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Complications Following Overlapping Orthopaedic Procedures at an Ambulatory Surgery Center

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Background: Overlapping surgery occurs when a single surgeon is the primary surgeon for >1 patient in separate operating rooms simultaneously. The surgeon is present for the critical portions of each patient's operation although not present for the entirety of the case. While overlapping surgery has been widely utilized across surgical subspecialties, few large studies have compared the safety of overlapping and nonoverlapping surgery.

Methods: In this retrospective cohort study, we reviewed the charts of patients who had undergone orthopaedic surgery at our ambulatory surgery center during the period of April 2009 and October 2015. A database of operations, including patient and surgical characteristics, was compiled. Complications had been identified and logged into the database by surgeons monthly over the study period. These monthly reports and case logs were reviewed retrospectively to identify complications. Propensity-score weighting and logistic regression models were used to determine the association between outcomes and overlapping surgery.

Results: A total of 22,220 operations were included. Of these, 5,198 (23%) were overlapping, and 17,022 (77%) were nonoverlapping. The median duration of surgery overlap was 8 minutes (quartile 1 to quartile 3, 3 to 16 minutes); no operations were concurrent. After weighting, the only continuous variables that differed significantly between the groups were operative time (median, 57 compared with 56 minutes for the overlapping and the nonoverlapping group, respectively; $p = 0.022$), anesthesia time (median, 97 compared with 93 minutes; $p < 0.001$), and total tourniquet time (median, 26 compared with 22 minutes; $p = 0.0093$). Multivariable logistic regression models did not demonstrate an association between overlapping surgery and surgical site infection, noninfection surgical complications, hospitalization, or morbidity.

Conclusions: These data suggest that there is no association between briefly overlapping surgery and surgical site infection, noninfection surgical complications, hospitalization, and morbidity. When practiced in the manner described herein, overlapping orthopaedic surgery can be a safe practice in the ambulatory setting.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Overlapping surgery occurs when a single surgeon is the primary surgeon for >1 patient in separate operating rooms simultaneously. The surgeon is present for the critical portions of each patient's operation although not present for the entirety of the case. Although overlapping surgery has only recently been recognized by the greater public, its use has been supported to hone trainee skills, increase access to highly sought-after surgeons, and improve cost-effectiveness[1-3]. Additionally, prior work in multiple surgical subspecialties has shown that surgical resident involvement improves patient care by bringing additional knowledge and viewpoints, questions, and assistance during cases[4-10]. However, common concerns about overlapping surgery are that the attending surgeon is not present for the entirety of each case and there may be increased anesthesia and operative times, thereby putting patients at increased risk of anesthesia and wound-related complications[3,11,12].

Studies in neurosurgery, cardiothoracic surgery, otolaryngology, general surgery, and orthopaedic surgery have found, in the aggregate, no increase in the risk of complications from overlapping compared with nonoverlapping surgeries[11-20].

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However, a recently published study demonstrated that overlapping hip fracture procedures and total hip arthroplasties were associated with an increased risk of complications[21]. Another recent study, focusing on the practice of overlapping ambulatory orthopaedic surgery, found no difference in the rate of complications at 30 days among cases that were overlapping and those that were not[20].

The aims of the current study were to determine whether overlapping surgery is associated with postoperative complications such as surgical site infection (SSI), noninfection surgical complications, hospitalization, and overall morbidity at an academic orthopaedic ambulatory surgery center (ASC) and to identify patient and surgical risk factors associated with these outcomes. We hypothesized that there would be no difference in the rate of complications between overlapping and nonoverlapping operations.

Materials and Methods

We conducted a retrospective chart review of all surgical cases performed at our freestanding, single-specialty, orthopaedic ASC over a 6.5-year period (April 21, 2009 to October 31, 2015) by 21 board-certified orthopaedic surgeons practicing across 5 subspecialties. Procedures performed at this ASC are elective operations. Total joint replacements and spine operations are not performed. All surgeons are members of the Department of Orthopaedic Surgery at our university-affiliated tertiary care hospital, and medical student, resident, and fellow education occurs as a part of patient care.

Patient and surgical data were obtained through automated extraction from the electronic medical record in conjunction with our university's Perioperative Systems team and Clinical Investigation Data Exploration Repository (CIDER)[22]. Manual chart review was utilized to complete missing data and to check the final database for accuracy. If missing data could not be resolved, the observation was dropped. In total, 47 cases (0.2%) were excluded because they either could not be accurately classified (overlapping or nonoverlapping) due to the involvement of multiple surgeons for varying portions of the case or they were found to be duplicates. Of the cases removed, 2 had noninfection surgical complications and 1 patient was hospitalized. All patients completed routine follow-up with their surgeon as appropriate for their surgical procedure.

Continuous variables examined were age, body mass index (BMI), overlap time, overlap percent, operative time, anesthesia time, and tourniquet time. Categorical factors included sex, advanced age (≥70 years), obesity (BMI of ≥30 kg/m^2), presence of diabetes mellitus, current smoking status, history of smoking, American Society of Anesthesiologists (ASA) score, anesthesia type, insurance type, race, whether a case was overlapping, the number of overlapping cases, the presence of a fracture at the surgical site, the use of an implant, tourniquet use, duration of tourniquet application (none, <1 hour, ≥1 hour), and anatomic surgical site. The age of 70 years was chosen as a cutoff because age of <70 versus ≥70 years was previously shown to be independently associated with hospital readmission following ambulatory surgery[23].

Operative time was defined as the time from skin incision to skin closure, and *anesthesia time* was defined as the time from induction of anesthesia to the return of independent respiratory function. *Tourniquet time* was calculated as the cumulative duration of all tourniquet applications. A case was categorized as *overlapping* if its attending surgeon had another case being performed (i.e., incision made) in a different room at any point during the course of the operation. Otherwise, the case was considered to be *nonoverlapping*. *Overlap time* was defined as the total number of minutes a case overlapped with any other case with the same attending surgeon at any point throughout its duration. *Overlap percent* was calculated as the overlap time as a percentage of the operative time. In our ASC, if the critical portion of a case is completed and the attending surgeon leaves the room to perform the critical portion of an overlapping case, it is policy that the index case be covered by another attending surgeon during the first surgeon's absence; this policy is congruent with American College of Surgeons principles[24]. We were unable, however, to determine when the critical steps of an operation occurred, as the only reliable measures with respect to case timing were skin incision and closure.

Study outcomes were SSI, noninfection surgical complications, and perioperative hospitalizations/unplanned same-day hospital admissions. We also combined these 3 categories into a single outcome that we called *morbidity*. *SSIs* were defined as occurring within 30 days of surgery and required the surgeon to make a diagnosis using clinical judgment. *Hospitalizations* were those for which patients required transfer to a hospital in the immediate perioperative setting for any reason or could not be discharged to home. For a list of the *noninfection surgical complications,* along with their frequencies, see the Appendix.

We attempted to minimize the possible bias of misclassification of complications by reviewing our infection report, which is based on a monthly query of surgeons and staff; site case logs, to identify cases in which the patient returned to the operating room for treatment of a complication; and Morbidity and Mortality Conference logs. None of the physicians have privileges outside of the hospital system, so all cases that returned to the operating room were captured. Moreover, since all of the primary procedures included in the study were scheduled elective outpatient operations, patients completed appropriate scheduled follow-up with their surgeon.

Statistical Analysis

Continuous variables are presented as the median and first and third quartiles (Q1, Q3). Categorical variables are presented as the number and percentage. Wilcoxon rank-sum and chi-square tests were used to compare continuous and categorical data, respectively. Significance was assessed at the level of $p < 0.05$, and all p values were 2-tailed. Missing data points for each observation were imputed before analysis using multiple imputation by chained equations[25]. Categories with imputed values included anesthesia time, smoking history, and current smoker, but the amount of data missing in each column was <2% of the total observations for each field. Additional data points were missing for race, anatomic area, ASA score, and insurance, and these were omitted from

TABLE I Bivariate Analyses of Patient and Surgical Factors: Overlapping Versus Nonoverlapping, Before and After ATT PS Weighting*

	Overlapping	Nonoverlapping		P Value	
	Unweighted (N = 5,198)	Unweighted (N = 17,022)	Weighted (N = 5,197)	Unweighted	Weighted
Age *(yr)*	44.2 (25.3-55.5)	45.1 (27.2-56.5)	43.4 (25.1-55.5)	<0.0001†	0.53
BMI *(kg/m^2)*	27.5 (24-31.6)	27.4 (23.9-31.7)	27.4 (24-31.6)	0.77	0.99
Tourniquet time *(min)*	26 (0-54)	23 (0-50)	22 (0-48)	0.6	0.0093†
Operative time *(min)*	57 (35-90)	51 (29-83)	56 (33-88)	<0.0001†	0.022†
Anesthesia time *(min)*	97 (68-133)	86 (59-124)	93 (64-130)	<0.0001†	<0.001†
Diabetes mellitus	344 (6.6)	1,178 (6.9)	347 (6.7)	0.47	0.93
Smoking history	1,551 (29.8)	5,255 (30.9)	1,564 (30.1)	0.15	0.77
Current smoker	603 (11.6)	1,979 (11.6)	609 (11.7)	0.95	0.86
BMI ≥30 kg/m^2	1,754 (33.7)	5,799 (34.1)	1,774 (34.1)	0.68	0.69
Age ≥70 yr	148 (2.8)	665 (3.9)	144 (2.8)	<0.001†	0.87
Preop. antibiotics	4,442 (85.5)	13,921 (81.8)	4,430 (85.2)	<0.0001†	0.76
Fracture	384 (7.4)	1,724 (10.1)	387 (7.4)	<0.0001†	0.94
Implant used	2,401 (46.2)	6,955 (40.9)	2,392 (46.0)	<0.0001†	0.88
Male sex	3,028 (58.3)	8,970 (52.7)	3,031 (58.3)	<0.0001†	0.96
Tourniquet used	3,446 (66.3)	11,912 (70.0)	3,443 (66.3)	<0.0001†	0.98
Tourniquet duration				<0.0001†	0.029†
No tourniquet	1,752 (33.7)	5,110 (30.0)	1,754 (33.7)		
<1 hr	2,307 (44.4)	8,472 (49.8)	2,408 (46.3)		
≥1 hr	1,139 (21.9)	3,440 (20.2)	1,035 (19.9)		
Race				0.59	0.74
Black	422 (8.1)	1,353 (7.9)	424 (8.1)		
Caucasian	4,132 (79.5)	13,759 (80.8)	4,198 (80.8)		
Other	245 (4.7)	766 (4.5)	232 (4.5)		
Anatomic area				<0.0001†	0.98
Shoulder	1,156 (22.2)	2,943 (17.3)	1,149 (22.1)		
Hand and elbow	1,257 (24.2)	5,268 (30.9)	1,265 (24.3)		
Hip	124 (2.4)	301 (1.8)	137 (2.6)		
Knee and leg	2,034 (39.1)	4,983 (29.3)	2,023 (38.9)		
Foot and ankle	202 (3.9)	2,127 (12.5)	203 (3.9)		
Multiple locations	407 (7.8)	1,368 (8.0)	411 (7.9)		
ASA score				0.0038†	1
1	1,747 (33.6)	5,305 (31.2)	1,744 (33.6)		
2	2,939 (56.5)	10,018 (58.9)	2,942 (56.6)		
≥3	511 (9.8)	1,687 (9.9)	509 (9.8)		
Insurance				0.19	0.71
Private	3,978 (76.5)	12,900 (75.8)	3,973 (76.4)		
Medicare	726 (14.0)	2,594 (15.2)	735 (14.1)		
Medicaid	206 (4.0)	698 (4.1)	227 (4.4)		
Uninsured	101 (1.9)	350 (2.1)	111 (2.1)		
Anesthesia type				<0.0001†	0.97
General	4,093 (78.7)	11,865 (69.7)	4,083 (78.6)		
Regional	183 (3.5)	1,040 (6.1)	184 (3.5)		
Combined	922 (17.7)	4,117 (24.2)	931 (17.9)		

*ATT PS weighting = average-treatment-effect-for treated propensity-score weighting. Continuous variables are given as the median, with the first and third quartiles in parentheses, and categorical variables are given as the number, with the percentage in parentheses. †Significant.

TABLE II Bivariate Analyses of Outcomes: Overlapping Versus Nonoverlapping

	Overlapping*	Nonoverlapping*		P Value	
	Unweighted (N = 5,198)	Unweighted (N = 17,022)	Weighted (N = 5,197)	Unweighted	Weighted
SSI	13 (0.3)	58 (0.3)	14 (0.3)	0.38	0.99
Noninfection complication	14 (0.3)	40 (0.2)	12 (0.2)	0.78	0.9
Hospitalization	1 (0.0)	18 (0.1)	6 (0.1)	0.11	0.13
Morbidity	28 (0.5)	113 (0.7)	31 (0.6)	0.37	0.76

*The values are given as the number, with the percentage in parentheses.

analysis. The total amount of data missing for anatomic area, ASA score, and insurance was ≤3%; and for race, <7%.

Propensity-score weighting was used to adjust for significant differences between the overlapping and nonoverlapping groups. A logistic regression analysis with overlapping or nonoverlapping surgery as the outcome was performed using variables that were significantly different between the study groups ($p < 0.05$), and the average-treatment-effect-for-treated weights was determined from the predicted probabilities. Bivariate analyses of the covariates in the overlapping and

TABLE III Multivariable Logistic Regression Models for Each Outcome of Interest*

	Outcome of Interest Reported			95% CI		
	Yes	No	Odds Ratio	2.5%	97.5%	P Value
SSI						
N	27	10,368				
Surgery overlap	13 (48.2)	5,185 (50.0)	0.948	0.444	2.01	0.89
Operative time *(min)*	73 (46-113)	57 (34-89)	1.01	1	1.02	0.003†
Age ≥70 yr	3 (11.1)	290 (2.8)	3.8	0.857	12.5	0.075
Shoulder	1 (3.7)	2,304 (22.2)	0.0851	0.00849	0.364	<0.001†
Multiple anatomic locations	1 (3.7)	817 (7.9)	0.275	0.024	1.16	0.086
ASA score ≥3	6 (22.2)	1,014 (9.8)	3.55	1.3	8.52	0.016†
Combined anesthesia	9 (33.3)	1,843 (17.8)	3.46	1.34	8.9	0.011†
Noninfection complication						
N	26	10,369				
Surgery overlap	14 (53.8)	5,184 (50.0)	1.15	0.541	2.49	0.71
Operative time *(min)*	80 (58-121)	57 (34-89)	1.01	1	1.02	0.059
Implant used	20 (76.9)	4,773 (46.0)	2.67	1	7.88	0.05†
Private insurance	15 (57.7)	7,936 (76.5)	0.38	0.179	0.827	0.016†
Hospitalization						
N	7	10,388				
Surgery overlap	1 (14.3)	5,197 (50.0)	0.232	0.0242	1.11	0.068
Tourniquet used	2 (28.6)	6,887 (66.3)	0.226	0.0381	0.995	0.049†
ASA score ≥3	3 (42.9)	1,017 (9.8)	5.58	1.16	22.9	0.034†
Morbidity						
N	59	10,336				
Surgery overlap	28 (47.5)	5,170 (50.0)	0.914	0.547	1.52	0.73
Operative time *(min)*	78 (50-113)	57 (34-89)	1.01	1	1.02	0.0054†
Implant used	40 (67.8)	4,753 (46.0)	1.82	0.959	3.52	0.067
ASA score ≥3	12 (20.3)	1,008 (9.8)	2.75	1.39	5.02	0.0048†

*Continuous variables (operative time) are given as the median, with the first and third quartiles in parentheses, and categorical variables are given as the number, with the percentage in parentheses. †Significant.

TABLE IV Univariate Logistic Regression Models Evaluating Overlap Time and Overlap Percent for Cases with and without Outcomes of Interest

	Outcome of Interest Reported			95% CI		
	Yes	No	Odds Ratio	2.5%	97.5%	P Value
SSI						
N	27	10,368				
Surgery overlap time* *(min)*	0 (0-5)	1 (0-8)	0.995	0.946	1.03	0.81
Surgery overlap percent* *(%)*	0 (0-10)	0 (0-15)	0.991	0.96	1.01	0.46
Noninfection complication						
N	26	10,369				
Surgery overlap time* *(min)*	2 (0-7)	0 (0-8)	1.01	0.968	1.04	0.66
Surgery overlap percent* *(%)*	2 (0-10)	0 (0-15)	0.989	0.956	1.01	0.4
Hospitalization						
N	7	10,388				
Surgery overlap time* *(min)*	0 (0-0)	1 (0-8)	0.965	0.789	1.05	0.53
Surgery overlap percent* *(%)*	0 (0-0)	0 (0-15)	0.991	0.909	1.03	0.74
Morbidity						
N	59	10,336				
Surgery overlap time* *(min)*	0 (0-6)	1 (0-8)	0.996	0.966	1.02	0.74
Surgery overlap percent* *(%)*	0 (0-10)	0 (0-15)	0.987	0.966	1	0.14

*The values are given as the median, with the first and third quartiles in parentheses.

nonoverlapping groups were performed before and after average-treatment-effect-for-treated propensity-score weighting (Table I). To assess whether there was clustering for each outcome by attending surgeon, intraclass correlation coefficients were calculated (0.00556, 0.0195, <0.001, and 0.0104 for SSI, noninfection surgical complications, hospitalization, and morbidity, respectively). Because all coefficients were <0.2, each outcome and the attending surgeon were independent variables, and clustering was ruled out.

Multivariable logistic regression assessed the association between overlapping and nonoverlapping status and the other covariates for each outcome. All variables were screened for association with each outcome using bivariate analysis (see Appendix). Correlation was assessed for each pair of covariates, and tourniquet time, anesthesia time, and operative time were found to be collinear. Operative time was chosen for inclusion as the most relevant surgical variable. Features with a p value of <0.2 or clinical suspicion were entered into the multivariable models. Observations were weighted by the average-treatment-effect-for-treated propensity-score weights, and the logit of the propensity score was included in the models as a covariate. Stepwise backward model selection was performed to determine the most parsimonious model. The overlapping and nonoverlapping surgery groups and the logit of the propensity score were forced for inclusion in each model.

A significance level of $p < 0.1$ was used as the criterion for potential variable elimination. The Firth penalized likelihood method was applied to control for quasi-complete separation in rare event analyses[26]. Adjusted odds ratios (ORs) with penalized 95% confidence intervals (CIs) and p values are reported for each model. Fit was assessed using the Hosmer-Lemeshow and C-statistics (see Appendix). To estimate the effect and stability of overlapping surgery in the SSI model, a bootstrap of 10,000 replicate samples of the original data was used to refit the model. Finally, logistic regression analysis was performed using overlap minutes or percent to determine if a dose-dependent relationship with these outcomes existed. All data analysis was performed using Python 3.6.2 (Python Software Foundation) and R 3.4.2 (The R Foundation) with libraries RPy2 2.9.1, NumPy 1.13.3, SciPy 0.19.1, Sci-Kit-Learn 0.19.0, and Statsmodels 0.8.0 for Python and ICC 2.3.0, Logistf 1.22, ResourceSelection 0.3-1, and pROC 1.10.0 for R.

Results

A total of 22,220 operations were included in this study. Of these, 5,198 (23%) were overlapping and 17,022 (77%) were nonoverlapping. Of the cases that were overlapping, the median duration of surgery overlap was 8 minutes (Q1 to Q3, 3 to 16 minutes), and the median percent of overlap was 15% (Q1 to Q3, 7% to 28%). No concurrent operations were performed. A small number of cases (89 cases, 0.40% of the procedures) overlapped another case for 100% of their durations. Each of these cases was short in duration (mean, 25 minutes) and was performed during a noncritical portion of its overlapping case, typically during closure of a notably longer associated case. An attending surgeon audited each of these cases and confirmed that no concurrent surgery occurred. The rates of complications were as follows: SSI, 0.25% in the overlapping group and 0.34% in the nonoverlapping group; noninfection complications, 0.27% and 0.23% in the 2 groups, respectively; hospitalization, 0.02% and 0.11%; and morbidity, 0.54% and 0.66%.

Before weighting, 13 variables differed significantly between the 2 study groups (Table I). Following weighting, the only variables that were significantly different were total tourniquet time (median, 26 compared with 22 minutes for overlapping and nonoverlapping, respectively; $p = 0.0093$), operative time (median, 57 compared with 56 minutes; $p = 0.022$), anesthesia time (median, 97 compared with 93 minutes; $p < 0.001$), and duration of tourniquet application (tourniquet time of <1 hour, 44.4% compared with 46.3% of the cases; tourniquet time of ≥1 hour, 21.9% compared with 19.9% of cases; $p = 0.029$) (Table I). No significant difference was observed between the overlapping and nonoverlapping groups for each of the outcomes, before and after weighting (Table II).

After identifying candidate features using bivariate analysis (see Appendix), stepwise multivariable analysis was performed (Table III). After adjusting for covariates, the presence of overlapping surgery was not associated with SSI (OR, 0.948; 95% CI, 0.444 to 2.01; $p = 0.89$), noninfection surgical complications (OR, 1.15; 95% CI, 0.541 to 2.49; $p = 0.71$), hospitalization (OR, 0.232; 95% CI, 0.0242 to 1.11; $p = 0.068$), or morbidity (OR, 0.914; 95% CI, 0.547 to 1.52; $p = 0.73$), and the 95% CI for the OR for overlapping versus nonoverlapping remained nonsignificant at 0.07 to 5.6 for the SSI model refit with the 10,000 bootstrap samples. Neither overlap time nor overlap percent was associated with adverse outcomes (Table IV).

Discussion

Our results suggest that overlapping orthopaedic surgery can be performed safely for brief periods of time in the ambulatory setting without increasing the risk of SSI, noninfection surgical complications, hospitalization, or morbidity.

After statistical weighting, significant differences between the study groups disappeared, with 4 exceptions. The continuous variables of tourniquet time, operative time, and anesthesia time together with the categorical variable of tourniquet duration of <1 hour and tourniquet duration of ≥1 hour compared with no tourniquet time differed significantly between the overlapping and nonoverlapping groups. In contrast, a prior study demonstrated no significant difference between similar groups in mean procedure time or mean total operating room time[20]. While this raises the possibility of intercenter variability, it is unlikely that our significant time differences are clinically important. Several authors have raised concerns that overlapping surgery can lead to increased operative times and anesthesia time and thereby could result in more complications[3,11,12]. The slightly longer operative times and anesthesia times among our patients did not increase the risk of SSI, noninfection surgical complications, hospitalization, or morbidity, which is in agreement with previous reports[11-20].

Our study results complement those of a recent study performed at another orthopaedic ASC[20]. Although the majority of that center's cases were overlapping (68%) compared with the minority of cases in the current study (23%), the results are largely congruent. Neither study found any significant difference between the study groups with respect to age, sex, BMI, or ASA score, and they found no difference in mean procedure time or total time in the operating room. As mentioned, although we did find significant differences in operative time and anesthesia time between the study groups, the small differences are unlikely to be clinically important. Both that center and ours had low rates of overall complications, with no significant difference between overlapping and nonoverlapping groups (1.1% versus 1.3% in the previous study and 0.54% versus 0.66% in the current study for overlapping versus nonoverlapping groups, respectively). Finally, both the previous study and ours failed to demonstrate any change in the risk of complications with increasing overlap time. Both studies suggest that overlapping surgery does not impact the risk of complications in the ambulatory orthopaedic surgery setting.

An aspect of overlapping surgery that was not examined in this study is the effect of the attending surgeon. Although overlapping surgery appears safe in the ambulatory orthopaedic surgery setting, much is left to the judgment of the attending surgeon: the surgeon determines which cases are overlapping and by how long each case overlaps. By definition, overlapping operations only overlap for "noncritical" portions of the procedure[24], but there is no standard definition of "noncritical" and each surgeon makes this determination. The surgeon must appraise the abilities of the ancillary staff assisting with the operation, whether they be physician assistants, residents, or fellows, and bestow only an appropriate amount of autonomy to ensure patient safety. At our ASC, the attending surgeon must be present for the surgical timeout, and if he or she leaves the room to perform the critical portion of an overlapping case, an additional attending surgeon must be available to cover the index case.

There were several limitations to our investigation that may affect its generalizability. Most notably, the study was performed at a single ASC, and therefore, the findings may not be transferable to other centers where policies and procedures may differ. Although we used statistical weighting to reduce bias, the study was retrospective, and it is possible that we did not account for all notable influencers. There were limitations in data availability based on changes in electronic medical record structure, protocols for recorded patient data, and clinic workflow. While patients completed the expected surgical follow-up for their procedure, we did not contact patients independently for this study, nor did we calculate the average duration of follow-up for the cohort. Therefore, it is possible that some postoperative complications, such as infections, may have not been discovered, but there is no reason to assume that the rate of underreporting would have been different between the 2 study groups. Although we performed manual checks on all inconsistent and outlying data, we may not have identified all problematic prerecorded data in the patient chart.

In summary, our data suggest that, according to our model, briefly overlapping surgery is a safe practice in the ambulatory orthopaedic surgery setting. We found no association with SSI, noninfection surgical complications, hospitalization, or morbidity based on the presence of overlap. Practitioners, payers, and patients should be reassured that limited overlapping surgery is appropriate and reasonable in this setting.

Appendix

eA A table listing noninfection surgical complications and their frequency, and tables showing the results of bivariate analyses of the association of patient and surgical factors and the outcomes of interest after average-treatment-effect-for-treated propensity-score weighting, are available with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/F15). ■

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