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Effect of Overlapping Operations on Outcomes in Microvascular Reconstructions of the Head and Neck

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Abstract

Objective. To compare outcomes after microvascular reconstructions of head and neck defects between overlapping and nonoverlapping operations.

Study Design. Retrospective cohort study.

Setting. Tertiary care center.

Subjects and Methods. Patients undergoing microvascular free tissue transfer operations between January 2010 and February 2015 at 2 tertiary care institutions were included (n = 1315). Patients were divided into 2 cohorts by whether the senior authors performed a single or consecutive microvascular reconstruction (nonoverlapping; n = 773, 59%) vs performing overlapping microvascular reconstructions (overlapping; n = 542, 41%). Variables reviewed were as follows: defect location, indication, T classification, surgical details, duration of the operation and hospitalization, and complications (major, minor, medical).

Results. Microvascular free tissue transfers performed included radial forearm (49%, n = 639), osteocutaneous radial forearm (14%, n = 182), anterior lateral thigh (12%, n = 153), fibula (10%, n = 135), rectus abdominis (7%, n = 92), latissimus dorsi (6%, n = 78), and scapula (<1%, n = 4). The mean duration of the overlapping operations was 21 minutes longer than nonoverlapping operations ($P = .003$). Mean duration of hospitalization was similar for nonoverlapping (9.5 days) and overlapping (9.1 days) cohorts ($P = .39$). There was no difference in complication rates when stratified by overlapping (45%, n = 241) and nonoverlapping (45%, n = 344) ($P = .99$). Subset analysis yielded similar results when minor, major, and medical complications between groups were assessed. The overall survival rate of free tissue transfers was 96%, and this was same for overlapping (96%) and nonoverlapping (96%) operations ($P = .71$).

Conclusions. Patients had similar complication rates and durations of hospitalization for overlapping and nonoverlapping operations.

Keywords

overlapping operations, head and neck reconstruction, surgical complications

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There has been growing concern regarding patient safety in the setting of an attending surgeon being responsible for multiple operating rooms in which, for at least a portion of the procedure, more than 1 operation is going on at the same time. Overlapping operations are defined as operations that are being overseen by the same attending that either overlap for extended periods of time or are performed simultaneously. This does not include cases that have short overlaps at either the beginning or end of an operation. The appeal of overlapping operations is the ability to provide superior outcomes at lower health care costs and to decrease patient wait times for operations, especially those that are time sensitive for treatment or diagnosis, such as malignancies.[1] Overlapping operations involve scheduling substantial portions of more than 1 operation to occur during the same time. In these overlapping operations, delegation of responsibility to trainees and assistants is necessary. Currently, there is a paucity of peer-reviewed literature and data published on the practice of overlapping operations. With the recent public attention on this topic, the health care community has been challenged to develop protocols and

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data to support the practice of overlapping operations. Investigations such as this one are integral to the process of determining what is safe for patients and surgeons.

One of the regularly preformed overlapping operations at our institutions is reconstruction of complex head and neck defects with microvascular free tissue transfers. The goals of head and neck reconstruction include restoration of function, enhancement of cosmesis, and improvement in overall quality of life. Overall, survival rates and outcomes of microvascular tissue transfers have improved over time, with current survival rates cited to be between 94% and 96%.[2,3] However, when complications do occur, there is potential for devastating and debilitating outcomes.[3] These complications often require additional operations, increased duration of hospitalization, and greater health care cost. Several variables have been found to correlate with complication rates in microvascular free tissue transfers and include age, sex, tobacco use, hypertension, previous radiation therapy, elevated body mass index, and previous operations at the recipient site.[4] However, there are no studies to date determining if there are increased rates of complications when overlapping microvascular reconstructions of the head and neck are performed. Therefore, the purpose of this study was to review outcomes for overlapping and nonoverlapping microvascular reconstructions performed at our institutions. We hypothesize that complication rates, length of hospitalization, and outcomes will be similar, regardless of whether an overlapping microvascular reconstruction was performed.

Methods

Patient Selection

Following institutional review board approval (Review of Head and Neck Reconstruction Outcomes [UAB] and Free Tissue Transfer Clinical Outcomes Database [OHSU]), a retrospective review of prospectively collected databases was performed. Patients who had a microvascular free tissue transfer reconstruction for a head and neck defect at either the University of Alabama at Birmingham or Oregon Health and Science University between January 2010 and February 2015 were included (n = 1315). These patients were stratified by whether the senior authors (E.L.R. or M.K.W.) performed a single or consecutive microvascular free tissue transfer (nonoverlapping; n = 773, 59%) vs performing simultaneous or overlapping microvascular free tissue transfers (overlapping; n = 542, 41%) on a given day. The overlapping cohort included operations in which both operations had a first start, or the second operation began in another operating room at least 1 hour prior to the first operation being concluded. For the overlapping operations, the attending surgeon ensured that the critical components of the operation were not to be performed concurrently. The critical portion of the procedure varied depending on the level of expertise of the assisting surgeon. In all cases, the attending surgeon was present for the flap design, vessel harvest and dissection, flap inset, anastomosis, and portions of the closure. As part of the informed consent, patients are counseled that the operation involves a team of surgeons and assistants under the direction and supervision of the attending surgeon. There may be times when aspects of the operations are overlapping; however, the attending surgeon is present for the critical portions of the procedure and available at any time. In addition, the attending surgeon ensures that when it is necessary to delegate responsibilities, these aspects of the procedure fall within the scope of the assistants' technical level of expertise and that the attending surgeon is immediately available if needed.

The anatomic locations of the defects were reviewed and classified as oral cavity, oropharynx, hypopharynx, larynx, nasopharynx, midface, parotid, scalp, lateral temporal bone, or cutaneous (lesions presenting in the head and neck region that did not meet criteria for the former categories listed). Duration of the operation and hospitalization was reviewed. The timeframe in which the patient was exposed to general anesthesia was used to determine the duration of the operation and included both ablative and reconstructive portions of the operation. The type of microvascular free tissue transfer used and whether a neck dissection (unilateral or bilateral) was performed on the day of the reconstructive operation were also reviewed.

Complications

Complications that occurred within 30 days of the initial microvascular free tissue transfer operation were included. The complications were further subdivided into major or minor surgical complications and medical complications. Major surgical complications included those that required additional surgical intervention (hematoma evacuation, operative control of a hemorrhage, fistula repair, infection, reanastomosis for arterial insufficiency or venous congestion, or pneumothorax requiring a chest tube), as well as skin graft survival at the donor site of $<30\%$, foot drop, compartment syndrome, cerebral spinal fluid leak, and death. Operative intervention for an infection included incision and drainage of an abscess, washout of infected tissues, and wound debridement. Minor surgical complications were those that resolved with minimal intervention and included a hematoma that did not require surgical evacuation, donor or recipient site infections treated with antibiotics only, skin graft survival at the donor site of $>30\%$ and $<70\%$, fistulas that were managed with conservative measures (packing of the fistula tract, antibiotics), and pneumothorax that resolved without intervention. Medical complications included pneumonia or pleural effusion, respiratory failure, deep vein thrombosis or pulmonary embolism, myocardial infarction, cardiac arrhythmia requiring intervention, cardiac arrest, cerebrovascular accident, renal failure or acute kidney injury, and other (pancreatitis, enterocolitis or small bowel obstruction, seizure, syndrome of inappropriate antidiuretic hormone secretion). Indications for readmission to the hospital were found to be the result of one of the complications listed above; therefore, these were analyzed and included with the complication that resulted in the readmission to the hospital.

Statistical Analyses

Descriptive variables were summarized by mean ± standard deviation for continuous variables and n (%) for categorical variables. A univariate analysis was performed using χ^2 or Fisher's exact test for categorical variables, and a Student *t* test was used for comparing continuous variables. A contingency analysis was used to analyze relationships between categorical factors and responses. Box plot was used to graphically represent operative duration as a 1-way analysis of quantiles, with median being the 50th percentile and the 25th and 75th percentiles being quantiles. The means/analysis of variance (ANOVA) were used for analysis of variance. The *t* test was set to assume equal variance. Only operative duration was found to have a statistically significant correlation with outcomes, and therefore multivariate analysis was not performed. A *P* value of $<.05$ was considered statistically significant. Statistical analysis was performed using Jmp 12 software (SAS Institute, Cary, North Carolina). When further dividing complications by specifics, many categories had low power. Therefore, operations occurring in different operating rooms with either similar surgical start times or with >1-hour overlap were included in the overlapping cohort.

Results

Patient Characteristics

The mean age of the patients was 59 years (range, 6-96 years), with the majority of the patients being male (71%, n = 935). The most common indication for surgery was resection of malignancy (79%, n = 1047), followed by osteoradionecrosis and osteomyelitis (8%, n = 102), resection of benign lesions (4%, n = 52), and repair of a fistula (4%, n = 49) (**Table 1**).

A total of 1315 microvascular free tissue transfers for reconstruction of a defect in the head and neck region were performed. The most common location being reconstructed was the oral cavity (40%, n = 526), followed by the larynx (15%, n = 195), midface (10%, n = 128), oropharynx (9%, n = 113), hypopharynx (7%, n = 91), scalp (5%, n = 60), lateral temporal bone (4%, n = 59), cutaneous (4%, n = 57), and parotid (4%, n = 55) (**Table 1**). When stratified by donor tissue used for the reconstruction, the most common donor tissue selected was the radial forearm free flap (RFFF; 49%, n = 639), followed by the osteocutaneous radial forearm free flap (OCRFFF; 14%, n = 182), anterior lateral thigh (ALT) free flap (12%, n = 153), fibula free flap (10%, n = 135), rectus abdominis free flap (7%, n = 92), and latissimus free flap (6%, n = 78) (**Table 1**). Thirty-seven percent of patients did not undergo a neck dissection (n = 489), while 37% underwent a unilateral neck dissection (n = 490) and 26% underwent a bilateral neck dissection (n = 336) (**Table 1**). The mean duration of the operation was 7.1 ± 2.2 hours. The addition of a neck dissection increased the duration of the operation by an average of 54 to 66 minutes per neck dissection. The mean duration of the operation was 8.3 ± 1.9 hours for those that included bilateral neck dissections and 7.2 ± 1.9 hours for those that included unilateral neck dissections, compared with 6.3 ± 2.2 hours for operations in which no neck dissection was performed (*P* < .0001). The mean duration of hospitalization was 9.3 ± 0.5 days.

Comparison of Overlapping and Nonoverlapping Operations

When comparing patients who underwent overlapping and nonoverlapping operations, there was no difference in mean ages (*P* = .57), sex (*P* = .30), indication for the operation (*P* = .65), site of defect (*P* = .17), donor tissue used for the microvascular free tissue reconstruction (*P* = .63), or whether a neck dissection was performed (*P* = .50) (**Table 1**). The mean duration of the overlapping operations was 21 minutes longer than nonoverlapping operations (*P* = .004; **Figure 1**). Mean duration of hospitalization was 9.3 ± 0.48 days, and this did not differ between nonoverlapping (9.5 ± 0.56 days) and overlapping (9.1 ± 0.68 days) operations (*P* = .39; **Table 1**). In addition, we found that there was no statistical difference between the donor tissue used for the reconstruction and whether an overlapping operation had been performed (*P* = .63; **Figure 2**).

Complications

A complication occurred in 45% of cases (n = 585). When subdivided by the type of complication, medical complications were the least common (7%, n = 88), followed by minor surgical complications (12%, n = 164) and major surgical complications (25%, n = 333). The specifics of the complications can be found in **Table 2**. The incidence of minor surgical (*P* = .31), major surgical (*P* = .72), and medical (*P* = .47) complications was the same for overlapping and nonoverlapping operations (**Figure 3**). Twelve percent of complications were associated with the donor site (n = 71/585). Donor site complication included infection (n = 28), skin graft take of <70% (n = 20), hematoma (n = 12), skin graft take of <30% (n = 8), and foot drop or compartment syndrome (n = 3). Donor site complication rates were similar between overlapping (n = 30) and nonoverlapping (n = 41) operation cohorts (*P* = .72). The occurrence of more than 1 complication was not affected by whether an overlapping operation (10%, n = 53/542) or nonoverlapping operation (8%, n = 59/773) was performed (*P* = .17). Complication rates were similar for operations that included a neck dissection (45%, n = 371/826) compared with operations that did not include a neck dissection (44%, n = 214/489) (*P* = .68). When stratified by indication for the operation, complication rates were found to be similar (*P* = .64).

The microvascular free tissue transfer was salvaged for 57% of revision operations, resulting in a free tissue transfer failure rate of 4% for both overlapping (n = 23) and nonoverlapping (n = 31) operations (*P* = .83) (**Table 3**). When stratified by the indication for the operation, the free tissue transfer survival rates were similar (*P* = .64).

Discussion

Performing a surgical operation requires precision, coordination, and standardization that allows intricate and complex

Table 1. Overall Patient Characteristics.[a]

Characteristic	Total	Overlapping Operations		P Value
		None	Yes	
Age, mean (range), y	59 (6-96)	59 (6-89)	59 (7-96)	.57
Sex				
Male	935 (71)	547 (42)	388 (29)	.75
Female	380 (29)	226 (17)	154 (12)	
Indication				
Malignant neoplasm	1047 (79)	614 (47)	433 (33)	.47
ORN/osteomyelitis	102 (8)	58 (4)	44 (3)	
Benign neoplasm	52 (4)	33 (2)	19 (1)	
Fistula	49 (4)	34 (3)	15 (1)	
Trauma	16 (1)	6 (<1)	10 (<1)	
Nonhealing wound	20 (1)	11 (<1)	9 (<1)	
Nonfunctional larynx	12 (1)	7 (<1)	5 (<1)	
Velopalatine insufficiency	10 (<1)	7 (<1)	3 (<1)	
Other[b]	3 (<1)	1 (<1)	2 (<1)	
Defect location				
Oral cavity	526 (40)	325 (25)	201 (15)	.35
Larynx	195 (15)	105 (8)	90 (7)	
Midface	128 (10)	70 (5)	58 (4)	
Oropharynx	113 (9)	64 (5)	52 (4)	
Hypopharynx	91 (7)	56 (4)	35 (3)	
Scalp	60 (5)	37 (3)	23 (2)	
Lateral temporal bone	59 (4)	27 (2)	32 (2)	
Cutaneous	57 (4)	37 (3)	20 (1)	
Parotid	55 (4)	33 (2)	22 (2)	
Skull base	18 (1)	12 (<1)	6 (<1)	
Nasopharynx	9 (<1)	6 (<1)	3 (<1)	
Donor tissue				
RFFF	639 (49)	377 (29)	262 (20)	.63
OCRFFF	182 (14)	99 (8)	83 (6)	
ALT	153 (12)	89 (7)	64 (5)	
Fibula	135 (10)	85 (6)	50 (4)	
Rectus	92 (7)	50 (4)	42 (3)	
Latissimus	78 (6)	49 (4)	29 (2)	
Ulna	14 (1)	11 (<1)	3 (<1)	
Scapula	4 (<1)	2 (<1)	2 (<1)	
Other[c]	18 (1)	11 (<1)	7 (<1)	
Neck dissections				
None	489 (37)	297 (23)	192 (14)	.50
Unilateral	490 (37)	285 (22)	205 (15)	
Bilateral	336 (26)	191 (15)	145 (11)	
Duration of operation, h				
Mean ± SD	7.2 ± 2.2	7.0 ± 2.1	7.35 ± 2.2	**.004**
<8	844 (64)	519 (39)	325 (25)	**.008**
≥8	471 (36)	254 (19)	217 (17)	
Duration of hospitalization, mean ± SD, d	9.3 ± 0.5	9.5 ± 0.6	9.1 ± 0.7	.37

Abbreviations: ALT, anterior lateral thigh; OCRFFF, osteocutaneous radial forearm free flap; ORN, osteoradionecrosis; Rectus, rectus abdominis free flap; RFFF, radial forearm free flap; SD, standard deviation.

[a]Values are presented as number (%) unless otherwise indicated. Bolded *P* values indicate statistical significance.

[b]Other includes microvascular free tissue transfers for repair of cerebral spinal fluid leaks and strictures.

[c]Other microvascular reconstructions included free tissue transfers of jejunal, ileocolic, salivary gland, or serratus rib.

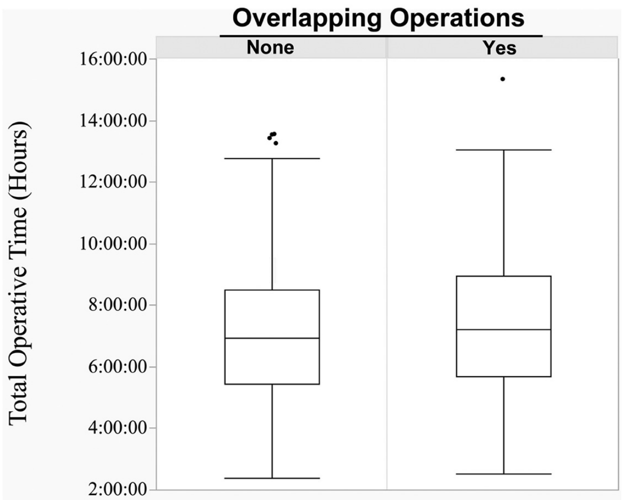

Figure 1. Operative duration was 21 minutes longer for overlapping operations compared with those operations that were not overlapping ($P < .01$).

procedures to be achieved with great outcomes. Increased specialization of surgical teams enable surgeons to perform a greater number of operations on more patients with higher quality.[1] In order for this be achieved, the talents and strengths of each team member, including the attending, need to be maximized. The scheduling of overlapping surgical cases in 2 operating rooms by 1 surgeon improves efficiency and utilization of resources while maintaining excellent patient care.[5] For this to be accomplished, the attending surgeon must recognize the skill sets of the team members involved, be physically present for the critical portions of the operation, provide supervision and guidance, and be immediately available for the entire duration of the operation.[26] This utilization of resources enables more patients to benefit from an attending surgeon's specialized surgical skills. To date there, have been limited data published on outcomes following overlapping operations. As a result, there is a need for investigations that provide a critical assessment of surgical outcomes following overlapping operations to determine the safety and quality of these practices. Since the impact of overlapping operations on outcomes following reconstruction of head and neck defects with microvascular free tissue transfers has not yet been investigated, this was the aim of the current study.

The goals of reconstructing complex defects of the head and neck are to restore function and cosmesis. As a result, complications can have devastating sequelae as failure of the reconstruction can result in poor functional and aesthetic outcomes associated with significant morbidity. Since there are a limited number of surgeons who have been trained in this specialized skill set, many institutions have employed the practice of running overlapping or simultaneous operating rooms to maximize utilization of their expertise. Previous publications have shown lower complication rates and improved outcomes when operations are performed by surgeons who have completed large numbers of similar operations.[6-10] In this study, we found postoperative complications occurred in 44% of cases, which is similar to previous publications, in which complications rates were 48% to 71% following microvascular free tissue reconstruction of the head and neck.[11,12] Similarly, total loss of the microvascular free tissue occurred in 4% of cases, with rates cited in the literature between 1% and 15%.[3,4,13-19] Our rates of arterial insufficiency (6%) and venous congestion (3%) were also similar to published rates of 4% to 5% and 2%, respectively.[3,4,13-19] Importantly, in this study, there was no difference in complication rates or free tissue transfer failure rates between the overlapping and nonoverlapping operations.

Those who oppose overlapping operations cite concerns about patients being under anesthesia for extended periods

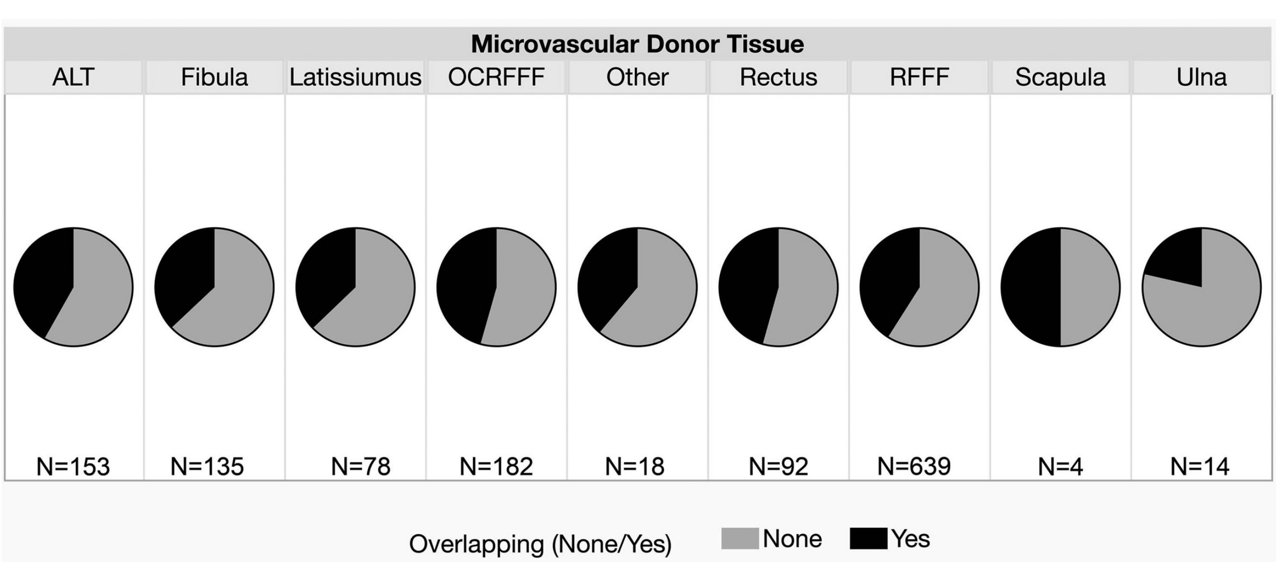

Figure 2. The donor tissue selected for the microvascular free tissue reconstruction did not vary between the overlapping operations and nonoverlapping operation cohorts ($P > .05$). ALT, anterior lateral thigh; OCRFFF, osteocutaneous radial forearm free flap; RFFF, radial forearm free flap. Other: jejunal, ileocolic, salivary gland, or serratus rib microvascular free tissue transfers.

Table 2. Surgical and Medical Complications within 30 Days of the Microvascular Reconstruction.

Characteristic	Total, No. (%)	Overlapping Operations, No. (%)		*P* Value
		None	Yes	
Minor complications				
Infection[a]	124 (75)	67 (41)	57 (35)	.31
Donor skin graft take ≥30% and <70%	29 (18)	18 (11)	11 (7)	
Fistula[b]	5 (3)	4 (2)	1 (<1)	
Hematoma[b]	3 (2)	1 (<1)	2 (1)	
Pneumothorax[b]	3 (2)	3 (2)	0 (0)	
Major complications				
Infection[c]	83 (25)	48 (14)	35 (11)	.72
Hematoma/hemorrhage[d]	61 (18)	35 (11)	26 (8)	
Arterial insufficiency	85 (26)	50 (15)	35 (11)	
Venous congestion	42 (13)	26 (8)	16 (5)	
Fistula	28 (8)	15 (5)	13 (4)	
Donor skin graft take <30%	16 (5)	8 (2)	8 (2)	
Death	10 (3)	7 (2)	3 (<1)	
Foot drop/compartment syndrome	4 (1)	1 (<1)	3 (<1)	
Pneumothorax	2 (<1)	2 (<1)	0 (0)	
CSF leak	2 (<1)	2 (<1)	0 (0)	
Medical complications				
Respiratory failure	21 (24)	11 (14)	10 (12)	.47
Pneumonia/pleural effusion	20 (23)	12 (15)	8 (10)	
Cardiac[e]	14 (16)	10 (12)	4 (5)	
DVT/PE	7 (8)	4 (5)	3 (4)	
Cerebrovascular accident	7 (8)	6 (7)	1 (1)	
Renal failure/AKI	4 (5)	4 (5)	0 (0)	
Other[f]	15 (16)	10 (12)	5 (6)	

Abbreviations: AKI, acute kidney injury; DVT, deep vein thrombosis; PE, pulmonary embolism.
[a]Infection treated with antibiotics.
[b]Did not require operative intervention.
[c]Infection treated with operative drainage, washout, or debridement.
[d]Hematoma or hemorrhage requiring operative evacuation.
[e]Cardiac included myocardial infarction, arrhythmia requiring intervention, and cardiac arrest.
[f]Other includes pancreatitis, enterocolitis, seizure, and syndrome of inappropriate antidiuretic hormone secretion.

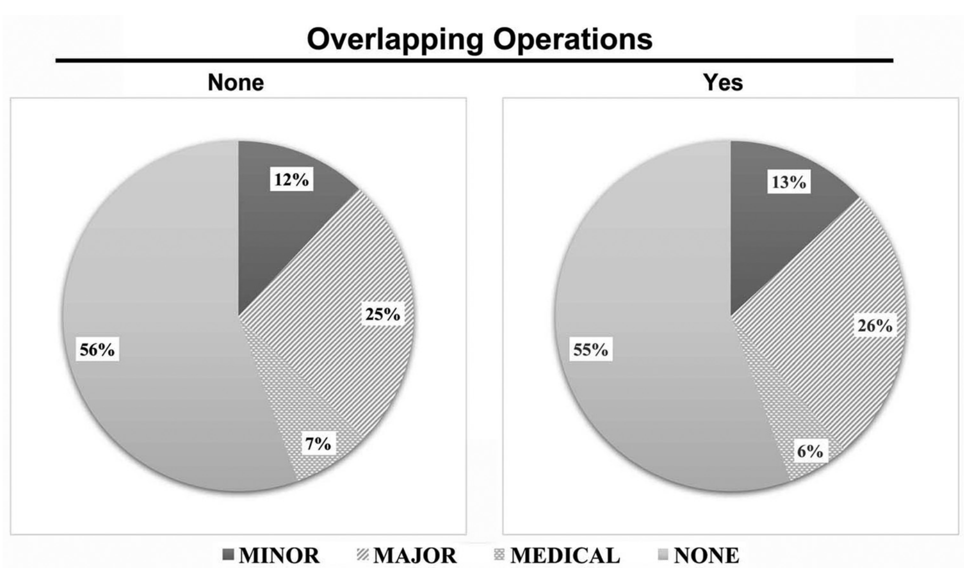

Figure 3. Complication rates were similar when stratified by whether an overlapping operation was performed or not ($P > .05$).

Table 3. Indication for Revision of Microvascular Anastomosis and Outcomes.

Characteristic	Total, No. (%)	Overlapping Operations, No. (%)		*P* Value
		None	Yes	
Indication for anastomosis revision				
Arterial insufficiency	85 (6)	50 (6)	35 (6)	.74
Venous congestion	42 (3)	26 (3)	16 (3)	
Status of the free tissue transfer				
Salvaged	73 (6)	45 (6)	28 (5)	.63
Total loss	54 (4)	31 (4)	23 (4)	
Survival rates of free tissue transfers	1261 (96)	742 (96)	519 (96)	.83

of time while an attending surgeon is working on a different overlapping case. In our study, we found overlapping operations were on average 21 minutes longer than nonoverlapping operations. In agreement with our study, a previous study found that duration of operative time, and subsequently exposure to anesthetic, did not correlate with complication rates or severity in microvascular reconstructions of the head and neck.[11,20] Postoperative complications following microvascular reconstruction of head and neck defects have been found to correlate with underlying patient comorbidities and the complexity of the resection and reconstruction.[3,11,18,21,22]

Although there are limited data available on overlapping operations, that which is available has been favorable. Overlapping operations were found to have no effect on surgery start times.[23] In addition, similar to our study, operative times were found to be 20 minutes longer when an attending surgeon was running 2 operating rooms, and there was no significant differences in observed or risk-adjusted postoperative complications, duration of hospitalization, or operative mortality.[23] Therefore, it has been concluded that the practice of running overlapping or simultaneous operating rooms can be done efficiently and without negatively affecting patient outcomes.[23]

Advantages of overlapping operations include reduced wait times for highly specialized operations in which limited experts are available and development of trainees to ensure the same standard of care is available for future generations.[24] The autonomy of operating independently is best developed gradually, with increasing independence appropriate for the skill level during training. The gradual development of surgical skills and competency is vital to maintaining the same surgical standards for generations to come.[25-27] Delegation of skill appropriate tasks is accepted in all professional fields, including health care.[26] In the operating room, this entails entrusting procedures of lesser complexity to qualified surgical trainees and physician extenders. In order for this to done safely, the surgical trainee should have the competency to progress the case safely and without prolonging the patients exposure to anesthesia. To determine if resident involvement affected complication rates, there have been several investigations on the impact of resident involvement in surgical operations. Those studies have found that there was no difference in overall outcomes in surgical cases performed with or without the use of residents.[9,28-35] Thus far, the data support comparable outcomes and efficiency between cases which do not involve trainees and cases involving trainees.[26,35]

The operating room is one of the costliest aspects of health care; therefore, maximizing utilization through overlapping or simultaneous operations allows for improvements in the delivery of cost-effective and timely care.[26] There is agreement that patients should be provided with full disclosure regarding the practice of overlapping or simultaneous operations, including an understanding that the practice occurs and that the surgeon and institution have in place protocols to ensure patient safety.[1,24] Education can help the public appreciate that the systems in place permit great surgical teams to care for patients safely and with comparable outcomes.

One limitation of this study was that for the purposes of statistical analysis, operations occurring in 2 different operating rooms with similar surgical start times and operations occurring in 2 different operating rooms in which the second operation began in another operating room prior to the first operation being completed were grouped together as ''overlapping.'' This was to allow for more meaningful statistical analyses, since further dividing the groups would have resulted in several variables having values less than 5. However, this prevented a comparison between those operations that had similar start times compared with those with significant overlap. Another limitation is that both of the attending surgeons were greater than 10 years out from fellowship, therefore limiting the ability to extrapolate these data to recent graduates. In addition, there are the limitations inherent to all retrospective studies, including selection bias and information bias.

Studies such as this one, with a focus on the critical assessment of surgical outcomes, are needed to determine if overlapping operations are a means for delivering safe, high-quality, and cost-effective care. Consistent with previous publications, this study supports that overlapping operations can be performed efficiently and with equivalent quality as operations that do not overlap.[26] Through the oversight of overlapping operating rooms, the skill and experience of the attending surgeon are maximized, improving the efficiency with which health care can be delivered.[26] Operations can be staggered to ensure that the critical portions of each do not occur simultaneously. However, the attending surgeon should ensure there is another attending available to cover, should the critical portions overlap. Many institutions are investigating their own practices to determine how to manage overlapping operations, create policies with appropriate restrictions, and address how to properly disclose to patients. Based on findings in our study and existing data, we support the continued practice of surgeons conducting overlapping operations.

Author Contributions

Larissa Sweeny, substantial contributions to conception, design, data collection, analysis and interpretation, statistics, manuscript composition drafting and editing, final approval, and accountability for all aspects of the work; **Eben L. Rosenthal**, substantial contributions to design, conception, data analysis and interpretation, manuscript editing, revising the manuscript critically for important intellectual content, final approval, and accountability for all aspects of the work; **Tyler Light**, substantial contributions to data collection, revising the manuscript critically for important intellectual content, final approval, and accountability for all aspects of the work; **Jessica Grayson**, substantial contributions to data collection, revising the manuscript critically for important intellectual content, final approval, and accountability for all aspects of the work; **Daniel Petrisor**, substantial contributions to data collection, revising the manuscript critically for important intellectual content, final approval, and accountability for all aspects of the work; **Scott H. Troob**, substantial contributions to data collection, revising the manuscript critically for important intellectual content, final approval, and accountability for all aspects of the work; **Benjamin J. Greene**, substantial contributions to data collection, conception, revising the manuscript critically for important intellectual content, final approval, and accountability for all aspects of the work; **William R. Carroll**, substantial contributions to data collection, conception, revising the manuscript critically for important intellectual content, final approval, and accountability for all aspects of the work; **Mark K. Wax**, substantial contributions to conception, design, data collection, data analysis and interpretation, manuscript drafting and editing, final approval, and accountability for all aspects of the work.

Disclosures

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References

1. Johnson D. Misdirected fury: the Boston Globe ''Spotlights'' concurrent surgeries. http://www.4sighthealth.com/misdirected-fury-the-boston-globe-spotlights-concurrent-surgeries/. Published March 1, 2016. Accessed April 19, 2016.
2. Genden EM, Rinaldo A, Suarez C, et al. Complications of free flap transfers for head and neck reconstruction following cancer resection. *Oral Oncol*. 2004;40:979-984.
3. Pohlenz P, Klatt J, Schon G, et al. Microvascular free flaps in head and neck surgery: complications and outcome of 1000 flaps. *Int J Oral Maxillofac Surg*. 2012;41:739-743.
4. Las DE, de Jong T, Zuidam JM, et al. Identification of independent risk factors for flap failure: a retrospective analysis of 1530 free flaps for breast, head and neck and extremity reconstruction. *J Plast Reconstr Aesthetic Surg*. 2016;69:894-906.
5. Romeo AA. Healio. http://www.healio.com/orthopedics/business-of-orthopedics/news/print/orthopedics-today/%7Bbbeb5e32-00f9-4d15-b518-e5f575b4ea30%7D/concurrent-surgery-no-evidence-care-is-compromised. Accessed April 19, 2016.
6. Yeo HL, Abelson JS, Mao J, et al. Surgeon annual and cumulative volumes predict early postoperative outcomes after rectal cancer resection [published online February 16, 2016]. *Ann Surg*.
7. Aquina CT, Probst CP, Becerra AZ, et al. High volume improves outcomes: the argument for centralization of rectal cancer surgery. *Surgery*. 2016;159:736-748.
8. Trinh QD, Bjartell A, Freedland SJ, et al. A systematic review of the volume-outcome relationship for radical prostatectomy. *Eur Urol*. 2013;64:786-798.
9. Kohn GP, Nikfarjam M. The effect of surgical volume and the provision of residency and fellowship training on complications of major hepatic resection. *J Gastrointest Surg*. 2010;14:1981-1989.
10. Hammond JW, Queale WS, Kim TK, et al. Surgeon experience and clinical and economic outcomes for shoulder arthroplasty. *J Bone Joint Surg Am*. 2003;85:2318-2324.
11. Ettinger KS, Arce K, Lohse CM, et al. Higher perioperative fluid administration is associated with increased rates of complications following head and neck microvascular reconstruction with fibular free flaps [published online April 21, 2016]. *Microsurgery*.
12. Corbitt C, Skoracki RJ, Yu P, et al. Free flap failure in head and neck reconstruction. *Head Neck*. 2014;36:1440-1445.
13. Bozikov K, Arnez ZM. Factors predicting free flap complications in head and neck reconstruction. *J Plast Reconstr Aesthetic Surg*. 2006;59:737-742.
14. Dassonville O, Poissonnet G, Chamorey E, et al. Head and neck reconstruction with free flaps: a report on 213 cases. *Eur Arch Otorhinolaryngol*. 2008;265:85-95.
15. Frederick JW, Sweeny L, Carroll WR, et al. Microvascular anastomotic coupler assessment in head and neck reconstruction. *Otolaryngol Head Neck Surg*. 2013;149:67-70.
16. le Nobel GJ, Higgins KM, Enepekides DJ. Predictors of complications of free flap reconstruction in head and neck surgery: analysis of 304 free flap reconstruction procedures. *Laryngoscope*. 2012;122:1014-1019.
17. Nakatsuka T, Harii K, Asato H, et al. Analytic review of 2372 free flap transfers for head and neck reconstruction following cancer resection. *J Reconstr Microsurg*. 2003;19:363-369.
18. Suh JD, Sercarz JA, Abemayor E, et al. Analysis of outcome and complications in 400 cases of microvascular head and neck reconstruction. *Arch Otolaryngol Head Neck Surg*. 2004;130:962-966.

19. Yu P, Chang DW, Miller MJ, et al. Analysis of 49 cases of flap compromise in 1310 free flaps for head and neck reconstruction. *Head Neck*. 2009;31:45-51.
20. Haughey BH, Wilson E, Kluwe L, et al. Free flap reconstruction of the head and neck: analysis of 241 cases. *Otolaryngol Head Neck Surg*. 2001;125:10-17.
21. Ettinger KS, Moore EJ, Lohse CM, et al. Application of the surgical Apgar score to microvascular head and neck reconstruction. *J Oral Maxillofac Surg*. 2016;74:1668-1677.
22. Pohlenz P, Blessmann M, Heiland M, et al. Postoperative complications in 202 cases of microvascular head and neck reconstruction. *J Craniomaxillofac Surg*. 2007;35:311-315.
23. Yount KW, Gillen JR, Kron IL, et al. Attendings performing simultaneous operations in academic cardiothoracic surgery does not increase operative duration or negatively affect patient outcomes. Available at: http://aats.org/annualmeeting/Program-Books/2014/2.cgi. Accessed February 6, 2015.
24. Mello MM, Livingston EH. Managing the risks of concurrent surgeries. *JAMA*. 2016;315:1563-1564.
25. Dall TM, Gallo PD, Chakrabarti R, et al. An aging population and growing disease burden will require a large and specialized health care workforce by 2025. *Health Aff (Millwood)*. 2013;32:2013-2020.
26. Beasley GM, Pappas TN, Kirk AD. Procedure delegation by attending surgeons performing concurrent operations in academic medical centers: balancing safety and efficiency. *Ann Surg*. 2015;261:1044-1045.
27. Millwood IY, Li L, Smith M, et al. Alcohol consumption in 0.5 million people from 10 diverse regions of China: prevalence, patterns and socio-demographic and health-related correlates. *Int J Epidemiol*. 2013;42:816-827.
28. Massenburg BB, Sanati-Mehrizy P, Jablonka EM, et al. The impact of resident participation in outpatient plastic surgical procedures. *Aesthetic Plast Surg*. 2016;40:584-591.
29. Loppenberg B, Cheng PJ, Speed JM, et al. The effect of resident involvement on surgical outcomes for common urologic procedures: a case study of uni- and bilateral hydrocele repair. *Urology*. 2016;94:70-76.
30. Whealon MD, Young MT, Phelan MJ, et al. Effect of resident involvement on patient outcomes in complex laparoscopic gastrointestinal operations. *J Am Coll Surg*. 2016;223:186-192.
31. Saliba AN, Taher AT, Tamim H, et al. Impact of Resident Involvement in Surgery (IRIS-NSQIP): looking at the bigger picture based on the American College of Surgeons-NSQIP database. *J Am Coll Surg*. 2016;222:30-40.
32. Vieira BL, Hernandez DJ, Qin C, et al. The impact of resident involvement on otolaryngology surgical outcomes. *Laryngoscope*. 2016;126:602-607.
33. Cvetanovich GL, Schairer WW, Haughom BD, et al. Does resident involvement have an impact on postoperative complications after total shoulder arthroplasty? An analysis of 1382 cases. *J Shoulder Elbow Surg*. 2015;24:1567-1573.
34. Trinh QD, Sun M, Kim SP, et al. The impact of hospital volume, residency, and fellowship training on perioperative outcomes after radical prostatectomy. *Urol Oncol*. 2014;32:29.e13-20.e20.
35. Patel UA, Lin AC. Flap outcomes when training residents in microvascular anastomosis in the head and neck. *Am J Otolaryngol*. 2013;34:407-410.