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The Effect of the Coronavirus Disease 2019 (COVID-19) Pandemic on Elective Cervical Spine Surgery Utilization and Complications in the United States: A Nationwide Temporal Trends Analysis

Q1 Q5
Q6 Q7

Q4 Adem Idrizi^{1,2}, Adam M. Gordon¹, Aaron Lam¹, Charles Conway¹, Ahmed Saleh¹

■ **OBJECTIVES:** As a result of the coronavirus disease 2019 (COVID-19) pandemic, elective surgeries nationwide were suspended. The objective was to compare temporal trends in patient demographics, case volumes, and postoperative complications of patients undergoing elective cervical spine surgery from pre-COVID-19 (2019–2020 Q1) to post-COVID-19 (2020 Q2–Q4).

■ **METHODS:** The 2019 to 2020 American College of Surgeon's National Surgery Quality Improvement Program database was queried for common elective cervical spine surgeries. Patients pre-COVID-19 (2019–2020 Q1) were compared with those undergoing surgery during post-COVID-19 (2020 Q2–Q4) protocols. Procedural use, patient demographics, and complications were compared. Linear regression was used to evaluate case volume changes over time. *P* values less than 0.05 were significant.

■ **RESULTS:** In total, 31,013 patients underwent elective cervical spine surgery in 2019 (*N* = 16,316) and 2020 (*N* = 14,697); an overall 10% decline. Compared with the calendar year 2019 through 2020 Q1 mean, elective surgery volume decreased by 21.6% in 2020 Q2 and never returned to prepandemic baseline. The percentage decline in case volume from 2019 to 2020 Q1 to 2020 Q2 was greatest for anterior cervical discectomy and fusion (23.3%), followed by cervical decompression (23.4%), posterior cervical fusion (15.0%), and cervical disc arthroplasty and vertebral corpectomy (13.7%). Patients undergoing surgery in 2020

Q2–Q4 had overall greater comorbidity burden (American Society of Anesthesiologists grade 3 and 4) (*P* < 0.001). From 2019–2020 Q1 versus 2020 Q2–Q4, there was a significant increase in total complication (5.5% vs. 6.8%, *P* < 0.001), reoperation (1.9% vs. 2.2%, *P* = 0.048), and mortality (0.25% vs. 0.37%, *P* = 0.049) rates.

■ **CONCLUSIONS:** Elective surgery declined drastically during the second quarter of 2020. Patients undergoing surgery during the pandemic had an overall greater comorbidity burden, resulting in increased total complication and mortality rates over the study period.

INTRODUCTION

The severe acute respiratory syndrome coronavirus 2^{Q3} (coronavirus disease 2019 [COVID-19]) virus was first reported in the United States on January 30, 2020.¹ Soon after, the World Health Organization declared the novel COVID-19 outbreak a global pandemic on March 10, 2020.² Subsequently, the United States Surgeon General and the Centers for Medicare & Medicaid Services declared the cancellation of all elective surgery in the United States.³ This announcement led to unprecedented changes in the health care systems. As it relates to orthopedic and neurosurgery spine surgeons, both the American Academy of Orthopaedic Surgeons

Key words

- ACDF
- Cervical disc arthroplasty
- Cervical spine
- Cervical spine fusion
- Complications
- COVID-19
- Telemedicine

Abbreviations and Acronyms

ACDF: Anterior cervical discectomy and fusion

COVID-19: Coronavirus disease 2019

NSQIP: National Surgery Quality Improvement Program

From the ¹Department of Orthopaedic Surgery, Maimonides Medical Center; and ²SUNY Downstate Health Sciences University, College of Medicine, Brooklyn, New York, USA

To whom correspondence should be addressed: Adam M. Gordon, M.D.
[E-mail: MMCOthoresearch1@gmail.com]

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Table 1. Baseline Demographics of Patients Who Underwent Elective Cervical Spine Surgery Before and During COVID-19

Demographics	2019–2020 Q1 (n = 20,596)		2020 Q2–Q4 (n = 10,417)		P Value
	n	%	n	%	
Age, years					0.169
<50	5567	27.03	2760	26.50	
50–59	6013	29.19	2999	28.79	
60–69	5499	26.70	2776	26.65	
70+	3517	17.08	1882	18.07	
Sex					0.035
Female	9795	47.56	4814	46.21	
Male	10,799	52.43	5603	53.79	
Race					<0.001
American Indian or Alaska Native	111	0.54	61	0.59	
Asian	508	2.47	404	3.88	
Black or African American	2423	11.76	1299	12.47	
Native Hawaiian	61	0.30	30	0.29	
Unknown	2192	10.64	1120	10.75	
White	15,301	74.29	7503	72.03	
BMI					0.008
<18.5	179	0.87	116	1.11	
18.5–24.9	3690	17.92	1924	18.47	
25.0–29.9	6783	32.93	3425	32.88	
30.0–34.9	5465	26.53	2683	25.76	
35.0–39.9	2744	13.32	1285	12.34	
40.0+	1632	7.92	890	8.54	
Diabetes mellitus					0.003
Insulin	1254	6.09	724	6.95	
No	16,774	81.44	8338	80.04	
No insulin	2568	12.47	1355	13.01	
Smoking status within 1 year					0.625
Nonsmoker	16,028	77.82	8132	78.06	
Smoker	4568	22.18	2285	21.94	
Dyspnea					0.310
At rest	61	0.30	30	0.29	
Moderate exertion	1061	5.15	495	4.75	
No	19,474	94.55	9892	94.96	
Functional health status					<0.001
Independent	20,081	97.50	10,116	97.11	
Partially dependent	376	1.83	255	2.45	
Totally dependent	55	0.27	33	0.32	
Unknown	84	0.41	13	0.12	

Continues

Table 1. Continued

Demographics	2019–2020 Q1 (n = 20,596)		2020 Q2–Q4 (n = 10,417)		P Value
	n	%	n	%	
Ventilator dependent					<0.001
No	20,586	99.95	10,398	99.82	
Yes	10	0.05	19	0.18	
History of severe COPD					
No	19,624	95.28	9887	94.91	0.153
Yes	972	4.72	530	5.09	
Ascites					0.315
No	20,594	99.99	10,417	100.00	
Yes	2	0.01	0	0.00	
Congestive heart failure					0.044
No	20,508	99.57	10,355	99.40	
Yes	88	0.43	62	0.60	
Hypertension					0.234
No	10,306	50.04	5138	49.32	
Yes	10,290	49.96	5279	50.68	
Currently on dialysis					0.013
No	20,520	99.63	10,358	99.43	
Yes	76	0.37	59	0.57	
Steroid use					0.876
No	19,754	95.91	9995	95.95	
Yes	842	4.09	422	4.05	
Bleeding disorders					0.112
No	20,364	98.87	10,278	98.67	
Yes	232	1.13	139	1.33	
MFI					0.004
0	9178	44.56	4526	43.45	
1	7663	37.21	3794	36.42	
2	3368	16.35	1868	17.93	
3	348	1.69	210	2.02	
4	35	0.17	17	0.16	
5	4	0.02	2	0.02	
Inpatient/outpatient status					0.870
Inpatient	12,545	60.91	6335	60.81	
Outpatient	8051	39.09	4082	39.19	

COVID-19, coronavirus disease 2019; BMI, body mass index; COPD, chronic obstructive pulmonary disease; MFI, 5-Item Modified Frailty Index; ASA, American Society of Anesthesiologists; MAC, monitored anesthesia care; IV, intravenous; LOS, length of stay.

Continues

Table 1. Continued

Demographics	2019–2020 Q1 (n = 20,596)		2020 Q2–Q4 (n = 10,417)		P Value
	n	%	n	%	
ASA class					<0.001
I	572	2.78	234	2.25	
II	9494	46.10	4614	44.29	
III	10,005	48.58	5239	50.29	
IV	510	2.48	324	3.11	
Anesthetic technique					0.259
General	20,547	99.76	10,397	99.81	
MAC/IV sedation	11	0.05	4	0.04	
Other	38	0.18	16	0.15	
LOS					<0.001
0	2535	12.31	1651	15.85	
1	9938	48.25	4427	42.50	
2+	8081	39.24	4311	41.38	

COVID-19, coronavirus disease 2019; BMI, body mass index; COPD, chronic obstructive pulmonary disease; MFI, 5-Item Modified Frailty Index; ASA, American Society of Anesthesiologists; MAC, monitored anesthesia care; IV, intravenous; LOS, length of stay.

and North American Spine Society developed recommendations for triaging spine surgical cases.⁴⁻⁶

The ramifications of canceling elective spine surgery were felt by both patients and spine surgeons in the United States and worldwide.⁷⁻¹⁵ From a surgeon perspective, the projected backlog of cases was estimated to take as long as 16 months to recover.⁷ Elective lumbar spine procedures decreased by 90% in the first 2 months of the pandemic, with telemedicine comprising two-thirds of outpatient spine appointments.¹¹ The financial effect of canceling elective spine surgery was also noticeable, given cervical and lumbar fusion procedural volumes are consistently rising, and these procedures rank among some of the most costly surgeries performed in the United States.¹⁶⁻¹⁹ Anterior cervical discectomy and fusion (ACDF), posterior cervical decompression, and posterior cervical fusion represent the most common cervical spine procedures and are indicated for symptomatic cervical myelopathy and radiculopathy. With careful resumption of surgery using standardized protocols, the recovery of spine surgery utilization and implications on postoperative outcomes is unknown.²⁰ Studies currently analyzing resumption protocols and trends in case volumes and outcomes are limited to the single institutional level or within hospitals outside the United States.^{8,21} Therefore, an understanding of potential changes in patient demographics undergoing spinal surgery and complication rates is warranted.

Due to the consequence of the COVID-19 pandemic on cervical spine surgery suspensions and the lack of a nationwide reporting, the primary purpose of this study is to compare temporal trends in case volume of elective cervical spine surgery from 2019–2020 Q1

versus 2020 Q2–Q4 in the United States using a nationwide database. The secondary outcomes include comparing patient demographics and postoperative complications of those undergoing cervical spine surgery before and during the pandemic.

METHODS

Database and Patient Selection

This study is a retrospective case–control analysis of prospectively collected data from the American College of Surgeon's National Surgery Quality Improvement Program (NSQIP) database. This database includes details of patient demographics and preoperative and 30-day postoperative outcomes following surgery. Currently, NSQIP database contains more than 1 million cases from more than 700 participating institutions in the United States. Many studies have used the NSQIP database to report postoperative outcomes and complications following spine surgery.^{22,23}

The NSQIP database was queried for all patients undergoing elective cervical spine surgery (ACDF, spinal decompression/laminectomy, posterior cervical fusion, vertebral corpectomy, and cervical disc arthroplasty) in 2019 and 2020 using Current Procedural Terminology for each procedure type (Supplementary Table 1). Any nonelective cases were excluded from this study in addition to patients with missing demographic data. Exclusions from the study also included those patients undergoing surgery for trauma, infections, or malignant etiologies using the International Classification of Diseases, Ninth or Tenth Revision codes. As the data were derived from a deidentified national surgical

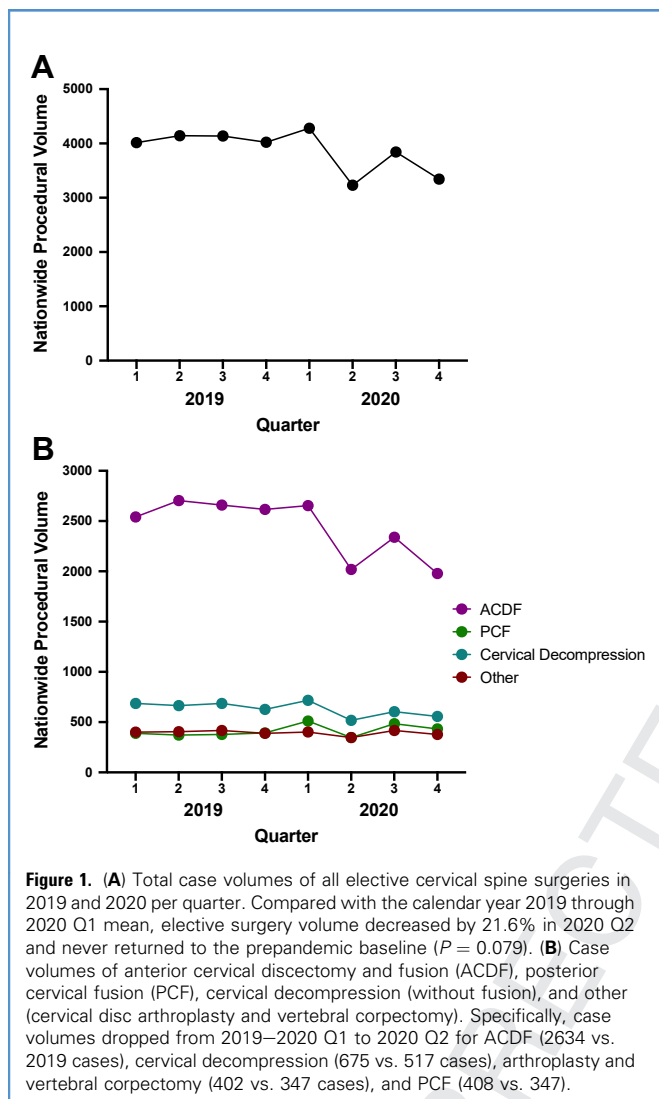


Figure 1. (A) Total case volumes of all elective cervical spine surgeries in 2019 and 2020 per quarter. Compared with the calendar year 2019 through 2020 Q1 mean, elective surgery volume decreased by 21.6% in 2020 Q2 and never returned to the prepandemic baseline ($P = 0.079$). (B) Case volumes of anterior cervical discectomy and fusion (ACDF), posterior cervical fusion (PCF), cervical decompression (without fusion), and other (cervical disc arthroplasty and vertebral corpectomy). Specifically, case volumes dropped from 2019–2020 Q1 to 2020 Q2 for ACDF (2634 vs. 2019 cases), cervical decompression (675 vs. 517 cases), arthroplasty and vertebral corpectomy (402 vs. 347 cases), and PCF (408 vs. 347).

database, the study was therefore exempt from institutional review board approval.

Variables and Outcomes Studied

Primary outcomes of this study were to compare patient demographics and case volumes between pre-COVID-19 (2019–2020 Q1) versus post-COVID-19 (2020 Q2–Q4) time periods. Patient demographics studied included age, sex, race, body mass index, and several comorbidities (diabetes mellitus, smoking status, chronic obstructive pulmonary disease, congestive heart failure, hypertension, ventilator and dialysis dependence, chronic steroid use, modified frailty index, and functional health status). Perioperative data also were collected, including inpatient/outpatient status, American Society of Anesthesiologists status, anesthetic technique, and length of stay.

In addition, we analyzed annual postoperative outcomes, including 30-day complications (major or minor), reoperations,

and readmissions between the time periods 2019–2020 Q1 and 2020 Q2–Q4. Major complications included deep infections, organ infections, unplanned intubations, pulmonary emboli, ventilator use >48 hours, strokes, cardiac arrests, deep vein thromboses, sepsis, acute renal failures, blood transfusions, return to the operating room, and death. Complications were further broken down into the following broad categories: infection (superficial or deep surgical-site infection), wound (wound dehiscence or other complication, not including surgical-site infection), cardiac (cardiac arrest or myocardial infarction), pulmonary (pneumonia, pulmonary embolism, unplanned reintubation), hematology (deep vein thromboembolism, need for transfusion), and renal (progressive renal insufficiency, acute kidney failure). The frequency of Clavien–Dindo IV complications (life-threatening complications including cardiac arrest, myocardial infarction, septic shock, pulmonary embolism, and renal failure) were collected and analyzed independently.²⁴

Statistical Analysis

To assess for significant differences in patient demographics between pre-COVID-19 (2019–2020Q1) and post-COVID-19 (2020 Q2–Q4) time periods in addition to admission quarters, Pearson χ^2 tests, Student *t* test, and analysis of variance were used. Linear regression models were constructed to evaluate for changes in the case volume over the study period. A statistical significance threshold of $P < 0.05$ was used. Statistical analyses were performed using the open programming language known as R version, 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Patient Demographics

A total of 31,013 patients underwent elective cervical spine surgery in 2019 ($N = 16,316$) and 2020 ($N = 14,697$). The majority of patients were White, male, and younger than 60 years old. Patient demographics between the 2019–2020 Q1 and 2020 Q2–Q4 cohorts were similar with respect to several comorbidities: age, chronic obstructive pulmonary disease, hypertension, steroid use, and smoking status (Table 1). Overall comorbidity burden was greater in 2020 Q2–Q4 as the relative proportion of American Society of Anesthesiologists grades III and IV were greater. Perioperative variables including inpatient/outpatient status and principal anesthetic technique used were also comparable between 2019–2020 Q1 and 2020 Q2–Q4 patient cohorts. A statistically significant difference was also found in length of stay between the time intervals (0 days: 12.31% vs. 15.85%, 1 day: 48.25% vs. 42.50%, 2+ days: 39.24% vs. 41.38%, $P < 0.001$) (Table 1).

Trends in Cervical Spine Surgery Procedures Quarterly

A total of 31,013 patients underwent elective cervical spine surgery in 2019 ($N = 16,316$) and 2020 ($N = 14,697$), resulting in an overall 10% decline (Figure 1A). The relative decline in mean case volume from 2019 Q3–2020 Q1 versus 2020 Q2–Q4 was 16.3%. Compared with the calendar year 2019 through 2020 Q1 mean, elective surgery volume decreased by 21.6% in 2020 Q2 and never returned to prepandemic baseline ($P = 0.079$) (Figure 1A). The

percentage decline in case volume from 2019 to 2020 Q1 to 2020 Q2 was greatest for ACDF (23.3%, $P = 0.029$), followed by cervical decompression (23.4%, $P = 0.062$), posterior cervical fusion (15.0%, $P = 0.257$), and cervical disc arthroplasty and vertebral corpectomy (13.7%, $P = 0.370$) (Figure 1B). Specifically, case volumes dropped from 2019–2020 Q1 to 2020 Q2 for ACDF (2634 vs. 2019 cases), cervical decompression (675 vs. 517 cases), arthroplasty and vertebral corpectomy (402 vs. 347 cases), and posterior cervical fusion (408 vs. 347) (Figure 1B).

Postoperative Complications

Comparing 2019–2020 Q1 versus 2020 Q2–Q4, there was a significant increase in total complications (5.46% vs. 6.80%, $P < 0.001$), major complications (4.12% vs. 5.33%, $P < 0.001$), minor complications (2.04% vs. 2.40%, $P = 0.039$), infection complications (0.98% vs. 1.43%, $P < 0.001$), pulmonary complications (1.27% vs. 1.58%, $P = 0.024$), hematologic complications (1.26% vs. 1.80%, $P < 0.001$), reoperations (1.85% vs. 2.18%, $P = 0.048$), and mortality rates (0.25% vs. 0.37%, $P = 0.049$).

DISCUSSION

The effects of the COVID-19 pandemic on elective spine surgery case volumes in the United States are still being investigated.²⁵ An adequate nationwide representation of spine surgery decline in the calendar year 2020 after the second quarter has yet to be reported. In the present study, we report the first temporal trends analysis of elective cervical spine surgery in the year before and during the COVID-19 pandemic. In this study, we found an overall 10% decline in annual elective cases from 2019 to 2020. The volume of cases in 2019 Q1 through 2020 Q1 remained relatively constant, with a significant 21.6% decline in 2020 Q2. These results confirmed our hypothesis that in quarter 2 of 2020, the effects of the pandemic related restrictions on elective spine surgery would be apparent. Unknown to the spine community was whether case volumes would recover over the remaining quarters of the calendar year or remain lower than the year prior. In addition, our study showed that despite these lower case volumes, the patients who did have surgery displayed a greater comorbidity burden. This may explain the increased complication rates seen in 2020 versus the year prior.

Degenerative spine conditions represent an enormous societal burden. Likewise, spine surgery continues to remain responsible for a significant amount of revenue for the health care system but was also viewed as a nonessential procedure during the onset of the COVID-19 pandemic for any degenerative conditions.^{4,6,18} The 21.6% decline in case volumes after pandemic-related protocols were implemented mirror survey responses by spine surgeons nationally and worldwide related to their clinical practices during this time. The proportion of spine surgeons who reported a dramatic reduction of performing surgery and as a result, transitioned to a more telemedicine-based practice increased.^{26,27} The consequences of the pandemic-related restrictions included a projected backlog of cases estimated to take between 7 and 16 months to recover.⁷ In the present study, stratification of each procedure demonstrated different rates of resiliency and return

to prepandemic baselines in quarters 3 and 4 of 2020. These trends unfortunately may require further long-term analysis to fully understand and may predominately represent surgeon preferences or practice patterns.

Perhaps the most clinically important finding of our study was the increased comorbidity burden of patient's undergoing cervical spine surgery in addition to the increased complication rates. These results could be multifactorial and warrant further study to understand their etiologies. Specifically, increased 30-day pulmonary complications, infectious complications, and mortality may be a consequence of unknown factors that cannot be answered in the present study. Despite decreased case volumes for these cervical spine surgeries, those patients who did have surgery from 2020 Q2–Q4 appeared to have a greater comorbidity burden. Thus, the complication rates may be a result of these patients' overall health, placing them at greater risk. Furthermore, likely only patients with more severe symptoms were permitted to undergo surgery and may reflect the differences in complication rates seen in the present study.

There are a few limitations to the study that warrant discussion with any national database evaluation of retrospectively collected data. The database used for this study is one of the largest nationwide representative samples; however, it does not capture every hospital or spine surgery in the United States. Therefore, the case volume trends reported in this study should be taken in the appropriate context, given that private or privademic spine surgeons reported to perform elective spine surgery during COVID-19 at a lower rate compared with academic or public hospital employed surgeons.¹³ Our inclusion criteria were narrowed to include only elective cervical spine cases, as this would ensure a homogeneous sample when comparing 2019–2020 Q1 versus 2020 Q2–Q4. We were unable to verify these elective cases and relied on the hospital documentation of the procedures as being elective. The present study trends may be a result of other confounding factors including changes in clinical spine practice instead of directly to the COVID-19 pandemic. Data accuracy is potentially a concern; however, the NSQIP undergoes auditing for interrater reliability to ensure the validity of the data.²⁸ All dependent variables of interest including complications, reoperations, and readmissions were limited to 30 days postoperatively, which do not capture patients who presented to the hospital after that time. Despite these limitations, this is the first nationwide sample using these data to compare temporal trends in elective cervical spine procedures before and during suspension of nonemergent surgery.

CONCLUSIONS

Elective cervical spine surgery declined drastically during the second quarter of 2020. Patients undergoing surgery during the pandemic (2020 Q2–Q4) had an overall greater comorbidity burden, resulting in increased total complication and mortality rates over the study period. Spine surgeons nationally and internationally can use this information to better counsel spine surgery patients on the possible outcomes following their surgical procedure.

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SUPPLEMENTARY DATA

Supplementary Table 1. Cervical Spine Procedure CPT Codes

Spine Surgery	CPT Code
Anterior Cervical Discectomy and Fusion	22551, 22552, 22554
Posterior Cervical Fusion	22590, 22595, 22600
Cervical Decompression without Fusion	63015, 63020, 63040, 63045, 63050, 63051, 63075
Cervical Disc Arthroplasty	22856, 22858
Vertebral Corpectomy	63081
CPT, Current Procedural Terminology.	

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