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Diabetes status and postoperative complications for patients receiving open rotator cuff repair

Theodore Quan[1], Joseph Emanuele Manzi[2], Frank R Chen[3], Ryan Rauck[4], Melina Recarey[5], Natalia Roszkowska[6], Chenel Morrison[6] and Zachary R Zimmer[1]

Abstract

Background: Diabetic patients are known to have poor wound healing and worse outcomes following surgeries. The purpose of this study is to evaluate diabetes status and complications for patients receiving open rotator cuff repair.
Methods: Patients undergoing open rotator cuff repair from 2006 to 2018 were identified in a national database. Patients were stratified into 3 cohorts: no diabetes mellitus, non-insulin dependent diabetes mellitus (NIDDM), and insulin dependent diabetes mellitus (IDDM). Differences in demographics, comorbidities, and complications were assessed with the use of bivariate and multivariate analyses.
Results: Of 7678 total patients undergoing open rotator cuff repair, 6256 patients (81.5%) had no diabetes, 975 (12.7%) had NIDDM, and 447 (5.8%) had IDDM. Bivariate analyses revealed that IDDM patients had increased risk of mortality, extended length of stay, and readmission compared to non-diabetic patients ($p < 0.05$ for all). IDDM patients had higher risks of major complications and readmission relative to NIDDM patients ($p < 0.05$ for both). On multivariate analysis, there were no differences in any postoperative complications between the non-diabetic, NIDDM, and IDDM groups.
Discussion: Diabetes does not affect postoperative complications following open rotator cuff repairs. Physicians should be aware of this finding and counsel their patients appropriately.
Level of Evidence: III

Keywords

open rotator cuff repair, diabetes mellitus, non-insulin dependent, insulin dependent, postoperative complications

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Introduction

The number of rotator cuff repair procedures performed has increased steadily over the past 20 years.[1] Individuals with diabetes mellitus (DM) have been shown to have worse postoperative outcomes and more complications after a variety of surgical procedures.[2–4] The impact of DM status on postoperative complication rates following open rotator cuff repair has not been fully elucidated.

Diabetic status and postoperative complications have been investigated for other orthopedic surgeries. In foot and ankle surgery, each one-percent increase in HbA1c increases the odds of infection by a factor of 1.59 and increases the odds of postoperative wound complications by a factor of 1.25.[5] In joint replacement surgery, hyperglycemia is believed to increase the risk of infections, impaired

[1]Orthopaedic Surgery, The George Washington University School of Medicine and Health Sciences, Washington, District of Columbia, United States
[2]Weill Cornell Medicine, New York, United States
[3]Department of Anesthesiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, United States
[4]Sports Medicine, Hospital for Special Surgery, New York, United States
[5]Department of Orthopaedic Surgery, The George Washington University School of Medicine and Health Sciences, Washington, District of Columbia, United States
[6]Weill Cornell Medical College, New York, United States

Corresponding author:
Theodore Quan, Orthopaedic Surgery, The George Washington University School of Medicine and Health Sciences, 2300 I St NWWashington, District of Columbia 20052, United States.
Email: teddyquan@gwmail.gwu.edu

wound healing, cardiovascular events, venous thromboembolism, and mortality.[6] In primary total hip arthroplasty, an HbA1c level of 7.5 mg/dL or greater is associated with an increased risk of deep infection compared to patients below this threshold (OR: 2.6).[7]

However, beyond examining differences between patients with diabetes and patients without diabetes, there are important distinctions with respect to the etiology and pathophysiology of the disease. insulin dependent diabetes mellitus (IDDM) and non-insulin-dependent diabetes mellitus (NIDDM) differ with respect to the average age, race, ethnicity, geography, and socioeconomic status of the populations they preferentially affect.[8–11] They also differ with respect to genetic factors and environmental modifiers, including obesity.[8–10]

While short term complications following rotator cuff repair procedures are uncommon, they are more prevalent following open repairs than arthroscopic repairs (OR: 1.6).[12] Unplanned surgical interventions and deep wound infections are two of the most common complications following open rotator cuff repairs.[12,13] Several risk factors for complications following open surgery have been identified, including smoking, which increases the risk of venous thromboembolic events and pulmonary embolism.[13] It has also been postulated that the indications for surgery are influential in determining postoperative outcomes: as arthroscopy continues to become more widely available and used, open surgery may yet yield better outcomes in cases of compromised bone and tendon tissue quality or massive tear size.[14]

The purpose of this study was to investigate DM status and postoperative complications for patients receiving open rotator cuff repair. Based on previous reports of increased postoperative complications in patients with DM in other procedure types, it was hypothesized that patients with DM would have higher rates of postoperative complications following open rotator cuff repair. In addition, based on the pathophysiological differences between IDDM and NIDDM, it was hypothesized that there would be differences in postoperative complications between the two subcategories of patients with diabetes.

Materials and methods

A retrospective cohort study was performed with the utilization of data collected from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database for the years 2006 to 2018. The ACS-NSQIP is a national registry that includes de-identified patient-level data on surgical procedures from more than 700 participating institutions. Rigorous data collection by trained clinical reviewers has led to high inter-rater reliability when using this database.[15,16] This database includes preoperative demographic and comorbidity information, perioperative events, and postoperative complications for patients undergoing orthopedic and non-orthopedic surgical procedures.[17–19]

Patient selection

Patients who underwent open rotator cuff repair were identified using Current Procedural Terminology codes 23,410 and 23,412. Patients were excluded from this study if they had missing baseline demographics data, including gender, race, or American Society of Anesthesiologists (ASA) class was unknown. Patients with disseminated cancer, wound infection, and sepsis on admission were also excluded from our study. Three subgroups were used to assess the impact of diabetes on complications following surgery: patients without diabetes mellitus (non-DM), patients with NIDDM, and patients with IDDM.

Patient characteristics

Data regarding patients' baseline demographics and clinical characteristics included age, gender, race, body mass index (BMI), ASA class, smoking status, and functional status. Functional status focused on the patient's abilities to perform activities of daily living, including bathing, dressing, feeding, toileting, and mobility. Patients who were defined as having an independent functional status did not require assistance from another person for any activities of daily living. Dependent functional status was defined as those who required some assistance or total assistance for activities of daily living. Patient medical comorbidities and anesthesia type were identified.

Postoperative outcomes

The primary outcomes were the rate of complications and unplanned hospital readmission within 30 days of open rotator cuff repair. Based on the type of complication, thirty-day postoperative complications were classified into clinically relevant domains. These domains included wound (superficial surgical site infection, deep surgical site infection, organ or space infections, or wound disruption), cardiac (cardiac arrest or myocardial infarction), pulmonary (pneumonia, reintubation, or failure to wean off ventilator for more than 48 h), renal (renal failure or renal insufficiency), thromboembolic (deep vein thrombosis, pulmonary embolism, or stroke), and sepsis (sepsis or septic shock). Based on previous studies, major complications (cardiac arrest, pulmonary embolism, intubation, myocardial infarction, sepsis, septic shock, renal failure, deep surgical site infection or mortality) and minor complications (urinary tract infection, deep vein thrombosis, pneumonia, or superficial surgical site infection) were also categorized.[20,21] In addition, postoperative transfusion requirement, postoperative admission, extended length of stay, reoperation and readmission were recorded. Based on the

Table 1. Demographics and clinical characteristics Among patients undergoing open rotator cuff repair.

Demographics	No DM	NIDDM	IDDM	*p*-value: NIDDM vs No DM	*p*-value: IDDM vs No DM	*p*-value: IDDM vs NIDDM
Total patients, n	6256	975	447			
Sex, n (%)				**0.029**[a]	**0.001**[a]	0.149[a]
Female	2687 (43.0)	455 (46.7)	227 (50.8)			
Male	3569 (57.0)	520 (53.3)	220 (49.2)			
Ethnicity, n (%)				**< 0.001**[a]	**< 0.001**[a]	**0.022**[a]
Caucasian	5065 (81.0)	715 (73.3)	340 (76.1)			
Black or African American	394 (6.3)	84 (8.6)	49 (11.0)			
Hispanic	503 (8.0)	111 (11.4)	46 (10.3)			
American Indian or Alaska Native	78 (1.2)	13 (1.3)	5 (1.1)			
Asian	175 (2.8)	41 (4.2)	5 (1.1)			
Native Hawaiian or Pacific Islander	41 (0.7)	11 (1.1)	2 (0.4)			
ASA, n (%)				**< 0.001**[a]	**< 0.001**[a]	**< 0.001**[a]
I	490 (7.8)	2 (0.2)	2 (0.4)			
II	3713 (59.4)	335 (34.4)	92 (20.6)			
III	1996 (31.9)	611 (62.7)	322 (72.0)			
IV	57 (0.9)	27 (2.8)	31 (6.9)			
Smoker, n (%)	1188 (19.0)	163 (16.7)	86 (19.2)	0.090[a]	0.897[a]	0.245[a]
Functional status, n (%)				0.071[a]	**< 0.001**[a]	**0.036**[a]
Independent	6138 (99.6)	949 (99.1)	429 (97.3)			
Partially dependent	26 (0.4)	8 (0.8)	10 (2.3)			
Totally dependent	1 (0.0)	1 (0.1)	2 (0.5)			
Mean age, yrs (SD)	59.09 (11.11)	62.46 (9.82)	61.08 (9.72)	**< 0.001**[b]	**< 0.001**[b]	**0.014**[b]
Mean BMI (SD)	30.76 (6.72)	34.26 (7.60)	34.98 (7.51)	**< 0.001**[b]	**< 0.001**[b]	0.097[b]

[a]Pearson's chi-squared test.
[b]Analysis of variance.
DM, diabetes mellitus; NIDDM, non-insulin dependent diabetes mellitus; IDDM, insulin dependent diabetes mellitus; ASA, American Society of Anesthesiologists; SD, standard deviation; BMI, body mass index.
Bolding indicates that the p-value is significant, which means that it is less than 0.05.

existing literature, postoperative admission was defined as at least one overnight stay in the hospital immediately after the surgery.[22,23] Extended length of stay was defined as > 3 days, or one standard deviation above the mean length of stay for the patients in this study.

Statistical analysis

Statistical Package for the Social Sciences (SPSS; Version 26; Armonk, NY) software was used to conduct the statistical analyses in this study. Using bivariate analyses, data on patient demographics, comorbidities, and postoperative complications were analyzed using Pearson's Chi-squared test and analysis of variance where appropriate. Logistic regressions were performed for multivariate analyses to determine the risk factors that are independently associated with postoperative complications. Demographic and comorbidity variables that achieved significance at $p < 0.20$ were included in the multivariable logistic regression.[24,25] Postoperative complication variables with a p-value <0.05 were selected for multivariate analyses. A p-value of < 0.05 was the cut-off value for statistical significance in this study.

Results

In total, 7678 patients who underwent open rotator cuff repair were included in the analysis after application of the exclusion criteria. There were 6256 patients (81.5%) in the non-DM group. Among the patients with diabetes, 975 (12.7%) were in the NIDDM group and 447 (5.8%) were in the IDDM group. Compared to patients without diabetes, patients with NIDDM were more likely to be older, female, non-Caucasian, have a higher BMI, and have an ASA class of III or IV ($p < 0.05$ for all). Similar demographics were seen when comparing patients with IDDM to patients without diabetes, except that patients with IDDM were more likely to have a dependent functional status

Table 2. Comorbidities and intraoperative variables Among patients undergoing open rotator cuff repair.

Comorbidities	No DM	NIDDM	IDDM	p-value: NIDDM vs No DM[a]	p-value: IDDM vs No DM[a]	p-value: IDDM vs NIDDM[a]
Total patients, n	6256	975	447			
COPD, n (%)	251 (4.0)	65 (6.7)	49 (11.0)	**< 0.001**	**< 0.001**	**0.006**
CHF, n (%)	2 (0.0)	1 (0.1)	5 (1.1)	0.314	**< 0.001**	**0.006**
Hypertension, n (%)	2878 (46.0)	795 (81.5)	377 (84.3)	**< 0.001**	**< 0.001**	0.198
Dialysis, n (%)	6 (0.1)	1 (0.1)	4 (0.9)	0.950	**< 0.001**	**0.019**
Renal failure, n (%)	0 (0.0)	2 (0.2)	1 (0.2)	**< 0.001**	**< 0.001**	0.943
Steroid use, n (%)	131 (2.1)	14 (1.4)	6 (1.3)	0.173	0.278	0.889
Bleeding disorder, n (%)	106 (1.7)	20 (2.1)	19 (4.3)	0.428	**< 0.001**	**0.018**
Dyspnea, n (%)				**0.010**	**< 0.001**	**0.004**
No dyspnea	5945 (95.0)	906 (92.9)	393 (87.9)			
Moderate exertion	285 (4.6)	66 (6.8)	49 (11.0)			
At rest	26 (0.4)	3 (0.3)	5 (1.1)			
Anesthesia type, n (%)				0.622	0.832	0.663
General	5980 (95.7)	937 (96.2)	433 (96.9)			
Neuraxial	7 (0.1)	0 (0.0)	0 (0.0)			
Regional	197 (3.2)	32 (3.3)	11 (2.5)			
MAC	52 (0.8)	4 (0.4)	3 (0.7)			

[a]Pearson's chi-squared test.

DM, diabetes mellitus; NIDDM, non-insulin dependent diabetes mellitus; IDDM, insulin dependent diabetes mellitus; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; MAC, monitored anesthetic care.

Bolding indicates that the p-value is significant, which means that it is less than 0.05.

($p < 0.01$ for all). Compared to NIDDM patients, patients with IDDM were more likely to be younger ($p = 0.014$), Caucasian or Black ($p = 0.022$), have an ASA class of III or IV ($p < 0.001$), and have a dependent functional status ($p = 0.036$) (Table 1).

Relative to patients without diabetes, patients with NIDDM were more likely to have comorbidities, including chronic obstructive pulmonary disease (COPD) ($p < 0.001$), hypertension ($p < 0.001$), renal failure ($p < 0.001$), and dyspnea ($p = 0.010$). Similar comorbidity findings were seen between non-diabetic and patients with IDDM, except that patients with IDDM were more likely to have congestive heart failure (CHF), dialysis, and bleeding disorders ($p < 0.001$ for all). Compared to patients with NIDDM, patients with IDDM were more likely to have COPD ($p = 0.006$), CHF ($p = 0.006$), dialysis ($p = 0.019$), bleeding disorders ($p = 0.018$), and dyspnea ($p = 0.004$) (Table 2).

On bivariate analysis, patients with NIDDM had no significant difference in developing postoperative complications compared to non-diabetic patients ($p > 0.05$ for all). Compared to patients without diabetes, patients with IDDM were at increased risk of mortality ($p = 0.014$), extended length of stay ($p = 0.014$), and readmission ($p = 0.005$). Relative to patients with NIDDM, patients with IDDM were at increased risk of major complications ($p = 0.019$) and readmission ($p = 0.025$) (Table 3). Following adjustment for covariates on multivariate analyses, there were no differences in any postoperative complications between the non-diabetic, NIDDM, and IDDM groups ($p > 0.05$ for all) (Table 4).

Discussion

Multivariate analyses demonstrated no significant differences in postoperative complication rates between the

Table 3. Bivariate analysis of postoperative complications of patients following open rotator cuff repair.

Complications	No DM	NIDDM	*p*-value: NIDDM vs No DM[a]	IDDM	*p*-value: IDDM vs No DM[a]	*p*-value: IDDM vs NIDDM[a]
Total patients, n	6256	975		447		
Any complication, n (%)	93 (1.5)	12 (1.2)	0.535	11 (2.5)	0.107	0.088
Major complication, n (%)[b]	22 (0.4)	1 (0.1)	0.199	4 (0.9)	0.074	**0.019**
Minor complication, n (%)[c]	62 (1.0)	10 (1.0)	0.919	7 (1.6)	0.245	0.384
Death, n (%)	1 (0.0)	0 (0.0)	0.693	1 (0.2)	**0.014**	0.140
Wound complication, n (%)	34 (0.5)	5 (0.5)	0.903	5 (1.1)	0.122	0.204
Cardiac complication, n (%)	4 (0.1)	1 (0.1)	0.670	1 (0.2)	0.232	0.571
Pulmonary complication, n (%)	10 (0.2)	3 (0.3)	0.311	2 (0.4)	0.165	0.679
Renal complication, n (%)	0 (0.0)	0 (0.0)	-	0 (0.0)	-	-
Thromboembolic complication, n (%)	21 (0.3)	1 (0.1)	0.219	2 (0.4)	0.696	0.188
Sepsis complication, n (%)	1 (0.0)	0 (0.0)	0.693	0 (0.0)	0.789	-
Urinary tract infection, n (%)	19 (0.3)	2 (0.2)	0.595	1 (0.2)	0.765	0.943
Postoperative transfusion, n (%)	6 (0.1)	1 (0.1)	0.950	0 (0.0)	0.512	0.498
Postoperative admission, n (%)	1441 (23.0)	234 (24.0)	0.506	114 (25.5)	0.232	0.540
Extended length of stay, n (%)	62 (1.0)	12 (1.2)	0.489	10 (2.2)	**0.014**	0.153
Reoperation, n (%)	40 (0.6)	9 (0.9)	0.315	6 (1.3)	0.082	0.473
Readmission, n (%)	78 (1.8)	12 (1.7)	0.864	13 (4.0)	**0.005**	**0.025**

[a]Pearson's chi-squared test.
[b]Includes cardiac arrest, pulmonary embolism, myocardial infarction, unplanned intubation, sepsis, septic shock, acute renal failure, or mortality.
[c]Includes urinary tract infection, pneumonia, deep venous thrombosis, superficial surgical site infection, or deep surgical site infection.
DM, diabetes mellitus; NIDDM, non-insulin dependent diabetes mellitus; IDDM, insulin dependent diabetes mellitus.
Bolding indicates that the p-value is significant, which means that it is less than 0.05.

Table 4. Multivariate analysis of postoperative complications of patients following open rotator cuff repair.

	NIDDM		IDDM		IDDM	
Complications	*p*-value	Odds ratio (NIDDM/No DM) (95% CI)	*p*-value	Odds ratio (IDDM/No DM) (95% CI)	*p*-value	Odds ratio (IDDM/ NIDDM) (95% CI)
Major complication[a]	0.216	0.275 (0.036 to 2.121)	0.140	2.415 (0.749 to 7.791)	0.177	4.983 (0.484 to 51.254)
Death	0.263	0.921 (0.799 to 1.063)	0.185	6.618 (0.404 to 108.417)	0.500	1.099 (0.835 to 1.446)
Extended length of stay	0.861	0.942 (0.482 to 1.840)	0.297	1.493 (0.703 to 3.172)	0.335	1.553 (0.635 to 3.802)
Readmission	0.527	0.811 (0.423 to 1.553)	0.303	1.445 (0.717 to 2.914)	0.110	2.014 (0.853 to 4.754)

[a]Includes cardiac arrest, pulmonary embolism, myocardial infarction, unplanned intubation, sepsis, septic shock, acute renal failure, or mortality.
DM, diabetes mellitus; NIDDM, non-insulin dependent diabetes mellitus; IDDM, insulin dependent diabetes mellitus; CI, confidence interval.

three groups. This is contrary to both hypotheses of this study: there was no increase in complication rates in patients with IDDM or patients with NIDDM compared to patients without diabetes, and there was no difference in complication rates between patients with IDDM and patients with NIDDM. However, the analyses show statistically insignificant trends towards increased rates of major complications and death in the IDDM group compared to the non-diabetic group and increased rates of major complications and readmission in the IDDM group compared to the NIDDM group.

Major complications included cardiac arrest, pulmonary embolism, myocardial infarction, unplanned intubation, sepsis, septic shock, acute renal failure, or mortality. The trend towards an increase in these complications in patients with IDDM is likely due to the metabolic consequences of the disease, which have been quantified.[26–32] The trend towards increased readmission rates in the IDDM group compared to the NIDDM group could be, at least in part, due to acute episodes of diabetic ketoacidosis, a common cause of hospital readmissions in patients with IDDM.[33] There is also evidence that postpartum women with pregnancies complicated by pregestational IDDM are at increased risk of readmission in the 60 days following childbirth, potentially due to increases in hypertensive diseases of pregnancy.[34]

This study has several limitations. One limitation is that we did not compare A1C levels for diabetic patients and were unable to investigate if poorly controlled DM patients did worse.[35] In addition, there were several potentially confounding demographic and comorbidities variable between the patients with NIDDM and IDDM. Given that diabetes is associated with many disparate medical conditions, we are unable to conclude if diabetic status alone contributes to postoperative complications even when adjusting for these confounders. This is because diabetes is a systemic disease that affects all organ systems. Another limitation is that while we did not find associations between diabetes and postoperative complications for open rotator cuff repair within our 30-day postoperative window, they could have experienced complications at a later time point. Future studies should examine complications of diabetic patients following open rotator cuff repair beyond the 30-day follow-up period. We were also unable to confirm if patients were at increased risk of rotator cuff retears, which has been reported with Yang et al.'s meta-analysis in 2020.[36]

Future work could investigate additional subsets of patients with DM.[37–40] Bloomgarden and Drexler established four subcategories of DM: severe insulin deficiency diabetes, severe insulin resistance diabetes, mild obesity-related diabetes, and mild age-related diabetes.[41] There are differences across the four groups with respect to HbA1c levels, BMI, and age of diagnosis—all of which are factors that may play into the postoperative complication rate.

In conclusion, in this large national database study, we found that diabetes status does not affect postoperative complications for patients undergoing open rotator cuff repairs when adjusting for demographic and comorbidity variables.

Contributorship

TQ, JM, FC, RR, NR, CM, and MR researched literature and conceived the study. TQ, JM, FC, and RR wrote the first draft of the manuscript. ZZ reviewed and provided corrections to the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript

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Ethical approval (*include full name of committee approving the research and if available mention reference number of that approval)*

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Guarantor

*TQ

ORCID iDs

Theodore Quan https://orcid.org/0000-0001-8730-0804
Joseph Emanuele Manzi https://orcid.org/0000-0002-8825-0105

References

1. Jancuska J, Matthews J, Miller T, et al. A systematic summary of systematic reviews on the topic of the rotator cuff. *Orthop J Sports Med* 2018; 6: 2325967118797891.
2. Alfonso AR, Kantar RS, Ramly EP, et al. Diabetes is associated with an increased risk of wound complications and readmission in patients with surgically managed pressure ulcers. *Wound Repair Regen* 2019; 27: 249–256.
3. Hart A, Funderburk CD, Chu CK, et al. The impact of diabetes mellitus on wound healing in breast reconstruction. *Ann Plast Surg* 2017; 78: 260–263.
4. Schairer WW, Nwachukwu BU, Fu MC, et al. Risk factors for short-term complications after rotator cuff repair in the United States. *Arthroscopy* 2018; 34: 1158–1163.
5. Humphers J, Shibuya N, Fluhman BL, et al. The impact of glycosylated hemoglobin and diabetes mellitus on postoperative wound healing complications and infection following foot and ankle surgery. *J Am Podiatr Med Assoc* 2014; 104: 320–329.
6. Lopez LF, Reaven PD and Harman SM. Review: the relationship of hemoglobin A1c to postoperative surgical risk with an emphasis on joint replacement surgery. *J Diabetes Complications* 2017; 31: 1710–1718.
7. Cancienne JM, Werner BC and Browne JA. Is there a threshold value of hemoglobin A1c that predicts risk of infection following primary total hip arthroplasty? *J Arthroplasty* 2017; 32: S236–S240.
8. Chan JM, Rimm EB, Colditz GA, et al. Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. *Diabetes Care* 1994; 17: 961–969.
9. Colditz GA, Willett WC, Rotnitzky A, et al. Weight gain as a risk factor for clinical diabetes mellitus in women. *Ann Intern Med* 1995; 122: 481–486.
10. Prasad RB and Groop L. Genetics of type 2 diabetes-pitfalls and possibilities. *Genes (Basel)* 2015; 6: 87–123.
11. Skyler JS, Bakris GL, Bonifacio E, et al. Differentiation of diabetes by pathophysiology, natural history, and prognosis. *Diabetes* 2017; 66: 241–255.
12. Day M, Westermann R, Duchman K, et al. Comparison of short-term complications after rotator cuff repair: open versus arthroscopic. *Arthroscopy* 2018; 34: 1130–1136.
13. Best MJ, Aziz KT, Nayar SK, et al. Smoking is an independent risk factor for complications following open rotator cuff repair. *Phys Sportsmed* 2020; 48: 469–472.
14. Gil JA and Owens BD. Editorial commentary: don't throw away the retractors: complications of open versus arthroscopic rotator cuff repair could be influenced by indications. *Arthroscopy* 2018; 34: 1137–1138.
15. Tornero E, García-Oltra E, García-Ramiro S, et al. Prosthetic joint infections due to staphylococcus aureus and coagulase-negative staphylococci. *Int J Artif Organs* 2012; 35: 884–892.
16. Trickey AW, Wright JM, Donovan J, et al. Interrater reliability of hospital readmission evaluations for surgical patients. *Am J Med Qual* 2017; 32: 201–207.
17. Bohl DD, Ondeck NT, Darrith B, et al. Impact of operative time on adverse events following primary total joint arthroplasty. *J Arthroplasty* 2018; 33: 2256–2262.e4.
18. Bovonratwet P, Malpani R, Ondeck NT, et al. Elective total shoulder arthroplasty in octogenarians: a safe procedure. *J Am Acad Orthop Surg* 2019; 27: 145–154.
19. Surace P, Sultan AA, George J, et al. The association between operative time and short-term complications in total aip arthroplasty: an analysis of 89,802 surgeries. *J Arthroplasty* 2019; 34: 426–432.
20. Dieterich JD, Fields AC and Moucha CS. Short term outcomes of revision total knee arthroplasty. *J Arthroplasty* 2014; 29: 2163–2166.
21. Liodakis E, Bergeron SG, Zukor DJ, et al. Perioperative complications and length of stay after revision total hip and knee arthroplasties: an analysis of the NSQIP database. *J Arthroplasty* 2015; 30: 1868–1871.
22. Agarwalla A, Gowd AK, Yao K, et al. A 15-minute incremental increase in operative duration is associated with an additional risk of complications within 30 days after arthroscopic rotator cuff repair. *Orthop J Sports Med* 2019; 7: 2325967119860752.
23. McGlone PJ, Li LT, Bokshan SL, et al. Preoperative malnutrition increases odds of hospital admission and extended length of stay following arthroscopic rotator cuff repair. *Phys Sportsmed* 2021; 49: 236–240.
24. Chen AZ, Gu A, Selemon NA, et al. Preoperative estimated glomerular filtration rate is a marker for postoperative complications following aseptic revision total hip arthroplasty. *Eur J Orthop Surg Traumatol* 2021; 31: 175–182.
25. Tihista M, Gu A, Wei C, et al. The impact of long-term corticosteroid use on acute postoperative complications following lumbar decompression surgery. *J Clin Orthop Trauma* 2020; 11: 921–927.
26. de Beer JC and Liebenberg L. Does cancer risk increase with HbA1c, independent of diabetes? *Br J Cancer* 2014; 110: 2361–2368.
27. Dubovi I, Levy ST, Levy M, et al. Glycemic control in adolescents with type 1 diabetes: are computerized simulations effective learning tools? *Pediatr Diabetes* 2020; 21: 328–338.

28. Garg G, Tyler JR, Yang JH, et al. Type 1 diabetes-associated IL2RA variation lowers IL-2 signaling and contributes to diminished CD4 + CD25 + regulatory T cell function. *J Immunol* 2012; 188: 4644–4653.
29. Jenny L, Ajjan R, King R, et al. Plasma levels of mannan-binding lectin-associated serine proteases MASP-1 and MASP-2 are elevated in type 1 diabetes and correlate with glycaemic control. *Clin Exp Immunol* 2015; 180: 227–232.
30. Lohse Z, Bytoft B, Knorr S, et al. Abnormal levels of adipokines in adolescent offspring of women with type 1 diabetes - results from the EPICOM study. *Metabolism* 2017; 72: 47–56.
31. Sevaliev N, Strich D, Avnon-Ziv C, et al. The metabolic consequences of overweight in a cohort of children with type 1 diabetes. *J Pediatr Endocrinol Metab* 2019; 32: 715–719.
32. Zarranz-Ventura J, Barraso M, Alé-Chilet A, et al. Evaluation of microvascular changes in the perifoveal vascular network using optical coherence tomography angiography (OCTA) in type I diabetes mellitus: a large scale prospective trial. *BMC Med Imaging* 2019; 19: 91. doi: 10.1186/s12880-019-0391-8
33. Everett E and Mathioudakis NN. Association of socioeconomic status and DKA readmission in adults with type 1 diabetes: analysis of the US national readmission database. *BMJ Open Diabetes Res Care* 2019; 7: e000621.
34. Mourad M, Wen T, Friedman AM, et al. Postpartum readmissions among women dith diabetes. *Obstet Gynecol* 2020; 135: 80–89.
35. International Expert Committee. International expert committee report on the role of the A1C assay in the diagnosis of diabetes. *Diabetes Care* 2009; 32: 1327–1334.
36. Yang L, Zhang J, Ruan D, et al. Clinical and structural outcomes after rotator cuff repair in patients with diabetes: a meta-analysis. *Orthop J Sports Med* 2020; 8: 2325967120948499.
37. Beck RW, Connor CG, Mullen DM, et al. The fallacy of average: how using HbA_{1c} alone to assess glycemic control can be misleading. *Diabetes Care* 2017; 40: 994–999.
38. Cohen RM, Franco RS, Khera PK, et al. Red cell life span heterogeneity in hematologically normal people is sufficient to alter HbA1c. *Blood* 2008; 112: 4284–4291.
39. Hainsworth DP, Bebu I, Aiello LP, et al. Risk factors for retinopathy in type 1 diabetes: the DCCT/EDIC study. *Diabetes Care* 2019; 42: 875–882.
40. Malka R, Nathan DM and Higgins JM. Mechanistic modeling of hemoglobin glycation and red blood cell kinetics enables personalized diabetes monitoring. *Sci Transl Med* 2016; 8: 359ra130.
41. Bloomgarden Z and Drexler A. Diabetes phenotypes: beyond IDDM vs NIDDM. *J Diabetes* 2019; 11: 698–699.