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Impact of the COVID-19 pandemic on shoulder arthroplasty: surgical trends and postoperative care pathway analysis

The Avant-Garde Health and Codman Shoulder Society Value Based Care Group

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Background: COVID-19 triggered disruption in the conventional care pathways for many orthopedic procedures. The current study aims to quantify the impact of the COVID-19 pandemic on shoulder arthroplasty hospital surgical volume, trends in surgical case distribution, length of hospitalization, posthospital disposition, and 30-day readmission rates.

Methods: This study queried all Medicare (100% sample) fee-for-service beneficiaries who underwent a shoulder arthroplasty

This study was exempt from IRB review because the data are deidentified and publicly available.

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procedure (Diagnosis-Related Group code 483, *Current Procedural Terminology* code 23472) from January 1, 2019, to December 18, 2020. Fracture cases were separated from nonfracture cases, which were further subdivided into anatomic or reverse arthroplasty. Volume per 1000 Medicare beneficiaries was calculated from April to December 2020 and compared to the same months in 2019. Length of stay (LOS), discharged-home rate, and 30-day readmission for the same period were obtained. The yearly difference adjusted for age, sex, race (white vs. nonwhite), Centers for Medicare & Medicaid Services Hierarchical Condition Category risk score, month fixed effects, and Core-Based Statistical Area fixed effects, with standard errors clustered at the provider level, was calculated using a multivariate analysis ($P < .05$).

Results: A total of 49,412 and 41,554 total shoulder arthroplasty (TSA) cases were observed April through December for 2019 and 2020, respectively. There was an overall decrease in shoulder arthroplasty volume per 1000 Medicare beneficiaries by 14% (19% reduction in anatomic TSA, 13% reduction in reverse shoulder arthroplasty, and 3% reduction in fracture cases). LOS for all shoulder arthroplasty cases decreased by 16% (-0.27 days, $P < .001$) when adjusted for confounders. There was a 5% increase in the discharged-home rate (88.0% to 92.7%, $P < .001$), which was most prominent in fracture cases, with a 20% increase in discharged-home cases (65.0% to 73.4%, $P < .001$). There was no significant change in 30-day hospital readmission rates overall ($P = .20$) or when broken down by individual procedures.

Conclusions: There was an overall decrease in shoulder arthroplasty volume per 1000 Medicare beneficiaries by 14% during the COVID-19 pandemic. A decrease in LOS and increase in the discharged-home rates was also observed with no significant change in 30-day hospital readmission, indicating that a shift toward an outpatient surgical model can be performed safely and efficiently and has the potential to provide value.

Level of Evidence: Level IV; Case Series; Descriptive Epidemiology Study using Large Database Analysis

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Traditional care pathways and paradigms for orthopedic surgeons and their patients were critically disrupted by the COVID-19 pandemic, the full effects of which are still to be defined. Although the overall impact of the pandemic on the orthopedic surgery specialty and medical field as a whole is difficult to comprehend and, quite frankly, digest in its entirety, evaluating its effects in smaller subspecialties, more specifically high-volume procedures, can provide insight and guidance for future planning. Evaluating the effect of the COVID-19 pandemic on shoulder arthroplasty can allow insights for innovation and lead to process improvement^{11,12} in the short term as well as in the postpandemic world.

Total shoulder arthroplasty is a rapidly growing procedure with an estimated pre-COVID pandemic annual incidence between 3.3 and 6.3 per 10,000 patients per year.^{9,15} Wagner et al¹⁵ observed a 103.7% increase in total shoulder arthroplasty (TSA) procedures from 2011 to 2017. Looking at other major joint replacement procedures, total knee arthroplasty and total hip arthroplasty increased by 17.8% and 29.1%, respectively, over this same time period. This is a trend that spans age groups for the treatment of both traumatic and degenerative conditions. From 2002 to 2011, Padegimas et al¹⁴ identified an increase in the TSA volume of 8.2% per year in patients aged <55 years and 12.1% per year in patients aged >55 years. From 2011 to 2030, they anticipated a 333.3% and 755.4% volume increase in patients aged <55 years and older adult populations, respectively. Furthermore, this trend is not isolated to the United States. Similar increases in demand for shoulder arthroplasty have been observed in international patient registries.^{6,10} The widespread applications of TSA

and the dramatic increase in TSA volume pre-COVID make this an ideal procedure to gauge the impact of the pandemic on shoulder arthroplasty procedure volume as well as postoperative care pathways.

Dillon et al³ evaluated the impact of the COVID pandemic shelter-in-place order in California on the case volume of reverse shoulder arthroplasty for proximal humerus fracture. They observed not only a drop in case numbers over the shelter-in-place order time period (March 19, 2020, to May 31, 2020) but also an increase in the number of patients that were safely discharged on the day of surgery. No prior work has evaluated the full effect of the COVID-19 pandemic on shoulder arthroplasty over the year 2020, specifically focusing on trends in surgery and post-surgical care specific to shoulder arthroplasty. The purpose of this study is to quantify the impact of the COVID-19 pandemic on shoulder arthroplasty hospital surgical volume, trends in surgical case distribution, length of hospitalization, posthospital disposition, and 30-day readmission rates.

Methods

Data and variables

This was a retrospective cohort study. We used a 100% sample of Centers for Medicare & Medicaid Services (CMS) fee-for-service (FFS) inpatient and outpatient claims data and Medicare enrollment data spanning from 2019 through 2020. We identified April 2020 as the first full month after the onset of the COVID-19 pandemic and, therefore, set April 1, 2020, as the start date for the COVID-19 period. At the time of our analysis, claims data

extended through December 31, 2020. As such, we examined cases admitted by December 18, 2020, to make sure that data surrounding the full length of stay (LOS) was captured. We examined the same time period of cases (April 1 to December 18 admissions) in 2019 as in 2020 to ensure comparability between the years. The study included primary TSAs that were coded as inpatient using Diagnosis-Related Group (DRG) 483, and as outpatient using primary *Current Procedural Terminology (CPT)* code 23472. Outpatient TSAs only made up a small percentage of total TSA cases. This is most likely due to the recent removal of the TSA procedure code from the inpatient-only list in early 2021. We further divided TSAs into nonfracture anatomic arthroplasties, nonfracture reverse arthroplasties, and fracture TSAs (anatomic and reverse combined) based on each case's primary *International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM)*, diagnosis codes and *ICD-10 Procedure Coding System (ICD-10-PCS)* codes.

For outcome metrics, we examined the TSA rate per 1000 Medicare beneficiaries, the index hospitalization (hospitalization where the TSA occurred), LOS, percentage of cases discharged home post arthroplasty (as opposed to a skilled nursing or rehabilitation facility), and percentage of cases readmitted within 30 days after the index hospitalization.

Statistical analysis

We calculated the total TSA hospitalization volume per 1000 Medicare beneficiaries, index LOS, discharged-home rate, and 30-day readmission between April 1 and December 18 in 2019 and 2020, where 2020 is considered as during COVID. A regression model at hospital-month level was fit adjusted for indicator of during-COVID, age, sex, race, CMS Hierarchical Condition Category risk score, time fixed effects at month level, and Core-Based Statistical Area fixed effects to study the effect of COVID on different outcome variables. Standard errors were clustered at the hospital level. We controlled for the CMS Hierarchical Condition Category risk score because it is a measure reflecting the expected future health costs for each patient based on the patient demographics and chronic illnesses. Regressions were conducted for all TSAs collectively and within each TSA procedure group. *P* values and 95% confidence intervals (CIs) were calculated.

Results

Shoulder arthroplasty surgical trends

Between April and December 2019 and 2020, there were 49,412 and 41,554 TSA cases performed respectively. Overall, a decrease in shoulder arthroplasty volume from 1.51 to 1.30 procedures per 1000 Medicare beneficiaries—a 14% reduction—was observed (Table I). Stratifying by procedure type, anatomic shoulder arthroplasty saw a 19% reduction from 0.45 to 0.36 procedures per 1000 Medicare beneficiaries. Reverse shoulder arthroplasty experienced a 13% reduction from 0.91 to 0.80 procedures per 1000 Medicare beneficiaries. Arthroplasty for fracture

experienced a 3% reduction from 0.15 to 0.145 procedures per 1000 Medicare beneficiaries.

Figure 1 demonstrates the weekly average of shoulder arthroplasty hospitalization volume per 1000 Medicare beneficiaries per day by week for 2019 and 2020. From week 1 to week 11, the TSA volume for 2020 had surpassed that for 2019. Starting week 12, with the onset of the COVID-19 pandemic, the TSA volume for 2020 dropped dramatically within 2 weeks, reached its trough between week 13 and 17, then slowly recovered to the same level as 2019 at week 22. The 2020 TSA volume stayed at a level comparable to that of 2019 throughout the rest of the year.

Surgical trends by region

Figure 2 demonstrates TSA hospitalization volume per 1000 Medicare beneficiaries by week for 2019 and 2020 broken down by geographic region. Most regions had a return of 2020 case volumes to similar levels to 2019 between week 21 and week 23. New England and the Middle Atlantic Region had the slowest return to prior years' case volume, seeing this occur at week 25.

Hospitalization LOS

Index hospitalization LOS for all shoulder arthroplasty cases was significantly reduced by 16% (−0.27 days, CI −0.34, −0.20; *P* < .001) when adjusted for age, sex, race (white vs. nonwhite), CMS Hierarchical Condition Category risk score, month fixed effects, and Core-Based Statistical Area fixed effects (Table II). Index hospitalization LOS for anatomic shoulder arthroplasty cases was significantly reduced by 20% (−0.28 days, CI −0.37, −0.19; *P* < .001). Index hospitalization LOS for reverse shoulder arthroplasty cases was significantly reduced by 21% (−0.33 days, CI −0.40, −0.26; *P* < .001). Interestingly, arthroplasty for fracture cases LOS was reduced by 7% (−0.21 days, CI −0.58, 0.16; *P* = .26), yet this was not statistically significant.

Figure 3, A, demonstrates the average hospitalization LOS by week for 2019 and 2020. From the start of 2020, a consistent decrease in LOS was observed before the onset of the COVID-19 pandemic. LOS increased for 2020 between week 12 and 18. After week 18, the LOS decreased for 2020 compared with 2019, and this decrease was sustained through the rest of the year.

Discharged-home rate

There was a 5% increase in the overall discharged-home rate (88.0% to 92.7%, *P* < .001). Anatomic shoulder arthroplasty had a 3% increase in the discharged-home rate (93.4% to 96.8%, *P* < .001). Reverse shoulder arthroplasty had a 6% increase in the discharged-home rate (89.2% to 94.4%, *P* < .001). Arthroplasty for fracture had the largest

Table I Changes in rates of TSAs per 1000 Medicare beneficiaries during the COVID-19 pandemic

	2019 Apr-Dec	2020 Apr-Dec	% change
All TSAs (sum of types below)	1.51	1.30	-14
Anatomic TSA nonfracture	0.45	0.36	-19
Reverse TSA nonfracture	0.91	0.80	-13
Arthroplasty for fracture	0.15	0.15	-3

TSA, total shoulder arthroplasty.

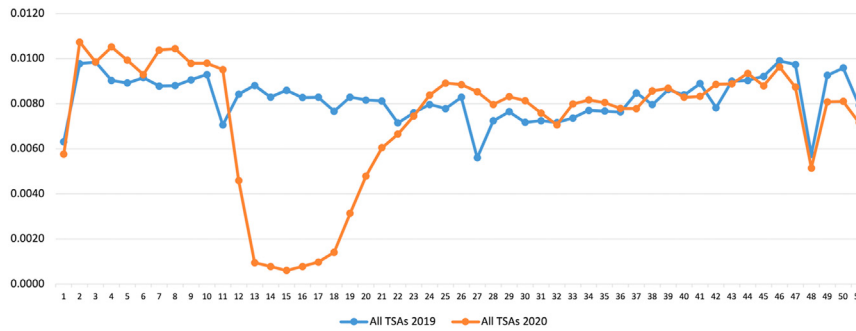


Figure 1 Weekly average of total shoulder arthroplasty (TSA) volume per 1000 Medicare beneficiaries nationally.



Figure 2 Weekly average of total shoulder arthroplasty (TSA) volume per 1000 Medicare beneficiaries by region.

increase in discharged-home cases at 20% (65.0% to 73.4%, $P < .001$).

Figure 3, B, demonstrates the average discharged-home rate for cases by week for 2019 and 2020. The discharged-home rate started at a similar level for 2019 and 2020 and increased for 2020 with the onset of COVID-19 between weeks 12 and 17. From week 19 onward, there

was a consistent increase in the 2020 discharged-home rate compared with 2019.

Thirty-day hospital readmission

There was no significant change in 30-day hospital readmission rates overall ($P = .20$) or when broken down by

Table II Changes in outcome metrics during the COVID-19 pandemic

	2019	2020	Unadjusted difference	Adjusted difference* (95% CI)	% change	P value
Index hospitalization length of stay [†]						
All TSA	1.64	1.40	-0.25	-0.27 (-0.34, -0.20)	-16	<.001
Anatomic TSA nonfracture	1.42	1.15	-0.27	-0.28 (-0.37, -0.19)	-20	<.001
Reverse TSA nonfracture	1.53	1.26	-0.28	-0.33 (-0.40, -0.26)	-21	<.001
Arthroplasty for fracture	2.99	2.78	-0.22	-0.21 (-0.58, 0.16)	-7	.260
Percentage of discharged-home cases [†]						
All TSA	88.0	92.7	4.7	4.7 (3.6, 5.9)	5	<.001
Anatomic TSA nonfracture	93.4	96.8	3.5	2.9 (1.4, 4.5)	3	<.001
Reverse TSA nonfracture	89.2	94.4	5.2	5.4 (4.0, 6.8)	6	<.001
Arthroplasty for fracture	65.0	73.4	8.4	12.7 (7.0, 18.4)	20	<.001
Percentage of cases readmitted within 30 d [‡]						
All TSA	3.4	3.2	-0.2	0.5 (-0.2, 1.2)	14	.200
Anatomic TSA nonfracture	2.4	2.2	-0.3	0.5 (-0.6, 1.5)	19	.390
Reverse TSA nonfracture	3.5	3.3	-0.2	0.2 (-0.7, 1.1)	6	.670
Arthroplasty for fracture	6.3	5.7	-0.6	0.3 (-2.5, 3.1)	4	.850

TSA, total shoulder arthroplasty; CI, confidence interval.

* Adjusted changes of outcome metrics were made from the statistical model, adjusted for age, sex, race, Centers for Medicare & Medicaid Services Hierarchical Condition Category risk score, month fixed effects, and Core-Based Statistical Area fixed effects, with standard errors clustered at the provider level.

[†] Results for index hospitalization length of stay and percentage of discharged-home cases were made comparing April through December data for 2020 and 2019.

[‡] Results for percentage of cases readmitted within 30 days were made comparing April through November data for 2020 and 2019.

individual procedure: anatomic shoulder arthroplasty ($P = .39$), reverse shoulder arthroplasty ($P = .67$), and arthroplasty for fracture ($P = .85$) (Table II).

Figure 3, C, demonstrates the weekly average 30-day readmission rate for 2019 and 2020. From week 15 to 17, there was an increase in the 2020 30-day hospital readmission rates compared with 2019. Outside of those 3 weeks, there was no trend toward a significant change in 2020 30-day hospital readmission rates compared with 2019.

Discussion

In contrast to prior consistent yearly growth in shoulder arthroplasty volume noted before the COVID-19 pandemic,^{2,9,15} this study observed a 14% decrease in overall shoulder arthroplasty volume over the period of time defined as the 2020 COVID-19 pandemic. Interestingly, when evaluating this trend more carefully, this observed drop was specific to the first 10 weeks of the pandemic (Fig. 1). Following return to elective surgery, there was a fairly robust return to surgical case volumes equivalent to weekly case volume observed before the pandemic; this is in spite of diminished hospital economic resources, personnel, and space as well as increased barriers to preoperative case approval and potential patient hesitancy to undergo an elective operation.¹ The drop in nonfracture shoulder arthroplasty cases can be explained by

the period of time in which elective procedures were banned. However, the exact reason for the significant drop in arthroplasty for fracture cases by 3% may be more complex or have a multifactorial basis. A similar decrease in arthroplasty for fracture over the shelter-in-place time period was observed in California.³ Yet, stable numbers of fragility fractures with lower-energy mechanisms (ie, domestic fall) have been reported during the pandemic.^{5,13} Therefore, this trend may have been more a result of hesitancy on the patient side to seek medical treatment¹ vs. hesitancy on the surgeon's side to treat some of these injuries operatively.

When surgical volume was broken down by geographic region, there was a fairly consistent drop in case volume across all regions during week 11-12 in 2020, corresponding with the pause on elective surgical cases. The return to case volume equivalent to levels in the prior year was variable by region (Fig. 2). New England and the Middle Atlantic regions had the slowest return to prepandemic case volume levels. Shoulder arthroplasty utilization has been shown to be most utilized in metropolitan areas and less common in rural regions.^{4,9} Therefore, the significant effect of the pandemic on the major cities in the northeast and Middle Atlantic regions can likely explain this slower return to pre-COVID TSA levels in these regions as hospital resources were likely still being allocated to support hospitalized COVID patients.

There was an overall statistically significant decrease of 16% (from 1.64 to 1.40 days) in hospitalization LOS

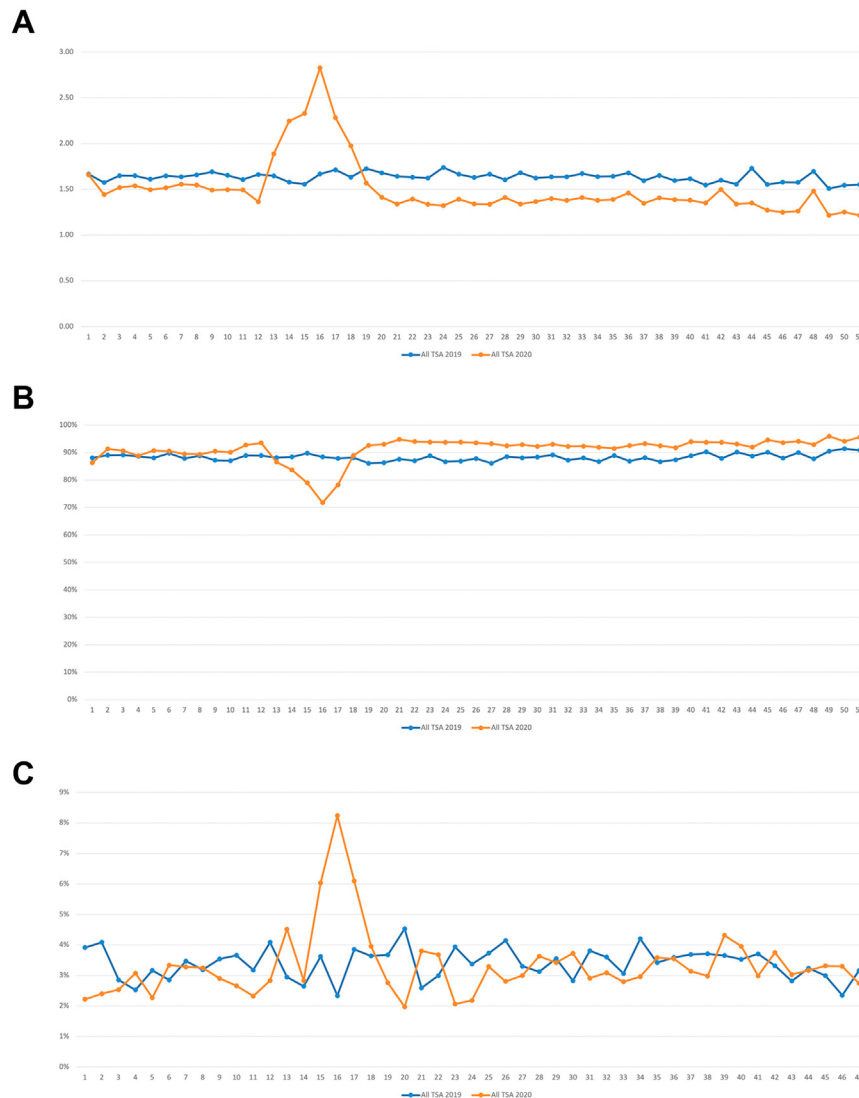


Figure 3 Weekly average of (A) index hospitalization length of stay, (B) discharged-home cases, and (C) percentage of cases readmitted within 30 days. TSA, total shoulder arthroplasty.

observed for all shoulder arthroplasty cases. When broken down by individual procedure, this was sustained as a statistically significant decrease for both anatomic and reverse shoulder arthroplasty nonfracture cases. Although a decrease in hospital LOS from 2.99 to 2.78 days was observed for arthroplasty for fracture cases, the magnitude of this change did not reach statistical significance. Looking at this breakdown by week, there was a consistent trend in decreased hospital LOS in 2020 relative to 2019 until week 13, at which point there was a drastic increase in hospital LOS for week 13 through 18. This time period corresponds with the early stages of the elective case ban in which the majority of arthroplasty cases were performed for fracture. In week 19, the hospital LOS dropped relative to 2019 and consistently remained lower throughout the rest of the year. This was likely a change in both the case distribution (more nonfracture cases being added with time)

as well as a push to decrease inpatient postoperative LOS to help diminish patient exposures as well as free up hospital beds and resources.

Discharged-home rates overall increased by 5% in 2020; this was the most appreciable in arthroplasty for fracture cases with an increase from 65.0% to 73.4%, a 20% change. Given the increased burden of the COVID-19 pandemic on both hospital and skilled nursing facilities, this was a necessary and impactful shift to observe during the pandemic. Breakdown by week shows that this change was less pronounced in the first 2 months of 2020, but postpandemic it was a consistent trend. From week 14 to 18, there was a brief decrease in discharged-home rates. We believe this to be a result of the halt in elective procedures, resulting in a relative increase in fracture cases, skewing the data toward a comparative increase in patients with more medical comorbidities undergoing surgery. No prior work

has specifically evaluated discharged-home rates following shoulder arthroplasty. Dillon et al³ evaluated same-day discharge rates for shoulder arthroplasty for fracture, and they found a significant 33.2% increase in shoulder arthroplasty fractures that were discharged same day without seeing a corresponding increase in hospital 30-day readmission rates.

Our study showed similar results with regard to 30-day readmission rates: despite a decrease in LOS and increase in discharged-home rates, no significant change in hospital 30-day readmission rates was observed. Furthermore, when this was broken down by week, there was a spike in 30-day readmission rates from week 14 to 18; similar to the reasoning for diminished discharged-home rates during this time period, we believe this also to be attributed to diminished rates of elective procedures being performed during this time period, resulting in a relative increase in medically complex patients that manifested as increased readmission rates.

Several studies have suggested that transitioning elective shoulder arthroplasty procedures to a short stay, same-day discharge, or even outpatient setting does not have an effect on readmission rates or adverse patient outcomes.^{3,7,8} This study adds to the body of evidence that following shoulder arthroplasty for both fracture and nonfracture cases, disposition home with lower length of hospital stays can be performed safely.

This study had several limitations. This was a retrospective analysis limited to the Medicare patient population. We did not evaluate shoulder arthroplasty trends in patients with other insurance types. Therefore, we would not have captured subtle trends or variances that could have resulted from insurance provider pressures or procedure approval demands. Our data were able to demonstrate overall trends and give overarching assessment of patient indications (fracture vs. nonfracture case), but we were not able to get more granular with regard to assessing trends in specific procedural indications for elective procedures. Finally, given the limitations of this database, we were not able to assess long-term patient outcomes or complications. Although a trend toward shorter hospital stays and increased rate of home disposition did not pose any immediate changes in readmission and initial complications, we did not assess long-term complications, patient satisfaction, or long-term outcomes. These are all important outcomes measures that should be investigated in further detail.

Conclusion

Shoulder arthroplasty volume per 1000 Medicare beneficiaries decreased by 14% in 2020 as a result of the COVID-19 pandemic. When broken down by geographic region, the New England and Middle Atlantic regions had the slowest return to prepandemic surgical case volume. Despite an overall decrease in

index hospitalization LOS and increase in the discharged-home rates, no significant change in 30-day hospital readmission rates was observed. As we continue to combat the pandemic, limiting postsurgical exposure through reducing LOS and skilled nursing facility dispositions can be performed safely and does not appear to have unintended acute hospital readmission consequences. In the long term, these data will empower surgeons and hospital administrators to make informed decisions as we modernize and streamline our post-operative arthroplasty care pathways and continue to shift toward an outpatient model that can be performed safely and efficiently and provide value.

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