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The effect of a statewide COVID-19 shelter-in-place order on shoulder arthroplasty for proximal humerus fracture volume and length of stay

Mark T. Dillon, MD[a,*], *Priscilla H. Chan, MS*[b], *Heather A. Prentice, PhD*[b], *Kathryn E. Royse, PhD*[b], *Elizabeth W. Paxton, PhD*[b], *Kanu Okike, MD*[c], *Monti Khatod, MD*[d], *and Ronald A. Navarro, MD*[e]

[a]*Department of Orthopedic Surgery, The Permanente Medical Group, Sacramento, CA, USA*
[b]*Surgical Outcomes and Analysis, Kaiser Permanente, San Diego, CA, USA*
[c]*Department of Orthopedic Surgery, Hawaii Permanente Medical Group, Honolulu, HI, USA*
[d]*Department of Orthopedic Surgery, Southern California Permanente Medical Group, West Los Angeles, CA, USA*
[e]*Department of Orthopedic Surgery, Southern California Permanente Medical Group, South Bay, CA, USA*

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ABSTRACT

Background: Although the COVID-19 pandemic has disrupted elective shoulder arthroplasty throughput, traumatic shoulder arthroplasty procedures are less apt to be postponed. We sought to evaluate shoulder arthroplasty utilization for fracture during the COVID-19 pandemic and California's associated shelter-in-place order compared to historical controls.
Methods: We conducted a cohort study with historical controls, identifying patients who underwent shoulder arthroplasty for proximal humerus fracture in California using our integrated electronic health record. The time period of interest was following the implementation of the statewide shelter-in-place order: March 19, 2020-May 31, 2020. This was compared to three historical periods: January 1, 2020-March 18, 2020, March 18, 2019-May 31, 2019, and January 1, 2019-March 18, 2019. Procedure volume, patient characteristics, in-hospital length of stay, and 30-day events (emergency department visit, readmission, infection, pneumonia, and death) were reported. Changes over time were analyzed using linear regression adjusted for usual seasonal and yearly changes and age, sex, comorbidities, and postadmission factors.
Results: Surgical volume dropped from an average of 4.4, 5.2, and 2.6 surgeries per week in the historical time periods, respectively, to 2.4 surgeries per week after shelter-in-place. While no more than 30% of all shoulder arthroplasty procedures performed during any given week were for fracture during the historical time periods, arthroplasties performed for fracture was the overwhelming primary indication immediately after the shelter-in-place order. More patients were discharged the day of surgery (+33.2%, $P = .019$) after the shelter-in-place order, but we did not observe a change in any of the corresponding 30-day events.
Conclusions: The volume of shoulder arthroplasty for fracture dropped during the time of COVID-19. The reduction in volume could be due to less shoulder trauma due to shelter-in-

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*Corresponding author: Mark T. Dillon, MD, The Permanente Medical Group, 2025 Morse Ave, 1st floor, Sacramento, CA 95825, USA
E-mail address: Mark.T.Dillon@kp.org (M.T. Dillon).

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place or a change in the indications for arthroplasty given the perceived higher risks associated with intubation and surgical care. We noted more patients undergoing shoulder arthroplasty for fracture were safely discharged on the day of surgery, suggesting this may be a safe practice that can be adopted moving forward.
Level of Evidence: Level III; Retrospective Case-control Comparative Study
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The coronavirus disease 19 (COVID-19) pandemic has impacted all areas of geography and society and will be the primary global public health issue of this generation [26]. Healthcare systems and providers alike face the new challenge of treating individuals infected with the novel virus at the center of the pandemic, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). As case numbers increased, hospital beds and personal protective equipment became in short supply in various areas of the United States (US). In response to these challenges, on March 14, 2020, US Surgeon General Jerome Adams recommended postponing elective surgeries [18]. Shortly after this, the White House Coronavirus Task Force and Centers for Medicare & Medicaid Services issued recommendations to cancel all elective surgeries [7,25]. On March 18, 2020, Governor of California Gavin Newsom issued a shelter-in-place order for the entire state in an attempt to reduce virus transmission [21]. The months that followed were difficult times for both patients requiring care and the physicians providing these needed services.

While healthcare systems and orthopedic surgeons are finding it challenging to return to "business as usual" [20], looking at the impact of shelter-in-place will allow us to better understand where we have been in order to move forward and to prepare for future pandemics. Although a reduction of elective surgeries was expected during the shelter-in-place order, it is unknown what effect the pandemic would have on nonelective procedure volumes, adverse postoperative events, and hospital disposition following surgery. The purpose of this study was to report procedure volume and evaluate the effect of the California shelter-in-place order upon the characteristics and adverse postoperative events of patients with proximal humerus fracture requiring shoulder arthroplasty within a large integrated healthcare system. We hypothesized there would be a difference in patient characteristics and adverse events for shoulder arthroplasties performed for proximal humerus fractures following implementation of the shelter-in-place order compared to historical time periods.

Patients and methods

We conducted a retrospective cohort study with historical controls using data from Kaiser Permanente. This healthcare system serves over 12 million people in 8 regions of the United States. There are over 9 million members in the Northern and Southern California regions [15], which served as the basis for this study. Data was extracted from the healthcare system's shoulder arthroplasty registry and integrated electronic health record (EHR, Epic; Epic Systems, Verona, WI, USA). Details for data collection and validation methodologies have been previously published [8,24]. The shoulder arthroplasty registry is a surveillance tool for all shoulder arthroplasty procedures performed within the healthcare system, and it collects a predefined set of patient, procedure, implant, surgeon, and hospital information using intraoperative forms that are completed at the point-of-care by the operating surgeon. Additional patient information is then supplemented using data from the integrated EHR, administrative claims data, healthcare plan membership records, and mortality records. Once included in the registry, patients are prospectively monitored for adverse events using electronic screening algorithms. Adverse events are then validated through chart review by trained research associates.

Weekly volumes of all shoulder arthroplasty procedures performed from January 1, 2019-May 31, 2020 are reported. The time period of interest was following the implementation of the statewide shelter-in-place order in California: March 19, 2020-May 31, 2020. This was compared to 3 historical time periods for any seasonal and yearly changes: (1) January 1, 2020-March 18, 2020 the time period immediately prior to the statewide shelter-in-place order, (2) March 18, 2019-May 31, 2019 1 year prior to shelter-in-place order to control for yearly changes, and (3) January 1, 2019-March 18, 2019 1 year prior to pre shelter-in-place order to control for normal seasonal change. Information from June 1, 2019-December 31, 2019 was excluded from the historical time periods used for comparisons.

The study sample for comparisons comprised all primary shoulder arthroplasties performed for proximal humerus fractures during the time periods of interest. Weekly shoulder arthroplasty procedure volume during these time periods is presented. Patient characteristics, including age, sex, race/ethnicity, Elixhauser comorbidities (total burden, and $\geq$3 comorbidities), and procedure type (reverse total shoulder arthroplasty (TSA) vs. hemiarthroplasty) are also reported. In-hospital length of stay and 30-day adverse postoperative events are also presented, including: emergency department (ED) visit, readmission, deep infection, pneumonia, and death. For the time period of interest, positive SARS-CoV-2 diagnoses were identified using the EHR.

Statistical analysis

Changes in mean over time were analyzed using linear regression to account for seasonal and yearly variation. Beta estimates, standard errors, and *P*-values are reported. The regression model contained weekly procedure volume as the dependent variable while operative time period (March 19-May 31 vs. January 1-March 18), operative year (2020 vs. 2019), and their interaction term were independent variables. For 30-day events, age, sex, and Elixhauser comorbidities were included as covariates in regression models. An α of 0.05 was used as the threshold for

statistical significance and all tests were two-sided. All analyses were performed using R version 3.6.2 software.

Results

Of the 1334 primary shoulder arthroplasties performed during the time periods included, 152 were for the treatment of proximal humerus fracture and comprised the study sample, 21 of these patients underwent treatment following the statewide shelter-in-place order specifically. Less than 30% of all shoulder arthroplasties performed during any given week were for fracture during the historical time periods, but it was the primary indication for arthroplasty immediately after the shelter-in-place order (Fig. 1), including some weeks in March and April where no elective shoulder arthroplasties were performed.

Of the 152 patients with proximal humerus fractures, no differences were observed in patient characteristics when comparing procedures before and after the shelter-in-place order (Table 1). The proportion of reverse TSA performed did not change after the shelter-in-place order (−8.9%, $P = .485$). Included fracture procedures were performed by 75 surgeons at 30 healthcare centers.

Volume changed from an average of 4.4 (standard deviation [SD] = 1.6), 5.2 (SD = 2.3), and 2.6 (SD = 1.7) surgeries per week during January-March 18, 2019, March 19-May 31, 2019, and January-March 18, 2020, respectively, to 2.4 (SD = 1.3) surgeries per week after shelter-in-place (Fig. 2).

In-hospital length of stay and adverse postoperative events by time period are presented in Table 2. More same-day procedures were performed after the shelter-in-place order (+33.2%, $P = .019$): 16.3%, 12.7%, and 37.0% during January-March 18, 2019, March 19-May 31, 2019, and January-March 18, 2020 to 66.7% after shelter-in-place. After adjusting for covariates, we did not observe a change in any of the 30-day events across time periods.

Of the 49 shoulder arthroplasties for fracture performed during the 2020 time periods, there were no positive SARS-CoV-2 diagnoses prior to the index procedure or within 30-days of the index procedure.

Discussion

This study of over 150 shoulder arthroplasties performed for proximal humerus fracture demonstrated a significant decrease in volume following the COVID-19 pandemic California shelter-in-place order. Reverse TSA was the most common procedure of choice within the healthcare plan as we have previously demonstrated [9]. Interestingly, we noted an increased likelihood that patients having a shoulder arthroplasty performed for fracture would be discharged the same day of surgery. The overall number of comorbidities was similar across time periods, so it does not appear that overall patient health impacted medical decision-making about whether to proceed with shoulder arthroplasty.

Early in the pandemic, information out of Wuhan, China suggested those patients with COVID-19 who sustained a

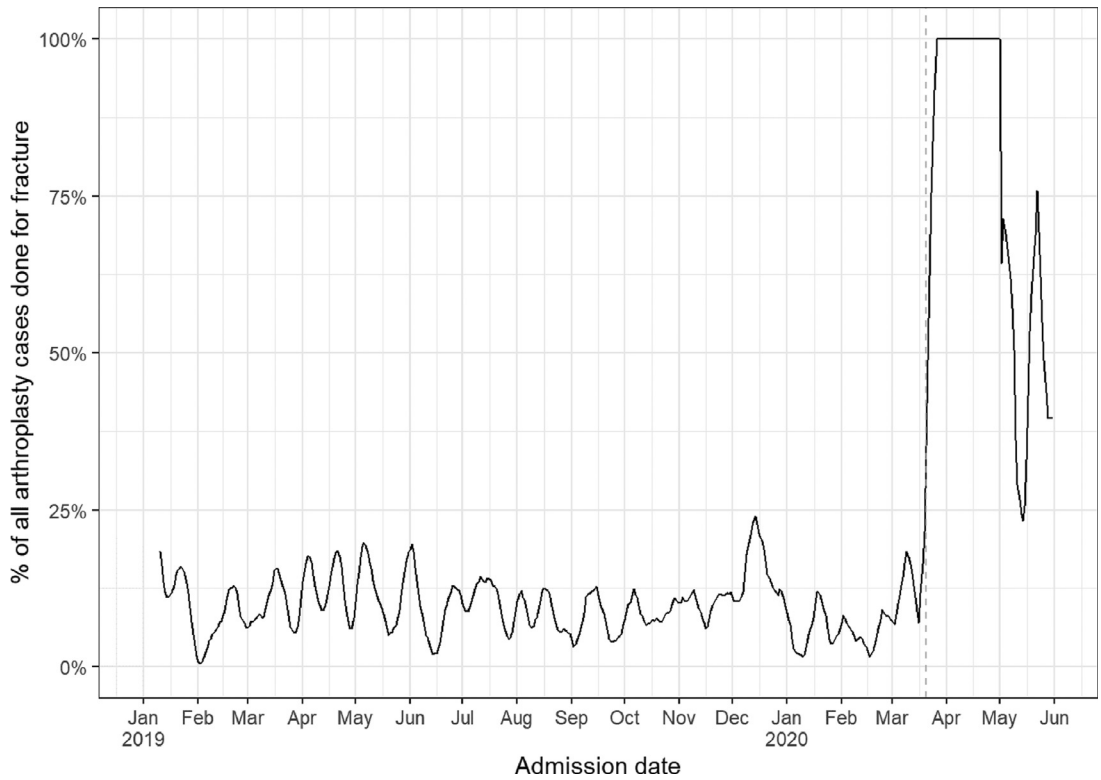

Figure 1 – Percent of all primary shoulder arthroplasty procedures done for fracture in January 2019 through May 2020, showing weekly rolling average. The dashed vertical line denotes when shelter-in-place was instituted in California (March 19, 2020).

Table 1 – Characteristics of 152 patients who underwent shoulder arthroplasty for proximal humerus fracture.

Characteristic	2019		2020			P value
	January 1-March 18	March 19-May 31	January 1-March 18	March 19-May 31*	Change after shelter-in-place order†	
Total N	49	55	27	21		
Reverse TSA, n (%)	40 (81.6)	46 (83.6)	25 (92.6)	18 (85.7)	−8.9% (12.7)	.485
Patient characteristics						
Age, in years, mean ± SD	73.0 ± 9.2	71.3 ± 10.7	69.7 ± 8.8	72.3 ± 8.5	+4.2 years (3.4)	.216
Male, n (%)	15 (30.6)	8 (14.5)	3 (11.1)	2 (9.5)	+14.5% (13.4)	.283
Race/ethnicity, n (%)						
Asian	3 (6.1)	1 (1.8)	1 (3.7)	3 (14.3)	+14.9% (7.8)	.059
Black	1 (2.0)	2 (3.6)	0 (0.0)	0 (0.0)	−1.6% (4.9)	.746
Hispanic	12 (24.5)	7 (12.7)	4 (14.8)	0 (0.0)	−3.1% (12.4)	.806
White	33 (67.3)	45 (81.8)	22 (81.5)	18 (85.7)	−10.2% (14.6)	.484
Elixhauser comorbidities						
Mean ± SD	3.9 ± 2.5	3.7 ± 2.4	3.3 ± 2.4	3.0 ± 2.6	−0.1% (0.9)	.922
≥3, n (%)	36 (73.5)	38 (69.1)	15 (55.6)	11 (52.4)	+1.2% (16.6)	.942

SD, standard deviation; *TSA*, total shoulder arthroplasty.
* Shelter-in-place instituted in California.
† Coefficient (standard error) of operative year and operative month interaction in linear regression, no significant differences from zero were observed.

fracture did more poorly than those without a fracture [19]. However, little has been reported on the outcomes of patients during the pandemic with upper extremity fractures or those requiring surgery, much less so specifically on those undergoing arthroplasties for proximal humerus fractures. Only 36 fractures of the humerus were reported by the Spanish National Health System between March 10, 2020 and April 25, 2020 [12]. Of these, 11 required surgery, with one needing a reverse TSA. Only 1 patient was noted to be positive for SARS-CoV-2 at the time of surgery. In our study we had no positive SARS-CoV-2 diagnoses prior to surgery or within the 30-days postoperative period.

Reports out of Italy noted a 65% reduction in trauma services provided for shoulder and elbow injuries during the time residents were asked to stay in the home [13]. Within our healthcare plan, the COVID-19 pandemic will likely result in a substantial decrease in the annual number of shoulder arthroplasties performed for fracture when compared with our previously reported annual volume [9]. Following the period of shelter-in-place, weekly arthroplasty volumes

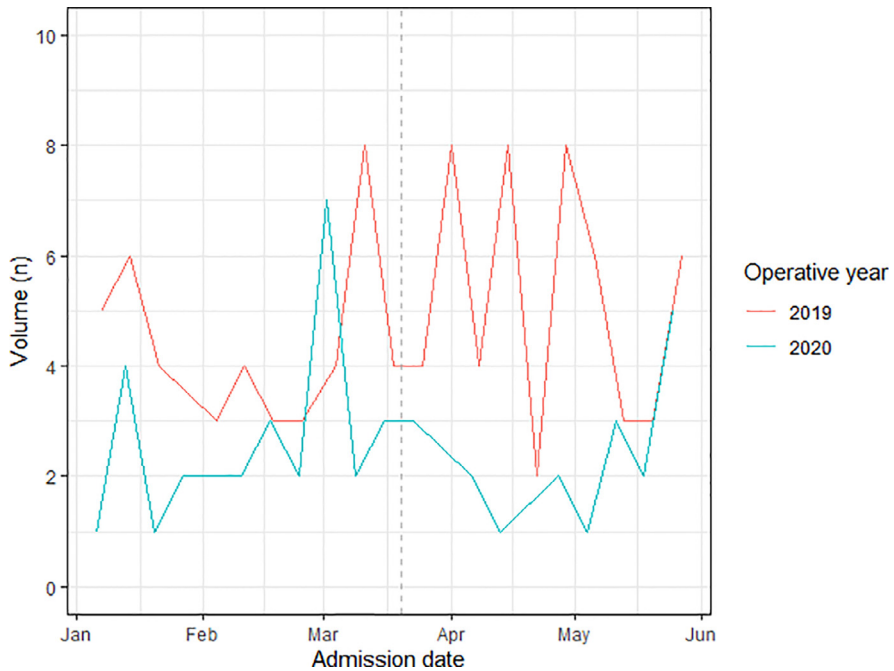

Figure 2 – Weekly number of shoulder arthroplasties for proximal humerus fracture performed in an integrated healthcare system. The dashed vertical line denotes when shelter-in-place was instituted in California (March 19, 2020).

Table 2 – In-hospital length of stay and adverse postoperative events for 152 patients who underwent shoulder arthroplasty for proximal humerus fracture.

Outcome	2019		2020		Change after shelter-in-place order[†]	P value
	January 1-March 18	March 19-May 31	January 1-March 18	March 19-May 31[*]		
Total N	49	55	27	21		
Length of stay, in days, n (%)						
0	8 (16.3)	7 (12.7)	10 (37.0)	14 (66.7)	**+33.2% (14.1)**	**0.019**
1	22 (44.9)	25 (45.5)	9 (33.3)	3 (14.3)	-19.6% (16.9)	0.248
2-6	17 (34.7)	21 (38.2)	8 (29.6)	4 (19.0)	-14.1% (16.6)	0.397
≥7	2 (4.1)	2 (3.6)	0 (0.0)	0 (0.0)	+0.4% (5.7)	0.937
30-day events, n (%)						
Emergency department visit	4 (8.2)	9 (16.4)	3 (11.1)	1 (4.8)	-15.3% (11.2)	0.173
Readmission	3 (6.1)	1 (1.8)	1 (3.7)	1 (4.8)	+4.6% (6.9)	0.509
Deep infection	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.0% (0.0)	1.000
Death	0 (0.0)	2 (3.6)	0 (0.0)	0 (0.0)	-3.5% (4.0)	0.372

Bold text indicates statistical significance.

[*] Shelter-in-place instituted in California.

[†] Coefficient (standard error) of operative year and operative month interaction in linear regression, bold indicated significantly different from zero.

decreased by approximately 80%. While a previous study from our registry reported that roughly 17% of all arthroplasties were performed for trauma [8], during the time of shelter-in-place, trauma was the overwhelming indication for shoulder arthroplasty performed within the healthcare plan.

The exact reason for the decrease in shoulder arthroplasty procedures performed for fractures is unknown, though it is likely multifactorial. Interestingly, we noted a decrease in arthroplasty volume for fracture early in the pandemic, as patients may have been self-quarantining even before shelter-in-place. It may simply be there were fewer proximal humerus fractures during this time. With a shelter-in-place order in effect, older patients more prone to falling in unfamiliar environments may have simply stayed home and avoided injury. However, others have reported osteoporotic fractures rates remained stable during the pandemic [13,22], suggesting many of these types of fractures occur within the home. Instead, fearful patients may have declined to go to a hospital to see a surgeon, let alone consent to having surgery performed. Recent reports have documented a drastic decline in ED patient visits during the early period of the pandemic, with one health system in New York reporting an over 60% decline in total ED visits [14]. It is also possible surgeon behavior may have contributed to the decline in shoulder arthroplasties performed. It is well established that the overwhelming majority of proximal humerus fractures can be treated nonoperatively. During the pandemic, surgeons' thresholds for recommending surgery may have become more stringent, as they may not have wanted to expose their older, more at-risk patients to a hospital stay and risk their patients contracting the virus.

While outpatient shoulder arthroplasty can be safe and effective in selected patients [1-6,10,11,16,17,23], studies have tended to focus primarily on carefully selected patients undergoing arthroplasty, usually TSA, on an elective basis. Patients with proximal humerus fractures, however, cannot be "selected," and as a result often have more medical comorbidities and cannot be medically optimized prior to surgery. As a result, little is known about same-day discharge of patients requiring shoulder arthroplasty for proximal humerus fractures.

We noted an increase in the percentage of patients undergoing shoulder replacement for fracture that were discharged the day of their surgery. It is difficult to say whether this increase in same-day discharge following shoulder arthroplasty for trauma is due to continued effort by surgeons and the healthcare plan to provide patients with the option to recover at home safely following surgery, or whether it was driven by surgeons to reduce hospital admissions and potential exposure of their patients to COVID-19. However, in the present cohort, we found same-day discharge with home recovery is a safe option for those patients having surgery performed for fracture. We did not note an increase in readmission or ED visits in those patients who underwent same-day discharge during the time of shelter-in-place. Clearly this is an area that warrants further study.

The results of our study are to be considered in light of our study design. Given it was an observational study, our results should be not be taken to demonstrate causation. With only 21 arthroplasties performed for proximal humerus fracture during the period of interest, our sample size is relatively small which could impact estimates (ie, larger standard errors). The effect of COVID-19 can vary widely, so it is possible our experiences may not be shared by those in other geographic areas or practice settings. We also cannot state if the time from injury to surgery had an impact on the patient's postoperative course, including whether a patient was able to be discharged to home following surgery. Finally, our study was conducted in the early stages of the pandemic, when compliance with shelter-in-place measures in California was high.

Conclusions

We found the volume of shoulder arthroplasty for proximal humerus fracture dropped during the COVID-19 pandemic

and following implementation of a stay-at-home order in California. Whether there was less shoulder trauma during this time due to the shelter-in-place or the indications for arthroplasty were modulated given the potentially higher risks associated with intubation and operation or other reasons is unknown. We also noted a higher rate of same-day discharge following shoulder arthroplasty without a corresponding increase in adverse 30-day events, suggesting that this may be a viable option in the future for those patients having surgery for proximal humerus fracture.

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