Comorbidities in Total Hip and Knee Arthroplasty Patients: When Is It Okay to Say No?

Faisal Akram, MD[a,*,1], Joyee Tseng, MD[b,2], Omar Behery, MD, MPH[b,2], Brett R. Levine, MD, MS[b,2]

KEYWORDS

• Primary total knee arthroplasty • Primary total hip arthroplasty • Ethics of surgical cutoffs • Preoperative optimization • Postoperative complications • Bundled payment system • Morbid obesity • Diabetes mellitus

KEY POINTS

- Preoperative optimization in primary total hip and knee arthroplasty reduces postoperative complications and enhances patient outcomes.
- Balancing surgical risk and benefit in higher risk total joint arthroplasty, while maintaining the principles of beneficence and nonmaleficence, is the ethical responsibility the surgeons.
- The authors provide a set of recommended guidelines for obesity, diabetes mellitus, and active smoking.
- This article discusses ethics of surgical cutoffs, delaying care, and impact on health care disparities.

INTRODUCTION

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) continue to remain an effective operative intervention for end-stage osteoarthritis with excellent long-term outcomes and improvements in pain relief, range of motion, and functional mobility. The annual numbers of primary THAs and TKAs are predicted to exponentially increase by 174% to 572,000 and by 673% to 3.48 million by 2030, respectively.[1] Subsequently, projected growth for rates of revision of hip and knee arthroplasties are also expected to increase by 137% and 601% between 2005 and 2030.[1,2] Within this growing population, an increased prevalence of comorbidities including morbid obesity (body mass index [BMI] $\geq$ 40 kg/m^2), diabetes mellitus, and active tobacco use poses a higher risk of complications after surgery.[3,4] This increased risk of complication creates a complex, ethical dilemma regarding when to say no to these patients for an elective THA or TKA.

The goal of THA and TKA surgery is to relieve pain and improve the quality of life for patients, yet the unintended consequence associated with complications in these "high-risk" cases may compromise outcomes.[5] As orthopedic surgeons, we often feel a deep sense of empathy and a Hippocratic responsibility in wanting to help patients, while maintaining the expectations of doing no harm. Therefore, surgeons must maintain a clear

Knee and Hip Reconstruction Section of the *Ethics and Professionalism in Orthopedics* issue of *Orthopedic Clinics of North America*.

[a] Department of Orthopaedic Surgery, Corewell Health and Michigan State University, Grand Rapids, MI, USA; [b] Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, IL, USA
[1]Present address: 100 Michigan Street Northeast, MC188, Grand Rapids, MI 49503.
[2]Present address: 1611 West Harrison Street, Suite 300, Chicago, IL 60612.
* Corresponding author. Department of Orthopaedic Surgery, Rush University Medical Center, 1611 West Harrison Street, Suite 300, Chicago, IL 60612.
E-mail address: faisalakrammd@gmail.com

Orthop Clin N Am 56 (2025) 1–12
https://doi.org/10.1016/j.ocl.2024.01.003

understanding of potential modifiable risk factors and perioperative complications to engage in an informed patient-centered discussion to manage expected surgical outcomes. Creating definitive cutoffs may lead to access-to-care issues creating a difficult balance between helping and harming patients based upon their perioperative comorbidities. Certainly for modifiable risk factors, patients and surgeons should participate in a shared decision-making process to determine when it is most optimal to proceed with surgery.

Bundled payment systems have added another layer of complexity, making it financially difficult and challenging for surgeons to take on patients at higher risk for postoperative complications. Strict numerical cutoffs for BMI, hemoglobin A1c (HbA1c), and smoking cessation with preoperative nicotine testing, imposed by health care institutions, have dehumanized and disincentivized surgeons, resulting in "cherry picking" the healthiest patients to maintain better outcome scorecards and financial viability.[6] These cutoffs inevitably affect populations prone to socioeconomic health care disparities (African American, Hispanic, and other non-Caucasian ethnicities) that are often lacking access to primary care providers (PCPs) and specialty preoperative optimization services.[7] This often disproportionately impacts underserved communities pushing these quality of life–improving procedures further out of reach, and thus, widening the gap in attaining TKA and THA among marginalized populations.[8]

Preoperative optimization of modifiable risk factors for THA and TKA remains a foundational cornerstone in reducing postoperative complications and enhancing patient outcomes. Furthermore, preoperative optimization continues to demonstrate the ability to improve patient's health through enhanced nutrition, controlled weight loss, diabetes management, smoking cessation, reduction in alcohol consumption, strengthening through preoperative physical therapy, and improved cardiovascular health.[9,10] Optimization of modifiable risk factors in elective THA and TKA is thought to afford a reduction in the risk of postoperative complications including periprosthetic joint infections (PJIs), venous thromboembolism (VTE) events, length of hospital stay, length of postoperative rehabilitation, peri-anesthesia complications (cerebral and myocardial infarctions), and functional mobility.[11] This review aims to evaluate modifiable comorbidities including (1) morbid obesity, (2) diabetes mellitus, and (3) active tobacco use and in what scenarios it may be a benefit to the patient to say no to surgery, while opting for delaying surgical intervention with continued medical optimization of risk factors and conservative nonoperative management.

DISCUSSION

Obesity

Obesity, defined as a BMI $\geq$30 kg/m^2, continues to remain a growing pandemic across the United States, with the adult prevalence from 2000 to March 2020 increasing from 30.5% to 41.9%.[11,12] Obesity remains a major risk factor for osteoarthritis due to increased joint reactive forces, maintaining a 3-fold to 5-fold increased risk for developing osteoarthritis in obese patients compared to nonobese patients.[13] With the overlapping and growing rates of obesity among patients with osteoarthritis, the utility of risk-averse elective THA and TKA has become increasingly challenging.[14] Similarly, as many health care systems shift to adopt bundled payment models, efforts to provide cost-effective care[15] in an otherwise increased cost-to-treat patient population has made treatment difficult due to increased length of stay (LOS), operating room times, and a higher risk of 30-day and 90-day complications.[16–20] While morbid obesity is a significant risk factor for postoperative complications, additional concomitant medical conditions may serve as a multiplier for these adverse events.[21]

With a wide range of strict numerical BMI cutoffs ranging from 35 to 45 kg/m^2 among many health care institutions and orthopedic surgeons, the importance of discussing when to say no and the ethics of delaying arthroplasty surgery for obesity risk factor modification (weight loss, healthy dieting, bariatric surgery, exercise, and strengthening with prehabilitation) are crucial.[22] The importance of balancing early access to total joint arthroplasty (TJA) with decreased risk for postoperative complications remains a delicate balance. Delaying an otherwise potentially life-changing arthroplasty surgery for preoperative risk factor modification comes at the cost of lost wages, increased weight gain due to painful mobility, increased use of pain medications (nonsteroidal anti-inflammatory drugs [NSAIDs] and narcotics), worsening deformity and bone quality, and potentially worse functional outcomes.[23–25] Financial pressures and physical limitations can contribute to worsening mental health and self-image in this patient population. Given the influence and motivation a TJA can provide in the setting of obesity for targeted weight loss and potential optimization of other associated comorbidities (diabetes, hypertension, and

malnutrition), orthopedic surgeons will continue to find themselves at the forefront of managing concomitant obesity and osteoarthritis.[26]

The American Association of Hip and Knee Surgeons' (AAHKS) most recent workgroup committee position statement on obesity in the setting of THA and TKA reflects a balanced approach to an otherwise complex problem. Although obese patients (BMI $\geq$30 kg/m^2) maintain an independent risk factor for increased postoperative complications following THA and TKA, the morbidly obese (BMI 40–49 kg/m^2) and super obese (BMI $\geq$50 kg/m^2) patient populations have a disproportionate risk for surgical complications which may outweigh functional benefits. The latter groups may have complication rates higher than patients undergoing a revision arthroplasty.[27] These populations should be counseled on preoperative risk and modifiable interventions with consideration in delaying surgical management for healthy alternative weight loss options. The AAHKS workgroup committee tempered their recommendations without any notable strict BMI cutoffs, but instead with recommendations of a wholistic patient approach.[28] Although bariatric surgery may support effective weight loss, studies have demonstrated postbariatric paradoxic states of malnutrition due to increased difficulty in nutrient absorption resulting in proportional risk to non-bariatric obese patients undergoing THA and TKA.[29–31] The importance placed on a thorough patient-centered preoperative discussion of risk with a potential increase in postoperative complications and decreased functional mid-term to long-term outcomes is essential.

A recent 2021 AAHKS survey aimed to evaluate surgeon decision-making affecting BMI thresholds in obese patients highlighted the impact of the bundled payment model among orthopedic surgeons with 49.9% requiring a BMI $\leq$ 40 kg/m^2 and 24.5% requiring a BMI $\leq$ 45 kg/m^2 prior to proceeding with an elective THA or TKA. Furthermore, 23.8% of surgeons felt a BMI $\leq$ 40 kg/m^2 cutoff would adversely affect their practice volume, while surgeons being more likely to proceed with a TKA with morbid obesity than a THA.[32] Similarly, in a large National Surgical Quality Improvement Program (NSQIP) database retrospective study of 15,321 patients evaluating the incidence of 30-day postoperative complications following TKA, Belmont Jr. and colleagues[33] demonstrated a BMI $\geq$40 kg/m^2 was an independent predictor of both postoperative complications (odds ratio [OR] = 1.47; 95% confidence interval [CI] = 1.09–1.98) including VTE, PJI, postoperative sepsis, renal failure, and cardiac arrest, in addition to minor local complications (OR = 2.01; 95% CI 1.02–3.97) including superficial wound infection and surgical wound dehiscence. Similarly, many studies have evaluated a new classification of super obesity (BMI $\geq$50 kg/m^2) and its effects on postoperative outcomes in elective THA and TKA. Studying the effects of super obesity among the THA and THA population, Schwarzkopf and colleagues demonstrated an overall increased postoperative complication rate (OR, 8.44) with each incremental 5-unit (kg/m^2) BMI increase over BMI $\geq$45 kg/m^2 with an increased risk of developing in hospital complications (OR, 1.69) outpatient complications (OR, 2.71), readmission (OR, 2.0), and increased LOS by 13.8%.[34]

Although morbid and super obesity remain an independent variable for increased postoperative complications, it is important to note that a number of associated comorbidities (uncontrolled diabetes mellitus,[35] chronic renal failure,[36] coronary artery disease, malnutrition,[37] anemia, depression, and active tobacco use) can exponentially increase and compound this risk. In a large single-center analysis of 7181 primary THA and TKAs, the risk of obesity and glycemic control was studied in association with predictors for PJIs. Jämsen and colleagues demonstrated an increased infection rate from 0.37% (95% CI, 0.15% to 0.96%) in patients with a normal BMI ($\leq$30 kg/m^2) to 4.66% (95% CI, 2.47% to 8.62%) in the morbidly obese group. The rate of infection was highest among morbidly obese patients with diabetes at 9.8% (95% CI, 4.26% to 20.98%).[35] Preoperative optimization in these patients is crucial in helping decrease postoperative complications, while being mindful, that delayed surgical intervention may lead to decreased functional mobility due to progressive degenerative joint destruction, potentially causing an increase in weight gain, pain scores, and worsening of associated comorbidities. For this reason, it is imperative that orthopedic surgeons play an advocative and supportive role in encouraging modifiable comorbidity optimization through a multidisciplinary approach.

Several studies have shown the impactful improvement on quality of life TJA has among obese patients with equivalent improvements of validated patient-reported outcome measures (PROMs), functional mobility, and pain scores when compared to nonobese patients undergoing primary THA and TKA.[38] In a national multi-institutional study of a large prospective cohort, Li and colleagues identified 2040 and 2964 patients who underwent primary THA and

TKA, respectively, evaluating for postoperative functional gain and pain relief in the obese patient population. This study demonstrated that although obese patients with hip and knee osteoarthritis had lower preoperative pain catastrophizing scores, hip disability and osteoarthritis outcome scores (HOOS), and knee disability and osteoarthritis outcome scores (KOOS) pain scores ($P<.001$), at 6 months postoperatively both THA and TKA patients showed equivalent mean improvements compared to their matched nonobese patients.[39] Morbidly obese patients can have significant improvements of functional mobility and pain score outcomes at 6 months following primary THA and TKA, demonstrating obesity as an isolated risk factor should not be prohibitive in discussing possible joint arthroplasty.[39] Additionally, in a large retrospective study of 49,475 THA and 77,785 TKA patients, Adhikary and colleagues demonstrated an increased 30-day postoperative complications among morbidly obese patients with a BMI $\geq$45 kg/m^2.[20] While many orthopedic surgeons may recommend delaying surgical intervention beyond BMI $\geq$40 kg/m^2 given the substantial evidence-based literature demonstrating increasing BMI as an independent risk factor of postoperative complications, the ethics of when to say no in the setting of known improvements in postoperative functional mobility, PROMs (HOOS and KOOS), and pain scores continues to remain a highly discussed subject.

Although a strict numerical cutoff is not recommended, we do support utilizing the BMI scale as a guideline to initiating an early discussion about risk factor modification among obese (BMI 35–40 kg/m^2) and morbidly obese (BMI 40–45 kg/m^2) patients identified as THA or TKA candidates. Recommending weight loss through healthy alternatives including dieting and exercise is important so that patients are not self-inducing a paradoxic state of malnutrition prior to surgery, which is equally hazardous. Establishing goals in this patient population can be motivating in giving patients a target to work toward. Studies have shown a target goal of BMI $\leq$40 kg/m^2 or 5% to 10% weight loss leads to clinically significant metabolic improvements including improved control of glycemic index, blood pressure, lipid profile, and overall cardiovascular risk.[40] With even these modest weight loss goals of 5% to 10% of initial body weight, studies demonstrate improved perioperative risk and decreased postoperative complications in patients with morbid obesity undergoing primary THA or TKA.[41] Alternatively, patients that have failed conservative weight loss plans should be referred to specialists to evaluate for personalized plans including possible behavioral counseling, adjuvant pharmacologic management, or surgical interventions.[42] In pursuing risk modification among obese patients, we recommend a wholistic and balanced approach. As orthopedic surgeons, we should advocate encouraging healthy weight loss with a target goal of BMI $\leq$40 kg/m^2 of weight loss, while being mindful obesity may only be a truly "modifiable" risk factor in a small subset of patients. Strict BMI cutoffs should be discouraged as potentially unethical and short sighted. These cutoffs ultimately reduce access to functionally life-changing TJA procedures, with increased prevalence of obesity among lower socioeconomic communities that have limited accessibility to specialized medical care.

Diabetes Mellitus

With a growing prevalence of diabetes mellitus within the United States, poor glycemic control in an aging population continues to remain a difficult risk factor to optimize in patients pursuing TJA. Furthermore, overlapping rates of diabetes and obesity among a population functionally crippled by degenerative osteoarthritis[36] has made risk-averse THA and TKA increasingly challenging for surgeons to navigate. The prevalence of diabetes mellitus among adults in the United States in 2019 was 11.3% (37.3 million), with a higher prevalence of 29.2% (15.9 million) affecting adults 65 years or older.[43] Rates of diabetes disproportionately affect marginalized populations and underserved rural communities with a higher prevalence among American Indians (14.5%), African Americans (12.1%), Hispanics (11.8%), and Asian Americans (9.5%), compared to Caucasians (1.4%).[43] African American and Hispanic populations affected by many racial and geographic disparities are more prone to having overlapping incidences of uncontrolled diabetes and severe osteoarthritis, but remain less likely to undergo TJA.[44–46] The American Diabetes Association (ADA) utilizes HbA1c as a serum marker as a diagnostic criterion for evaluating dysglycemia, with HbA1c $\geq$ 6.5% indicative of diabetes mellitus and poor glycemic control measuring an average blood glucose control over the past 2 to 3 months. Furthermore, the ADA recommends a target HgbA1c $\leq$ 7.0% for patients with diabetes mellitus suggestive of a well-controlled glycemic index. Poor glycemic control has been well documented in the literature as an independent risk factor linked to increased risk

of postoperative surgical wound complications and PJIs among the diabetic TJA population.[46]

With many health care institutions and orthopedic surgeons adhering to a wide range of HbA1c cutoffs, ranging from 7.0% to 8.0%, the importance of discussing when to say no and the ethics of delaying TJA for further preoperative optimization are crucial. This is primarily due to the inconsistencies found in the current literature: (1) the degree of preoperative hyperglycemia directly correlating to a higher risk for postoperative complications and (2) the utility of HbA1c as an accurate screening tool for perioperative diabetic control. Diabetic control continues to remain an elusive and somewhat difficult modifiable risk factor among populations prone to socioeconomic disparities including racial minorities, rural communities, and less-affluent patients. The ability to both attain, and maintain, a strict HbA1c cutoff $\leq$7.0% may not be medically advisable in these patient populations.[47] Giori and colleagues evaluated a cohort of diabetic patients with delayed TJA with a targeted preoperative optimization goal of less than 7% with only 59% of patients (35/59) able to obtain this target cutoff with a mean duration to reach glycemic control of 8 months. In some situations, achieving an HbA1c $\leq$ 8.0% may be more attainable while still resulting in similar risk reduction of postoperative complications.[48] Similarly, adhering to a tighter control of postoperative blood glucose levels to $\leq$200 mg/dL can maintain this risk reduction profile.[49] Several factors can additionally pose as barriers to achieving a controlled glycemic index among underprivileged patient populations including (1) maintaining a healthy diet due to food deserts and food insecurity, (2) inability to access glucometers and testing strips, (3) limited resources in facilitating transportation for medical care, (4) limited access to specialty diabetic care (endocrinologists, surgical optimization clinics, nutritionists, and other such specialists), and (5) inconsistent social support.

The use of HbA1c presents an obstacle in the setting of preoperative optimization in utilizing a screening tool designed to represent a summation of chronic diabetic control over the course of 2 to 3 months, thereby evaluating chronic control as opposed to acute change. Furthermore, glycemic control in the immediate perioperative period has shown an increased association in predicting risk for postoperative complications than chronic glycemic index.[50] There is conflicting evidence supporting the use of HbA1c as a screening tool among TJA patients with some studies demonstrating a poor association between HbA1c levels and postoperative complication rates.[51,52] Many studies have evaluated the utility of fructosamine as a substitute screening tool in predicting the likelihood of risk in early postoperative complications and determining an associated threshold above which there is an increased risk of complications within TJA. In a large multi-institutional prospective study, Shohat and colleagues evaluated the utility of fructosamine compared to HbA1c among 1119 (both diabetic and nondiabetic) patients undergoing TKA evaluating the predictive threshold of determining early 30-day postoperative complications. Patients with high fructosamine levels greater than 293 μmol/L were 11.2 times more likely to develop postoperative wound complications including PJIs, with hospital readmission and revision rates were, respectively, 4.2 (P=.005) and 4.5 (P=.019) times higher in patients with elevated fructosamine levels (>293 μmol/L).[53] Despite the utility of HbA1c in both diagnosing and monitoring control of diabetes mellitus, its role in the setting of TJA continues to remain questionable.

Periprosthetic hip and knee infections are not only a functionally devastating complication with estimated costs to treat ranging up to $389,307 to $474,004 in the United States.[54] In the modern health care environment, it has become increasingly difficult to manage both the cost and risk of postoperative complications including early surgical wound infections and PJIs seen in diabetic patients undergoing TJA.[55] Courtney and colleagues performed a consecutive series review of 9511 primary THA and TKA evaluating the effect of poor glycemic control on episode-of-care (EOC) costs with Medicare claims data in the setting of bundled payment costs assessing postoperative complications, hospital readmissions, and 90-day global EOC costs among patients with diabetes. Diabetic patients (n = 1042) demonstrated a higher EOC cost ($20,577 vs $19,414, P<.001) than patients without diabetes with higher stratified HbA1c levels associated with increased mean EOC costs (HbA1c 6.5% to 6.9% = $18,912; HbA1c 7.0% to 7.49% = $19,832; HbA1c 7.5% to 7.9% = $20,827; >8% = $21,169).[56] Similarly, patients with an HbA1c level greater than 7.5% compared to nondiabetic patients had a higher EOC cost of $2331 (95% CI $511-$4151; P=.012), increased rates of complications (7% vs 3%, P=.049), and readmissions (11% vs 5%, P=.020).[56] In a value-based health

care system, many orthopedic surgeons advocate for preoperative screening for adequate glycemic control among diabetic patients undergoing THA and TKA, with up to 33.6% of patients having undiagnosed dysglycemia.[57]

Despite an extensive amount of research on the utility of predictive glycemic markers evaluating perioperative complications, there remains little consensus on a HbA1c threshold in correlating increased risk of deep postoperative infection following primary THA and TKA. In a large multi-institutional retrospective study by the AAHKS research committee, Tarabichi and colleagues evaluated 1645 diabetic patients undergoing THA (641 patients) and TKA (1004 patients) with the primary outcome being HbA1c levels predicting occurrence of a PJI at 1-year based on the Musculoskeletal Infection Society criteria.[58] Overall, there were 22 cases (1.3%) of postoperative PJI at 1-year follow-up with HbA1c levels of 7.7% demonstrating a predictive threshold (95% CI, 0.51–0.78). At HbA1c 7.7%, the rates of PJI increased from 0.8% to 5.4%, with PJI remaining the only variable associated with higher HbA1c (OR, 1.5; CI, 1.2–2.0; P=.0001).[59] This AAHKS research committee identified HbA1c 7.7% as a significant threshold associated with increased risk for PJI providing a greater range of opportunity for preoperative control of glycemic index among diabetic patients, thereby unnecessarily limiting access or delaying patients pursing TJA in the setting of functionally debilitating osteoarthritis. Similarly, in a large retrospective database study of 7736 patients who underwent THA with diabetes, Browne and colleagues demonstrated a significantly higher infection rate of 2.4% among patients with a HbA1c level greater than 7.5%, compared to an infection rate of 1.0% in patients with a HbA1c level below 7.5%.[60] Patients with a HbA1c level greater than 7.5% had a statistically significant higher risk of deep infection compared to patients below this threshold (OR, 2.6; 95% CI, 1.9–3.4, P<.0001). While many orthopedic surgeons may recommend delaying surgical intervention beyond ranges of HbA1c $\geq$ 7.5% - 8.0%, the threshold for predictivity of postoperative complications continues to remain debated. Similarly, the ethics of when to say no in the setting of known improvements among diabetic patients undergoing THA and TKA in postoperative functional mobility, PROMs (HOOS and KOOS),[61] and pain scores[62] continues to remain a widely discussed topic.

Although a strict numerical cutoff for HbA1c or fructosamine is not recommended, we do support utilizing these screening tests as a guideline to starting an early discussion about risk factor modification in moderately controlled (HbA1c 6.5% - 7.9%) or poorly controlled (HbA1c $\geq$ 8%) glycemic index among diabetic patients identified as a THA or TKA candidate. We suggest orthopedic surgeons advocate for (1) initial preoperative screening on patients with morbid obesity, cardiovascular disease, uncontrolled hypertension, renal insufficiency, and family history of diabetes mellitus,[43,63] (2) target HbA1c $\leq$ 7.7%[60] while being mindful a HbA1c $\leq$ 8.0% may not be medically advisable in a subset of diabetic populations,[48] (3) target fructosamine $\leq$ 293 μmol/L to evaluate acute glycemic control,[53] and (4) adherence to closely monitored postoperative blood glucose control less than 200 mg/L.[49,64,65]

In pursuing risk modification among diabetic patients, we suggest a wholistic and balanced approach. Establishing goals in this patient population can be motivating in giving patients a target to work toward on the path to TJA. As orthopedic surgeons, we should encourage glycemic control through healthy lifestyle alternatives including a (1) controlled weight loss among diabetic obese patients, (2) well-balanced diabetic diet with the help of a nutritionist, (3) smoking cessation, (4) routine aerobic exercise and continued mobility, and (5) daily continuous monitoring of blood glucose levels with a care plan implemented by a PCP or endocrinologist for target blood glucose levels. The goal is a sustainable lifestyle in which adequate glucose control may concomitantly help maintain an appropriate weight and improved mental and physical health. Alternatively, patients that have failed conservative glycemic control plans in conjunction with their PCP should be referred to diabetic endocrinology specialists to evaluate for personalized plans including possible dietitian or nutritionist counseling, care management (social workers) to evaluate for socioeconomic barriers to adequate glucose monitoring equipment, and changes in adjuvant glycemic pharmacologic management. Preoperative optimization of uncontrolled glycemic index among diabetic patients is recommended in decreasing risk of postoperative complications and improving functional outcomes in THA and TKA. Orthopedic surgeons should individualize care while identifying barriers and challenges patients may face. Strict cutoffs should be discouraged as a more ethical approach is a partnership with goals and specific targets to achieve prior to TJA.

Smoking

The prevalence of active tobacco use and smoking in the United States is approximately 19%[66] with an estimated 10% to 40% of patients

actively smoking undergoing THA and TKA.[67] With the continued rise in late-stage osteoarthritis in an aging population intersecting with increasing diversity among arthroplasty patients, orthopedists continue to debate the duration of smoking cessation cutoffs while balancing risk and access to TJA. Among patients with hip and knee osteoarthritis seeking surgical intervention, an inevitable portion of these patients are smoking dependent. Multiple studies have demonstrated the detrimental effects of smoking in not just joint arthroplasty, but consistently throughout orthopedic surgical procedures, with increased rates of postoperative healing complications due to stunted inflammatory cell functions and microenvironment tissue ischemia.[67] With such a large population of active tobacco users seeking THA and TKA, it is crucial to understand how to approach a balanced discussion of risk with the emphasis of smoking cessation as a preoperative modifiable risk factor.

There is no debate regarding the hazardous health effects of carcinogenic tobacco use and the importance of smoking cessation for patients undergoing TJA with associated poor postoperative outcomes and increased risk for complications. Studies have shown higher readmission rates, increased surgical complications, and increased rates of deep surgical site complications with patients who smoke compared to nonsmokers.[68] In a large retrospective study of 1251 active smokers undergoing THA and TKA, active smokers compared to the control group demonstrated a higher 30-day readmission rate (4.8% vs 3.2%, P=.041), increased risk for postoperative surgical complication (OR 1.84, 95% CI 1.21–2.80), and a higher rate of deep surgical site infection (1.1% vs 0.2%, P=.007).[68] Furthermore, PJIs are a morbidly devastating complication among primary THA and TKA patients with increased risk associated to smokers throughout many studies.[69] More specifically, current tobacco users have been seen to have a significantly increased risk compared to former tobacco users with an OR of 1.52[70] with increased risk for subsequent revision, whereas former smokers did not have increased risk although packs per decade were independently associated with increased risk of readmission regardless of smoking status.[71] Smoking holds a higher OR for postoperative complications than alcohol or malnutrition; it is severely vital to understand a patient's smoking history prior to surgery. With such a large body of evidence supporting complete smoking cessation prior to considering elective surgery, it is important to discuss the ethics and profound effect of strict smoking cessation cutoff due to the disproportionate representation in lower socioeconomic populations and marginalized racial minorities.

Before the idea of thresholds for the quantity and duration of smoking cessation can be discussed, it is imperative to acknowledge the unequivocally higher rates of tobacco use among underprivileged populations already prone to many long-standing health care disparities. Lower socioeconomic status is generally associated with increased cigarette smoking among all ages, ethnicities, sex, and regions[72] with almost double the amount of smokers in the United States among populations below the poverty level compared to those at or above the poverty level.[73] There is similarly an inverse association between lower levels of education and smoking prevalence adding to an already disproportionate health care access burden.[73] Given the profound effects of smoking on postoperative outcomes seen in THA and TKA with smoking as a known modifiable risk factor, smoking cessation prior to elective joint arthroplasty should be strongly encouraged. Although complete smoking cessation is recommended, studies have shown partial smoking cessation can still attain beneficial outcomes with a lower risk profile compared to no attempted smoking cessation.[74] It is important to be mindful of the addictive nature of smoking and the challenges associated with smoking while offering motivation and encouragement in a potentially life-changing health improvement beyond functionally limiting hip and knee osteoarthritis. Although the ideal period of smoking and tobacco abstinence remains inconsistent throughout the literature, many orthopedic surgeons and health care institutions draw strict cutoffs for smoking cessation ranging from 4 to 8 weeks prior to surgery and nicotine testing on day of surgery with possible cancellation or delay of surgery if positive.

The American College of Rheumatology and the AAHKS released a guideline summary in conjunction highlighting the recommendation of delaying THA and TKA to achieve nicotine cessation or reduction.[75] A separate summary released by AAHKS explains the premise of 4 to 6 weeks smoking cessation prior to surgery and 4 weeks cessation after surgery having potential to reduce postoperative complications up to 50% compared to active smoking. Although there is currently no official guideline consensus on duration of smoking cessation prior to surgery, the literature on smoking cessation among patients undergoing THA and TKA has shown cessation 4 to 6 weeks prior to

surgery can potentially decrease the risk complications. This timeframe is hypothesized to be the duration needed to allow for metabolic and immune functions to recuperate and normalize from the hazardous effects of smoking. Although, this duration of cessation does not equate to the reversal of permanent long-term effects of smoking on stunted cellular function.

Lindstrom and colleagues demonstrated in a randomized controlled trial comparing smokers who received smoking cessation therapy 4 weeks prior and continued cessation after surgery versus smokers who received little to no information on quitting tobacco prior to surgery an increased overall complication rate of 41% in the control group compared to 21% in the intervention group (relative risk reduction = 49.0%).[76] Similarly, a meta-analysis performed by Wong and colleagues evaluating short-term smoking cessation (defined as <4 weeks) demonstrating no significant increase in risk of postoperative complications, with smoking abstinence of at least 4 weeks reducing wound-healing complications (relative risk = 0.69–0.80).[77] Patients proved to have lower infection rates when participating in smoking cessation programs prior to surgery given higher quit rates[78] which can affect overall lower health care costs as well.[79] Abdel and colleagues demonstrated the utility of transparent serum cotinine testing preoperatively among patients improving the likelihood of smoking cessation, with both an increase in self-reported cessation rates and identifying false abstinence reports, ensuring better patient care with continued counseling for modifiable risks.[80] Generally, longer periods of smoking cessation are afford decreased incidences of postoperative complications, but this needs to be balanced by the surgical urgency of THA and TKA.

The onus of smoking cessation should fall on both the patient being treated and orthopedic surgeons whom they seek care from. Moller and colleagues demonstrated counseling and nicotine replacement therapy may be more impactful than pharmaceutical smoking cessation agents in decreasing tobacco use among patients prior to surgery, further guiding recommendations on early preoperative patient-surgeon smoking cessation discussions.[81] As physicians, we bear the responsibility to help facilitate resources for smoking cessation whether it be guiding patients in establishing a relationship with a PCP, smoking cessation programs, possible over-the-counter nicotine replacement options, or direct counseling during the encounter. Even with a large amount of support, smokers still find it challenging to quit secondary to the addictive nature of nicotine. While surgeons have different tolerances of tobacco use among patients pursing THA and TKA in their arthroplasty practice, the sentiment to motivate patients to quit smoking should be similar across the board. Not only does smoking cessation decrease the risk of postoperative complications, it can have long-term positive health effects as well, with a higher likelihood to remaining cigarette-free postoperatively.[80]

Smoking cessation should be strongly encouraged among patients pursuing arthroplasty. Limitation in access to THA and TKA among the smoking population with no subsequent plan for risk factor modification should be similarly strongly discouraged as unethical. Possible interventions that can help mitigate this type of obstacle may be referring the patient to public health cessation programs, PCPs, or local resources that are available beyond counseling of risks. Although we do not advocate a strict cutoff duration for smoking cessation, the literature supports preoperative smoking cessation of 4 to 6 weeks minimum prior to elective TJA. In the age of the bundled payment model, orthopedic surgeons are continuously financially pressured to perform surgeries while minimizing the risk for postoperative complications. As surgeons, we bear the ethical responsibility of balancing the benefits of temporizing a delay in surgical intervention for risk factor modification with the risks of perioperative complications individualized to each patient, while maintaining the principles of beneficence and nonmaleficence.

SUMMARY

Risk stratification and medical optimization have been modern advancements introduced by arthroplasty surgeons to make TJA safer and more effective in generating satisfied patients with improved outcomes. As we continue to develop pathways, algorithms, and predictive models to guide optimization protocols, we are left with an ethical dilemma such that TJA will be withheld from the identified high-risk populations, which often coincide with the already underserved populations in the United States. With the ultimate goal to do no harm, it can be argued that at a certain risk-level, there may be more chance for a negative than positive outcome. The question then becomes, who makes these decisions and what level of risk is the limit or cutoff to offer TJA. Further, is this process predicated on cost (increased cost per EOC in high-risk patients), concern for

complications (both harm to patients and negative surgeon scorecards/reviews), and/or technically more demanding cases requiring greater surgical skill and time requirements. It may be that specific regional centers are needed to deal with the burden of high-risk patients, as those dealing with higher volumes of these difficult patients seem to have better outcomes. In the end, there is no right answer. It is important to remain mindful of not only our clinical judgements, but to continuously question our own ethics and level of appropriate refusal of care, to assure we are fulfilling our Hippocratic Oath as physicians. The risk each surgeon and patient are willing to accept varies and there are essentially no ethical guidelines that exist; it boils down to how willing you are to work with your patients and to what level of ethical confidence you have so that you may "sleep better at night."

CLINICS CARE POINTS

- Preoperative optimization of modifiable risk factors for THA and TKA remains a foundational cornerstone in reducing postoperative complications and enhancing patient outcomes.
- BMI scale should be used as a guideline to initiating an early discussion about risk factor modification among obese (BMI 35–40 kg/m^2) and morbidly obese (BMI 40–45 kg/m^2) patients identified as THA or TKA candidates, while being mindful obesity may only be a truly "modifiable" risk factor in a small subset of patients.
- Diabetes screening tests should be used as a guideline to starting an early discussion about risk factor modification in moderately controlled (HbA1c 6.5% - 7.9%) or poorly controlled (HbA1c $\geq$ 8%) glycemic index among diabetic patients for (1) initial preoperative screening on patients with morbid obesity, cardiovascular disease, uncontrolled hypertension, renal insufficiency, and family history of diabetes mellitus,[43,63] (2) target HbA1c $\leq$ 7.7%[60] while being mindful a HbA1c $\leq$ 8.0% may not be medically advisable in a subset of diabetic populations,[48] (3) target fructosamine $\leq$ 293 μmol/L to evaluate acute glycemic control,[53] and (4) adherence to closely monitored postoperative blood glucose control less than 200 mg/L.[49,64,65]
- Smoking cessation should be strongly encouraged among patients pursuing THA and TKA with preoperative smoking cessation of 4 to 6 weeks minimum with possible interventions of (1) facilitating resources for smoking cessation, (2) establishing a relationship with a PCP, (3) public health smoking cessation programs, (4) over-the-counter nicotine replacement options, or (5) direct counseling during the encounter.

DISCLOSURES

Royalties: Link. Consultant: Link Lia, Exactech, Zimmer-Biomet, Medacta. Editorial Boards: Journal of Arthroplasty, Orthopedics, and Arthroplasty Today (Deputy Editor). Committees: MAOA (Education Committee Chair), AAHKS (Quality Committee), AAOS-EQBV Committee; Knee/Hip Society-Digital Media Committee; BOD OLC. From the author's listed disclosures, there are no relavent or pertinent conflicts of interest contributing to content of this article.

REFERENCES

1. Sloan M, Premkumar A, Sheth NP. Projected Volume of Primary Total Joint Arthroplasty in the U.S., 2014 to 2030. J Bone Jt Surg Am Vol 2018;100(17):1455–60.
2. Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89(4):780–5.
3. Wu M, Belay E, Cochrane N, et al. Comorbidity Burden Contributing to Racial Disparities in Outpatient Versus Inpatient Total Knee Arthroplasty. J Am Acad Orthop Surg 2021;29(12):537–43.
4. Losina E, Thornhill TS, Rome BN, et al. The dramatic increase in total knee replacement utilization rates in the United States cannot be fully explained by growth in population size and the obesity epidemic. J Bone Joint Surg 2012;94(3):201–7.
5. Bronson WH, Fewer M, Godlewski K, et al. The Ethics of Patient Risk Modification Prior to Elective Joint Replacement Surgery. J Bone Jt Surg Am Vol 2014;96(13):e113.
6. Humbyrd CJ. The Ethics of Bundled Payments in Total Joint Replacement: "Cherry Picking" and "Lemon Dropping". J Clin Ethics 2018;28(1):62–8.
7. Weiner JA, Adhia AH, Feinglass JM, et al. Disparities in Hip Arthroplasty Outcomes: Results of a Statewide Hospital Registry From 2016 to 2018. J Arthroplasty 2020;35(7):1776–83.e1.
8. Hsiang WR, Lukasiewicz A, Gentry M, et al. Medicaid Patients Have Greater Difficulty Scheduling Health Care Appointments Compared With Private Insurance Patients: A Meta-Analysis. Inquiry 2019;56. 46958019838118.

9. Kim KY, Anoushiravani AA, Chen KK, et al. Perioperative Orthopedic Surgical Home: Optimizing Total Joint Arthroplasty Candidates and Preventing Readmission. J Arthroplasty 2019;34(7S):S91–6.
10. Castano-Betancourt MC, Fruschein Annichino R, de Azevedo E Souza Munhoz M, et al. Identification of high-risk groups for complication after arthroplasty: predictive value of patient's related risk factors. J Orthop Surg Res 2018;13(1):328.
11. Dlott CC, Moore A, Nelson C, et al. Preoperative risk factor optimization lowers hospital length of stay and postoperative emergency department visits in primary total hip and knee arthroplasty patients. J Arthroplasty 2020;35(6):1508–15.e2.
12. Ward ZJ, Bleich SN, Cradock AL, et al. Projected U.S. State-Level Prevalence of Adult Obesity and Severe Obesity. N Engl J Med 2019;381(25):2440–50.
13. Centers for Disease Control and Prevention (CDC). National center for health statistics (NCHS). National health and nutrition examination survey data. Available at:. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention; 2021 https://www.cdc.gov/obesity/data/adult.
14. Martin JR, Jennings JM, Dennis DA. Morbid Obesity and Total Knee Arthroplasty: A Growing Problem. J Am Acad Orthop Surg 2017;25(3):188–94.
15. Kremers HM, Visscher SL, Kremers WK, et al. The effect of obesity on direct medical costs in total knee arthroplasty. J Bone Jt Surg Am Vol 2014;96(9):718–24.
16. Meller MM, Toossi N, Johanson NA, et al. Risk and Cost of 90-Day Complications in Morbidly and Superobese Patients After Total Knee Arthroplasty. J Arthroplasty 2016;31(10):2091–8.
17. Jenkins PJ, Clement ND, Hamilton DF, et al. Predicting the cost-effectiveness of total hip and knee replacement: a health economic analysis. The bone & joint journal 2013;95-B(1):115–21.
18. George J, Piuzzi NS, Ng M, et al. Association Between Body Mass Index and Thirty-Day Complications After Total Knee Arthroplasty. J Arthroplasty 2018;33(3):865–71.
19. Roth A, Khlopas A, George J, et al. The Effect of Body Mass Index on 30-day Complications After Revision Total Hip and Knee Arthroplasty. J Arthroplasty 2019;34(7S):S242–8.
20. Adhikary SD, Liu WM, Memtsoudis SG, et al. Body Mass Index More Than 45 kg/m(2) as a Cutoff Point Is Associated With Dramatically Increased Postoperative Complications in Total Knee Arthroplasty and Total Hip Arthroplasty. J Arthroplasty 2016;31(4):749–53.
21. D'Apuzzo MR, Novicoff WM, Browne JA. The John Insall Award: Morbid obesity independently impacts complications, mortality, and resource use after TKA. Clin Orthop Relat Res 2015;473(1):57–63.
22. Vasarhelyi EM, MacDonald SJ. The influence of obesity on total joint arthroplasty. J Bone Joint Surg. British volume 2012;94(11 Suppl A):100–2.
23. Shaw J. A. (2018). Surgical Decision-Making: The Province of the Patient or the Surgeon?: Commentary on an article by Nicholas J. Giori, et al.: "Risk reduction compared with access to care: quantifying the trade-off of enforcing a body mass index eligibility criterion for joint replacement". J Bone Jt Surg Am Vol, 100(7), e45.
24. Roth A, Anis HK, Emara AK, et al, Cleveland Clinic OME Arthroplasty Group. The Potential Effects of Imposing a Body Mass Index Threshold on Patient-Reported Outcomes After Total Knee Arthroplasty. J Arthroplasty 2021;36(7S):S198–208.
25. Foreman CW, Callaghan JJ, Brown TS, et al. Total Joint Arthroplasty in the Morbidly Obese: How Body Mass Index ≥40 Influences Patient Retention, Treatment Decisions, and Treatment Outcomes. J Arthroplasty 2020;35(1):39–44.
26. MacFarlane LA, Kim E, Cook NR, et al. Racial Variation in Total Knee Replacement in a Diverse Nationwide Clinical Trial. J Clin Rheumatol 2018;24(1):1–5.
27. Werner BC, Evans CL, Carothers JT, et al. Primary Total Knee Arthroplasty in Super-obese Patients: Dramatically Higher Postoperative Complication Rates Even Compared to Revision Surgery. J Arthroplasty 2015;30(5):849–53.
28. Workgroup of the American Association of Hip and Knee Surgeons Evidence Based Committee. Obesity and total joint arthroplasty: a literature based review. J Arthroplasty 2013;28(5):714–21.
29. Bookman JS, Schwarzkopf R, Rathod P, et al. Obesity: The Modifiable Risk Factor in Total Joint Arthroplasty. Orthop Clin N Am 2018;49(3):291–6.
30. Mangan A, Le Roux CW, Miller NG, et al. Iron and Vitamin D/Calcium Deficiency after Gastric Bypass: Mechanisms Involved and Strategies to Improve Oral Supplement Disposition. Curr Drug Metabol 2019;20(3):244–52.
31. Peterson LA, Cheskin LJ, Furtado M, et al. Malnutrition in Bariatric Surgery Candidates: Multiple Micronutrient Deficiencies Prior to Surgery. Obes Surg 2016;26(4):833–8.
32. Sherman WF, Patel AH, Kale NN, et al. Surgeon Decision-Making for Individuals With Obesity When Indicating Total Joint Arthroplasty. J Arthroplasty 2021;36(8):2708–15.e1.
33. Belmont PJ Jr, Goodman GP, Waterman BR, et al. Thirty-day postoperative complications and mortality following total knee arthroplasty: incidence and risk factors among a national sample of 15,321 patients. J Bone Jt Surg Am Vol 2014;96(1):20–6.

34. Schwarzkopf R, Thompson SL, Adwar SJ, et al. Postoperative complication rates in the "super-obese" hip and knee arthroplasty population. J Arthroplasty 2012;27(3):397–401.
35. Jämsen E, Nevalainen P, Eskelinen A, et al. Obesity, diabetes, and preoperative hyperglycemia as predictors of periprosthetic joint infection: a single-center analysis of 7181 primary hip and knee replacements for osteoarthritis. J Bone Joint Surg Am 2012;94(14):e101.
36. DiMagno AN, Hajj-Hussein I, Othmani AE, et al. Chronic kidney disease impact on total joint arthroplasty outcomes: A National Inpatient Sample-based study. J Orthop Surg 2020;28(3). 2309499020916129.
37. Courtney PM, Rozell JC, Melnic CM, et al. Effect of Malnutrition and Morbid Obesity on Complication Rates Following Primary Total Joint Arthroplasty. J Surg Orthop Adv 2016;25(2):99–104.
38. Jameson SS, Mason JM, Baker PN, et al. The impact of body mass index on patient reported outcome measures (PROMs) and complications following primary hip arthroplasty. J Arthroplasty 2014;29(10):1889–98.
39. Li W, Ayers DC, Lewis CG, et al. Functional Gain and Pain Relief After Total Joint Replacement According to Obesity Status. J Bone Jt Surg Am Vol 2017;99(14):1183–9.
40. Wing RR, Lang W, Wadden TA, et al, Look AHEAD Research Group. Benefits of modest weight loss in improving cardiovascular risk factors in overweight and obese individuals with type 2 diabetes. Diabetes Care 2011;34(7):1481–6.
41. Chen MJ, Bhowmick S, Beseler L, et al. Strategies for Weight Reduction Prior to Total Joint Arthroplasty. J Bone Jt Surg Am Vol 2018;100(21):1888–96.
42. Lingamfelter M, Orozco FR, Beck CN, et al. Nutritional Counseling Program for Morbidly Obese Patients Enables Weight Optimization for Safe Total Joint Arthroplasty. Orthopedics 2020;43(4):e316–22.
43. American Diabetes Association. Statistics about Diabetes, Diabetes care in the hospital: Standards of medical care in diabetes-2021. Diabetes Care 2021;44:S211–20.
44. Nelson AE, Braga L, Renner JB, et al. Characterization of individual radiographic features of hip osteoarthritis in African American and White women and men: the Johnston County Osteoarthritis Project. Arthritis Care Res 2010;62(2):190–7.
45. Singh JA, Lu X, Rosenthal GE, et al. Racial disparities in knee and hip total joint arthroplasty: an 18-year analysis of national Medicare data. Ann Rheum Dis 2014;73(12):2107–15.
46. Maradit Kremers H, Lewallen LW, Mabry TM, et al. Diabetes mellitus, hyperglycemia, hemoglobin A1C and the risk of prosthetic joint infections in total hip and knee arthroplasty. J Arthroplasty 2015;30:439e43.
47. Stryker LS. Modifying Risk Factors: Strategies That Work Diabetes Mellitus. J Arthroplasty 2016;31(8):1625–7.
48. Giori NJ, Ellerbe LS, Bowe T, et al. Many diabetic total joint arthroplasty candidates are unable to achieve a preoperative hemoglobin A1c goal of 7% or less. J Bone Jt Surg Am Vol 2014;96(6):500–4.
49. Stryker LS, Abdel MP, Morrey ME, et al. Elevated postoperative blood glucose and preoperative hemoglobin A1C are associated with increased wound complications following total joint arthroplasty. J Bone Joint Surg. American volume 2013;95(9). 808–S2.
50. Shohat N, Restrepo C, Allierezaie A, et al. Increased postoperative glucose variability is associated with adverse outcomes following total joint arthroplasty. J Bone Joint Surg [Am] 2018;100-A:1110–7.
51. Jiranek W, Kigera JWM, Klatt BA, et al. General assembly, prevention, host risk mitigation - general factors: proceedings of international consensus on orthopedic infections. J Arthroplasty 2019;34(2S):S43–8.
52. Shohat N, Muhsen K, Gilat R, et al. Inadequate glycemic control is associated with increased surgical site infection in total joint arthroplasty: a systematic review and meta-analysis. J Arthroplasty 2018;33:2312–21.e3.
53. Shohat N, Tarabichi M, Tan TL, et al. John Insall Award: Fructosamine is a better glycaemic marker compared with glycated haemoglobin (HbA1C) in predicting adverse outcomes following total knee arthroplasty: a prospective multicentre study. The bone & joint journal 2019;101-B(7_Supple_C). 3–9.
54. Parisi TJ, Konopka JF, Bedair HS. What is the long-term economic societal effect of periprosthetic infections after THA? A Markov analysis. Clin Orthop Relat Res 2017;475:1891–900.
55. Padegimas EM, Verma K, Zmistowski B, et al. Medicare reimbursement for total joint arthroplasty: the driving forces. J Bone Joint Surg Am 2016;98:1007e13.
56. Kavin M, Yayac M, Grosso MJ, et al. Preoperative hemoglobin A1c >7.5 is associated with increased bundled payment costs in total hip and knee arthroplasties. J Am Acad Orthop Surg 2021;29(22):970–6.
57. Capozzi JD, Lepkowsky ER, Callari MM, et al. The prevalence of diabetes mellitus and routine hemoglobin A1c screening in elective total joint arthroplasty patients. J Arthroplasty 2017;32(1):304–8.
58. Parvizi J, Gehrke T. International consensus group on periprosthetic joint infection. Definition of periprosthetic joint infection. J Arthroplasty 2014;29:1331.

59. Tarabichi M, Shohat N, Kheir MM, et al. Determining the threshold for HbA1c as a predictor for adverse outcomes after total joint arthroplasty: a multicenter, retrospective study. J Arthroplasty 2017;32(9S):263–7.e1.
60. Cancienne JM, Werner BC, Browne JA. Is there a threshold value of hemoglobin a1c that predicts risk of infection following primary total hip arthroplasty? J Arthroplasty 2017;32(9S):S236–40.
61. Adams AL, Paxton EW, Wang JQ, et al. Surgical outcomes of total knee replacement according to diabetes status and glycemic control, 2001 to 2009. J Bone Joint Surg Am 2013;95:481e7.
62. Bolognesi MP, Marchant MH, Viens NA, et al. The impact of diabetes on perioperative patient outcomes after total hip and total knee arthroplasty in the United States. J Arthroplasty 2008;23:92e8.
63. Himes CP, Ganesh R, Wight EC, et al. Perioperative evaluation and management of endocrine disorders. Mayo Clin Proc 2020;95(12):2760–74.
64. Parvizi J, Tan TL, Goswami K, et al. The 2018 definition of periprosthetic hip and knee infection: an evidence-based and validated criteria. J Arthroplasty 2018; 33(5):1309–14.e2.
65. Schwarz EM, Parvizi J, Gehrke T, et al. 2018 International consensus meeting on musculoskeletal infection: research priorities from the general assembly questions. J Orthop Res 2019;37(5):997–1006.
66. Cornelius ME, Loretan CG, Wang TW, et al. Tobacco product use among adults - United States, 2020. MMWR. Morbidity and mortality weekly report 2022;71(11):397–405.
67. Duchman KR, Gao Y, Pugely AJ, et al. The effect of smoking on short-term complications following total hip and knee arthroplasty. J Bone Jt Surg Am Vol 2015;97(13):1049–58.
68. Sahota S, Lovecchio F, Harold RE, et al. The effect of smoking on thirty-day postoperative complications after total joint arthroplasty: a propensity score-matched analysis. J Arthroplasty 2018;33(1):30–5.
69. Kunutsor SK, Whitehouse MR, Blom AW, et al, INFORM Team. Patient-related risk factors for periprosthetic joint infection after total joint arthroplasty: a systematic review and meta-analysis. PLoS One 2016;11(3):e0150866.
70. Bedard NA, DeMik DE, Owens JM, et al. Tobacco use and risk of wound complications and periprosthetic joint infection: a systematic review and meta-analysis of primary total joint arthroplasty procedures. J Arthroplasty 2019;34(2):385–96.e4.
71. Ehnert S, Aspera-Werz RH, Ihle C, et al. Smoking dependent alterations in bone formation and inflammation represent major risk factors for complications following total joint arthroplasty. J Clin Med 2019;8(3):406.
72. Hiscock R, Bauld L, Amos A, et al. Socioeconomic status and smoking: a review. Ann N Y Acad Sci 2012;1248:107–23.
73. Jamal A, King BA, Neff LJ, et al. Current cigarette smoking among adults—United States, 2005–2015. Morb Mortal Wkly Rep 2016;65(44):1205–11.
74. Hart A, Rainer WG, Taunton MJ, et al. Smoking cessation before and after total joint arthroplasty-an uphill battle. J Arthroplasty 2019;34(7S):S140–3.
75. American College of Rheumatology (ACR) and American Association of Hip and Knee Surgeons (AAHKS) Clinical Practice Guideline for the Optimal Timing of Elective Total Hip or Knee Arthroplasty for Patients with Symptomatic Moderate to Severe Osteoarthritis or Osteonecrosis Who Have Failed Nonoperative Therapy. 2023.https://assets.contentstack.io/v3/assets/bltee37abb6b278ab2c/blt7e2dab19eaec9de2/total-joint-arthroplasty-guideline-summary-2023.pdf.
76. Lindström D, Sadr Azodi O, Wladis A, et al. Effects of a perioperative smoking cessation intervention on postoperative complications: a randomized trial. Ann Surg 2008;248(5):739–45.
77. Wong J, Lam DP, Abrishami A, et al. Short-term preoperative smoking cessation and postoperative complications: a systematic review and meta-analysis. Can J Anaesth 2012;59(3):268–79.
78. Herrero C, Tang A, Wasterlain A, et al. Smoking cessation correlates with a decrease in infection rates following total joint arthroplasty. J Orthop 2020;21:390–4.
79. Boylan MR, Bosco JA 3rd, Slover JD. Cost-effectiveness of preoperative smoking cessation interventions in total joint arthroplasty. J Arthroplasty 2019;34(2):215–20.
80. Hart A, Rainer WG, Taunton MJ, et al. Cotinine testing improves smoking cessation before total joint arthroplasty. J Arthroplasty 2019;34(7S):S148–51.
81. Thomsen T, Villebro N, Møller AM. Interventions for preoperative smoking cessation. Cochrane Database Syst Rev 2014;(3):CD002294.