 2021). Patient records and data were deidentified as part of our institutional quality improvement program; however, a human-subjects review by our institutional review board was obtained prior to this study.

Data Collection

Patient demographic data including gender, race, body mass index (BMI; kg/m^2), American Society of Anesthesiology (ASA) classification, smoking status, and surgical status (pTHA or rTHA) were collected. In addition, clinical data including length of stay (LOS; days), surgical time (minutes), SSI, and discharge disposition were collected from our electronic patient medical record system, Epic (Epic Caboodle. version 15; Verona, Wisconsin) using Microsoft SQL Server Management Studio 2017 (Redmond, Washington). LOS was evaluated in days spent in the hospital following surgery and surgical time was calculated as the time difference between initial skin incision and closure.

Outcome Measures

The primary outcomes included all SSIs, superficial SSIs, and deep SSIs. The secondary outcomes included perioperative data, such as surgical time, LOS, and discharge disposition.

Statistical Analysis

All data were organized and collected using Microsoft Excel software (Microsoft Corporation, Richmond, Washington). A binary variable was created to identify patients who underwent THA during the prepandemic and pandemic periods, and if during the pandemic, periods 1 and 2 as well. Demographic and clinical baseline characteristics of study participants were described as means with standard deviations (SDs) for continuous variables and frequencies with percentages for categorical variables. Statistical differences in continuous categorical variables were detected using independent sample *t*-test and Chi-squared (χ^2) test, respectively. Changes in the incidence of categorical outcomes were expressed in absolute and relative percentages.

Results

Primary Total Hip Arthroplasty

A total of 2,682 primary THA patients from January 2019 to June 2021 were included: 1,549 (57.8%) in the prepandemic group and 1,133 (42.2%) in the pandemic group. Further sub-analysis of the pandemic cohort yielded 574 (50.7%) patients in period 1 and 559 (49.3%) patients in period 2.

An analysis of demographic characteristics (Table 1) showed a lower proportion of males in the pandemic group (41.8% versus 37.2%, $P = .016$). In addition, there were significant differences in racial demographics between cohorts ($P = .008$), with a 4% decrease in the proportion of White patients and a 3.6% increase in the proportion of Black patients during the pandemic. There were no differences in age ($P = .077$), BMI ($P = .493$), ASA Classification ($P = .121$), and smoking status ($P = .961$). In a subgroup analysis of the pandemic cohort, the first period had younger patients than the second period (65.2 versus 66.5 years, $P = .046$).

For perioperative outcomes (Table 2), the incidence of all SSIs ($P = .372$), superficial SSIs ($P = .242$), and deep SSIs ($P = .221$) did not significantly differ between groups. Operative times were significantly longer (114.7 ± 28.5 versus 104.0 ± 27.6 minutes, $P < .001$) during COVID-19. Hospital LOS decreased during the pandemic period (2.00 ± 1.56 versus 2.15 ± 1.30 days, $P = .006$). Furthermore, there was a significant decrease in hospital LOS between period 1 and period 2 of the pandemic (2.10 ± 1.87 versus 1.90 ± 1.16, $P = .025$). In addition, discharge disposition also differed ($P < .001$); during the pandemic, patients were more likely to be discharged home (94.9% versus 88.9%), less likely to be discharged to skilled nursing facilities (4.1% versus 10.3%), and similarly likely to be discharged to acute rehab centers (1.1% versus 0.8%). There were no additional differences in perioperative outcome metrics between the pandemic subgroups.

Revision Total Hip Arthroplasty

A total of 402 revision THA patients were included, including 216 (53.7%) in the prepandemic group and 186 (46.2%) in the pandemic group. In a subgroup analysis of the pandemic cohort, period 1 had 100 (53.5%) patients and period 2 had 87 (46.5%) patients. At baseline, the prepandemic cohort had a higher mean BMI than the pandemic cohort (29.5 ± 6.7 versus 28.1 ± 6.2, $P = .030$) (Table 1). Age ($P = .206$), gender ($P = .303$), ASA classification ($P = .888$), race ($P = .313$), and smoking status ($P = .232$) did not significantly differ between groups.

For SSI in revision THA, there were no significant differences for all SSIs ($P = .420$), superficial SSIs ($P = .282$), and deep SSIs ($P = .583$) between the prepandemic and pandemic groups. In a subgroup analysis of the pandemic cohort, both all SSIs (−0.43% [−82.9%], $P = .029$) and deep SSIs (−0.36% [−80.5%], $P = .049$) significantly decreased from period 1 to period 2. Similar to the primary THA cohort, the revision THA cohort showed significant differences in operative time, LOS, and discharge disposition (Table 2). During the pandemic, operative times were longer (150.5 ± 57.3 versus 134.8 ± 51.8 minutes, $P = .004$). In contrast to the primary THA cohort, LOS for revision THA increased during the pandemic (3.62 ± 2.64 versus 3.10 ± 2.58 days, $P = .046$). Discharge disposition also differed between groups ($P < .001$). More patients were discharged home (85% versus 83.8%) and to acute rehab centers (8.6% versus 1.4%), whereas few were discharged to skilled nursing facilities (6.4% versus 14.8%).

Discussion

The COVID-19 pandemic provoked a surge in the use of handwashing and personal protective equipment (PPE) both in and out of the hospital setting. In our orthopedic hospital, strict mask use and hand hygiene were enforced in all areas of the hospital for all patients and staff. In addition, patient visitor limitations were employed as a measure of social distancing. The purpose of this article was to retrospectively analyze if the implementation of

Table 1
Demographic Characteristics of Patients Undergoing Total Hip Arthroplasty Before and After the Introduction of COVID-19 Motivated Hygienic Practices.

Time Period	Primary THA						Revision THA					
	Overall			Pandemic			Overall			Pandemic		
	Prepandemic[a] (n = 1,549)	Pandemic[b] (n = 1,133)	*P* Value	Period 1[c] (n = 574)	Period 2[d] (n = 559)	*P* Value	Prepandemic (n = 216)	Pandemic (n = 186)	*P* Value	Period 1 (n = 100)	Period 2 (n = 87)	*P* Value
Age (y)	65.0 ± 11.7	65.8 ± 11.2	.077	65.2 ± 11.6	66.5 ± 10.8	.046[e]	65.7 ± 10.9	67.1 ± 11.7	.206	68.0 ± 11.3	66.1 ± 12.1	.256
Male- no. (%)	644 (41.8)	421 (37.2)	.016[e]	210 (36.6)	211 (37.7)	.686	104 (48.1)	80 (43.0)	.303	43 (43.4)	37 (42.5)	.901
BMI (kg/m^2)	29.8 ± 6.2	30.0 ± 6.4	.493	29.8 ± 6.3	30.2 ± 6.5	.324	29.5 ± 6.7	28.1 ± 6.2	.030[e]	28.2 ± 5.6	28.0 ± 6.7	.840
ASA Classification- no. (%)			.121			.455			.888			.819
1	96 (6.2)	54 (4.8)		31 (5.4)	23 (4.1)		7 (3.2)	7 (3.7)		6 (6.0)	1 (1.1)	
2	955 (61.7)	746 (65.8)		375 (65.3)	371 (66.4)		121 (56.0)	110 (58.8)		61 (61.0)	49 (56.3)	
3	483 (31.2)	323 (28.5)		161 (28.0)	162 (29.0)		86 (39.8)	69 (36.9)		33 (33.0)	36 (41.4)	
4	15 (1.0)	10 (0.9)		7 (1.2)	3 (0.5)		2 (0.9)	1 (0.5)		0 (0.0)	1 (1.1)	
Race- no. (%)			.008[e]			.159			.313			.762
White	1,094 (70.6)	755 (66.6)		382 (66.6)	373 (66.7)		157 (72.7)	130 (69.5)		70 (70.0)	60 (69.0)	
African American	221 (14.3)	203 (17.9)		114 (19.9)	89 (15.9)		20 (9.3)	24 (12.8)		13 (13.0)	11 (12.6)	
Asian	37 (2.4)	15 (1.3)		6 (1.0)	9 (1.6)		5 (2.3)	1 (0.5)		0 (0.0)	1 (1.1)	
Other	197 (12.7)	160 (14.1)		72 (12.5)	88 (15.7)		34 (15.7)	32 (17.1)		17 (17.0)	15 (17.2)	
Smoking Status- no. (%)			.961			.508			.232			.819
Never	774 (50.0)	566 (50.0)		283 (49.3)	283 (50.6)		98 (45.4)	100 (53.5)		53 (53.0)	47 (54.0)	
Former	642 (41.4)	473 (41.7)		238 (41.5)	235 (42.0)		97 (44.9)	74 (39.6)		41 (41.0)	33 (37.9)	
Current	133 (8.6)	94 (8.3)		53 (9.2)	41 (7.3)		21 (9.7)	13 (7.0)		6 (6.0)	7 (8.0)	

ASA, American Society of Anesthesiologists; BMI, body mass index; No., number; SD, standard deviation; THA, total hip arthroplasty.
[a] Before COVID-19 includes all patients undergoing arthroplasty from January 2019 to February 2020.
[b] During COVID-19 includes all patients undergoing arthroplasty from May 2020 to June 2021.
[c] Period 1 includes all patients undergoing arthroplasty from May 2020 to November 2020.
[d] Period 2 includes all patients undergoing arthroplasty from December 2020 to June 2021.
[e] $P < .05$.

Table 2
Outcomes of Patients Undergoing Total Hip Arthroplasty Before and After the Introduction of COVID-19 Motivat ed Hygienic Practices.

Time Period	Primary THA Overall			Primary THA Pandemic			Revision THA Overall			Revision THA Pandemic		
	Prepandemic (n = 1,549)	Pandemic (n = 1,133)	*P* Value	Period 1 (n = 574)	Period 2 (n = 559)	*P* Value	Prepandemic (n = 216)	Pandemic (n = 186)	*P* Value	Period 1 (n = 100)	Period 2 (n = 87)	*P* Value
SSI- Absolute (relative) change in incidence- no. (%)												
All	-	−0.26 (−37.9)	.372	-	−0.29 (−40.5)	.188	-	0.34 (75.8)	.420	-	−0.43 (−82.9)	.029[b]
Superficial	0 (0.0)[a]	1 (0.1)[a]	.242	-	−0.08 (−100.0)	.324	0 (0.0)[a]	1 (0.5)[a]	.282	-	−0.06 (−100.0)	.350
Deep	-	−0.36 (−50.3)	.221	-	−0.37 (−52.4)	.329	-	0.25 (56.2)	.583	-	−0.36 (−80.5)	.049[b]
Operative Time (min)	104.0 ± 27.6	114.7 ± 28.5	<.001[b]	114.4 ± 29.3	115.0 ± 27.7	.759	134.8 ± 51.8	150.5 ± 57.3	.004[b]	153.5 ± 55.8	147.1 ± 59.1	.442
Length of Stay (h)	2.15 ± 1.30	2.00 ± 1.56	.006[b]	2.10 ± 1.87	1.90 ± 1.16	.025[b]	3.10 ± 2.58	3.62 ± 2.64	.046[b]	3.82 ± 2.74	3.39 ± 2.51	.263
Discharge Disposition- no. (%)			<.001[b]			.640			< .001[b]			.690
Home	1,377 (88.9)	1,075 (94.9)	.109	548 (95.5)	527 (94.3)	.836	181 (83.8)	159 (85.0)	.343	83 (83.0)	76 (87.4)	.747
Skilled Nursing Facility	160 (10.3)	46 (4.1)	<.001[b]	21 (3.7)	23 (4.5)	.697	32 (14.8)	12 (6.4)	.012[b]	7 (7.0)	5 (5.7)	.736
Acute Rehab Center	12 (0.8)	12 (1.1)	.442	5 (0.9)	7 (1.3)	.533	3 (1.4)	16 (8.6)	< .001[b]	10 (10.0)	6 (6.9)	.469

Min, minutes; No., number; SD, standard deviation; SSI, surgical site infection; THA, total hip arthroplasty; VTE, venous thromboembolism.
[a] Expressed as the number of events (%).
[b] $P < .05$.

pandemic-related hygiene protocols had an impact on perioperative operating room metrics, particularly SSI.

SSI is a well-known complication after THA with considerable morbidity and healthcare expenditures [20,21]. Numerous interventions have been employed over the years to combat this complication, including laminar flow systems, surgical site antiseptic preparation, perioperative antibiotics, and methicillin-susceptible Staphylococcus aureus decolonization among others [22–24]. While the use of masks has been shown to prevent the spread of bioaerosols including the COVID-19 virus [8–11], the impact of mask use on SSI is unclear. Several studies using blood agar plates and particle tracers demonstrated that masks worn by scrubbed staff can reduce surgical field bacterial contamination [25–27]. In addition, masks have been shown to protect scrubbed staff from fluid splashes and debris in the surgical field [28–30].

Despite these proposed advantages of wearing masks, direct comparisons of masked versus nonmasked personnel have not yielded clear benefits for the incidence of SSIs. A 2021 meta-analysis by Marson et al [15] analyzed 6 randomized controlled studies evaluating SSI in masked versus nonmasked cohorts for a total of 7,148 patients and they found a lower rate of SSI in the nonmasked group (OR = 0.76). However, in another meta-analysis of 2,106 clean surgical cases comparing masked and nonmasked cohorts, similar SSI rates were found [18]. In contrast, in a case-control study of 649 cataract arthroplasties by Kamalarajah et al [31], SSIs were more than 3 times higher in cases in which surgeons did not wear masks. Unfortunately, to our knowledge, there are no studies examining the effect of masks on SSI rates in the arthroplasty literature.

In our analysis of pTHA and rTHA, the implementation of pandemic protocols did not significantly affect SSI rates. Our pandemic cohort was subdivided into 2 time periods, as the COVID-19 infection burden decreased and COVID-19 vaccines were implemented during the second period. Notably, there were no changes in the pandemic hygiene protocols between these 2 periods. In comparing the 2 periods, we did see a statistically significant decrease in revision THA SSI in period 2 compared to period 1. It is possible that the implementation of COVID protocols had a delayed effect that preferentially affected the revision population. In addition, prior studies assessing the seasonality of infection have observed higher infection rates during warmer and wetter climatic conditions [32], although both cohorts included time periods with similar weather conditions. Unfortunately, it is difficult to draw conclusions from this outcome due to the study being inadequately powered, introducing the possibility of a type I error. In our post-hoc power analysis, 5,285 (period 1: 2,826 and period 2: 2.459) patients were required to achieve adequate power (80%) but only 187 (period 1: 100 and period 2: 87) patients were in the analysis.

Despite not observing a meaningful change in SSI after the implementation of pandemic protocols, we did find significant trends in operative time, LOS, and discharge disposition in both pTHA and rTHA. For operative time, we observed 11-minute and 13-minute increases in the primary and revision cohorts, respectively, after the implementation of pandemic protocols. The outcomes for operative time in the primary THA cohort did satisfy our power analysis. The revision THA cohort was underpowered by 39 patients. This trend could be explained by changes in patient selection influenced by the pandemic. A greater proportion of cases may have been in complex patients, whereas routine cases may have elected to defer surgery or to pursue surgery at local institutions and not at urban academic centers. Alternatively, the decreased case numbers seen during the pandemic may have also influenced operative times. Moreover, some surgeons at our institution began wearing N95 masks intraoperatively and may have experienced more fatigue during the pandemic, leading to longer operative times as well. pTHA and rTHA case numbers decreased by

27% and 14% during the pandemic, respectively. With a lower daily case burden, surgeons may have subconsciously worked slower, leading to longer operative times.

Statistically significant trends were observed for LOS in both the pTHA and rTHA cohorts. The pTHA group showed a 7.2% decrease in LOS during the pandemic. In addition, there was a 9.9% decrease in LOS between periods 1 and 2 of the pandemic. This trend may reflect a conscious effort to decrease potential COVID-19 exposure in elective pTHA patients by discharging patients earlier in their postoperative course. In contrast, the rTHA cohort had a 14.4% increase in LOS during the pandemic. This increase could have been due to an increased proportion of urgent or complex revision cases requiring longer postoperative stays. It is also possible that LOS increased in revision THA due to avoidance of placing patients to skilled nursing facilities for the fear of increased COVID exposure.

Our analysis showed a statistically significant change in discharge disposition for both pTHA and rTHA. For both primary and revision cases, the proportion of patients discharged to skilled nursing facilities decreased by 6.2% and 8.4% during the pandemic, respectively. Moreover, the pTHA group demonstrated a compensatory 6% increase in home disposition, whereas the rTHA group had a 1.2% and 7.2% increase in home and acute rehabilitation center disposition, respectively. In power analysis for the pTHA cohort, discharge to home and skilled nursing facilities were sufficiently powered. Our rTHA cohort was only adequately powered for the acute rehab disposition. This observed trend in discharge disposition during the pandemic likely corresponds with a conscious avoidance of discharging patients to skilled nursing facilities, as many of these facilities had higher COVID-19 case volumes [33].

Limitations

There are limitations to be considered in the present study. This study was retrospective, and therefore, selection bias and the possibility of errors in recorded data cannot be controlled for. Our analysis was underpowered with the exception of pTHA operative time, home and skilled nursing disposition, and rTHA acute rehab disposition. We were unable to adjust for this issue due to the temporal brevity of the COVID-19 pandemic. In addition, factors such as implant design, surgical approach, and the use of robotics and navigation may have also influenced the examined outcomes, but these variables were not recorded in this present study. Moreover, previous studies have found shorter LOS and lower discharge to skilled nursing facility rates during more recent years [34,35], and we were unable to differentiate between the effect of these trends and mask use alone. Finally, our institution employed multiple interventions simultaneously during the pandemic and we were also unable to distinguish between the effect of these changes and masks alone.

Conclusion

The COVID-19 pandemic led to the implementation of increased hygiene protocols, mask use, and social distancing throughout the hospital setting. Our study did not show a correlation between the implementation of pandemic protocols and a change in SSI. We did demonstrate longer operative times and decreased discharge to skilled nursing facilities in both pTHA and rTHA during the pandemic, although these results are likely due to the pandemic itself and not the implementation of hygiene protocols.

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