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The effect of patient factors on opioid use after anatomic and reverse shoulder arthroplasty

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Background: Prolonged opioid use can lead to suboptimal outcomes after total shoulder arthroplasty (TSA), and thus, reduced consumption is desirable. Our primary aims were to determine if differences in total morphine equivalent doses existed owing to (1) age less than or greater than 65 years, (2) sex, and (3) TSA type – reverse or anatomic total shoulder arthroplasty. We also characterized potential risk factors for (1) visiting another provider for pain, (2) pain control 6 weeks postoperatively, and (3) needing an opioid refill.

Methods: A retrospective cohort study of 100 patients who underwent TSA (reverse total shoulder arthroplasty $N_1 = 50$; anatomic total shoulder arthroplasty $N_2 = 50$) between 1 July 2018 and 31 December 2018 was performed. Demographics, perioperative treatments, and postoperative opioid prescriptions were recorded. Primary hypotheses were evaluated with Wilcoxon-Mann-Whitney testing. Univariate and multivariate analyses assessed potential risk factors for the 3 outcomes of interest. Results were given in adjusted odds ratios (aORs), 95% confidence intervals (CIs), and P values.

Results: There was a difference ($P = .009$) in total morphine equivalent doses used (in 5-milligram oxycodone tablets) between patients who were younger than 65 years of age (median: 83 tablets, interquartile range: 62-140) and those who were older than 65 years of age (median: 65 tablets, interquartile range: 52-90). Unemployment (aOR = 4.68, CI: 1.5-14.2, $P = .006$) and age less than 65 years (aOR = 4.18, CI: 1.6-11.2, $P = .004$) were independent risk factors for inadequate pain control 6 weeks postoperatively. Two independent risk factors for needing an opiate prescription refill after discharge were unemployment (aOR = 4.56, CI: 1.5-13.8, $P = .007$) and preoperative opiate use (aOR = 3.95, CI: 1.4-11.0, $P = .009$).

Conclusion: After TSA, morphine equivalent dose usage is higher for patients younger than 65 years of age, and several risk factors exist for requiring a refill and having inadequate pain control 6 weeks postoperatively. Prospective studies using these data to guide interventions may be beneficial.

The increase of total shoulder arthroplasty (TSA)[5,13,16,25] procedures in the last two decades has stimulated a need for improved pain control modalities, which is complicated by a concurrent rise in opioid-related drug deaths between 1999 and 2014.[24,26,28] An estimated 2 million people suffer from opioid use disorder directly related to increasing amounts of opioid prescriptions.[26] Furthermore, underlying behavioral disorders may increase the risk of prolonged postoperative opioid use.[3] Conversely, many patients frequently underutilize their prescribed opioid medications,[2,14] and this may elevate the risk for unintended uses.[1] Orthopedic surgeons are the third-highest opioid-prescribing specialty,[20] and this has prompted interventions to reduce opioid prescriptions, such as national guidelines[6] and preoperative counseling.[10,30]

Preoperative opioid medication usage has been associated with higher postoperative opiate requirements and reduced functional outcome scores after anatomic total shoulder arthroplasty (aTSA)[21] and reverse total shoulder arthroplasty (rTSA).[19] Moreover, age less than 60 years and chronic opioid use were found to be risk factors

Approval for this study was received from the Biomedical Institutional Review Board of the Ohio State University (#2014H0448).

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for increased opioid use postoperatively after elective TSA.[23] Regarding the arthroplasty procedure performed, Okoroha et al[22] described no difference in pain profiles between aTSA and rTSA after the first four hours of surgery. A comprehensive evaluation of potential patient- and surgical-based risk factors that adds to the aforementioned findings may be useful in preoperative counseling.

In this article, we describe a retrospective cohort study with the objective of elucidating risk factors for increased postoperative opioid consumption after TSA. Specifically, we tested the following three null hypotheses: total postoperative opioid requirements after TSA, in morphine equivalent doses (MEDs), are not significantly different between (1) patients younger than and older than 65 years of age, (2) male and female sex, and (3) rTSA and aTSA. As a secondary objective, we studied and characterized potential risk factors for (1) visiting a provider other than the surgeon (either in the emergency department or ambulatory settings), (2) inadequacy of postoperative pain control approximately 6 weeks from the date of surgery, and (3) needing an opioid medication refill after discharge.

Methods

Study population

After obtaining institutional review board study approval, we performed a retrospective cohort study of $N = 100$ patients treated in a single institution by one of three fellowship-trained shoulder surgeons from 1 July 2018 to 31 December 2018. Inclusion criteria for patients included age greater than 18 years and undergoing aTSA or rTSA. Exclusion criteria included active cancer diagnosis requiring baseline opioid prescription, prisoner status, additional operations within 42 days of TSA, revision TSA, concomitant open reduction and internal fixation for a fracture, arthroplasty for a fracture, and previous or current shoulder infection. In this study, all opioid dosages were first converted into MEDs (thus facilitating direct comparison between multiple opioid medications) and then equivalents of oxycodone 5-milligram (mg) tablets to facilitate clinical interpretation of results. An *a priori* power analysis was performed, and because no minimum clinically important difference (MCID) has been defined for MEDs consumed after TSA, we determined the MCID to be 83 MEDs for our primary null hypotheses. This corresponds to 11 doses of oxycodone 5-mg tablets or just over 2 tablets of oxycodone consumed every 4 hours at 5 time points in 1 day. We selected this MCID after discussion with our physician assistant-certified (PA-Cs) and surgeon staff members who determined, from their experience, that greater than 1 additional day, roughly 83 MEDs, of unanticipated opiate consumption often prompted patients to seek additional aid to help control pain postoperatively. Assuming a standard deviation of 167 MEDs used after TSA and assuming that most patients did not use opiates preoperatively (as found derived from the findings by Grace et al[8]) in the group with a mean 1 MCID higher than our baseline group, the number of patients ($N = 100$) we chose to select for the study would provide 83% power with an alpha level of 0.05 for our sample size.

Data collection and perioperative protocol

From electronic medical record review, demographics including age, sex, insurance type, employment status, and distance traveled to the site of surgery were collected. In addition, potentially influential behavioral qualities such as smoking status, alcohol abuse, marijuana drug use, intravenous drug use, baseline opioid use (defined as having an active prescription for opioids within 3 months of surgery),[15,18] and a documented history of a mental health disorder were noted. Preoperative steroid injections and duration of symptoms were also recorded. Perioperative data, such as length of surgery and medications prescribed during the inpatient stay and at discharge (including opiate MEDs), were also collected. Finally, outcomes included the number and type of opioid refills, total MEDs prescribed, opioid use beyond 42 days postoperatively, emergency department or alternative physician visits for additional opioid, a call or visit to the surgeon's office for opioid refills, and pain control at 2 weeks and 6 weeks postoperatively.

All surgeons involved in the study performed TSAs in the beach-chair position, with a pneumatic arm holder for the operative extremity, and used the deltopectoral interval for the surgical approach. In addition, all patients received general anesthetic and an interscalene regional anesthetic block to the operative extremity ($N = 38$ without a catheter, $N = 62$ with a catheter) but no local injections. Patients were immobilized in a sling postoperatively, and the motion was progressed by physical therapists using a standard protocol. Initial opioid prescriptions were given by 1 of 3 PA-Cs or a resident physician with a uniform protocol. All requests for refills were completed only by these 3 PA-Cs.

Documentation of opiate prescriptions

This investigation was performed in a state that has a comprehensive pharmacy database: the Ohio Automatic Rx Reporting System. We used the Ohio Automatic Rx Reporting System to accurately determine the amount and type of opioids prescribed for each patient by any licensed provider in the state. All opioid dosages were converted to MEDs and oxycodone 5-mg tablet equivalents, allowing for direct comparison between multiple opioid medications.

Statistical analysis

Statistical analyses were performed with standard software (Stata, version 15.0; StataCorp, College Station, TX, USA). Descriptive statistics included mean ± standard deviation for normal interval data, median with interquartile range (IQR) for non-normal interval data, and counts with proportions for categorical data. The Wilcoxon-Mann-Whitney test was used to evaluate for differences in total opioid prescription required between (1) patients younger than and older than 65 years of age, which was chosen owing to its threshold as the Medicare eligibility age, (2) male and female patients, and (3) aTSA and rTSA. After these analyses, a series of univariate logistic models were used to assess the unadjusted associations between multiple patient and surgical factors with the outcomes of (1) visiting the emergency department or another provider, (2) patient-reported adequate pain control without the need for opioids as reported by the patient 6 weeks postoperatively, and (3) needing an opioid refill. Multiple variable logistic regression models were then used to determine independent predictors of the aforementioned outcomes. This was performed by considering all factors in univariate analysis and then using a backward selection method with an exit criterion of $P > .05$. Model goodness of fit was confirmed with the Hosmer-Lemeshow test.[11] Discriminatory ability of the multivariate models was summarized by the area under the receiver operator curve (AUROC), with performance rated as poor for AUROC < 0.7, fair for 0.70-0.79, good for 0.80-0.89, and excellent for values greater than 0.90.[29] Results were summarized as odds ratios (ORs), 95% confidence intervals (CIs), and P values. The significance level was 0.05.

Results

Demographics and surgical characteristics

In the 100 enrolled patients, the mean age was 66.1 ± 9.1 years, 51.0% were women, 35.0% had private insurance, and 33.0% were employed (Table I). Moreover, 9.0% were actively smoking at the time of surgery, 35.0% had a preoperative diagnosis of a mental health disorder, and 25.0% were using opioids preoperatively within 3 months of the surgical date.

By the day of surgery, the patients had a median of 24 months (IQR: 6-48 months) of symptoms (Table II). Fifty of the 100 patients underwent an aTSA, and 50 underwent an rTSA for indications other than a fracture. The mean duration of surgery was 107.4 ± 24.0 minutes. On discharge, unless medical contraindication was present, all patients were given 100 mg of gabapentin three times daily and a median of 375 mg of MEDs (IQR: 375-450), equivalent to 50 tablets of oxycodone 5 mg (IQR: 50-60). It was found that 40.0% of the patients required a refill of opioids (median: 0 tablets, IQR: 0-38) prescribed in the 6-week postoperative period. There were 9 patients who saw another provider for opioid refills, and 33.7% of patients did not feel that pain was adequately controlled based on the need for more opioids at the 6-week postoperative visit.

Comparison of opioid use by age, sex, and implant type

In regards to our primary hypotheses (Fig. 1*A*), a difference ($P = .009$) in total MEDs used (in 5-milligram oxycodone tablets) between patients younger than (median: 83 tablets, IQR: 62-140) and those who were older than 65 years of age (median: 65 tablets, IQR: 52-90) existed. When comparing by sex (Fig. 1*B*), no difference existed ($P = .639$) in opioid usage between men (median: 66 tablets, IQR: 57-108) and women (median: 69 tablets, IQR: 53-110). Similarly, no difference existed ($P = .962$) by implant type (Fig. 1*C*) when comparing between aTSA (median: 67 tablets, IQR: 54-108) and rTSA (median: 72 tablets, IQR: 54-109).

Unadjusted risk factors for outcomes of interest

Without adjusting for confounding variables, significant risk factors for visiting another provider for opioid refills included current smoking status (OR = 7.1, CI: 1.4-35.6, $P = .017$) and preoperative opiate use within 3 months of surgery (OR = 7.6, CI: 1.7-33.1, $P = .007$). Significant risk factors for inadequate pain control 6 weeks postoperatively included unemployment (OR = 2.7, CI: 1.02-7.00, $P = .046$) and age less than 65 years (OR = 2.5, CI: 1.1-5.8, $P = .034$). As for requiring a refill after discharge, unemployment (OR = 3.6, CI: 1.4-9.4, $P = .009$) and preoperative opiate use within 3 months of surgery (OR = 4.8, CI: 1.8-12.7, $P = .002$) were the risk factors.

Independent risk factors for outcomes of interest

It was found that unemployment (aOR = 4.68, CI: 1.5-14.2, $P = .006$) and age less than 65 years (aOR = 4.18, CI: 1.6-11.2, $P = .004$) were the independent risk factors for inadequate pain control 6 weeks postoperatively, and the model had borderline fair ability (AUROC = 0.70) to predict the outcome (Fig. 2). Similarly, unemployment (aOR = 4.56, CI: 1.5-13.8, $P = .007$) and preoperative opiate use (aOR = 3.95, CI: 1.4-11.0, $P = .009$) were two independent risk factors for requiring an opioid refill after discharge; the model using these two factors with patient age had fair ability (AUROC = 0.75) to predict the need for a refill (Fig. 3).

Discussion

Previous investigations have explored potential associations with postoperative opioid consumption and outcomes after lumbar spinal fusion,[12] hand and upper extremity surgery, total hip and knee arthroplasty,[12,27] aTSA,[21] and rTSA,[19] with a focus on preoperative opioid consumption. Using the Kaiser Permanente shoulder arthroplasty registry, Rao et al[23] found that age less than 60 years, sex, race, body mass index, American Society of Anesthesiologists classification, and preoperative opioid use were patient-based risk factors for increased opioid use within 1 year of shoulder arthroplasty. Kolade et al[17] added that patients with preexisting psychiatric disorders, higher household income, smokers, and recipients of general anesthesia predicted increased inpatient opioid requirements after TSA, but the surgical procedure performed (aTSA vs. rTSA) had no impact on opioid requirements. Another study highlighted that baseline preoperative opioid users had higher inpatient opioid requirements after TSA than nonopioid users; however, opioid prescriptions at discharge were similar between the groups, suggesting that provider preference for standardized discharge protocols still exists despite variations in pain tolerance among different patient populations.[8] Here, our investigation sought to confirm the role of age, sex, and implant type on opioid prescription needs postoperatively and secondarily determine the patient- and procedural-based risk factors for suboptimal patient-reported pain control.

Table I
Summary of patient demographics and behavioral characteristics.

Variable	All study patients ($N = 100$)
Age (years)	66.1 ± 9.1
Sex (number of women)	51 (51.0%)
Insurance type (number with private insurance)	35 (35.0%)
Employment status (number employed)	33 (33.0%)
Distance traveled to surgery (miles)	18.7 (8.8-54.5)
Smoking status (number actively smoking)	9 (9.0%)
Marijuana use status (number actively using)	2 (2.0%)
Alcohol abuse status (number actively using)	2 (2.0%)
IVDU status (number actively using)	0 (0.0%)
Mental health history status (number with diagnosis)	35 (35.0%)
Preoperative opioid use status (number using within 3 months)	25 (25.0%)

IVDU, intravenous drug use.
Demographic data and pertinent behavioral statuses of all patients in the study who underwent total shoulder arthroplasty ($N = 100$ patients) are presented. Mean ± standard deviation is provided for normal variables, number and proportion are given for categorical variables, and median and interquartile range are shown for non-normal interval data.

Table II
Summary of preoperative treatments, perioperative interventions, and postoperative opioid use.

Variable	All study patients ($N = 100$)
Steroid injections (number received preoperatively)	0 (0-1)
Duration of symptoms (mo)	24 (10-53)
Anatomic total shoulder arthroplasty	50 (50.0%)
Reverse total shoulder arthroplasty − not for fracture	50 (50.0%)
Duration of surgery (min)	107.4 ± 24.0
Morphine equivalent doses within 24 h of discharge (milligrams)	38 (23-69)
Morphine equivalent doses during entire inpatient stay (milligrams)	48 (23-100)
Morphine equivalent doses prescribed at discharge (milligrams)	375 (375-450)
Patients requiring a refill (number receiving)	40 (40.0%)
Morphine equivalent doses refilled (milligrams)	0 (0-281)
Morphine equivalent doses given in total (milligrams)	509 (405-813)
Patients seeing another provider (number performing)	9 (9.0%)
Patients with uncontrolled pain 2 weeks postoperatively (number reporting)	56 (56.6%)
Patients with uncontrolled pain 6 weeks postoperatively (number reporting)	33 (33.7%)

Key data on preoperative symptoms duration, steroid injections, characteristics of the total shoulder arthroplasties performed, quantities of opioids prescribed, and pertinent patient outcomes with regards to pain control for all individuals ($N = 100$ patients) are presented. Mean ± standard deviation is provided for normal variables, number and proportion are given for categorical variables, and median and interquartile range are shown for non-normal interval data.

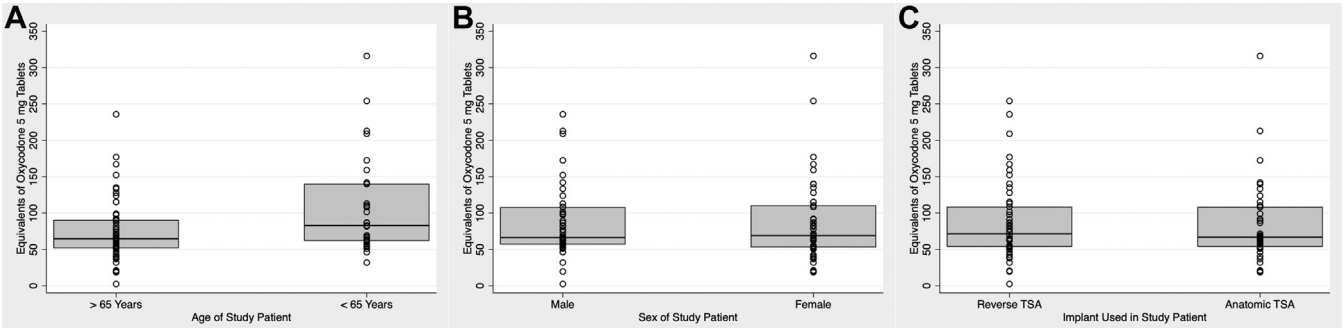

Figure 1 Combination box and scatter plots comparing total opioids prescribed to patients after total shoulder arthroplasty (in equivalents of 5-milligram [mg] tablets of oxycodone) on the basis of (**A**) age less than or greater than 65 years, (**B**) male or female sex, or (**C**) use of reverse or anatomic total shoulder arthroplasty for the implant. For equivalents of 5-mg tablets of oxycodone, the cumulative morphine equivalent dose was calculated for each patient and divided by the conversion ratio of 5 mg of oxycodone for every 7.5 mg of morphine. In the box plots, the lower box boundary represented the first quartile, the interior line represented the median, and the upper box boundary represented the third quartile. *TSA*, total shoulder arthroplasty.

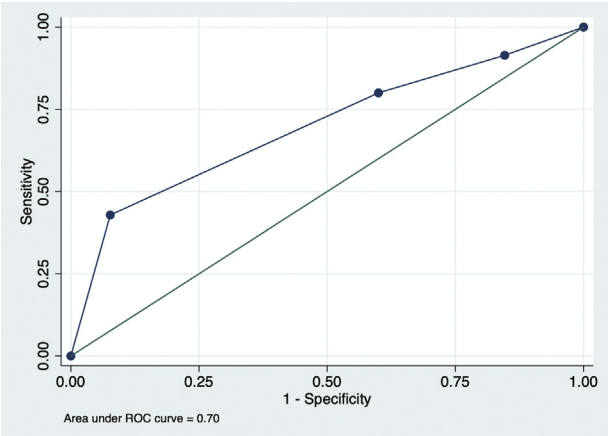

Figure 2 Summary of the predictive ability of a multiple logistic model for the outcome of inadequate pain control at the time of the 6-week postoperative visit after total shoulder arthroplasty (TSA). The two model predictors were (1) patient age less than or greater than 65 years (as a binary variable) and (2) unemployment status (as a binary variable). The area under the receiver operative characteristic curve of 0.70 indicated borderline fair ability for the model to predict the outcome. *ROC*, receiver operative characteristic.

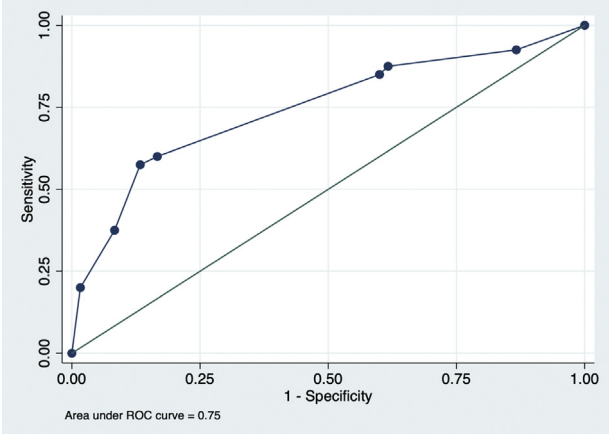

Figure 3 Summary of the predictive ability of a multiple logistic model for the outcome of needing an opiate medication refill after discharge from total shoulder arthroplasty (TSA). The three model predictors were (1) patient age less than or greater than 65 years (as a binary variable), (2) unemployment status (as a binary variable), and (3) whether opioids were used preoperatively by the patient within 3 months of the date of surgery. The area under the receiver operative characteristic curve of 0.75 indicated fair ability for the model to predict the outcome. *ROC*, receiver operative characteristic.

With attention to our study hypothesis, we were able to reject our first null hypothesis, as there was a difference in total postoperative opioid prescription between patients younger than and olderthan 65 years of age. However, we were unable to reject our second and third null hypotheses, as there was no difference in total postoperative opioid prescription (1) between male and female patients and (2) aTSAs and rTSAs. Our findings in regards to age were congruent with the findings that younger age would be a risk factor for increased MEDs postoperatively, as suggested by other researchers.[9,23] Further evaluation of the age-MED association would be useful and warranted in future prospective and retrospective studies with a different patient sample to confirm or refute this finding. As for our finding for sex-related differences, this differs from data from other studies of postoperative opioid use after shoulder operations.[4,23,31] Although no difference was observed between male and female sex in the immediate postoperative period, Rao et al[23] found that female sex is associated with increased opioid usage six to twelve months after surgery. Finally, our finding that no difference in opioid use exists between patients undergoing aTSA and rTSA is consistent with evidence in the literature.[17,22]

Another strength of our study is the elucidation of independent risk factors for the outcomes of (1) inadequate pain control by the time of the 6-week postoperative visit and (2) need for an opioid refill after discharge from TSA. Our first logistic regression model highlighted the significant associations between (1) patient employment status and (2) age less than 65 years with patient-reported inadequate pain control 6 weeks after TSA. Our findings in regards to age were once again consistent with those shown in other studies.[9,23] In patients treated by orthopedic trauma surgeons, unemployment was a risk factor for perceived inadequate pain control and higher opioid usage.[7] The second logistic regression model in our analysis illustrated that (1) unemployed patients and (2) preoperative opioid users were at a greater risk of requesting an opioid medication refill after TSA. The inclusion of patient age as a model covariate also aided the predictive capability of this model. Taken together, the clinical significance of these models could be of help to improve preoperative counseling and postoperative guidance for patients at risk for increased opioid requirements after TSA. Future studies could further add to knowledge obtained from this study by prospectively comparing postoperative pain control and functional measures by age, sex, and other groupings. In addition, a longer follow-up (1 year and beyond) and assessment of patient return to preoperative activities of daily living may be beneficial.

In addition to the several aforementioned strengths, our investigation did have limitations. For example, no standardized preoperative and postoperative assessments of pain, such as visual analog scale, and function, such as Disabilities of the Arm, Shoulder, and Hand and American Shoulder and Elbow Surgeons Standardized Form, were routinely available for all patients in the study. This is an inherent drawback of the retrospective nature of the study and limits precise quantification of pain reduction from preoperative levels and its variation as time from surgery progressed. It also limits comparisons of functional outcomes with those reported in the literature. Future investigations would ideally collect visual analog scale; Disabilities of the Arm, Shoulder, and Hand; American Shoulder and Elbow Surgeons; and other functional assessments at multiple time points, preoperatively and postoperatively. Another limitation of the study was a lack of standardization of a script for preoperative counseling, and systematic tracking of actual opioid pills consumed. Thus, the specific quantity of opioids consumed by patients was not documented *per se*, but the amount of opioids requested by the patient in the prescription was known. Related to this, the patients were not routinely prescribed nonsteroidal anti-inflammatory drugs or acetaminophen at discharge, but all the patients were recommended to take ibuprofen or acetaminophen for pain control, unless limited by medical history or allergies. The consumption of such nonopiate medications and their effect on pain control could not be measured. Ideally, standardization of preoperative and postoperative measurement and counseling of opioid usage, in the setting of a prospective randomized controlled trial, would help control for potential cofounders, and this could be a future research direction. The role of arthroplasty for fracture and opioid consumption was not explored in our investigation, and it would be interesting to explore further in a future study. Finally, our study interval of interest was up to the 6-week postoperative time point and may have benefited from a longer follow-up (eg, 1 year) for a more detailed assessment of functional assessments. However, we selected the 6-week time point because this represents the end of surgeon-driven opioid prescribing, as per our institution's policy.

Conclusion

This study represents a detailed evaluation of patient- and surgical-based risk factors for increased opioid requirements after TSA. After TSA, MED usage is higher for patients younger than 65 years of age. Moreover, age, preoperative opioid use, and unemployment status were shown to be the independent risk factors of suboptimal outcomes in patient-reported pain control. Prospective studies using these data to guide interventions may be beneficial.

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