

Appendix

Non-Inferiority Analysis Implementation

To conduct the non-inferiority analysis in our logistic regression analysis framework, we compared the 90% confidence interval (CI) upper bound with an odds ratio (OR) of 1.51, the OR under the null hypothesis reflecting our non-inferiority margin. The value of 1.51 was calculated from the odds of a complication in the overlapping surgery group divided by the odds in the non-overlapping surgery group. The non-overlapping surgery group's complication rate was 1.85% (in our full sample), so under the null hypothesis, the overlapping surgery group's rate would be $1.5 \times 1.85\% = 2.77\%$ or greater, which corresponds to an OR of $(0.0277/[1 - 0.0277]) / (0.0185/[1 - 0.0185]) = 1.51$. We conducted a 1-sided test comparing our OR with 1.51, and evaluated its significance at $p < 0.05$ (equivalent to comparing the 90% CI upper bound with 1.51). For simplicity and comparability to our secondary outcomes, we also conducted a conventional hypothesis test (comparing the OR with 1.0 using a 2-sided test and reporting a 95% CI).

Sensitivity Analysis 1

We performed a sensitivity analysis in which 1 institution with a lower percentage of overlapping cases was excluded, leaving 12,577 patients in the analysis. The results from the model generated in this sensitivity analysis were similar to the full model with regard to coefficient direction and significance (Tables E-1 and E-2).

Sensitivity Analysis 2

We ran a second sensitivity analysis for the most common procedure, total hip or knee arthroplasty. This analysis reduced our sample size by 57% to 6,083 patients. It removed potential confounding due to procedure type at the cost of decreased power and generalizability. The results from the model generated in this sensitivity analysis were similar to the full model with regard to coefficient direction and significance (but to a lesser magnitude) (Table E-3).

Sensitivity Analysis 3

We ran a third sensitivity analysis that only included surgeons who performed overlapping surgery. This analysis reduced our sample size to 12,889 patients. It minimized potential confounding due to surgeon workflow preferences or practices (Table E-4).

Sensitivity Analysis 4

We ran a fourth sensitivity analysis that excluded patients with propensity scores of <0.2 and >0.8 from the GEE model. This analysis reduced our sample size to 10,676 patients. It minimized potential confounding due to surgeon workflow preferences or practices (Table E-5).

TABLE E-1 GEE Model for the Primary Outcome, Weighted by Propensity Scores and Adjusting for Clustering within Surgeons, per Sensitivity Analysis 1*

Variable	OR†	P Value
Overlapping surgery‡	0.61 (0.42 to 0.89)	0.009
Institution		
Institution 1	Excluded	
Institution 2	2.78 (1.62 to 4.80)	<0.001
Institution 3	Reference	
Institution 4	0.51 (0.26 to 1.01)	0.054
Institution 5	0.51 (0.30 to 0.86)	0.011
Surgical procedure type		
Total joint replacement	Reference	
Spine	2.95 (1.71 to 5.09)	<0.001
Fracture treatment	1.56 (0.79 to 3.08)	0.2
Other procedures of bone and joint	2.69 (1.33 to 5.43)	0.006
Soft-tissue procedures	3.88 (1.95 to 7.70)	<0.001
Other	4.82 (1.70 to 13.62)	0.003
Admission severity of illness		
Minor	Reference	
Moderate	2.43 (1.35 to 4.35)	0.003
Major	5.62 (2.68 to 11.82)	<0.001
Extreme	27.88 (13.11 to 59.28)	<0.001

*One institution has been removed per Sensitivity Analysis 1. †The values are given as the OR, with the 95% CI in parentheses. ‡For overlapping surgery, the OR (and 90% CI) was 0.61 (0.45 to 0.83), and the 1-sided p value, which corresponds to our non-inferiority analysis, was $p < 0.001$.

TABLE E-2 GEE Model for the Secondary Outcomes of All-Cause 30-Day Hospital Admission, Length of Stay, and Inpatient Mortality, Adjusting for Clustering within Surgeons, per Sensitivity Analysis 2

Outcome	Estimates Associated with Overlapping Surgery	P Value
Length of stay*	0.93 (0.89 to 0.98)†	0.01
All-cause 30-day hospital readmission*	0.65 (0.50 to 0.86)‡	0.002
Inpatient mortality§	1.13 (0.52 to 2.45)‡	0.77

*The models for all-cause 30-day hospital admission and length of stay are adjusted for institution (1 institution has been removed per Sensitivity Analysis 1), procedure type, and admission severity of illness. †The value is given as the ratio in outcomes (with the 95% CI in parentheses) between the overlapping surgery group and the non-overlapping surgery group. ‡The values are given as the odds ratio, with the 95% CI in parentheses. §Because of the low number of inpatient deaths, the model for inpatient mortality adjusts only for the admission severity of illness.

TABLE E-3 GEE Model for the Primary Outcome, Weighted by Propensity Scores, Adjusting for Clustering within Surgeons, and Limited to Patients Undergoing Total Hip or Knee Arthroplasty, per Sensitivity Analysis 3

Variable	OR*	P Value
Overlapping surgery†	0.92 (0.55 to 1.55)	0.76
Institution		
Institution 1	0.51 (0.02 to 10.95)	0.67
Institution 2	3.21 (1.71 to 6.00)	<0.001
Institution 3	Reference	
Institution 4	0.45 (0.17 to 1.22)	0.12
Institution 5	0.85 (0.44 to 1.66)	0.64
Admission severity of illness		
Minor	Reference	
Moderate	2.18 (0.78 to 6.13)	0.14
Major	8.18 (2.41 to 27.82)	<0.001
Extreme	32.89 (2.77 to 390.56)	0.006

*The values are given as the OR, with the 95% CI in parentheses. †For our non-inferiority testing of overlapping surgery, the OR (and 90% CI) was 0.92 (0.6 to 1.43), and the 1-sided p value was p = 0.032.

TABLE E-4 GEE Model for the Primary Outcome, Weighted by Propensity Scores, Adjusting for Clustering within Surgeons, and Only Including Surgeons Who Performed Overlapping Surgery per Sensitivity Analysis 4*

Variable	OR†	P Value
Overlapping surgery‡	0.61 (0.42 to 0.88)	0.008
Institution		
1	1.32 (0.58 to 3.01)	0.51
2	2.78 (1.59 to 4.85)	<0.001
3	Reference	
4	0.49 (0.25 to 0.99)	0.047
5	0.54 (0.32 to 0.91)	0.021
Clinical Classification Software category		
Total joint replacement	Reference	
Spine	2.75 (1.59 to 4.73)	<0.001
Fracture treatment	1.56 (0.79 to 3.08)	0.20
Other procedures of bone or joint	2.59 (1.25 to 5.36)	0.011
Soft-tissue procedures	4.07 (2.01 to 8.21)	<0.001
Other	4.78 (1.72 to 13.26)	0.003
Admission severity of illness		
Minor	Reference	
Moderate	2.38 (1.34 to 4.26)	0.003
Major	4.99 (2.37 to 10.52)	<0.001
Extreme	26.62 (12.54 to 56.51)	<0.001

*We concluded that the overlapping surgery group was non-inferior, with 39% lower odds of complication (OR, 0.61 [90% CI, 0.45 to 0.83]; $p < 0.001$). We also used a conventional test of differences and found that the lower complication rate in the overlapping surgery group was significant ($p = 0.008$). †The values are given as the OR, with the 95% CI in parentheses. ‡For our non-inferiority testing of overlapping surgery, the OR (and 90% CI) was 0.61 (0.45 to 0.83), and the 1-sided p value was $p < 0.001$.

TABLE E-5 GEE Model for the Primary Outcome, Weighted by Propensity Scores, Adjusting for Clustering within Surgeons, and Excluding Patients with Propensity Scores of <0.2 and >0.8*

Predictor	OR†	P Value
Overlapping surgery‡	0.61 (0.42 to 0.90)	0.012
Institution		
1	Excluded	
2	2.82 (1.63 to 4.90)	<0.001
3	Reference	
4	0.48 (0.26 to 0.89)	0.020
5	0.64 (0.32 to 1.28)	0.21
Clinical Classification Software category		
Total joint replacement	Reference	
Spine	2.89 (1.65 to 5.07)	<0.001
Fracture treatment	1.49 (0.75 to 2.97)	0.26
Other procedures of bone or joint	2.72 (1.28 to 5.76)	0.009
Soft-tissue procedures	4.08 (2.02 to 8.23)	<0.001
Other	3.82 (1.20 to 12.21)	0.024
Admission severity of illness		
Minor	References	
Moderate	2.47 (1.35 to 4.54)	0.004
Major	5.78 (2.64 to 12.67)	<0.001
Extreme	30.58 (14.27 to 65.52)	<0.001

*We concluded that the overlapping surgery group was non-inferior, with 39% lower odds of complications (OR, 0.61 [90% CI, 0.44 to 0.84]; $p < 0.001$). We also used a conventional test of differences and found that the lower complication rate in the overlapping surgery group was significant ($p = 0.012$). †The values are given as the OR, with the 95% CI in parentheses. ‡For our non-inferiority testing of overlapping surgery, the OR (and 90% CI) was 0.61 (0.44 to 0.84), and the 1-sided p value was $p < 0.001$.