



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



# The resiliency of elective total shoulder arthroplasty case volumes in the United States during the COVID-19 pandemic: a nationwide temporal trends analysis

Adam M. Gordon, MD\*, Bhavya Sheth, MD, Charles Conway, MD, Matthew Magruder, MD, Ramin Sadeghpour, MD, Jack Choueka, MD

*Maimonides Medical Center, Department of Orthopaedic Surgery, Brooklyn, NY, USA*

**Background:** Total shoulder arthroplasty (TSA) is one of the fastest growing procedures in terms of volume performed in hospitals in the United States. In 2020, elective surgery was suspended nationwide as a result of the SARS-CoV-2 (COVID-19) pandemic, and the use trends in the wake of the pandemic have yet to be evaluated substantially. Nationwide case volume reduction for TSA is unknown; therefore, the aim of this study is to compare patient demographics, complications, and temporal trends in case volume of elective TSA in the calendar year 2019 (prepandemic) to 2020 in the United States.

**Methods:** Using a multicenter, nationwide representative sample from 2019 to 2020, a retrospective query was conducted for all patients undergoing elective TSA. Patients undergoing surgery pre-COVID (2019 and 2020 Q1) were compared to those during COVID (2020 Q2-Q4). Temporal trends in case volumes were compared between time frames. TSA use, patient demographics, complications, and length of stay were compared between years. Linear regression was used to evaluate for changes in the case volume over the study period. A statistical significance threshold of  $P < .05$  was used.

**Results:** In total, 9667 patients underwent elective TSA in 2019 ( $n = 5342$ ) and 2020 ( $n = 4325$ ). The proportion of patients who underwent outpatient TSA in 2020 was significantly greater than the year prior (20.6% vs. 13.9%;  $P < .001$ ). Overall, elective TSA case volume declined by 19.0% from 2019 to 2020. There was no significant difference in the volume of cases in 2019 Q1 ( $n = 1401$ ) through 2020 Q1 ( $n = 1296$ ) ( $P = .216$ ). However, elective TSA volumes declined by 54.6% in 2020 Q2. Elective TSA case volumes recovered to prepandemic baseline in 2020 Q3 and 2020 Q4. The average length of stay was comparable in 2020 vs. 2019 (1.29 vs. 1.32 days;  $P = .371$ ), with the proportion of same-day discharge increasing per quarter from 2019 to 2020 (from 11.8% to 26.8% of annual cases). There was no significant difference in the total complication rates in 2019 (4.6%) vs. 2020 (4.9%) ( $P = .441$ ).

**Conclusion:** Using a nationwide sample, elective TSA precipitously declined during the second quarter of 2020. Patient demographics of those undergoing elective TSA in 2020 were similar in comorbidity burden. A large proportion of surgeries were transitioned to the outpatient setting, with rates of same-day discharge doubling over the study period despite no change in overall complication rates.

**Level of Evidence:** Level IV; Descriptive Epidemiology Study

© 2022 Journal of Shoulder and Elbow Surgery Board of Trustees. All rights reserved.

**Keywords:** Total shoulder arthroplasty; COVID-19; elective surgery; same-day discharge; outpatient surgery; temporal trends

This study was determined to be exempt from the Institutional Review Board of Maimonides Medical Center.

\*Reprint requests: Adam M. Gordon, MD, Maimonides Medical Center, Department of Orthopaedic Surgery, 927 49th St, Brooklyn, NY 11219, USA.

E-mail address: [agordon55@gmail.com](mailto:agordon55@gmail.com) (A.M. Gordon).

Total joint arthroplasties are some of the highest-volume procedures performed in hospitals on an elective basis in the United States.<sup>21,22</sup> As a result, total joint arthroplasty is responsible for a significant amount of revenue for the health care system, but is also viewed as a nonessential procedure. Annual total shoulder arthroplasty (TSA) procedures have increased exponentially because of growing demand and indications, eclipsing the growth rates of total knee arthroplasty and total hip arthroplasty.<sup>20,22</sup> Unexpectedly, in the calendar year 2020 the orthopedic surgery specialty was impacted by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). On January 30, 2020, the SARS-CoV-2 (COVID-19) pandemic was first reported in the United States.<sup>6</sup> On March 10, 2020, the World Health Organization (WHO) declared COVID-19 a worldwide pandemic.<sup>9</sup> Subsequently, the United States Surgeon General and the Centers for Medicare & Medicaid Services (CMS) advised for the suspension of all elective surgery in the United States.<sup>7</sup> Finally in April 2020, the American Academy of Orthopaedic Surgeons (AAOS) released guidelines stratifying orthopedic conditions based on urgency to undergo surgery, of which total shoulder arthroplasty was not deemed urgent.<sup>11,14</sup> To prevent the spread of disease and allocate health care workers and resources appropriately, elective surgery including total joint arthroplasty was suspended nationwide.<sup>7</sup>

The ramifications of canceling elective joint arthroplasty have been felt by both patients and orthopedic upper extremity joint replacement surgeons in the United States.<sup>15,17</sup> The projected backlog of elective orthopedic cases was estimated to take between 7 and 16 months to recover.<sup>12</sup> Current total shoulder arthroplasty studies evaluating the decline in case volume due to COVID-19 are sparse. The few studies on this topic are either single-institutional evaluations, review articles, simple projections based on historical data, or from countries outside the United States.<sup>2,15,16</sup> However, a continuous tracking of nationwide case volumes throughout the calendar year 2020 in the United States are nonexistent in the literature.

In light of the worldwide suspension of elective total joint arthroplasty and the lack of nationwide reporting using an adequate representative sample, the primary purpose of the current study is to compare temporal trends in case volume of elective TSA from 2019 (prepandemic) to 2020 in the United States using a nationwide database. Secondly, we sought to compare patient demographics and postoperative outcomes of those undergoing surgery before and after the pandemic origin. We hypothesized that not only would case volumes precipitously decline in 2020, but patient demographics and postoperative outcomes would differ.

## Materials and methods

### Database and patient selection

This study is a retrospective analysis of prospectively collected data from the 2019 to 2020 American College of Surgeons

National Surgery Quality Improvement Program (ACS-NSQIP) database. The NSQIP database includes detailed patient demographics in addition to preoperative and 30-day postoperative outcomes on patients undergoing major surgery. As of 2020, the database contains more than 900,000 cases from 706 participating institutions in the United States. The database is a source of reliable data, recording in-hospital morbidity and mortality as well as 30-day complications. Many clinical research studies have used the NSQIP database to report 30-day complications following total joint arthroplasty procedures. Further details regarding data collection can be found on the ACS-NSQIP website.

The database was queried for all patients undergoing elective TSA (*Current Procedural Terminology* code 23472) in 2019 and 2020. Nonelective and revision TSA cases were excluded. Cases involving polytrauma, malignancy, or infections were excluded by using *International Classification of Diseases, Ninth or Tenth Revision*, codes. Patients whose demographic data was missing were additionally excluded from the study. As the data were derived from a deidentified national surgical database, the study was therefore exempt from our institution's institutional review board approval.

### Variables and outcomes studied

For the purpose of this study, we compared calendar years to understand the decline in national case volume from 2019 to 2020. Secondly, we directly compared admission quarters to understand the influence of the COVID-19 pandemic restrictions on TSA use over time. As admission quarter 1 (Q1) ends March 31, a comparison in the year prior to (2019) and during (2020) the COVID-19 pandemic was performed.

Patient demographics included as part of the study were age, gender, race, body mass index, and comorbidities (diabetes mellitus, smoking history, chronic obstructive pulmonary disease, congestive heart failure, hypertension, dialysis-dependent, disseminated cancer, chronic steroid use, bleeding disorder, ascites, dyspnea, and functional health status). The 5-item modified Frailty Index (mFI-5) was calculated for each patient by assigning 1 point for each comorbidity present: diabetes mellitus, hypertension, congestive heart failure, chronic obstructive pulmonary disease, and functionally dependent health status. Operative and postoperative data included American Society of Anesthesiologists (ASA) class, anesthesia administered, total operative time (minutes), and length of stay (days).

### Postoperative complications

Short-term postoperative complications (medical and surgical) were recorded and grouped into major and minor complications. 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), renal (progressive renal

**Table I** Comparison of patient demographics for elective total shoulder arthroplasty in 2019 vs. 2020

| Variable                            | 2019 (5342)        |        | 2020 (n = 4325)    |        | P value |
|-------------------------------------|--------------------|--------|--------------------|--------|---------|
|                                     | Number of patients | %      | Number of patients | %      |         |
| Age cohorts, yr                     |                    |        |                    |        |         |
| <40                                 | 29                 | 0.50   | 12                 | 0.30   | .184    |
| 40-44                               | 22                 | 0.40   | 29                 | 0.70   |         |
| 45-49                               | 69                 | 1.30   | 53                 | 1.20   |         |
| 50-54                               | 166                | 3.10   | 132                | 3.10   |         |
| 55-59                               | 382                | 7.20   | 323                | 7.50   |         |
| 60-64                               | 757                | 14.20  | 550                | 12.70  |         |
| 65-69                               | 1070               | 20.00  | 905                | 20.90  |         |
| 70-74                               | 1233               | 23.10  | 1041               | 24.10  |         |
| 75-79                               | 918                | 17.20  | 732                | 16.90  |         |
| 80-84                               | 481                | 9.00   | 387                | 8.90   |         |
| ≥85                                 | 215                | 4.00   | 161                | 3.70   |         |
| Sex                                 |                    |        |                    |        |         |
| Female                              | 2919               | 54.60  | 2409               | 55.70  | .299    |
| Male                                | 2423               | 45.40  | 1916               | 44.30  |         |
| Race                                |                    |        |                    |        |         |
| American Indian or Alaska Native    | 34                 | 0.60   | 26                 | 0.60   | .108    |
| Asian                               | 47                 | 0.90   | 40                 | 0.90   |         |
| Black or African American           | 230                | 4.30   | 201                | 4.60   |         |
| Native Hawaiian or Pacific Islander | 12                 | 0.20   | 8                  | 0.20   |         |
| Some other race                     | 0                  | 0.00   | 7                  | 0.20   |         |
| Unknown or not reported             | 670                | 12.50  | 566                | 13.10  |         |
| White                               | 4349               | 81.40  | 3477               | 80.40  |         |
| BMI category                        |                    |        |                    |        |         |
| <18.5                               | 34                 | 0.60   | 34                 | 0.80   | .728    |
| 18.5-24.9                           | 829                | 15.60  | 686                | 16.00  |         |
| 25.0-29.9                           | 1654               | 31.10  | 1376               | 32.00  |         |
| 30.0-34.9                           | 1476               | 27.70  | 1151               | 26.80  |         |
| 35.0-39.9                           | 764                | 14.40  | 608                | 14.20  |         |
| ≥40.0                               | 565                | 10.60  | 441                | 10.30  |         |
| Diabetes mellitus                   |                    |        |                    |        |         |
| Insulin dependent                   | 238                | 4.50   | 227                | 5.20   | .120    |
| No                                  | 4408               | 82.50  | 3510               | 81.20  |         |
| Non-insulin dependent               | 696                | 13.00  | 588                | 13.60  |         |
| Current smoker                      |                    |        |                    |        |         |
| No                                  | 4826               | 90.30  | 3943               | 91.20  | .164    |
| Yes                                 | 516                | 9.70   | 382                | 8.80   |         |
| Dyspnea                             |                    |        |                    |        |         |
| At rest                             | 14                 | 0.30   | 7                  | 0.20   | .426    |
| Moderate exertion                   | 343                | 6.40   | 295                | 6.80   |         |
| No                                  | 4985               | 93.30  | 4023               | 93.00  |         |
| Functional health status            |                    |        |                    |        |         |
| Independent                         | 5154               | 96.50  | 4205               | 97.20  | <.001   |
| Partially dependent                 | 80                 | 1.50   | 88                 | 2.00   |         |
| Totally dependent                   | 2                  | 0.00   | 6                  | 0.10   |         |
| Unknown                             | 106                | 2.00   | 26                 | 0.60   |         |
| Ventilator dependent, no            | 5342               | 100.00 | 4325               | 100.00 | —       |
| History of severe COPD              |                    |        |                    |        |         |
| No                                  | 4991               | 93.40  | 4056               | 93.80  | .484    |
| Yes                                 | 351                | 6.60   | 269                | 6.20   |         |
| Ascites                             |                    |        |                    |        |         |
| No                                  | 5341               | 100.00 | 4324               | 100.00 | .881    |
| Yes                                 | 1                  | 0.00   | 1                  | 0.00   |         |
| Congestive heart failure            |                    |        |                    |        |         |
| No                                  | 5300               | 99.20  | 4299               | 99.40  | .279    |

(continued on next page)

**Table I** Comparison of patient demographics for elective total shoulder arthroplasty in 2019 vs. 2020 (continued)

| Variable                              | 2019 (5342)        |       | 2020 (n = 4325)    |       | P value |
|---------------------------------------|--------------------|-------|--------------------|-------|---------|
|                                       | Number of patients | %     | Number of patients | %     |         |
| Yes                                   | 42                 | 0.80  | 26                 | 0.60  |         |
| Hypertension                          |                    |       |                    |       |         |
| No                                    | 1805               | 33.80 | 1513               | 35.00 | .219    |
| Yes                                   | 3537               | 66.20 | 2812               | 65.00 |         |
| Currently on dialysis (preoperation)  |                    |       |                    |       |         |
| No                                    | 5332               | 99.80 | 4314               | 99.70 | .481    |
| Yes                                   | 10                 | 0.20  | 11                 | 0.30  |         |
| Disseminated cancer                   |                    |       |                    |       |         |
| No                                    | 5331               | 99.80 | 4317               | 99.80 | .817    |
| Yes                                   | 11                 | 0.20  | 8                  | 0.20  |         |
| Steroid use for chronic condition     |                    |       |                    |       |         |
| No                                    | 5081               | 95.10 | 4121               | 95.30 | .699    |
| Yes                                   | 261                | 4.90  | 204                | 4.70  |         |
| >10% loss in body weight in last 6 mo |                    |       |                    |       |         |
| No                                    | 5334               | 99.90 | 4313               | 99.70 | .169    |
| Yes                                   | 8                  | 0.10  | 12                 | 0.30  |         |
| Bleeding disorders                    |                    |       |                    |       |         |
| No                                    | 5235               | 98.00 | 4196               | 97.00 | .002    |
| Yes                                   | 107                | 2.00  | 129                | 3.00  |         |
| mFI                                   |                    |       |                    |       |         |
| 0                                     | 1593               | 29.80 | 1330               | 30.80 | .301    |
| 1                                     | 2666               | 49.90 | 2076               | 48.00 |         |
| 2                                     | 974                | 18.20 | 825                | 19.10 |         |
| 3                                     | 104                | 1.90  | 86                 | 2.00  |         |
| 4                                     | 5                  | 0.10  | 8                  | 0.20  |         |
| Inpatient/outpatient                  |                    |       |                    |       |         |
| Inpatient                             | 4601               | 86.10 | 3432               | 79.40 | <.001   |
| Outpatient                            | 741                | 13.90 | 893                | 20.60 |         |
| ASA classification                    |                    |       |                    |       |         |
| 1: no disturbance                     | 70                 | 1.30  | 57                 | 1.30  | .921    |
| 2: mild disturbance                   | 2157               | 40.40 | 1729               | 40.00 |         |
| 3: severe disturbance                 | 2951               | 55.20 | 2392               | 55.30 |         |
| 4: life threatening                   | 160                | 3.00  | 143                | 3.30  |         |
| Principal anesthesia technique        |                    |       |                    |       |         |
| General                               | 5194               | 97.20 | 4187               | 96.80 | .196    |
| MAC and IV sedation                   | 50                 | 0.90  | 40                 | 0.90  |         |
| Regional                              | 74                 | 1.40  | 73                 | 1.70  |         |
| Other                                 | 24                 | 0.45  | 25                 | 0.58  |         |
| Preoperative serum sodium             | 139.59             |       | 139.12             |       | <.001   |
| Preoperative BUN                      | 18.77              |       | 19.13              |       | .052    |
| Preoperative serum creatinine         | 0.94               |       | 0.96               |       | .087    |
| Preoperative serum albumin            | 4.11               |       | 4.13               |       | .108    |
| Preoperative total bilirubin          | 0.56               |       | 0.56               |       | .891    |
| Preoperative SGOT                     | 24.26              |       | 24.46              |       | .645    |
| Preoperative alkaline phosphatase     | 83.25              |       | 83.80              |       | .61     |
| Preoperative WBC count                | 7.14               |       | 7.24               |       | .058    |
| Preoperative hematocrit               | 41.16              |       | 40.89              |       | .007    |
| Preoperative platelet count           | 251.24             |       | 250.76             |       | .77     |
| Preoperative PTT                      | 29.33              |       | 29.61              |       | .179    |
| Preoperative INR of PT values         | 1.04               |       | 1.04               |       | .397    |
| Total operation time, min             | 105.60             |       | 107.52             |       | .032    |
| Length of hospital stay, d            | 1.32               |       | 1.29               |       | .371    |

(continued on next page)

**Table I** Comparison of patient demographics for elective total shoulder arthroplasty in 2019 vs. 2020 (continued)

| Variable                   | 2019 (5342)        |       | 2020 (n = 4325)    |       | P value |
|----------------------------|--------------------|-------|--------------------|-------|---------|
|                            | Number of patients | %     | Number of patients | %     |         |
| Length of hospital stay, d |                    |       |                    |       |         |
| 0                          | 657                | 12.30 | 850                | 19.70 | <.001   |
| 1                          | 3398               | 63.60 | 2584               | 59.80 |         |
| ≥2                         | 1284               | 24.00 | 889                | 20.60 |         |

*BMI*, body mass index; *COPD*, chronic obstructive pulmonary disorder; *mFI*, Modified Frailty Index; *ASA*, American Society of Anesthesiologists; *MAC*, monitored anesthesia care; *IV*, intravenous; *BUN*, blood urea nitrogen; *SGOT*, serum glutamic oxaloacetic transaminase; *WBC*, white blood count; *PTT*, partial thromboplastin time; *INR*, International Normalized Ratio; *PT*, prothrombin time.

insufficiency, acute kidney failure), and adverse hospital discharge (discharge to other than home). Clavien Dindo IV complications (life-threatening complications including cardiac arrest, myocardial infarction, septic shock, pulmonary embolism, and renal failure) were collected and analyzed separately.<sup>10</sup> Rates of 30-day complications, reoperations, and readmissions were evaluated annually.

## Statistical analyses

Bivariate analysis using Pearson  $\chi^2$  tests, Student *t* test, and analysis of variance were used to assess for significant differences in patient demographics between years and admission quarters. Linear regression was used to evaluate for changes in the case volume over the study period. A statistical significance threshold of  $P < .05$  was used. Statistical analysis was performed using R, version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria).

## Results

### Patient demographics

A total of 9667 patients underwent elective TSA in 2019 ( $n = 5342$ ) and 2020 ( $n = 4325$ ) (Table I). The majority of patients were white, female, and 60 years of age or older, with an ASA class 3 comorbidity burden. Patient demographics of the 2019 vs. 2020 cohorts were similar with respect to age, gender, race, body mass index, ASA class, frailty, and the presence of the following comorbidities (diabetes, tobacco use, chronic obstructive pulmonary disease, congestive heart failure, hypertension) Table I. A significant increase was noted in the number of patients underwent outpatient TSA in 2020 vs. 2019 (20.6% vs. 13.9%,  $P < .001$ ). Further breakdown comparing 2019 and 2020 Q1 vs. 2020 Q2-Q4 demonstrated that patients undergoing elective surgery during the COVID pandemic stayed in the hospital shorter (1.25 vs. 1.34 days,  $P < .001$ ). A comparison of patient demographics for each quarter of the calendar years 2019 and 2020 demonstrated similarity with respect to multiple comorbidities Table II.

### Trends in TSA use quarterly

Overall, there was a 19.0% decline in elective TSA from 2019 to 2020. There was no significant quarterly difference in the volume of cases in 2019 Q1 through 2020 Q1 ( $P = .216$ ) (Fig. 1). However, elective TSA volumes declined by 54.6% in 2020 Q2 (Fig. 1). Elective TSA case volumes recovered to prepandemic baseline in 2020 Q3 and 2020 Q4 (Fig. 1).

### Postoperative outcomes and complications

The average length of stay was comparable in 2020 vs. 2019 (1.29 vs. 1.32 days,  $P = .371$ ). The proportion of same-day discharge increased per quarter from 2019 to 2020 (Fig. 2). The overall 30-day complication rate was 4.7% (456/9667). There was no significant difference in the total complication rates in 2019 (4.6%) vs. 2020 (4.9%) ( $P = .441$ ). When comparing 2019 to 2020, rates of major complications (3.2% vs. 3.7%,  $P = .243$ ), infection complications (0.61% vs. 0.92%,  $P = .136$ ), wound complications (0.04% vs. 0.11%,  $P = .155$ ), cardiac complications (0.21% vs. 0.26%,  $P = .257$ ), hematology complications (1.2% vs. 1.5%,  $P = .188$ ), renal complications (0.11% vs. 0.09%,  $P = .763$ ), and Clavien Dindo IV complications (0.43% vs. 0.72%,  $P = .060$ ) were similar. Pulmonary complications significantly increased from 2019 to 2020 (0.49% vs. 0.97%,  $P = .005$ ). The overall 30-day mortality was no different in 2019 (0.15%) vs. 2020 (0.12%),  $P = .649$ . Thirty-day reoperation (1.5% vs. 1.3%,  $P = .347$ ) and readmission rates (2.9% vs. 3.0%,  $P = .824$ ) were no different between calendar years.

## Discussion

Total joint arthroplasties are some of the highest-volume procedures performed in hospitals on an elective basis in the United States. The effects of the COVID-19 pandemic on elective total shoulder arthroplasty case volumes in the United States are unknown. To date, an adequate

**Table II** Comparison of patient demographics for elective total shoulder arthroplasty by quarter of admission in 2019-2020

| Variable                            | 2019             |                  |                  |                  | 2020             |                 |                  |                  | P value |
|-------------------------------------|------------------|------------------|------------------|------------------|------------------|-----------------|------------------|------------------|---------|
|                                     | Q1<br>(n = 1401) | Q2<br>(n = 1461) | Q3<br>(n = 1231) | Q4<br>(n = 1249) | Q1<br>(n = 1296) | Q2<br>(n = 603) | Q3<br>(n = 1249) | Q4<br>(n = 1177) |         |
| Age cohorts, yr                     |                  |                  |                  |                  |                  |                 |                  |                  |         |
| <40                                 | 13 (0.9)         | 6 (0.4)          | 6 (0.5)          | 4 (0.3)          | 3 (0.2)          | 2 (0.3)         | 3 (0.2)          | 4 (0.3)          | .053    |
| 40-44                               | 11 (0.8)         | 3 (0.2)          | 4 (0.3)          | 4 (0.3)          | 7 (0.5)          | 4 (0.7)         | 10 (0.8)         | 8 (0.7)          |         |
| 45-49                               | 17 (1.2)         | 19 (1.3)         | 15 (1.2)         | 18 (1.4)         | 16 (1.2)         | 6 (1.0)         | 15 (1.2)         | 16 (1.4)         |         |
| 50-54                               | 43 (3.1)         | 38 (2.6)         | 32 (2.6)         | 53 (4.2)         | 37 (2.9)         | 19 (3.2)        | 34 (2.7)         | 42 (3.6)         |         |
| 55-59                               | 100 (7.1)        | 89 (6.1)         | 96 (7.8)         | 97 (7.8)         | 94 (7.3)         | 47 (7.8)        | 87 (7.0)         | 95 (8.1)         |         |
| 60-64                               | 199 (14.2)       | 206 (14.1)       | 175 (14.2)       | 177 (14.2)       | 165 (12.7)       | 97 (16.1)       | 119 (9.5)        | 169 (14.4)       |         |
| 65-69                               | 292 (20.8)       | 286 (19.6)       | 246 (20.0)       | 246 (19.7)       | 268 (20.7)       | 123 (20.4)      | 258 (20.7)       | 256 (21.8)       |         |
| 70-74                               | 303 (21.6)       | 376 (25.7)       | 273 (22.2)       | 281 (22.5)       | 308 (23.8)       | 131 (21.7)      | 310 (24.8)       | 292 (24.8)       |         |
| 75-79                               | 229 (16.3)       | 253 (17.3)       | 218 (17.7)       | 218 (17.5)       | 225 (17.4)       | 98 (16.3)       | 237 (19.0)       | 172 (14.6)       |         |
| 80-84                               | 144 (10.3)       | 122 (8.4)        | 112 (9.1)        | 103 (8.2)        | 122 (9.4)        | 54 (9.0)        | 119 (9.5)        | 92 (7.8)         |         |
| ≥85                                 | 50 (3.6)         | 63 (4.3)         | 54 (4.4)         | 48 (3.8)         | 51 (3.9)         | 22 (3.6)        | 57 (4.6)         | 31 (2.6)         |         |
| Sex                                 |                  |                  |                  |                  |                  |                 |                  |                  |         |
| Female                              | 745 (53.2)       | 829 (56.7)       | 721 (58.6)       | 624 (50.0)       | 706 (54.5)       | 373 (61.9)      | 737 (59.0)       | 593 (50.4)       | <.001   |
| Male                                | 656 (46.8)       | 632 (43.3)       | 510 (41.4)       | 625 (50.0)       | 590 (45.5)       | 230 (38.1)      | 512 (41.0)       | 584 (49.6)       |         |
| Race                                |                  |                  |                  |                  |                  |                 |                  |                  |         |
| American Indian or Alaska Native    | 4 (0.3)          | 11 (0.8)         | 12 (1.0)         | 7 (0.6)          | 15 (1.2)         | 1 (0.2)         | 5 (0.4)          | 5 (0.4)          | <.001   |
| Asian                               | 10 (0.7)         | 14 (1.0)         | 15 (1.2)         | 8 (0.6)          | 10 (0.8)         | 9 (1.5)         | 12 (1.0)         | 9 (0.8)          |         |
| Black or African American           | 52 (3.7)         | 62 (4.2)         | 63 (5.1)         | 53 (4.2)         | 50 (3.9)         | 39 (6.5)        | 62 (5.0)         | 50 (4.2)         |         |
| Native Hawaiian or Pacific Islander | 2 (0.1)          | 2 (0.1)          | 4 (0.3)          | 4 (0.3)          | 3 (0.2)          | 3 (0.5)         | 2 (0.2)          | 0 (0.0)          |         |
| Some other race                     | 0 (0.0)          | 0 (0.0)          | 0 (0.0)          | 0 (0.0)          | 0 (0.0)          | 0 (0.0)         | 0 (0.0)          | 7 (0.6)          |         |
| Unknown or not reported             | 174 (12.4)       | 175 (12.0)       | 157 (12.8)       | 164 (13.1)       | 169 (13.0)       | 52 (8.6)        | 169 (13.5)       | 176 (15.0)       |         |
| White                               | 1159 (82.7)      | 1197 (81.9)      | 980 (79.6)       | 1013 (81.1)      | 1049 (80.9)      | 499 (82.8)      | 999 (80.0)       | 930 (79.0)       |         |
| BMI category                        |                  |                  |                  |                  |                  |                 |                  |                  |         |
| <18.5                               | 6 (0.4)          | 11 (0.8)         | 9 (0.7)          | 8 (0.6)          | 13 (1.0)         | 6 (1.0)         | 10 (0.8)         | 5 (0.4)          | .802    |
| 18.5-24.9                           | 230 (16.4)       | 223 (15.3)       | 185 (15.0)       | 191 (15.3)       | 200 (15.4)       | 105 (17.4)      | 195 (15.6)       | 186 (15.8)       |         |
| 25.0-29.9                           | 423 (30.2)       | 450 (30.8)       | 384 (31.2)       | 397 (31.8)       | 442 (34.1)       | 192 (31.8)      | 378 (30.3)       | 364 (30.9)       |         |
| 30.0-34.9                           | 376 (26.8)       | 404 (27.7)       | 344 (27.9)       | 352 (28.2)       | 325 (25.1)       | 145 (24.0)      | 349 (27.9)       | 332 (28.2)       |         |
| 35.0-39.9                           | 215 (15.3)       | 207 (14.2)       | 179 (14.5)       | 163 (13.1)       | 164 (12.7)       | 87 (14.4)       | 190 (15.2)       | 167 (14.2)       |         |
| ≥40.0                               | 145 (10.3)       | 161 (11.0)       | 123 (10.0)       | 136 (10.9)       | 148 (11.4)       | 60 (10.0)       | 120 (9.6)        | 113 (9.6)        |         |
| Diabetes mellitus                   |                  |                  |                  |                  |                  |                 |                  |                  |         |
| Insulin dependent                   | 58 (4.1)         | 61 (4.2)         | 56 (4.5)         | 63 (5.0)         | 67 (5.2)         | 32 (5.3)        | 66 (5.3)         | 62 (5.3)         | .837    |
| No                                  | 1161 (82.9)      | 1207 (82.6)      | 1014 (82.4)      | 1026 (82.1)      | 1066 (82.3)      | 485 (80.4)      | 999 (80.0)       | 960 (81.6)       |         |
| Non-insulin dependent               | 182 (13.0)       | 193 (13.2)       | 161 (13.1)       | 160 (12.8)       | 163 (12.6)       | 86 (14.3)       | 184 (14.7)       | 155 (13.2)       |         |
| Current smoker                      |                  |                  |                  |                  |                  |                 |                  |                  |         |
| No                                  | 1265 (90.3)      | 1315 (90.0)      | 1123 (91.2)      | 1123 (89.9)      | 1178 (90.9)      | 543 (90.0)      | 1150 (92.1)      | 1072 (91.1)      | .564    |
| Yes                                 | 136 (9.7)        | 146 (10.0)       | 108 (8.8)        | 126 (10.1)       | 118 (9.1)        | 60 (10.0)       | 99 (7.9)         | 105 (8.9)        |         |
| Dyspnea                             |                  |                  |                  |                  |                  |                 |                  |                  |         |
| At rest                             | 3 (0.2)          | 3 (0.2)          | 2 (0.2)          | 6 (0.5)          | 0 (0.0)          | 0 (0.0)         | 6 (0.5)          | 1 (0.1)          | .249    |

|                                      |              |              |              |              |              |             |              |              |       |
|--------------------------------------|--------------|--------------|--------------|--------------|--------------|-------------|--------------|--------------|-------|
| Moderate exertion                    | 95 (6.8)     | 98 (6.7)     | 76 (6.2)     | 74 (5.9)     | 88 (6.8)     | 36 (6.0)    | 81 (6.5)     | 90 (7.6)     |       |
| No                                   | 1303 (93.0)  | 1360 (93.1)  | 1153 (93.7)  | 1169 (93.6)  | 1208 (93.2)  | 567 (94.0)  | 1162 (93.0)  | 1086 (92.3)  |       |
| Functional health status             |              |              |              |              |              |             |              |              |       |
| Independent                          | 1355 (96.7)  | 1415 (96.9)  | 1176 (95.5)  | 1208 (96.7)  | 1259 (97.1)  | 592 (98.2)  | 1213 (97.1)  | 1141 (96.9)  | <.001 |
| Partially dependent                  | 20 (1.4)     | 14 (1.0)     | 26 (2.1)     | 20 (1.6)     | 27 (2.1)     | 7 (1.2)     | 28 (2.2)     | 26 (2.2)     |       |
| Totally dependent                    | 0 (0.0)      | 2 (0.1)      | 0 (0.0)      | 0 (0.0)      | 4 (0.3)      | 1 (0.2)     | 1 (0.1)      | 0 (0.0)      |       |
| Unknown                              | 26 (1.9)     | 30 (2.1)     | 29 (2.4)     | 21 (1.7)     | 6 (0.5)      | 3 (0.5)     | 7 (0.6)      | 10 (0.8)     |       |
| Ventilator dependent: no             | 1401 (100.0) | 1461 (100.0) | 1231 (100.0) | 1249 (100.0) | 1296 (100.0) | 603 (100.0) | 1249 (100.0) | 1177 (100.0) | —     |
| History of severe COPD               |              |              |              |              |              |             |              |              |       |
| No                                   | 1308 (93.4)  | 1362 (93.2)  | 1158 (94.1)  | 1163 (93.1)  | 1216 (93.8)  | 567 (94.0)  | 1170 (93.7)  | 1103 (93.7)  | .972  |
| Yes                                  | 93 (6.6)     | 99 (6.8)     | 73 (5.9)     | 86 (6.9)     | 80 (6.2)     | 36 (6.0)    | 79 (6.3)     | 74 (6.3)     |       |
| Ascites                              |              |              |              |              |              |             |              |              |       |
| No                                   | 1401 (100.0) | 1460 (99.9)  | 1231 (100.0) | 1249 (100.0) | 1295 (99.9)  | 603 (100.0) | 1249 (100.0) | 1177 (100.0) | .655  |
| Yes                                  | 0 (0.0)      | 1 (0.1)      | 0 (0.0)      | 0 (0.0)      | 1 (0.1)      | 0 (0.0)     | 0 (0.0)      | 0 (0.0)      |       |
| Congestive heart failure             |              |              |              |              |              |             |              |              |       |
| No                                   | 1390 (99.2)  | 1454 (99.5)  | 1225 (99.5)  | 1231 (98.6)  | 1292 (99.7)  | 600 (99.5)  | 1238 (99.1)  | 1169 (99.3)  | .029  |
| Yes                                  | 11 (0.8)     | 7 (0.5)      | 6 (0.5)      | 18 (1.4)     | 4 (0.3)      | 3 (0.5)     | 11 (0.9)     | 8 (0.7)      |       |
| Hypertension                         |              |              |              |              |              |             |              |              |       |
| No                                   | 509 (36.3)   | 468 (32.0)   | 401 (32.6)   | 427 (34.2)   | 463 (35.7)   | 195 (32.3)  | 422 (33.8)   | 433 (36.8)   | .070  |
| Yes                                  | 892 (63.7)   | 993 (68.0)   | 830 (67.4)   | 822 (65.8)   | 833 (64.3)   | 408 (67.7)  | 827 (66.2)   | 744 (63.2)   |       |
| Currently on dialysis (preoperation) |              |              |              |              |              |             |              |              |       |
| No                                   | 1398 (99.8)  | 1457 (99.7)  | 1229 (99.8)  | 1248 (99.9)  | 1293 (99.8)  | 601 (99.7)  | 1246 (99.8)  | 1174 (99.7)  | .962  |
| Yes                                  | 3 (0.2)      | 4 (0.3)      | 2 (0.2)      | 1 (0.1)      | 3 (0.2)      | 2 (0.3)     | 3 (0.2)      | 3 (0.3)      |       |
| Disseminated cancer                  |              |              |              |              |              |             |              |              |       |
| No                                   | 1398 (99.8)  | 1457 (99.7)  | 1230 (99.9)  | 1246 (99.8)  | 1293 (99.8)  | 602 (99.8)  | 1247 (99.8)  | 1175 (99.8)  | .976  |
| Yes                                  | 3 (0.2)      | 4 (0.3)      | 1 (0.1)      | 3 (0.2)      | 3 (0.2)      | 1 (0.2)     | 2 (0.2)      | 2 (0.2)      |       |
| Steroid use for chronic condition    |              |              |              |              |              |             |              |              |       |
| No                                   | 1324 (94.5)  | 1397 (95.6)  | 1181 (95.9)  | 1179 (94.4)  | 1240 (95.7)  | 570 (94.5)  | 1187 (95.0)  | 1124 (95.5)  | .448  |
| Yes                                  | 77 (5.5)     | 64 (4.4)     | 50 (4.1)     | 70 (5.6)     | 56 (4.3)     | 33 (5.5)    | 62 (5.0)     | 53 (4.5)     |       |
| >10% loss body weight in last 6 mo   |              |              |              |              |              |             |              |              |       |
| No                                   | 1398 (99.8)  | 1459 (99.9)  | 1228 (99.8)  | 1249 (100.0) | 1291 (99.6)  | 602 (99.8)  | 1244 (99.6)  | 1176 (99.9)  | .316  |
| Yes                                  | 3 (0.2)      | 2 (0.1)      | 3 (0.2)      | 0 (0.0)      | 5 (0.4)      | 1 (0.2)     | 5 (0.4)      | 1 (0.1)      |       |
| Bleeding disorders                   |              |              |              |              |              |             |              |              |       |
| No                                   | 1374 (98.1)  | 1435 (98.2)  | 1204 (97.8)  | 1222 (97.8)  | 1245 (96.1)  | 585 (97.0)  | 1215 (97.3)  | 1151 (97.8)  | .010  |
| Yes                                  | 27 (1.9)     | 26 (1.8)     | 27 (2.2)     | 27 (2.2)     | 51 (3.9)     | 18 (3.0)    | 34 (2.7)     | 26 (2.2)     |       |
| mFI                                  |              |              |              |              |              |             |              |              |       |
| 0                                    | 454 (32.4)   | 414 (28.3)   | 359 (29.2)   | 366 (29.3)   | 410 (31.6)   | 167 (27.7)  | 368 (29.5)   | 385 (32.7)   | .422  |
| 1                                    | 673 (48.0)   | 754 (51.6)   | 613 (49.8)   | 626 (50.1)   | 624 (48.1)   | 313 (51.9)  | 597 (47.8)   | 542 (46.0)   |       |
| 2                                    | 242 (17.3)   | 264 (18.1)   | 238 (19.3)   | 230 (18.4)   | 233 (18.0)   | 110 (18.2)  | 256 (20.5)   | 226 (19.2)   |       |
| 3                                    | 29 (2.1)     | 29 (2.0)     | 21 (1.7)     | 25 (2.0)     | 28 (2.2)     | 12 (2.0)    | 25 (2.0)     | 21 (1.8)     |       |
| 4                                    | 3 (0.2)      | 0 (0.0)      | 0 (0.0)      | 2 (0.2)      | 1 (0.1)      | 1 (0.2)     | 3 (0.2)      | 3 (0.3)      |       |
| Inpatient or outpatient              |              |              |              |              |              |             |              |              |       |
| Inpatient                            | 1232 (87.9)  | 1261 (86.3)  | 1062 (86.3)  | 1046 (83.7)  | 1065 (82.2)  | 480 (79.6)  | 1017 (81.4)  | 870 (73.9)   | <.001 |
| Outpatient                           | 169 (12.1)   | 200 (13.7)   | 169 (13.7)   | 203 (16.3)   | 231 (17.8)   | 123 (20.4)  | 232 (18.6)   | 307 (26.1)   |       |

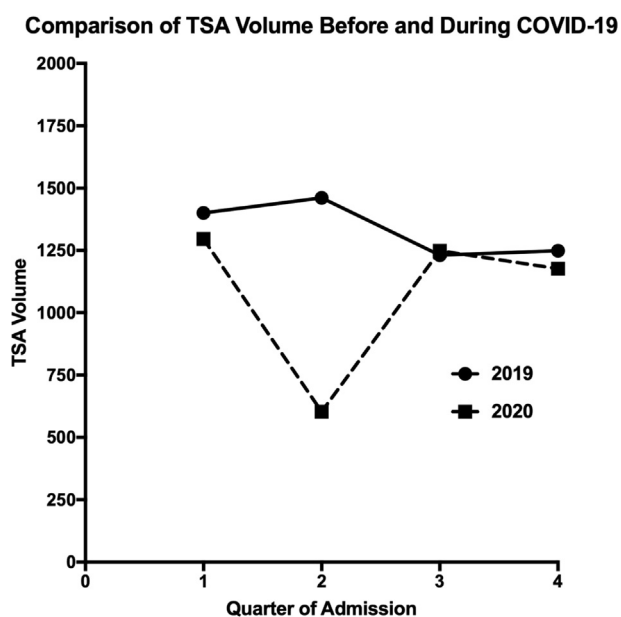
(continued on next page)



**Table II** Comparison of patient demographics for elective total shoulder arthroplasty by quarter of admission in 2019-2020 (continued)

| Variable                          | 2019             |                  |                  |                  | 2020             |                 |                  |                  | P value |
|-----------------------------------|------------------|------------------|------------------|------------------|------------------|-----------------|------------------|------------------|---------|
|                                   | Q1<br>(n = 1401) | Q2<br>(n = 1461) | Q3<br>(n = 1231) | Q4<br>(n = 1249) | Q1<br>(n = 1296) | Q2<br>(n = 603) | Q3<br>(n = 1249) | Q4<br>(n = 1177) |         |
| ASA classification                |                  |                  |                  |                  |                  |                 |                  |                  |         |
| 1: no disturbance                 | 26 (1.9)         | 19 (1.3)         | 10 (0.8)         | 15 (1.2)         | 19 (1.5)         | 8 (1.3)         | 10 (0.8)         | 20 (1.7)         | .692    |
| 2: mild disturbance               | 568 (40.5)       | 580 (39.7)       | 514 (41.8)       | 495 (39.6)       | 513 (39.6)       | 254 (42.1)      | 488 (39.1)       | 474 (40.3)       |         |
| 3: severe disturbance             | 764 (54.5)       | 822 (56.3)       | 674 (54.8)       | 691 (55.3)       | 714 (55.1)       | 326 (54.1)      | 708 (56.7)       | 644 (54.7)       |         |
| 4: life threatening               | 42 (3.0)         | 38 (2.6)         | 33 (2.7)         | 47 (3.8)         | 49 (3.8)         | 14 (2.3)        | 41 (3.3)         | 39 (3.3)         |         |
| Principal anesthesia technique    |                  |                  |                  |                  |                  |                 |                  |                  |         |
| General                           | 1360 (97.1)      | 1426 (97.6)      | 1201 (97.6)      | 1207 (96.6)      | 1263 (97.5)      | 588 (97.5)      | 1206 (96.6)      | 1130 (96.0)      | .084    |
| MAC and IV sedation               | 12 (0.9)         | 15 (1.0)         | 11 (0.9)         | 12 (1.0)         | 10 (0.8)         | 1 (0.2)         | 14 (1.1)         | 15 (1.3)         |         |
| Regional                          | 22 (1.6)         | 13 (0.9)         | 15 (1.2)         | 24 (1.9)         | 12 (0.9)         | 12 (2.0)        | 24 (1.9)         | 25 (2.1)         |         |
| Other                             | 7 (0.5)          | 7 (0.5)          | 4 (0.3)          | 6 (0.5)          | 11 (0.8)         | 2 (0.3)         | 5 (0.4)          | 7 (0.6)          |         |
| Preoperative serum sodium         | 139.57           | 139.60           | 139.52           | 139.65           | 139.31           | 138.79          | 139.18           | 139.02           | <.001   |
| Preoperative BUN                  | 18.43            | 18.86            | 18.81            | 18.98            | 19.01            | 18.71           | 19.56            | 19.00            | .129    |
| Preoperative serum creatinine     | 0.94             | 0.94             | 0.94             | 0.93             | 0.96             | 0.93            | 0.97             | 0.95             | .413    |
| Preoperative serum albumin        | 4.08             | 4.14             | 4.10             | 4.10             | 4.10             | 4.11            | 4.13             | 4.17             | .006    |
| Preoperative total bilirubin      | 0.58             | 0.56             | 0.58             | 0.54             | 0.59             | 0.55            | 0.56             | 0.55             | .353    |
| Preoperative SGOT                 | 24.47            | 23.87            | 24.29            | 24.44            | 25.04            | 24.00           | 24.15            | 24.36            | .926    |
| Preoperative alkaline phosphatase | 82.99            | 80.51            | 85.42            | 84.55            | 83.73            | 79.07           | 84.50            | 85.56            | .063    |
| Preoperative WBC count            | 7.18             | 7.17             | 7.05             | 7.15             | 7.28             | 7.22            | 7.21             | 7.24             | .490    |
| Preoperative hematocrit           | 41.34            | 41.11            | 40.86            | 41.31            | 41.05            | 40.13           | 40.74            | 41.26            | <.001   |
| Preoperative platelet count       | 254.96           | 251.56           | 248.35           | 249.57           | 252.83           | 254.06          | 248.55           | 249.16           | .280    |
| Preoperative PTT                  | 29.33            | 29.04            | 29.44            | 29.57            | 29.67            | 29.66           | 29.81            | 29.28            | .594    |
| Preoperative INR of PT values     | 1.03             | 1.05             | 1.03             | 1.03             | 1.07             | 1.03            | 1.04             | 1.03             | .097    |
| Total operation time, min         | 104.54           | 104.11           | 106.31           | 107.82           | 106.40           | 110.94          | 103.78           | 110.98           | <.001   |
| Length of hospital stay, d        | 1.41             | 1.29             | 1.32             | 1.26             | 1.41             | 1.31            | 1.35             | 1.09             | <.001   |
| Length of hospital stay, d        |                  |                  |                  |                  |                  |                 |                  |                  |         |
| 0                                 | 165 (11.8)       | 171 (11.7)       | 145 (11.8)       | 176 (14.1)       | 180 (13.9)       | 109 (18.1)      | 246 (19.7)       | 315 (26.8)       | <.001   |
| 1                                 | 872 (62.2)       | 952 (65.2)       | 768 (62.4)       | 806 (64.5)       | 827 (63.8)       | 353 (58.5)      | 742 (59.4)       | 662 (56.2)       |         |
| ≥2                                | 361 (25.8)       | 338 (23.1)       | 318 (25.8)       | 267 (21.4)       | 287 (22.1)       | 141 (23.4)      | 261 (20.9)       | 200 (17.0)       |         |

BMI, body mass index; COPD, chronic obstructive pulmonary disorder; mFI, Modified Frailty Index; ASA, American Society of Anesthesiologists; MAC, monitored anesthesia care; IV, intravenous; BUN, blood urea nitrogen; SGOT, serum glutamic oxaloacetic transaminase; WBC, white blood count; PTT, partial thromboplastin time; INR, International Normalized Ratio; PT, prothrombin time. Values are reported as n (%).



**Figure 1** Nationwide comparison of elective TSA volume by quarter. There was no significant difference in the volume of cases in 2019 Q1 through 2020 Q1 ( $P = .216$ ). However, elective TSA volumes declined by 54.6% in 2020 Q2. Elective TSA case volumes returned to prepandemic baseline in 2020Q3 and 2020Q4. TSA, total shoulder arthroplasty.

nationwide representation of TSA decline in the calendar year 2020 has yet to be reported as a result of the pandemic. Here we present the first temporal trends analysis of elective TSA in the year prior to and during the COVID-19 pandemic. In this study, overall there was a 19.0% decline in elective TSA from 2019 to 2020. The volume of cases in 2019 Q1 through 2020 Q1 remained constant, with a significant 54.6% decline in 2020 Q2. Ultimately, the TSA case volume after 2020 Q2 recovered to prepandemic baseline. These results confirmed our hypothesis that in Q2 of 2020, the effects of the pandemic-related restrictions on elective surgery would be apparent. Unknown to the orthopedic upper extremity arthroplasty community was whether case volumes would recover or remain lower than the year prior.

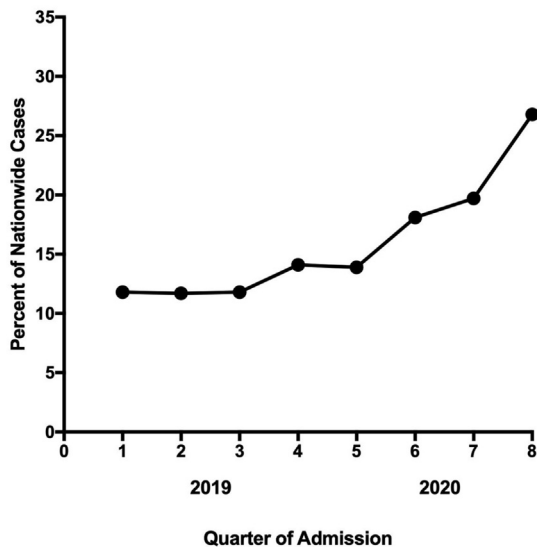
Elective TSA is responsible for a significant amount of revenue for the health care system but is also viewed as a nonessential procedure during the COVID-19 pandemic. The present study compared annual elective TSA, with overall case volumes declining by one-fifth of the total volume the year prior. From 2019 Q1 through 2020 Q1, there was no significant difference in the volume of elective TSA cases. However, compared with 2019, elective TSA volumes dramatically declined by 54.6% in 2020 Q2 before eventually returning to prepandemic baseline. Our results can be directly attributed to guidelines put forth by national organizations including the American Academy of

Orthopaedic Surgeons who stratified orthopedic conditions based on urgency to undergo surgery, of which total shoulder arthroplasty was not deemed urgent. Because of the allocation of health care workers and resources to more emergent cases, the precipitous decline was expected. Unknown to the orthopedic community was the resiliency to recover in Q3 and Q4 of 2020. The authors can only speculate that the increased use of TSAs in ambulatory surgery centers was responsible for this ability to return to baseline case volumes.<sup>5,13,18,19</sup> The shorter length of stay for outpatient shoulder surgery in comparison to lower extremity arthroplasty could be responsible for surgeons and patients feeling comfortable continuing with surgery during this time. In addition, the implementation of a COVID-free pathway for elective orthopedic procedures has allowed for the resumption of shoulder arthroplasty without increased risk to patients.<sup>8,23</sup>

To date, no studies have sufficiently evaluated the temporal trends in patient demographics of those undergoing elective TSA in the year prior to and during COVID-19. We hypothesized that nationwide, patients who did undergo surgery would be younger and healthier in order to promote minimal risk. Contrary to our hypothesis, we found that patients undergoing TSA in 2020 were similar with respect to age, gender, race, body mass index, ASA class, frailty, and the presence of multiple comorbidities. These results comparing patient demographics and comorbidities mimic findings from other investigators during the same period.<sup>16</sup> Orthopedic surgeons have queried patients about their perceptions and feelings about delaying total joint arthroplasties during the pandemic. Patients have generally felt an increase in anxiety and decline in quality of life. Although 85% of patients understood and agreed with the public health measures to curb infections, almost 90% of patients planned to reschedule their joint replacement as soon as possible.<sup>4</sup> These feelings are supported by our results, which showed the ability for shoulder surgeons to resume outpatient shoulder arthroplasty in the latter half of 2020 without compromising patients' health.

Perhaps the most clinically important finding of our study was the notable shift of TSA cases from the inpatient to outpatient surgery setting during the pandemic; we found a 1.5-fold increase in outpatient TSA cases. Furthermore, the frequencies of same-day discharge increased per quarter from 2019 to 2020 (from 11.8% to 26.8% of annual cases). In the present study, the overall 30-day complication rate was 4.7% (456/9667), with no significant differences in the rates of major complications, infection complications, cardiac complications, hematology complications, renal complications, and Clavien Dindo IV complications from 2019 to 2020. However, pulmonary complications doubled in incidence in 2020. The etiology for this doubling of pulmonary complications can only be speculated on, and possibly may be due to sequela from COVID-19. The 30-day reoperation (1.5% vs. 1.3%), readmission (2.9% vs.

### Frequency of Same Day Discharge Following Elective TSA



**Figure 2** The proportion of same-day discharge increased by quarter from 2019 (ranges 11.7%-14.1%) to 2020 (range 13.9%-26.8%). The percentage of same-day discharge after 2020 Q2 was significantly higher than 2019 and 2020 Q1.

3.0%), and mortality (0.15% vs. 0.12%) rates following elective TSA were low in our study and not affected by the COVID-19 pandemic. The 30-day complication, readmission, and reoperation rates in the present study were comparable to prior TSA studies.<sup>3</sup> Although our data are limited to short-term follow-up, it is imperative to show no increased rate of complication and mortality as a result of sequelae from the COVID-19 pandemic.

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 surgery in the United States. Therefore, the case volume trends reported in this study should be taken in the appropriate context. Our inclusion criteria were narrowed to include only elective total shoulder arthroplasty cases as this would ensure a homogeneous sample when comparing 2019 to 2020. The ability to differentiate anatomic vs. reverse shoulder arthroplasty was not available for further comparison. The present study trends may be a result of other confounding factors, including changes in clinical practice instead of directly to the COVID-19 pandemic. Data accuracy is potentially a concern; nevertheless, NSQIP undergoes auditing for interrater reliability to ensure the validity of the data.<sup>1</sup> All dependent variables of interest including complications, reoperations, readmissions, and mortality were limited to 30 days post-operatively, 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 TSA use prior to and during suspension of nonemergent surgery.

### Conclusion

In the United States, there was a 19.0% decline in elective TSA in 2020. Case volumes precipitously declined by 54.6% during the second quarter of 2020, before recovering to prepandemic baseline. Patient demographics of those undergoing elective TSA in 2020 were similar to 2019. There was a 1.5-fold increase in the number of surgeries performed in the outpatient setting in 2020, with rates of same-day discharge doubling over the study period (from 11.8% to 26.8% of annual cases). Overall 30-day complication, readmission, reoperation, and mortality rates were not increased during COVID-19.

### Disclaimers:

**Funding:** No funding was disclosed by the authors.  
**Conflicts of interest:** The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

### References

- American College of Surgeons NSQIP. User guide for the 2012 ACS NSQIP participant use data file. 2013. Available at: [https://www.facs.org/~media/files/quality\\_programs/nsqip/ug12.ashx](https://www.facs.org/~media/files/quality_programs/nsqip/ug12.ashx). Accessed May 10, 2021.
- Birsel O, Eren İ, Demirhan M. How the COVID-19 pandemic affected shoulder and elbow practice in Turkey? *JSES Int* 2020;4:705-8.e2. <https://doi.org/10.1016/J.JSEINT.2020.08.020>
- Bixby EC, Boddapati V, Anderson MJ, Mueller JD, Jobin CM, Levine WN. Trends in total shoulder arthroplasty from 2005 to 2018: lower complications rates and shorter lengths of stay despite patients with more comorbidities. *JSES Int* 2020;4:657-61. <https://doi.org/10.1016/J.JSEINT.2020.04.024>
- Brown TS, Bedard NA, Rojas EO, Anthony CA, Schwarzkopf R, Barnes CL, et al. The Effect of the COVID-19 pandemic on electively scheduled hip and knee arthroplasty patients in the United States. *J Arthroplasty* 2020;35:S49-55. <https://doi.org/10.1016/J.ARTH.2020.04.052>
- Cancienne JM, Brockmeier SF, Gulotta LV, Dines DM, Werner BC. Ambulatory total shoulder arthroplasty: a comprehensive analysis of current trends, complications, readmissions, and costs. *J Bone Joint Surg Am* 2017;99:629-37. <https://doi.org/10.2106/JBJS.16.00287>
- Centers for Disease Control and Prevention. CDC confirms person-to-person spread of new coronavirus in the United States | CDC Online Newsroom | CDC CDC Media Releases. 2020. Available at: <https://www.cdc.gov/media/releases/2020/p0130-coronavirus-spread.html>. Accessed December 20, 2021.
- Centers for Medicare & Medicaid Services. Non-emergent, elective medical services, and treatment recommendations. 2020. Available at:

- <https://www.cms.gov/Files/Document/31820-Cms-Adult-Elective-Surgery-and-Procedures-Recommendations.Pdf>. Accessed December 20, 2021.
8. Chang JS, Wignadasan W, Pradhan R, Kontoghiorghe C, Kayani B, Haddad FS. Elective orthopaedic surgery with a designated COVID-19-free pathway results in low perioperative viral transmission rates. *Bone Joint Open* 2020;1:562-7. <https://doi.org/10.1302/2633-1462.19.BJO-2020-0110.R1>
  9. Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed* 2020;91:157-60. <https://doi.org/10.23750/ABM.V91I11.9397>
  10. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205-13. <https://doi.org/10.1097/01.SLA.0000133083.54934>
  11. Guy DK, Bosco JASFI. AAOS guidelines for elective surgery. American Academy of Orthopaedic Surgeons. 2020. Available at: <https://www.aaos.org/about/covid-19-information-for-our-members/aaos-guidelines-for-elective-surgery/>. Accessed December 27, 2021.
  12. Jain A, Jain P, Aggarwal S. SARS-CoV-2 impact on elective orthopaedic surgery: implications for post-pandemic recovery. *J Bone Joint Surg Am* 2020;102:e68. <https://doi.org/10.2106/JBJS.20.00602>
  13. Leroux TS, Basques BA, Frank RM, Griffin JW, Nicholson GP, Cole BJ, et al. Outpatient total shoulder arthroplasty: a population-based study comparing adverse event and readmission rates to inpatient total shoulder arthroplasty. *J Shoulder Elbow Surg* 2016;25:1780-6. <https://doi.org/10.1016/j.jse.2016.04.006>
  14. Massey PA, McClary K, Zhang AS, Savoie FH, Barton RS. Orthopaedic surgical selection and inpatient paradigms during the coronavirus (COVID-19) pandemic. *J Am Acad Orthop Surg* 2020;28:436-50. <https://doi.org/10.5435/JAAOS-D-20-00360>
  15. Menendez ME, Jawa A, Haas DA, Warner JJP. Orthopedic surgery post COVID-19: an opportunity for innovation and transformation. *J Shoulder Elbow Surg* 2020;29:1083-6. <https://doi.org/10.1016/J.JSE.2020.03.024>
  16. Menendez ME, Keegan N, Werner BC, Denard PJ. COVID-19 as a catalyst for same-day discharge total shoulder arthroplasty. *J Clin Med* 2021;10:5908. <https://doi.org/10.3390/JCM10245908>
  17. Moverman MA, Puzzitiello RN, Pagani NR, Barnes CL, Jawa A, Menendez ME. Public perceptions of resuming elective surgery during the COVID-19 pandemic. *J Arthroplasty* 2021;36:397-402.e2. <https://doi.org/10.1016/J.ARTH.2020.07.037>
  18. O'Donnell EA, Fury MS, Maier SP, Bernstein DN, Carrier RE, Warner JJP. Outpatient shoulder arthroplasty patient selection, patient experience, and cost analyses. *JBJS Rev* 2021;9. <https://doi.org/10.2106/JBJS.RVW.20.00235>
  19. Ode GE, Odum S, Connor PM, Hamid N. Ambulatory versus inpatient shoulder arthroplasty: a population-based analysis of trends, outcomes, and charges. *JSES Int* 2020;4:127-32. <https://doi.org/10.1016/j.jses.2019.10.001>
  20. Padegimas EM, Maltenfort M, Lazarus MD, Ramsey ML, Williams GR, Namdari S. Future patient demand for shoulder arthroplasty by younger patients: national projections. *Clin Orthop Relat Res* 2015;473:1860-7. <https://doi.org/10.1007/S11999-015-4231-Z>
  21. Sloan M, Premkumar A, Sheth NP. Projected volume of primary total joint arthroplasty in the U.S., 2014 to 2030. *J Bone Joint Surg Am* 2018;100:1455-60. <https://doi.org/10.2106/JBJS.17.01617>
  22. Wagner ER, Farley KX, Higgins I, Wilson JM, Daly CA, Gottschalk MB. The incidence of shoulder arthroplasty: rise and future projections compared with hip and knee arthroplasty. *J Shoulder Elbow Surg* 2020;29:2601-9. <https://doi.org/10.1016/J.JSE.2020.03.049>
  23. Zorzi C, Piovan G, Screpis D, Natali S, Marocco S, Iacono V. Elective orthopaedic surgery during COVID-19: a safe way to get back on track. *JBJS Open Access* 2020;5:e20.00084. <https://doi.org/10.2106/JBJS.OA.20.00084>