



## Original research

# What Is the Fate of Total Joint Arthroplasty Patients Who Are Asked to Quit Smoking Prior to Surgery?

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## ABSTRACT

**Background:** Smoking is a known risk factor for complications following primary total joint arthroplasty (TJA). Little is known regarding the fate of patients who are asked to quit smoking before surgery. The purpose of this study was to evaluate the success of smoking cessation prior to primary TJA and the impact of smoking cessation on perioperative outcomes.

**Methods:** This is a retrospective review of patients who presented between 2008 and 2020 to a single academic medical center with a documented smoking history and were asked to quit smoking prior to receiving a date for primary TJA. The cohort was surveyed about smoking cessation, smoking history, use of quit aids, seeking surgery elsewhere due to the cessation policy, and postoperative complications. Descriptive statistics evaluated the relationship between demographics, smoking cessation, and post-operative complications.

**Results:** A total of 101 patients completed the survey with an overall response rate of 48%. Sixty-two percent of patients quit smoking before surgery, and 51% of these patients reported remaining smoke-free at 6 months postoperatively. The average time to quit before TJA was 45 days (range: 1–365 days), and 62% quit without quit aids. The wound complication/infection rate was significantly higher for patients who did not stop smoking prior to TJA (4 of 16; 27%) than for those who did quit prior to surgery (3 of 63; 5%;  $P = .02$ ).

**Conclusions:** This study demonstrates that most patients (62%) will stop smoking, if required, prior to primary TJA. Furthermore, 51% of patients reported abstinence from smoking at 6 months following TJA. TJA appears to be an effective motivator for smoking cessation.

**Level of Evidence:** III (retrospective cohort study).

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## Introduction

In the United States, tobacco use is the number 1 preventable cause of death, disease, and disability. In 2019, 34.1 million adults in the United States smoked cigarettes [1]. Today, smoking remains a substantial burden on the health-care system with nearly \$170 billion spent on direct medical care for smokers [1]. Most cigarette smokers (68%) desire to quit smoking, and 55% attempted to quit in

the past year, but only 7.5% are successful in ceasing smoking for >6 months [2]. Fewer than 30% of those who quit used evidence-based cessation methods to quit smoking [1–3].

It is well established that tobacco smokers are at an increased risk of wound complications, lower respiratory infections, myocardial infarction, and increased mortality rates following primary total hip arthroplasty and total knee arthroplasty [4–11]. Nicotine inhibits blood flow to tissues and disturbs the humoral and cellular mechanisms of immunity at surgical sites [12–14]. Reduced blood flow and compromised immune responses may contribute to poor wound healing and increased risk of periprosthetic joint infection [6,13,14]. Many surgeons require smoking cessation prior to indicating patients for elective, primary total joint

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arthroplasty (TJA). The American Academy of Orthopedic Surgeons recommends smoking cessation 4-6 weeks prior to surgical procedures [4]. At our institution, smoking cessation is required prior to scheduling an elective primary TJA, with cessation confirmed by urine screening tests. The preoperative period represents a potential target for impacting smoking cessation efforts [5–11]. This protocol offers a tangible incentive to quit smoking (TJA surgery) with continuity of care at perioperative visits. However, smoking cessation and continued abstinence from tobacco use in the perioperative period surrounding primary TJA have proven difficult for many patients [15–17]. Little is known about the fate of patients who present to an arthroplasty clinic but are asked to quit smoking prior to indication for TJA. The purpose of this study was to evaluate the success of smoking cessation among TJA candidates who were required to quit smoking prior to the surgery and the impact of smoking cessation on perioperative outcomes.

## Material and methods

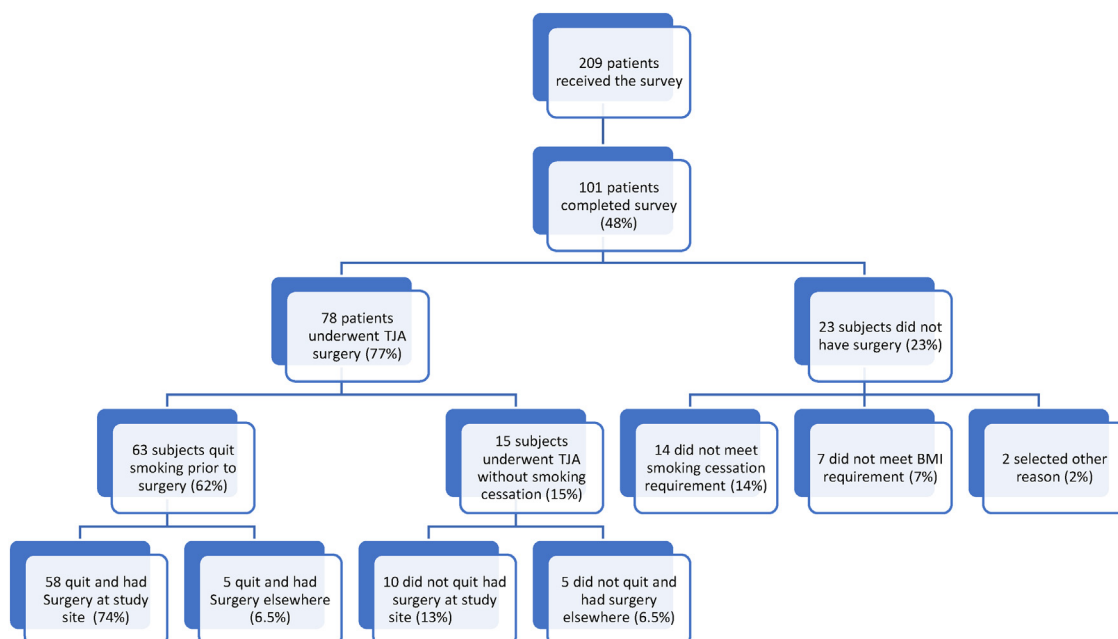
Institutional review board approval was obtained prior to the initiation of the study. A retrospective review of a single academic medical center's TJA clinic was performed from the year 2008 through 2020. The study period was chosen to start in 2008 to coincide with the implementation of a division-wide preoperative smoking cessation policy for elective TJA at our institution. Smoking cessation was confirmed through urine nicotine testing prior to scheduling an elective TJA.

### Study cohort

Subjects were identified through retrospective review of the institution's electronic medical record. All new patients presenting to the hip and knee arthroplasty clinic between 2008 and 2020 were identified. New patients presenting to hip and knee arthroplasty clinics completed an intake questionnaire with specific social history questions asked regarding the smoking status. The medical records of all new patients who indicated they were

actively smoking were reviewed to determine if they were otherwise a candidate for primary TJA. All patients that were indicated for primary TJA but denied scheduling surgery secondary to active smoking status were included. This allowed us to capture patients who may have never proceeded with the surgery or elected to have the surgery elsewhere due to the institution's smoking cessation policy. A survey was administered retrospectively to patients who were required to quit smoking prior to scheduling of TJA to obtain information regarding their success with smoking cessation, whether they received surgery at another institution, the length of time it took to quit smoking, smoking history (years smoking, amount), current smoking status, and whether any complications occurred in the year following TJA (Appendix 1). Surveys were administered at least 6 months after the index surgery. Smoking cessation prior to operation was confirmed with negative urine nicotine test 6 weeks prior to the surgery. The survey was administered electronically via REDCap (Research Electronic Data Capture). REDCap is a secure, Web-based application designed to support data capture and supported by thousands of consortium partner institutions [18]. The survey was distributed to 209 patients who met study inclusion criteria, and 101 patients completed the survey for a 48% response rate (Fig. 1).

Patient demographics, including age, sex, body mass index (BMI), total years smoking, and total pack years smoked were compared between patients who were able to successfully quit smoking prior to TJA and those who were unable to quit prior to surgery. Demographic variables were also compared to utilization rates of quit aids and rates of continued abstinence from smoking. Complications occurring within 1 year of surgery were noted and compared between patients who quit smoking prior to surgery and those who continued to smoke. Complication endpoints included any complication, any reoperation, and any wound complication or infection. Reoperation is defined as any additional surgery on the joint of interest. Wound complication/infection endpoints included periprosthetic joint infection, superficial soft tissue infection, delayed wound healing, and wound dehiscence.



**Figure 1.** Cohorts of study participants, and outcomes of each participant.

## Statistical analysis

Descriptive statistics were performed, and continuous variables were presented as median (interquartile range) due to nonnormal distributions while categorical variables were presented as frequencies (percentages). To evaluate the characteristics associated with smoking status and smoking cessation method, differences in continuous variables were evaluated using the Wilcoxon rank-sum test. Categorical variables and differences in complications rates were analyzed with the chi-square test. Analyses were completed using SAS statistical software version 9.4 (SAS Institute, Inc., Cary, NC). A  $P$  value  $<.05$  was considered statistically significant.

## Results

### Smoking cessation, demographics, and quit methods

Of the 101 patients who completed the survey, 63 patients (62%) quit smoking prior to undergoing primary TJA. Fifteen patients (15%) underwent TJA without smoking cessation. In total, 23 patients did not undergo TJA (23%); 19 of 23 patients were unable to quit smoking and thus remained ineligible for surgery, 2 patients were able to quit smoking but were unable to achieve a goal BMI prior to surgery, and 2 patients were able to quit smoking and then deferred surgery.

The average time from being asked to stop smoking to smoking cessation for patients who quit was 45 days (range, 1 to 365 days). There were no significant differences in age, sex, BMI, total years smoking, or total pack years between patients who quit smoking prior to TJA and those who continued to smoke prior to TJA (Table 1). Of the patients who quit smoking prior to TJA, 62% did so without any form of quit aid such as medication, support group, or nicotine replacement therapy (NRT) (Table 2). For the group who used NRT to successfully quit smoking, the average years smoking (39.5 years vs 25 years,  $P = .007$ ) and the pack-year history (17.5 vs 7.5,  $P = .0067$ ) were significantly higher than those of the group who did not use NRT (Table 3).

At 6 months following TJA, 32 of 63 patients (51%) reported continued abstinence from smoking, while 31 patients (49%) had resumed smoking (Table 4). There were no significant differences in demographics or smoking history when comparing the group who quit and continued to be abstinent from smoking vs the group who quit and returned to smoking postoperatively (Table 4).

### Postoperative complications

Overall, 7 of 78 patients (9%) who had a TJA surgery developed a surgical complication within 1 year postoperatively. All the

**Table 2**  
How subjects quit smoking.

Return to smoking?	How patients quit smoking					Total
	Not listed	No quit aid used	NRT	Non-nicotine Rx	Support group	
No	2	21	8	0	1	32
Yes	1	18	10	2	0	31
Total	3	39	18	2	1	63

Rx, prescription.

surgical complications that occurred were infection or wound-related complications (Table 5). Patients who did not quit smoking had a significantly higher rate of wound complications and/or infection (4 of 15, 27%) than patients who did quit smoking prior to TJA (3 of 63, 5%,  $P = .023$ ). Rates of any reoperation (13% vs 5%,  $P = .23$ ) were also higher in patients who did not quit smoking prior to TJA, but this difference was not statistically significant.

## Discussion

While there have been significant reductions in the incidence and prevalence of cigarette smoking among adults in the United States since the 1960s, smoking cessation remains a difficult process [2]. In 2018, Creamer et al. found that of the 55% of smokers that attempted to quit in the year prior, only 7.5% were successful in quitting for  $\geq 6$  months [2]. A randomized control trial with 8144 subjects demonstrated that 25%-35% of smokers are able to quit for more than 6 months when using an optimal treatment such as behavioral and pharmacotherapy [19]. In contrast, smokers who attempt to quit without an aid demonstrate a 6% sustained cessation rate at 1 year [20]. Given this difficulty, the indication for primary TJA may be time of increased education, motivation, or resources for patients to quit smoking [2,15–17]. In the present study, 62% of patients were able to successfully quit smoking, when required to do so, prior to primary TJA. Furthermore, 51% of patients reported remaining abstinent from smoking at least 6 months following the surgery.

Reported rates of smoking cessation to achieve eligibility for arthroplasty surgery are widely variable in current literature. Hart et al. evaluated a cohort of 28,758 primary TJAs; 2514 reported smoking in the year leading up to surgery [17]. Of these 2,514, only 405 (16%) were able to quit smoking prior to surgery [17]. Akhavan et al. examined the utility of a counseling program in order to facilitate smoking cessation prior to TJA [15]. Of 30 patients enrolled in the study, 21 (70%) were able to cease smoking for planned TJA; ultimately, only 18 patients (60%) underwent surgery [15]. Patients in the present study were able to cease smoking relatively quickly,

**Table 1**  
Demographic comparison of quit vs did not quit smoking prior to TJA.

Did they quit smoking?	Number of participants	Variable	Median	Mean	Standard deviation	$P$ value
No	15	Age	57.4	58.0	13.1	.6255
		BMI	34.9	34.8	8.1	.3258
		Female (n, %)	6 (40.0%)			.5210
		Total smoking years	30.0	28.2	12.7	.9696
		Total pack years	17.5	21.8	15.6	.0973
		Age	60.5	59.5	9.9	
Yes	63	BMI	30.9	33.0	9.1	
		Female (n, %)	32 (50.8%)			
		Total smoking years	28.0	28.0	13.1	
		Total pack years	10.0	16.1	15.7	

$P$  value, percent chance that the results are significant ( $\alpha = 0.05$ ).

**Table 3**  
Nicotine replacement therapy usage.

NRT usage	Number of participants	Variable	Median	P value
No	39	Age	60.5	.9521
		BMI	30.9	.3363
		Female (n, %)	20 (51.3%)	.6312
		Total smoking years	25.0	.0072
		Total pack years	7.5	.0067
Yes	18	Age	60.1	
		BMI	30.2	
		Female (n, %)	8 (44.4%)	
		Total smoking years	39.5	
		Total pack years	17.5	

P value, percent chance that the results are significant (alpha = 0.05).

with a median time to cessation of 45 days (range, 1-365 days). Taken together, results from the present study and existing data in the literature suggest that while smoking cessation as a means of eligibility for TJA surgery is far from being 100% successful, patients can achieve cessation rates relatively quickly and at much higher rates than those observed in the general population.

Long-term success with smoking cessation brought about by preparation for primary TJA has varied in the literature. In the present study, approximately half of patients (51%) that had quit smoking to undergo surgery had remained abstinent from cigarettes at 6 months postoperatively. Akhavan et al. found similar results, with 64% of patients remaining abstinent from cigarettes at 6 months postoperatively [15]. Hall et al. examined survey responses from 124 patients that quit smoking to undergo primary total knee arthroplasty or total hip arthroplasty [16]. At a mean time period of approximately 4 years postoperatively, 23% remained abstinent from cigarettes, and over half of the cohort (55%) relapsed and returned to cigarette use within 3 months postoperatively [16]. These data from the study by Hall et al. are similar to the 50% relapse rate observed in the present study [16]. Hart et al. found abstinence rates of 86% at 1 year after primary TJA; this rate declined to 45% at 8 years postoperatively [17]. In the present study, there were no patient demographics or portions of smoking history (duration or volume) that were predictive of continued smoking abstinence. Hall et al. also found no difference in patient demographics or use of quit aids between patients that maintained smoking abstinence after arthroplasty surgery and patients that resumed smoking [16]. While arthroplasty surgery may represent an opportunity to achieve initial smoking cessation, most patients return to smoking over time. Further evaluation into patient and provider factors that may influence continued abstinence from smoking following TJA is necessary.

**Table 4**  
Demographics and smoking years comparison between continued cessation and returning to smoking.

Return to smoking after quitting?	Number of participants	Variable	Median	P value
No	32	Age	60.9	.4704
		BMI	32.8	.1670
		Female (n, %)	16 (50.0%)	.8981
		Total smoking years	26.5	.3243
		Total pack years	9.0	.7564
Yes	31	Age	59.2	
		BMI	29.5	
		Female (n, %)	16 (51.6%)	
		Total smoking years	30.0	
		Total pack years	10.0	

P value, percent chance that the results are significant (alpha = 0.05).

Of the patients in the present study that successfully quit smoking prior to TJA surgery, a majority (62%) did so through the use of “cold turkey” techniques, without the use of quit aids in the form of medications, support groups, or NRT. Interestingly, patients that utilized NRT to help quit smoking had a longer history of cigarette use (40 years vs 25 years,  $P = .007$ ) and a higher overall volume of cigarette use (18 years vs 8 years,  $P = .007$ ) relative to patients that did not use NRT to quit. Patients utilizing NRT, while they are not smoking, may still be subject to the harmful effects of nicotine in the perioperative period, such as tissue hypoxia, alterations in collagen synthesis, and immune modulation [21]. Given these detrimental effects, consideration for reserving NRT for refractory cases may be of benefit; however, further study is needed.

There is a wealth of data demonstrating risks between smoking and perioperative complications following hip and knee arthroplasty, [7,14,22,23] as well as increased risk of hospital readmission and reoperation in smokers relative to nonsmokers [24–26]. In the present study, smokers had an increased rate of any complication (27% vs 5%,  $P = .012$ ) and wound complications/infection (27% vs 5%,  $P = .023$ ) relative to patients who ceased smoking prior to surgery. The data from this study support the findings from other studies demonstrating that active tobacco use at the time of TJA significantly increases the risk of complications, particularly wound-related complications, following surgery.

Along with reducing postoperative wound complications, a smoking cessation protocol prior to elective TJA could aid with public health efforts to reduce smoking. Worldwide, over 7 million deaths a year are attributable to tobacco use, and this number is rising [1–3]. It is estimated that 14% of the United States population smokes cigarettes [1]. Currently, smoking economic costs total over \$300 billion a year [1]. This indicates that there could be a large public health implication of using elective TJA surgery as an incentive for smoking cessation.

This study has limitations. Primarily, the survey responses were self-reported, so there could be reporting bias leading to discrepancies in notation of dates, complications, and so on. Second, there were multiple surgeons contributing to the care of patients in the cohort with varied documentation methods. The limitations in documentation made it difficult to determine why 10 of the 15 patients who had surgery despite reporting they continued to smoke preoperatively had the surgery at our institution while the protocol required smoking cessation. A possible explanation would include the surgeon was not aware the patient continued to smoke, surgery was allowed to proceed after discussing the risks and benefits with the patient, the patient resumed smoking after negative urine testing, and so on. This study was conducted at a single hospital, so generalization of outcomes could include population bias.

**Table 5**  
Postoperative complications within 1 year of surgery.

Patient	Stopped smoking prior to TJA	Postoperative complication	Reoperation	Reoperation details	Time to first reoperation
1	Yes	PJI	Yes	DAIR followed by 2-stage exchange for persistent PJI	3 d
2	No	Hematoma, delayed wound healing, superficial infection	No		
3	No	PJI	Yes	2-Stage exchange	21 d
4	No	Superficial wound infection	No		
5	No	Delayed wound healing and dehiscence	Yes	I&D and closure of delayed wound healing	46 d
6	Yes	PJI	Yes	DAIR	35 d
7	Yes	Delayed wound healing and dehiscence	Yes	I&D and closure of delayed wound healing	41 d

DAIR, irrigation and debridement with component retention and antibiotics; I&D, irrigation and debridement; PJI, periprosthetic joint infection.

## Conclusions

The data from this self-reported survey study demonstrate that most patients (62%) will quit smoking, if required to, for an elective TJA. The 6-month continued abstinence rate with TJA as the motivator appears to be significantly higher than the current national average smoking cessation rate of 7.5% at 6 months when using NRT as cited by the Centers for Disease Control and Prevention [1]. Along with long-term public health benefits of smoking cessation, the results of this study suggest that patients may be less likely to experience a wound-related complication or infection if they stop smoking prior to surgery. These data support the development of a standardized smoking cessation protocol before TJA to improve surgery outcomes and the health of individuals.

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## Author Contributions

K.P., N.O.N., T.S.B., and N.A.B. contributed to data collection. K.P. wrote the article. C.N.C. and N.A.B. provided writing assistance. All the authors contributed to proofreading the article.

## Data

Available upon request.

## Conflicts of interest

Dr. C. N. Carender is in the editorial board of the *Journal of Arthroplasty*. Dr. N. O. Noiseux is a paid consultant for MicroPort and receives research support as a principal investigator from Wright Medical, DePuy, and Smith & Nephew. Dr. J. M. Elkins receives research support as a principal investigator from DePuy/J&J and is in the editorial board of the *Journal of Arthroplasty*. Dr. T. S. Brown is a paid consultant for Stryker; is in the editorial board of the *Journal of Arthroplasty*; and is a board member in American Association of Hip and Knee Surgeons, Musculoskeletal Infection Society, and Mid-America Orthopedic Association. Dr. N. A. Bedard is a paid consultant for DePuy; is in the editorial board of the *Journal of Arthroplasty*; and is a board member of the American Association of Hip and Knee Surgeons. Katelyn Paulsen has no potential conflicts of interest.

For full disclosure statements refer to <https://doi.org/10.1016/j.artd.2022.101087>.

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