2018

The Practice of Overlapping Surgery Is Safe in Total Knee and Hip Arthroplasty

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Citation
JBJS Open Access (2018) 3(3):e0004

JB&JS OPEN ACCESS

The Practice of Overlapping Surgery Is Safe in Total Knee and Hip Arthroplasty

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Background: Overlapping surgery occurs when a surgeon performs 2 procedures in an overlapping time frame. This practice is commonplace in the setting of total joint arthroplasty and is intended to increase patient access to experienced surgeons, improve efficiency, and advance the surgical competence of surgeons and trainees. The practice of overlapping surgery has been questioned because of safety and ethical concerns. As the literature is scarce on this issue, we evaluated the unplanned hospital readmission and reoperation rates associated with overlapping and non-overlapping total joint arthroplasty procedures.

Methods: We reviewed 3,290 consecutive primary total knee and hip arthroplasty procedures that had been performed between November 2010 and July 2016 by 2 fellowship-trained senior surgeons at a single institution. Overlapping surgery was defined as the practice in which the attending surgeon performed a separate procedure in another room with an overlapping room time of at least 30 minutes. Patient baseline characteristics and 90-day rates of complications, readmissions, and reoperations were compared between overlapping and non-overlapping procedures. Subanalyses also were done on patients with a body mass index (BMI) of ≥30 kg/m^2 and those with an American Society of Anesthesiologists (ASA) score of 3 or 4. The level of significance was set at 0.05.

Results: Of the 2,833 procedures that met the inclusion criteria, 57% (1,610) were overlapping and 43% (1,223) were non-overlapping. Baseline demographics, BMI, and ASA scores were similar between the groups. No significant differences were found between the overlapping and non-overlapping procedures in terms of the 90-day rates of complications (5.2% vs. 6.6%, respectively; p = 0.104), unplanned readmissions (3.4% vs. 4.3%; p = 0.235), or reoperations (3.1 vs. 3.1; p = 1.0) in the analysis of the entire cohort or in subgroup analyses of obese patients and patients with an ASA score of 3 or 4. The total mean operating room time was 5.8 minutes higher for overlapping procedures.

Conclusions: Overlapping procedures showed no increase in terms of the 90-day rates of complications, readmissions, or reoperations when compared with non-overlapping procedures. There was just over a 5-minute increase in mean operating room time for overlapping procedures. Our data suggest that overlapping surgery does not lead to detrimental outcomes following total knee arthroplasty or total hip arthroplasty. Future investigations evaluating patient-oriented outcomes and satisfaction are warranted.

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

The practice of overlapping surgery has gained recent attention in the media and the scientific community because of ethical and safety concerns[1,2]. However, to our knowledge, its effects on safety and quality of care in the settings of total knee arthroplasty and total hip arthroplasty have not been studied.

The American College of Surgeons (ACS) defines overlapping surgery as a practice in which an attending surgeon performs 2 procedures during an overlapping time frame, with the surgeon performing the key or critical components of 1 procedure before starting another procedure in another operating room[3]. An experienced practitioner is delegated to complete the non-critical portions of the procedure, such as wound closure, while the primary surgeon transitions to start the second procedure in another operating room[4,5]. Critical components are

Disclosure: This investigation did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. On the **Disclosure of Potential Conflicts of Interest** forms, *which are provided with the online version of the article*, one or more of the authors checked "yes" to indicate that the author had a relevant financial relationship in the biomedical arena outside the submitted work (http://links.lww.com/JBJSOA/A55).

defined as those portions of the procedure in which the surgical experience and decisions of the attending surgeon are required, although such components are not well defined in the literature because they are left to the surgeon to determine, as permitted by the ACS and the Centers for Medicare & Medicaid Services (CMS)[4,5]. On the other hand, the ACS defines concurrent procedures as those in which the critical components of 2 procedures for which a single attending physician is responsible are occurring at the same time[3]. In contrast to overlapping procedures, concurrent procedures are deemed inappropriate according to ACS guidelines[4]. For billing purposes, CMS regulations state that, in cases of overlapping surgery, the primary surgeon must be present for the critical portions of the procedures, which are institution-dependent. Moreover, before assigning the appropriate delegates to take over, another qualified surgeon must be designated in case a complication arises that requires the skills and judgment of an experienced surgeon[6].

With overlapping surgery, the surgeon alternates between 2 rooms to minimize downtime associated with operating room clean-up and set-up[3]. Even though this practice does not reduce clean-up time or set-up time per room, it allows for a more efficient use of the surgeon's time. Overlapping procedures improve the workload that a single surgeon is able to accomplish in a day, facilitating patient access to high-volume, experienced surgeons. This practice also can benefit surgical centers by enhancing volume. Advocates of overlapping surgery also have argued that this practice helps in the training of medical professionals by allowing more independence and hands-on experience[4]. Overlapping surgery makes it possible for many time-consuming tasks that do not require the level of surgical expertise of the primary surgeon (e.g., surgical exposure, wound closure) to be done simultaneously, thereby improving efficiency[1,7]. Nevertheless, it cannot be overemphasized that surgical exposure and wound closure do require surgical expertise, and participating physician assistants and/or fellows must have such experience.

Hospital readmission rates and complications leading to reoperations are used as surrogates to measure the quality of care[8]. However, there is a paucity of investigations in the orthopaedic literature examining the practice of overlapping surgery in the settings of total knee arthroplasty and total hip arthroplasty. The effects of this practice on quality and safety remain uncertain. Therefore, the purposes of the present study were to determine (1) 90-day complication, unplanned readmission, and reoperation rates; (2) the mean operating room time; and (3) types of complications that lead to readmissions or reoperations, associated with overlapping and non-overlapping primary total knee arthroplasty and total hip arthroplasty.

TABLE I Baseline Demographic and Patient Characteristics of Overlapping and Non-Overlapping Groups

	Overlapping (N = 1,610)	Non-Overlapping (N = 1,223)	P Value
Age* *(yr)*	65.2 ± 10.5	65.2 ± 10.8	0.956
Sex *(no. of patients)*			0.568
Female	864 (53.7%)	670 (54.8%)	
Male	746 (46.3%)	553 (45.2%)	
Race† *(no. of patients)*			0.472
White	1,346 (83.7%)	1,031 (84.8%)	
Black	196 (12.2%)	147 (12.1%)	
Asian	12 (0.7%)	11 (0.9%)	
Native American	3 (0.2%)	2 (0.2%)	
Multiracial	51 (3.2%)	25 (2.1%)	
Ethnicity† *(no. of patients)*			0.386
Non-Hispanic	1,329 (82.7%)	1,018 (84.0%)	
Hispanic	278 (17.3%)	194 (16.0%)	
BMI* *(kg/m^2)*	29.7 ± 5.9	29.9 ± 6.1	0.478
ASA score† *(no. of patients)*			0.672
1	93 (5.8%)	70 (5.7%)	
2	983 (61.2%)	736 (60.4%)	
3	520 (32.4%)	408 (33.5%)	
4	10 (0.6%)	4 (0.3%)	
Procedure *(no. of patients)*			0.465
Total hip arthroplasty	932 (57.9%)	725 (59.3%)	
Total knee arthroplasty	678 (42.1%)	498 (40.7%)	

*The values are given as the mean and the standard deviation. †The values and percentages pertain to the number of patients with available data.

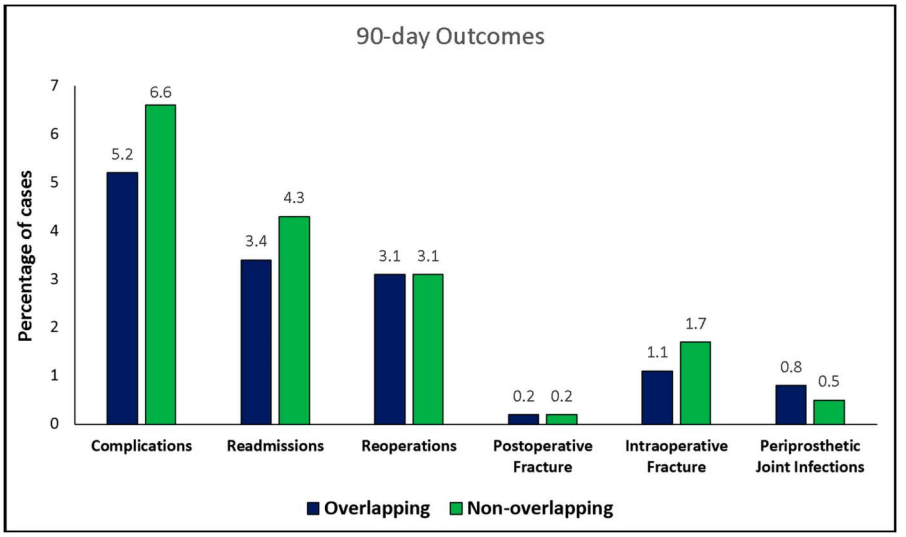

Fig. 1

Bar graph illustrating outcomes within 90 days after surgery in the overlapping and non-overlapping groups.

We sought to determine whether it is detrimental for patients to have a single attending surgeon responsible for 2 procedures that are performed simultaneously for a certain period of time. We hypothesized that the practice of overlapping surgery does not have detrimental effects on quality and safety because the primary surgeon always performs the critical components of all procedures whereas experienced fellows and/or physician assistants perform the non-critical portions.

Materials and Methods

We performed a retrospective review of 3,290 consecutive primary total knee and total hip arthroplasty procedures that had been performed between November 1, 2010, and July 8, 2016, by 2 fellowship-trained senior orthopaedic surgeons at a single institution. Institutional review board approval was obtained for this investigation. The inclusion criteria were treatment with primary total knee or total hip arthroplasty and a preoperative diagnosis of primary or secondary osteoarthritis, osteonecrosis, rheumatoid arthritis, dysplasia, or post-traumatic arthritis. Procedures performed because of fractures were excluded (n = 28). In order to guarantee the independence of observations, we also excluded 429 procedures that represented bilateral or additional total knee or total hip arthroplasties performed in the same patient. As a result, a total of 2,833 primary procedures, in the same number of patients, were included in the statistical analysis.

Operating room time (the time from the entrance to the departure of the patient) was reviewed to identify overlapping cases. Strictly speaking, any time frames during which 2 patients in different rooms were under the responsibility of a single surgeon would be considered to be overlapping. However, for methodological purposes, we wanted to evaluate overlapping time frames that could have clinical relevance. Therefore, only procedures with ≥30 minutes of operating room time overlap were included in the statistical analysis.

Our institution has a dedicated arthroplasty surgical team. When 2 operating rooms that run simultaneously during a certain period of time are under the responsibility of a single

TABLE II Outcomes of Overlapping and Non-Overlapping Procedures in Entire Cohort

	Overlapping (N = 1,610)	Non-Overlapping (N = 1,223)	P Value
Operating room time* *(min)*	142.2 ± 18.4	136.4 ± 22.5	<0.001
Postoperative findings within 90 days *(no. of patients)*			
Complications	83 (5.2%)	81 (6.6%)	0.104
Hospital readmissions	55 (3.4%)	53 (4.3%)	0.235
Reoperations	50 (3.1%)	38 (3.1%)	1.000
Periprosthetic joint infection	13 (0.8%)	6 (0.5%)	0.359
Intraoperative fracture	17 (1.1%)	21 (1.7%)	0.140
Postoperative fracture	3 (0.2%)	2 (0.2%)	1.000

*The values are given as the mean and the standard deviation for the patients with available data.

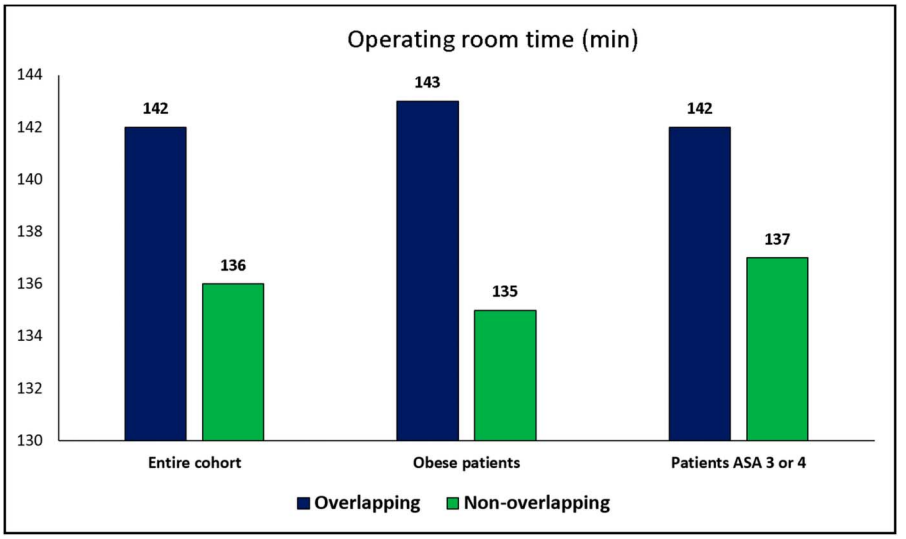

Fig. 2

Bar graph illustrating operating room times for the overlapping and non-overlapping groups for the entire cohort, obese patients, and patients with an ASA score of 3 or 4.

primary surgeon, either an arthroplasty fellow or an experienced physician assistant is assigned to each room in addition to the other supporting staff.

The primary surgeon either performs or is present for all critical components of the procedure. We acknowledge that the critical portions of a procedure are subject to interpretation. We consider the critical portions of total knee arthroplasty to be soft-tissue balancing, trialing, and cementing of the component, and we consider the critical portions of total hip arthroplasty to be femoral neck osteotomy, acetabular reaming, cup impaction, trialing, and stem insertion. As a fellow's surgical expertise improves, so does his or her ability to perform these critical portions independently. Fellows routinely perform the exposure, whereas physician assistants are more involved in the surgical setup and closure. Physician assistants never perform any of the critical components of the surgery even when in the presence of the primary surgeon. Concurrent surgery is not performed.

Recognized complex cases are scheduled at the end of the day in order to avoid conflicts with the workflow. The complex procedure usually starts 30 to 60 minutes later than the normal procedure located in the other operating room. As a matter of procedure, the second patient is brought into the other room when the critical components of the first operation are completed. If, under any circumstance, a complication arises during the non-critical portions of the initial overlapping procedure and the primary surgeon is performing the critical portions of the subsequent procedure, a second qualified surgeon is available to intervene. When the primary surgeon is delayed, the other procedure is also delayed.

TABLE III Outcomes of Overlapping and Non-Overlapping Procedures in Obese Patients and Patients with ASA Score of 3 or 4

	Obese Patients (BMI ≥30 kg/m^2)			Patients with ASA Score of 3 or 4		
	Overlapping (N = 737)	Non-Overlapping (N = 541)	P Value	Overlapping (N = 530)	Non-Overlapping (N = 412)	P Value
Operating room time* *(min)*	143.1 ± 19.7	135.3 ± 22.1	<0.001	142.2 ± 18.9	136.7 ± 24.6	<0.001
Postoperative findings within 90 days *(no. of patients)*						
Complications	45 (6.1%)	40 (7.4%)	0.366	31 (5.8%)	30 (7.3%)	0.424
Hospital readmissions	30 (4.1%)	29 (5.4%)	0.284	25 (4.7%)	24 (5.8%)	0.463
Reoperations	28 (3.8%)	21 (3.9%)	1.000	16 (3.0%)	16 (3.9%)	0.475
Periprosthetic joint infection	8 (1.1%)	4 (0.7%)	0.574	6 (1.1%)	4 (1.0%)	1.0
Intraoperative fracture	5 (0.7%)	7 (1.3%)	0.379	3 (0.6%)	5 (1.2%)	0.308
Postoperative fracture	2 (0.3%)	1 (0.2%)	1.000	2 (0.4%)	2 (0.5%)	1.0

*The values are given as the mean and the standard deviation for the patients with available data.

Baseline patient characteristics such as age, sex (female or male), race (white, black, Asian, native American, and multiracial), ethnicity (Hispanic or non-Hispanic), body mass index (BMI), and American Society of Anesthesiologists (ASA) physical status score were noted and collected from our electronic medical records system (EPIC) and were compared between both groups. The groups were also compared in terms of the rates of complications, readmissions, and reoperations within 90 days after surgery as well as in terms of the mean operating room time. We analyzed both medical and surgical complications that led to readmissions or reoperations within 90 days after surgery. Subgroup analyses of the outcomes of interest also were performed exclusively on patients with a BMI of ≥30 kg/m^2 (obese patients) and on those with an ASA score of either 3 or 4.

Statistical Analysis

Categorical variables such as sex, race, ethnicity, ASA scores, complication rates, and readmission and reoperation rates were compared with use of the Pearson chi-square and Fisher exact tests. Numerical variables such as age, BMI, and operating room time were compared with use of independent t tests. Numbers and percentages were used to describe the frequencies of the different types of complications that occurred within 90 days after surgery in both groups. Three separate statistical analyses were performed: 1 for the entire cohort, 1 for obese patients, and 1 for patients with an ASA score of 3 or 4. The level of significance was set at $p < 0.05$. All statistical analyses were performed with use of SPSS (version 24; IBM).

Results

Of the 2,833 procedures analyzed, 57% (1,610) were overlapping and 43% (1,223) were non-overlapping. At baseline, there were no significant differences between the groups in terms of demographics, BMI, or ASA score (Table I).

The overlapping and non-overlapping groups did not differ with regard to the rates of complications (5.2% vs. 6.6%, respectively; $p = 0.104$), unplanned readmissions (3.4% vs. 4.3%, respectively; $p = 0.235$), or reoperations (3.1% vs. 3.1%, respectively; $p = 1.000$) within 90 days after surgery. They also did not differ in terms of the rates of intraoperative fractures (1.1% vs. 1.7%, respectively; $p = 0.140$), postoperative fractures (0.2% vs. 0.2%, respectively; $p = 1.000$), or periprosthetic joint infections (0.8% vs. 0.5%, respectively; $p = 0.359$) (Fig. 1, Table II). The mean operating room time (and standard deviation) was significantly higher for the overlapping group than for the non-overlapping group (142.2 ± 18.4 vs. 136.4 ± 22.5 minutes; $p < 0.001$), with a mean difference (and standard error) of 5.8 ± 0.8 minutes (95% confidence interval, 4.2 to 7.3 minutes) (Table II).

The subgroup analyses of overlapping and non-overlapping procedures performed on obese patients or patients with an ASA score of 3 or 4 did not reveal significant differences in the rates of complications, readmissions, or reoperations. However, the mean operating room time remained significantly higher for the overlapping group in both analyses (Fig. 2, Table III). The types of complications that led to readmissions or reoperations within 90 days after surgery in both groups are listed in Table IV.

TABLE IV Types of Complications Leading to Readmissions or Reoperations Within 90 Days after Overlapping and Non-Overlapping Procedures*

	Overlapping (N = 1,610)	Non-Overlapping (N = 1,223)
Medical complications		
Pneumonia	1 (0.1%)	3 (0.2%)
Cholelithiasis	0 (0.0%)	1 (0.1%)
Gastroenteritis	1 (0.1%)	0 (0.0%)
Angioedema	2 (0.1%)	1 (0.1%)
Synovial impingement	1 (0.1%)	0 (0.0%)
Aphasia	1 (0.1%)	0 (0.0%)
Gastrointestinal bleeding	1 (0.1%)	0 (0.0%)
Small bowel obstruction	0 (0.0%)	1 (0.1%)
Pulmonary embolism	1 (0.1%)	0 (0.0%)
Chest pain	0 (0.0%)	2 (0.2%)
Cholecystitis	0 (0.0%)	1 (0.1%)
Deep-vein thrombosis	0 (0.0%)	2 (0.2%)
Bronchitis	0 (0.0%)	1 (0.1%)
Congestive heart failure	1 (0.1%)	0 (0.0%)
Colitis	0 (0.0%)	1 (0.1%)
Dehydration	0 (0.0%)	1 (0.1%)
Bacteremia	1 (0.1%)	0 (0.0%)
Adrenal insufficiency	1 (0.1%)	0 (0.0%)
Terminal cancer	0 (0.0%)	1 (0.1%)
Intractable nausea and vomiting	0 (0.0%)	1 (0.1%)
Orthostatic diastolic dysfunction	1 (0.1%)	0 (0.0%)
Pancreatitis	0 (0.0%)	1 (0.1%)
Surgical complications		
Arthrofibrosis	18 (1.1%)	17 (1.4%)
Fracture	20 (1.2%)	23 (1.9%)
Hematoma	10 (0.6%)	8 (0.7%)
Cellulitis	4 (0.2%)	2 (0.2%)
Periprosthetic joint infection	13 (0.8%)	6 (0.5%)
Synovitis	1 (0.1%)	0 (0.0%)
Retained catheter	0 (0.0%)	1 (0.1%)
Hemarthrosis	1 (0.1%)	0 (0.0%)
Dislocation	3 (0.2%)	3 (0.2%)
Open wound	2 (0.1%)	0 (0.0%)
Aseptic loosening	1 (0.1%)	1 (0.1%)
Knee extensor mechanism disruption	0 (0.0%)	1 (0.1%)
Knee swelling	1 (0.1%)	0 (0.0%)
Partial nerve palsy	1 (0.1%)	0 (0.0%)
Seroma	1 (0.1%)	1 (0.1%)
Removal of foreign body	0 (0.0%)	1 (0.1%)
Total	88 (5.5%)	81 (6.6%)

*The values are given as the number of patients with each complication. Some patients had >1 complication.

Discussion

The practice of scheduling surgical procedures with overlapping time frames is intended to increase patient access to high-volume, experienced surgeons; to promote efficiency; and to improve the surgical competence of surgeons and trainees[1]. Nevertheless, this practice has been questioned because of safety

concerns. There is a paucity of reports in the orthopaedic literature on this issue. As a result, we wanted to evaluate the effects of such practice on the (1) 90-day complication, readmission, and reoperation rates; (2) mean operating room time; and (3) types of complications leading to readmission or reoperation following overlapping and non-overlapping primary total knee and hip arthroplasties.

Our study should be viewed in light of certain limitations. It was a retrospective investigation and consequently there is a possibility of bias. However, our series consisted of a large cohort of consecutive patients who underwent primary total hip and knee arthroplasty in a consistent manner, and this circumstance helps to mitigate that possibility. Furthermore, important baseline patient characteristics known to affect outcomes, such as demographic characteristics (e.g., age, sex), BMI, and ASA score, were not found to be significantly different between overlapping and non-overlapping groups. We were unable to account for patients who had complications and were readmitted in other institutions. Nevertheless, we see no reason for patients from a particular group being more frequently readmitted in other institutions than the other. Therefore, although still possible, we think that bias was unlikely. A thorough chart review was performed to determine the presence or absence of complications that led to readmissions or reoperations within 90 days after surgery. The causes and nature of those events were established. Our findings could be extrapolated to other institutions as long as they have dedicated hip and/or knee arthroplasty surgical teams. We consider the constant presence of committed total knee arthroplasty and/or total hip arthroplasty fellows and/or physician assistants in each room during the performance overlapping procedures and high surgical volume to be the key characteristics of our team. It is crucial that the physician assistants always work with the same primary surgeons so that extensive experience on hip and/or knee arthroplasty can be guaranteed. Overlapping procedures are usually performed in high-volume hospitals as such volume facilitates the development of a seasoned hip and/or knee arthroplasty surgical team. The actual amount of time that the surgeon was present in the operating room or the extent of the involvement of physician assistants in each case was unavailable. However, at our institution, we do not perform concurrent procedures. Furthermore, the present study used operating room times in order to identify overlapping procedures, and it is precisely such overlapping in the scheduling of patients for surgery that is being called into question because of safety concerns. The fundamental question posed in the current investigation is whether it is detrimental for patients to have a single attending surgeon responsible for 2 operating rooms that are in use simultaneously for a certain period of time. We think that the methodology employed in the study allowed us to properly address this question. We studied a relatively small number of procedures (n = 2,833), and it is possible that significant differences could have been observed if the study had included a larger sample of patients. However, the differences in terms of complications, readmissions, and reoperations were low in magnitude, and, when present, typically favored the overlapping group in all analyses. Therefore, we do not think that this particular limitation affected the main conclusion of the study. Finally, we did not evaluate patient-reported outcomes and/or satisfaction. However, the rates of complications, readmissions, and reoperations are very important when it comes to safety, which was the focus of the current investigation.

It is important to note that events such as wrong-site surgery or wrong-procedure surgery did not occur during the study period. We always adhere to standard universal safety protocols and pre-procedure verification processes (e.g., time out).

There were no significant differences between our 2 groups in terms of the 90-day rates of complications, readmissions, and reoperations. Our results are in agreement with those reported by Zhang et al.[1], who performed a retrospective review of 3,640 procedures (including sports medicine, hand, and foot-and-ankle procedures) and found no significant differences between overlapping and non-overlapping procedures in terms of the 30-day rates of complications (1.1% vs. 1.3%, respectively), hospital readmissions (0.6% vs. 0.8%, respectively), or reoperations (0.5% vs. 0.4%, respectively). Similarly, studies outside of orthopaedic surgery also have shown no differences in outcomes between overlapping and non-overlapping procedures[4].

While no significant differences were noted with the sample size studied, when differences were observed, they typically favored the overlapping group. Specifically, our data showed a lower 90-day complication rate in the overlapping group (5.2% vs. 6.6%). To our knowledge, the current report is the first to describe the 90-day complication, readmission, and reoperation rates of overlapping and non-overlapping primary total knee and hip arthroplasties. Our data suggest that the practice of overlapping did not detrimentally affect the safety of hip and knee arthroplasty.

We found a longer mean operating room time in the overlapping group when compared with the non-overlapping group (mean difference and standard error, 5.8 ± 0.8 minutes; 95% confidence interval, 4.2 to 7.3 minutes; $p < 0.001$). In this case, our results are in disagreement with those reported by Zhang et al.[1], who found no significant difference between overlapping and non-overlapping groups in terms of operating room time (mean and standard deviation, 105.4 ± 43.2 vs. 105.5 ± 43.2 minutes, respectively; $p = 0.949$). The practice of overlapping surgery has been reported to increase the total procedure time, probably because of the involvement of trainees[6]. In our series, it is probable that a greater involvement of physician assistants in overlapping procedures was responsible for the elevated mean operating room time of those procedures as closure is performed with less assistance. In general, the involvement of trainees has been found to be associated with improved care[9-15]. In our series, there was no concurrence or overlap of critical components of the procedure as the primary surgeon was always present at all critical parts of the operation (i.e., soft-tissue balancing, bone cuts, trialing, insertion and cementing of components, neck osteotomy, acetabular reaming, femoral broaching) in order to ensure high-quality delivery of care and supervision. Physician assistants usually help during preparation, draping, starting the exposure, and closure while the surgeon operates on another patient in a different room.

In conclusion, our data suggest that overlapping surgery does not lead to an increase in the 90-day rates of complications,

readmissions, or reoperations following primary total knee or hip arthroplasty. We observed similar results when obese patients or patients with an ASA score of 3 or 4 were studied independently. Responsible execution of overlapping surgery does not add unnecessary risk in the setting of total joint arthroplasty. We observed a minimal increase in the mean operating room time of overlapping procedures, probably because of less personnel during the closure process. Further investigations evaluating the effects of overlapping procedures on patient-oriented outcomes and satisfaction are warranted. ■

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