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SPECIAL TOPIC

Do Microsurgical Outcomes Differ Based on Which Specialty Does the Operation? A NSQIP Analysis

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Background: Because plastic surgeons do not "own" a specific anatomic region, other surgical specialties have increasingly assumed procedures historically performed by plastic surgery. Decreased case volume is postulated to be associated with higher complication rates. Herein, we investigate whether volume and surgical specialty have an impact on microsurgical complications, specifically surgical site infection (SSI) and reoperation rates.

Methods: The 2005–2015 National Surgical Quality Improvement Program participant use file was queried by Current Procedural Terminology code for breast and head/neck microsurgeries. Multivariate logistic regression was performed to compare the outcomes between surgical specialties. A cumulative frequency variable was introduced to investigate the effect of case volume on complication rates.

Results: We captured 6,617 microsurgical cases. Multivariate logistic regression revealed that although the rate of SSI was lower in plastic surgery compared with otolaryngology for head and neck reconstructions (13.3% versus 10.5%) and compared with general surgery for breast reconstructions (5.4% versus 4.7%), there was no significant difference between specialties ($P = 0.13$; $P = 0.96$). Increased case volume is negatively correlated with complications.

Conclusions: Plastic surgery is at risk given case cannibalization by other specialties. We conclude that surgical specialty does not affect the rates of SSI and reoperation. We demonstrate a correlation between lower volumes and increased complications, implying that, once a specialty has amassed critical case experience, complication rates may decrease, and outcomes can be equivalent or superior. Case breadth and volumes should be maintained to preserve skills, optimize outcomes, and maintain the specialty as it currently exists. *(Plast Reconstr Surg Glob Open 2020;8:e2769; doi: 10.1097/GOX.0000000000002769; Published online 27 April 2020.)*

INTRODUCTION

Plastic surgery is a vast and complex surgical discipline based on fundamental principles. Plastic surgeons are not limited to working in one anatomical region and are not bound to a certain organ system, and as a result, reconstruct various types of tissues including bone, muscle, tendon, nerve, vessels, and skin. We are often described as the "Surgeon's Surgeon," closing complex wounds with ever more difficult surgeries, such as microvascular free flaps. However, because plastic and reconstructive surgeons do not "own" a specific anatomic region, do not control referrals, and are increasingly removed geographically from hospitals, other surgical specialties have increasingly assumed procedures historically performed by plastic surgery. These procedures including head and neck reconstructions by otolaryngology/ear, nose and throat (ENT) surgeons, breast reconstructions and burn surgery by general surgeons, local facial flap reconstructions by the Mohs surgeons/dermatologists, eyelid reconstructions by ophthalmologists and oculoplastics, hand surgery by our orthopedics colleagues,[1] and oral maxillofacial surgeons

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are involved in a large portion of facial traumas and orthognathic surgery.

There is much more overlap in our field than in any other field of surgery, stemming likely from the fact that plastic surgery is relatively young field, with modern roots in the post World War periods. Plastic surgeons are also trained in maintaining and restoring form and function, with ultimate results dictating the range of procedures available to the plastic surgeon's armamentarium. Gone are the days where flap failure was the only variable that defined success. Now, individual successes with flaps include restoration of anatomy, form, esthetics, and function.

Examples are many in the literature that exist for determining surgical outcomes as stratified by surgical specialty. There is no clear consensus on what factors between specialties are the most important when looking at surgical outcomes, and examples in the literature suggest minimal to modest differences.[2–5] Previous studies with marginal differences featured a small studied population, and only a few studies looked at the microsurgical outcomes.

Herein, we present a large-scale, big-data national comparison of the effect of differing surgical specialty and their outcomes with microsurgical reconstruction. The National Surgical Quality Improvement Program (NSQIP), an American College of Surgeon (ACS)-led initiative, is a robust, nationally validated, outcomes-based dataset. It tracks 136 demographic, preoperative, intraoperative, and postoperative 30-day complication data points.

The most costly NSQIP-tracked complications are those of reoperation, readmission, and surgical site infections (SSIs), which are measured in this study.[6] They can be stratified as major complications in terms of NSQIP-tracked outcomes. We also determine if case volume influences these complications. It is postulated that decreased case volumes are associated with higher complication rates, as evidenced previously in the literature.[7,8]

METHODS

The NSQIP Program Participant Use File[9] was queried by Current Procedural Terminology (CPT) code for breast and head/neck microsurgeries. The period of study was 2005–2015, inclusive, for a total of 11 years of data. To ensure the data qualify for research use, the ACS NSQIP developed standardized reporting mechanisms for the operating staff in ACS member hospitals. The 8-day cycle schedule undertakes the balance of its systematic sampling process, and several exclusion criteria have been established to maintain the integrity of the dataset; this methodology for case inclusion has been described previously.[10]

For our study, included CPT codes are listed in Table 1. These include breast reconstruction free flap (19354) and various musculocutaneous and other microvascular procedures (15756, 15757, 15758, 15842, 20955, 20962, 42894). These were extracted from the Participant Use File for analysis. Pedicled flaps were excluded because they did not feature a microsurgical anastomosis. Orthopedic and lower extremity reconstruction cases were excluded in this study because NSQIP does not capture traumatic cases and the ones captured were few in number.

Two independent reviewers searched all relevant CPT codes involving microsurgery, and it was established that these CPT codes were comprehensive for microsurgical operations. We then stratified by body area (ie, head and neck and breast) and surgical specialty, be it otolaryngologists, general surgeons, or plastic surgeons who would be the operating specialty.

Primary outcomes we evaluated included SSI, reoperation, and readmission rates for each of the breast and head/neck reconstruction subgroups. A multivariate logistic regression model was performed to compare outcomes between surgical specialties. The regression variables included sex, age, surgical specialty, height, weight, body mass index (BMI), diabetes, smoking, steroid used, wound class, American Association of Anesthesiologists Physical Status Classification (ASA Class), and total length of stay and postoperative diagnosis.

To investigate the effect of case volume on complication rates, a cumulative frequency variable was introduced into the regression model based on CPT code and surgical specialty. This was a surrogate for cumulative specialty experience, not surgeon experience, with a particular CPT code. Based on the International Classification of Diseases, Ninth Revision (ICD-9) diagnoses, the reasons for reoperation were categorized into complications relating to specific procedures, general medical, preexisting diseases, wound management, and unspecified.

Statistics

A P value of <0.05 was set at significant. Descriptive statistics such as the Student's t test and χ^2 were used. The multivariate logistic regression models were used to

Table 1. List of CPT Codes Included in the Study

CPT Code	Anatomical Location	Procedure Name
19364	Breast	Breast reconstruction free flap
15756	Head and neck	Muscle/myocutaneous flap with microvascular anastomosis
15757	Head and neck	Free skin flap with microvascular anastomosis
15758	Head and neck	Free fascial flap with microvascular anastomosis
15842	Head and neck	Graft for facial nerve paralysis; free muscle flap by microsurgical technique
20955	Head and neck	Bone graft microvascular anastomosis fibula
20962	Head and neck	Bone graft with microvascular anastomosis
42894	Head and neck	Resection of pharyngeal wall requiring closure with myocutaneous or fasciocutaneous flap or free muscle, skin, or fascial flap with microvascular anastomosis

quantify the effects of predicative variables (including surgical specialty) on SSI, reoperation, and readmission.

RESULTS

We focused our analysis on 2 anatomic regions: head/neck reconstruction and breast reconstruction. The 2005–2015 11-year dataset yielded 4,608,309 cases. NSQIP captured a total of 6,617 microsurgical cases or 0.14% of all NSQIP-captured cases. Flap location in the extremities, trunk and unknown locations, was excluded from the study due to insufficient power for analysis. For head and neck microsurgeries, otolaryngology performed 898 and plastic surgery performed 285 cases. For breast reconstruction using free flaps, plastic surgery performed 4,127 and general surgery performed 168 cases (Fig. 1).

Stratifying the surgeries performed by year illustrates the increase in captured cases by NSQIP. Although over time expanded definitions in NSQIP has permitted additional microsurgeries being captured overall, the number of microsurgical procedures has accelerated more rapidly in otolaryngology than in plastic surgery. This is not seen with the general surgery cohort.

Patient Population

Patient demographics are illustrated in Table 2. There were significant differences between the surgical subspecialty patient populations. Compared with plastic surgery, in the head and neck surgery cohort, the ENT population was significantly older ($P < 0.001$), and the operative time was significantly shorter ($P < 0.05$). In the breast surgery cohort, the general surgery population was significantly older ($P < 0.01$), higher BMI ($P < 0.01$), and had a longer operative time ($P < 0.01$). The remainder of the demographic and patient variables was comparable between the different subspecialties performing microsurgical reconstruction.

Raw Rates Analysis

The rate of each primary outcome is listed in Table 3. We found that there were no significant differences in SSI, reoperation, and unplanned readmission rates in head and neck microsurgeries as performed by ENT surgeons versus plastic surgeons. Similar results were attained when comparing breast free flaps performed by general surgeons versus plastic surgeons. There were slightly more deaths associated with ENT surgery, potentially attributable to an older patient population.

Although the rates of SSIs were lower in plastic surgery compared with otolaryngology for head and neck operations (10.5% versus 13.3%) and compared with general surgery for breast reconstructions (4.7% versus 5.4%), this failed to reach statistical significance ($P = 0.23$; $P = 0.66$). The raw rate of reoperation was lower in the surgical

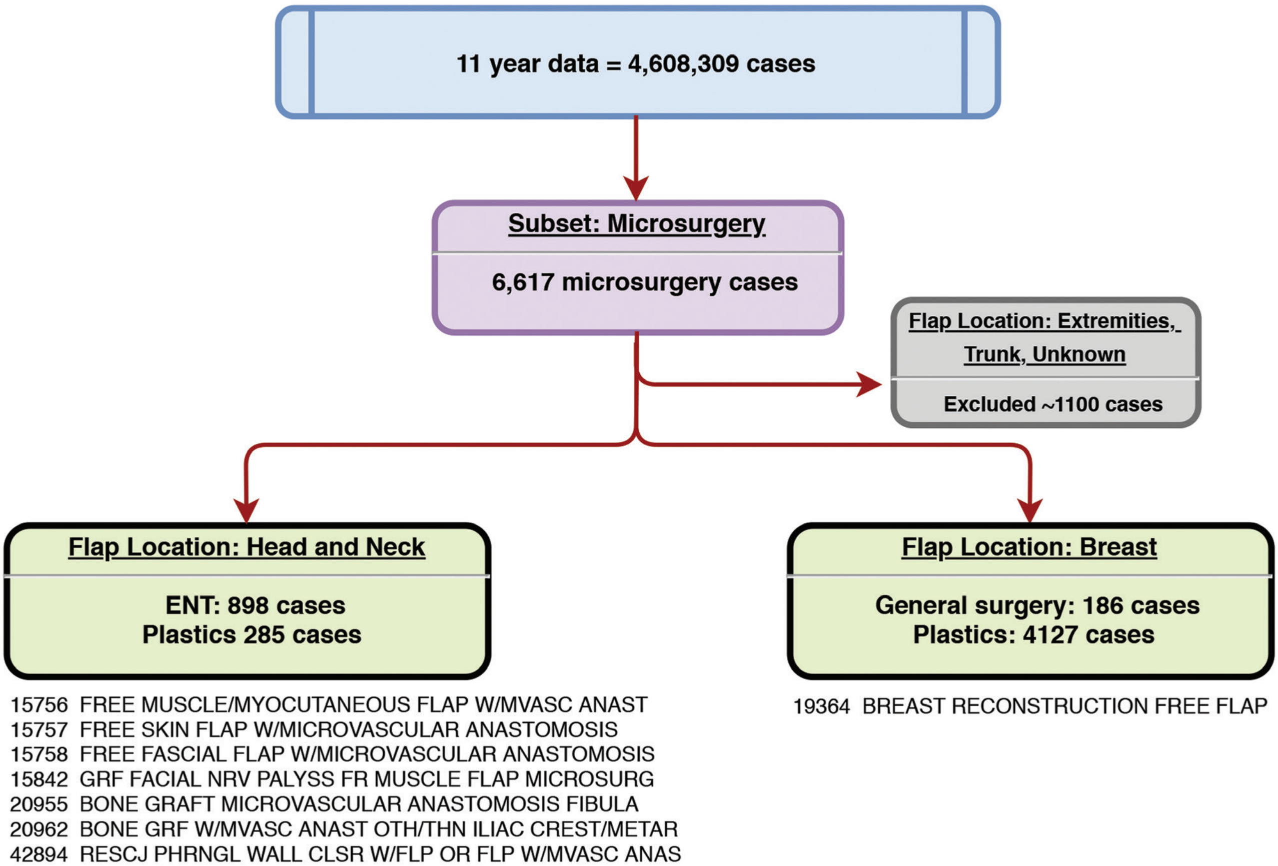

Fig. 1. Studied population flowchart.

Table 2. Patient Population, Demographics, and Characteristics

Flap Location	Head and Neck			Breast		
Demographics	Plastic Surgery, N = 285, Median ± SD/n (%)	Otolaryngology, N = 898, Median ± SD/n (%)	*P*, χ^2, *t* Test	Plastic Surgery, N = 4,127, Median ± SD/n (%)	General Surgery, N = 186, Median ± SD/n (%)	*P*, χ^2, *t* Test
Age (y)	56.0 ± 16.0	62.1 ± 13.6	<0.0001*	50.4 ± 9.2	52.4 ± 9.4	0.0038†
Sex						
Female	117 (41.1)	298 (33.2)	<0.0158‡	4,118 (99.8)	185 (99.5)	0.3754
Male	168 (58.9)	599 (66.7)		9 (0.2)	1 (0.5)	
Height	65.4 ± 14.4	66.6 ± 10.4	0.1248	63.4 ± 11.4	63.8 ± 2.7	0.6328
Weight	168.1 ± 43.7	165.6 ± 45.9	0.4179	170.2 ± 36.8	175.6 ± 36.7	0.0503
BMI	26.5 ± 6.1	25.8 ± 6.2	0.0958	29.2 ± 5.6	30.3 ± 5.7	0.0089†
Diabetes						
Insulin	10 (3.5)	31 (3.5)	0.2505	46 (1.1)	4 (2.2)	0.6001
Non-insulin	28 (9.7)	67 (7.5)		159 (3.9)	8 (4.3)	
Oral§	0 (0.0)	8 (0.9)		2 (0.0)	0 (0.0)	
None	247 (86.7)	792 (88.2)		3,920 (95.0)	174 (93.5)	
Smoking						
Yes	79 (27.7)	265 (29.5)	0.5619	323 (7.8)	18 (9.7)	0.3601
No	206 (72.3)	633 (70.5)		3,804 (92.2)	168 (90.3)	
Steroid use						
Yes	9 (3.2)	31 (3.5)	0.8108	53 (1.3)	3 (1.6)	0.6988
No	276 (96.8)	867 (96.5)		4,074 (92.2)	183 (90.3)	
ASA class						
1	8 (2.8)	15 (1.7)	0.0463‡	222 (5.4)	8 (4.3)	0.9083
2	86 (30.2)	203 (22.6)		2,309 (55.9)	108 (58.1)	
3	175 (61.4)	608 (67.7)		1,586 (38.4)	70 (37.6)	
4	16 (5.6)	71 (7.9)		7 (0.2)	0 (0.0)	
None assigned	0 (0.0)	1 (0.1)		3 (0.1)	0 (0.0)	
Wound class						
1: Clean	108 (37.9)	189 (21.0)	<0.00001*	4,058 (98.3)	182 (97.8)	0.4159
2: Clean/contaminated	145 (50.9)	646 (71.9)		45 (1.1)	4 (2.2)	
3: Contaminated	26 (9.1)	44 (4.9)		17 (0.4)	0 (0.0)	
4: Dirty/infected	6 (2.1)	19 (2.1)		7 (0.2)	0 (0.0)	
Operation time (min)	535.7 ± 210.1	510.0 ± 177.5	0.0422‡	493.1 ± 172.9	528.1 ± 209.2	0.0075†

*$P < 0.001$.
†$P < 0.01$.
‡$P < 0.05$, Statistical tests used: χ^2 test for categorical variables and Student's *t* test for continuous variables.
§By definition, same as non-insulin, labeling change in 2010.

Table 3. Microsurgery Raw Rates Outcomes Analysis

	Head and Neck			Breast		
Outcome	Plastic Surgery, N = 285, n (%)	Otolaryngology, N = 898, n (%)	*P*, χ^2, *t* Test	Plastic Surgery, N = 4,127, n (%)	General Surgery, N = 186, n (%)	*P*, χ^2, *t* Test
Surgical site infection	30 (10.5)	119 (13.3)	0.2270	193 (4.7)	10 (5.4)	0.6593
Reoperation	64 (22.5)	170 (18.9)	0.1930	531 (12.9)	33 (17.7)	0.0537
Unplanned readmission	19 (6.7)	74 (8.2)	0.3171	225 (5.5)	8 (4.3)	0.4970
Total length of stay (d)	12.5 ±15.7	10.4 ± 10.9	0.0117*	4.40 ± 6.5	4.69 ± 2.1	0.5439
Death	0 (0.0)	12 (1.3)	0.0498*	3 (0.07)	0 (0.0)	0.7130

*$P < 0.05$.
Statistical tests used: χ^2 test for categorical variables and Student's *t* test for continuous variables.

specialty performing a greater number of cases (Table 3), but again there was no statistical significance reached.

Multivariate Logistic Regression Analysis

A multivariate regression analysis was performed to control for patient comorbidities. The following variables were included: age, BMI, diabetes, smoking, steroid use, surgical wound classification, ASA class, and operative time. Surgical specialty was included to evaluate if it was an independent predicative factor of our primary outcomes of SSIs, reoperations, and readmissions. The significant factors are listed in Table 4.

In summary, surgical specialty was not a predicative factor of SSI, reoperation, and readmission between ENT surgeons versus plastic surgeons and general surgeons versus plastic surgeons (Table 4). Interestingly, smoking is not a significant risk factor in the head and neck population. In addition, higher ASA class resulted in a negative coefficient for SSIs and thus seemed protective.

To simplify the table, and to answer if there are differences between surgical specialties, the data are resummarized in Table 5, by surgical specialty. Although rates of SSI and readmission in head and neck microsurgical cases had a negative coefficient (protective effect) if plastic surgery was the specialty involved, this did not reach statistical significance. In the breast microsurgical population, SSI and

Table 4. Multivariate Analysis for SSI, Reoperation, and Readmission

	Flap Location	Head and Neck			Breast		
Outcome	Variable	Coefficient	Odds Ratio	*P*	Coefficient	Odds Ratio	*P*
SSI	Sex: male	−0.0883	0.9155	0.7383	0.8834	2.419	0.421
	Age	−0.0104	0.9896	0.129	0.0071	1.0071	0.3926
	Height	−0.129	0.879	0.1819	0.0419	1.0428	0.739
	Weight	0.0351	1.0358	0.0522	−0.0026	0.9974	0.9015
	BMI	−0.2264	0.7974	0.0561	0.1007	1.1059	0.4081
	Diabetes	−0.1583	0.8536	0.5931	0.6341	1.8853	0.0126*
	Smoking	0.0768	1.0798	0.6992	0.849	2.3373	0.0000†
	Steroid use	0.4473	1.5641	0.2895	0.795	2.2145	0.0765
	Wound class	0.369	1.4464	0.0122*	0.2392	1.2702	0.3953
	ASA class	0.1544	1.1669	0.3472	−0.3146	0.7301	0.0174*
	Operation time	0.1206	1.1282	0.0000†	0.0494	1.0507	0.0418*
	Surgical specialty: plastics	−0.3460	0.7075	0.1306	−0.0164	0.9837	0.9613
Reoperation	Sex: male	−0.2322	0.7928	0.2854	0.4587	1.582	0.5677
	Age	0.0073	1.0073	0.221	0.0031	1.0032	0.5386
	Height	0.0806	1.0839	0.3441	−0.0316	0.9689	0.6896
	Weight	−0.011	0.9891	0.5038	0.0036	1.0036	0.7939
	BMI	0.0397	1.0405	0.7049	0.0074	1.0074	0.9275
	Diabetes	0.383	1.4667	0.0877	−0.3771	0.6859	0.0904
	Smoking	0.0273	1.0276	0.8748	0.2068	1.2297	0.1916
	Steroid use	0.4478	1.5649	0.2274	0.3819	1.465	0.2668
	Wound class	0.3614	1.4353	0.0030‡	−0.294	0.7453	0.2969
	ASA class	0.2944	1.3423	0.0383*	0.2561	1.2919	0.0018‡
	Operation time	0.1337	1.143	0.0000†	0.0615	1.0634	0.0001†
	Surgical specialty: plastics	0.2713	1.3116	0.1274	−0.3073	0.7354	0.1243
Readmission	Sex: male	−0.003	0.997	0.9933	1.6659	5.2905	0.0427
	Age	0.0082	1.0082	0.4192	0.0179	1.0181	0.0305*
	Height	0.0613	1.0632	0.6618	0.1104	1.1168	0.3675
	Weight	−0.0062	0.9938	0.8159	−0.0138	0.9862	0.4924
	BMI	0.0278	1.0282	0.8712	0.1564	1.1693	0.1856
	Diabetes	0.3441	1.4107	0.3254	−0.4241	0.6544	0.217
	Smoking	0.028	1.0284	0.922	0.2821	1.326	0.254
	Steroid use	−0.399	0.671	0.5923	0.4162	1.5161	0.3976
	Wound class	0.2223	1.2489	0.282	−0.6102	0.5432	0.3092
	ASA class	0.1988	1.22	0.3848	0.0353	1.0359	0.7884
	Operation time	0.0277	1.0281	0.5045	0.0895	1.0937	0.0004†
	Surgical specialty: plastics	−0.3188	0.727	0.2876	0.4220	1.525	0.2878

*$P < 0.05$.
†$P < 0.001$.
‡$P < 0.01$.

Table 5. Multivariate Regression Analysis by Surgical Specialty

	Plastic Surgery versus Otolaryngology			Plastic Surgery versus General Surgery		
Outcome	Coefficient	Odds Ratio	*P*	Coefficient	Odds Ratio	*P*
SSI	−0.3460	0.7075	0.1306	−0.0164	0.9837	0.9613
Reoperation	0.2713	1.3116	0.1274	−0.3073	0.7354	0.1243
Readmission	−0.3188	0.727	0.2876	0.4220	1.525	0.2878

reoperation also had negative coefficients, but again did not reach statistical significance.

Cumulative Frequency Effect on Outcomes

With regard to cumulative frequency, a separate variable, named "Cumulative" or "CMLT," is created and included in the multivariate regression. This variable encompasses surgical specialty and cumulative volume. The result of the CMLT variable on SSI, reoperation, and readmission is shown in Table 6. There is a slight statistically significant improvement in SSI rates if the surgical specialty is plastic surgery.

Although there are some outliers, CMLT is an independent predictor of decreased SSI (coefficient, −0.0001; odds ratio, 0.9998623; R^2, 0.0478; $P < 0.05$) (Fig. 3). This is not significant for reoperation or readmission.

Table 6. Effect of Cumulative Case Load on SSI, Reoperation, and Readmission

Outcome	Coefficient	Odds Ratio*	*P*
CMLT			
SSI	−0.0001	0.9999	0.0133*
Reoperation	0	1	0.2364
Readmission	−0.0001	0.9999	0.1783

*Odds ratio in this chart is the odds of the specified outcome if surgical specialty performing the surgery was plastic surgery.

Reasons for reoperation are displayed in Table 7. There are no significant differences between the surgical specialties for each complication type. However, flap failure is not a separately tracked NSQIP complication. In addition, reoperation reasons and diagnoses are only tracked for the date from 2012 onward. For the head and neck subgroup, 124 (73.0%) of ENT and 53 (82.8%) of plastic

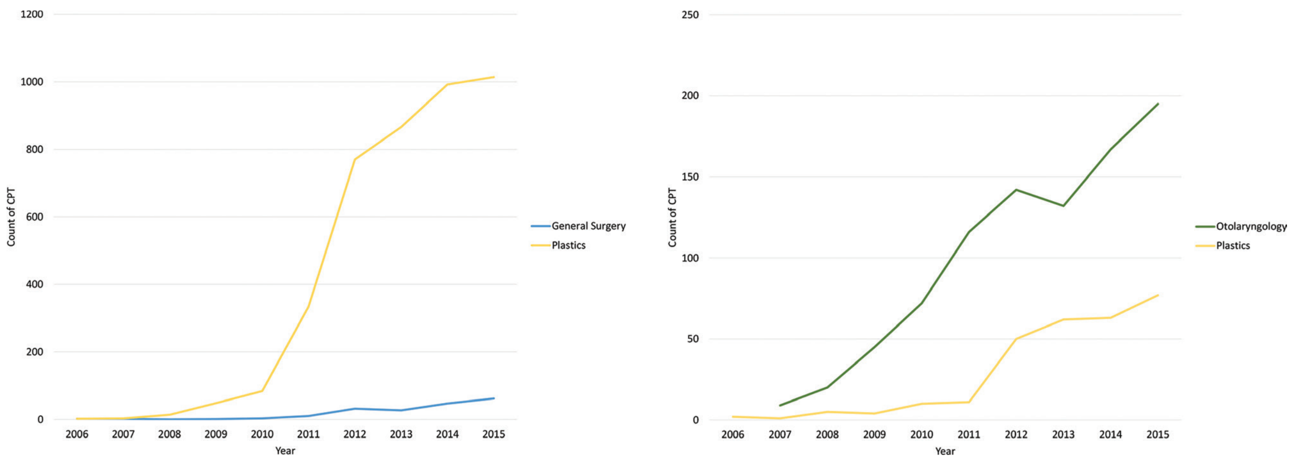

Fig. 2. A, NSQIP-captured microsurgical cases in general surgery and plastic surgery. B, NSQIP-captured microsurgical cases in ENT and plastic surgery.

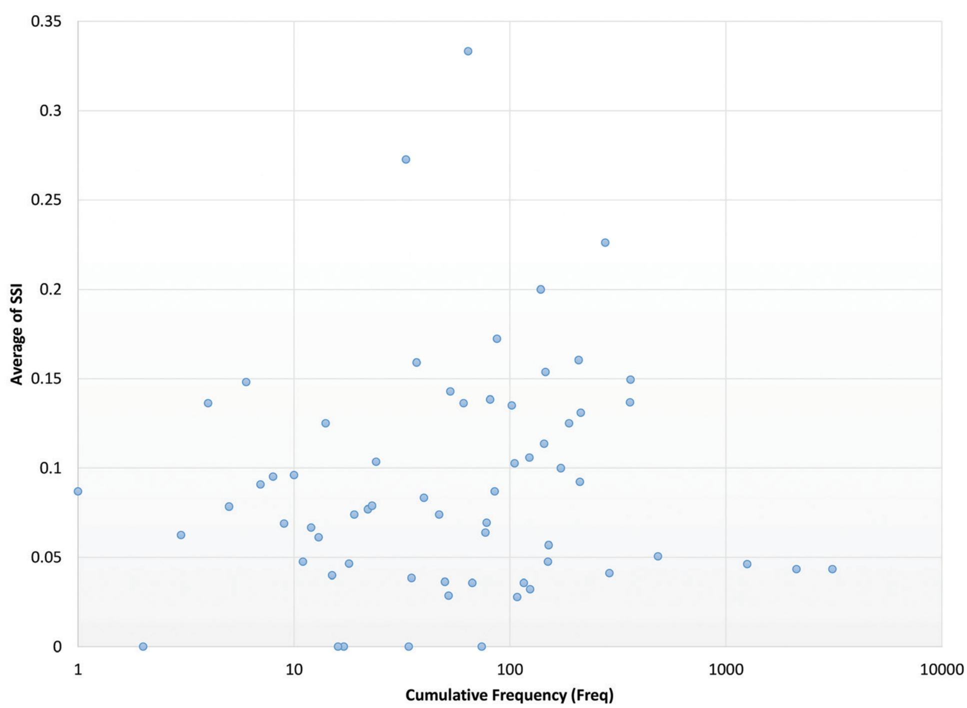

Fig. 3. Scatter plot of CMLT variable.

Table 7. Reasons for Reoperation

Flap Location	Head and Neck			Breast		
Complication Type*	**Plastic Surgery, n (%)**	**Otolaryngology, n (%)**	***P*, χ^2**	**Plastic Surgery, n (%)**	**General Surgery, n (%)**	***P*, χ^2**
Specific procedure†	12 (22.64)	35 (28.23)	0.5587	141 (29.31)	5 (15.63)	0.1444
General medical‡	6 (11.32)	8 (6.45)	0.4264	39 (8.11)	4 (12.50)	0.5901
Preexisting disease§	7 (13.21)	18 (14.52)	0.9947	22 (4.57)	1 (3.13)	0.9541
Wound management¶	21 (39.62)	41 (33.06)	0.5056	172 (35.76)	13 (40.63)	0.7151
Unspecified‖	7 (13.21)	22 (17.74)	0.5997	107 (22.25)	9 (28.13)	0.8863
Total	53	124		481	32	

*Complication groupings:
†Mechanical complication of internal prosthesis or graft, infection of internal prosthesis or graft, deformity and disproportion of reconstructed breast.
‡Cellulitis and abscess, venous thromboembolism and thrombosis (not related to microsurgery), stridor, edema.
§Malignancy, dysphagia, nutritional deficiencies.
¶Hematoma, seroma, hemorrhage complicating a procedure, disruption of surgical wound.
‖Any other NSQIP-captured reason.

surgery reasons are captured [total of 177 (75.6%)]. For the breast subgroup, 32 (97.0%) of general surgery and 481 (91.0%) of plastic surgery reasons are captured [total of 513 (91.0%)]. This is a significant limitation of NSQIP because complications related to microsurgical procedures, such as flap failure or thrombosis, are not directly tracked. However, operations due to a complication relating to the specific procedure are more common for ENT flaps than for plastic surgery flaps. In the general surgery database, a similar pattern emerges.

DISCUSSION

Subspecialty Outcomes: How Do They Differ?

This study sought to explore the influence of surgical specialty on the complications of SSI, reoperation, and readmission in microvascular free flap surgery. We find that the rates of these complications do not significantly change between the differing specialties, suggesting a further need to retain specific caseloads. This is especially important in this ever-evolving age of super-subspecializing.

Two other NSQIP projects with similar aims were found in the literature. A 2009 study in the same database by Drinane et al[11] used a similar date range from 2005 to 2015 and thus have similar numbers compared with this study. They only evaluated ENT surgeons versus plastic surgeons with a nonregression type analysis, despite recognizing that their patient populations differ. Thus, their conclusions may be confounded by patient factors.

An unpublished comparison by Butala et al[12] has sounder methodology. They used univariate and multivariate logistic regression on an analysis of 281 patients. They found that although plastic surgery patients were high risk in terms of comorbidity, the results do not differ in terms of SSI, flap failure, reoperation, and mortality. It was important to note, however, that flap failure was not a currently tracked NSQIP complication, and it was unclear how the authors define this. Interestingly, in their study, ENT surgeons performed more fasciocutaneous flaps compared with myocutaneous flaps.

Other small studies reveal relatively similar findings. Another small 193 patient study by Offodile et al[13] also found that complication rates and flap failure rates were not significantly different between plastic surgery and otolaryngology. They did, however, suggest that larger flaps performed by otolaryngology had more complications.

In all these articles, and including ours, one thing is loud and clear: ENT surgeons have a higher volume than plastic surgeons at head and neck free flaps (Fig. 2). Smoking does not have significant effect on the head and neck region, as demonstrated by the multivariate logistic regression (Table 4), perhaps due to the abundant vascular supply to this region.

Is Our Specialty at Risk? Can Any Surgeon Do Any Procedure Well?

Plastic surgery is vulnerable to competition from our subspecialty colleagues. Because more and more cases are being taken over by other specialties, plastic surgeons should aim to maintain their wide range of competencies and skills. Although plastic surgeons still "own" most of breast reconstruction, general surgery is increasingly starting to perform alloplastic and autologous breast reconstruction, including free flap microsurgery.

One of the reasons for this shift is likely secondary to referral patterns as the oncologic surgeon controls the referral to the reconstructive surgeon. They serve as the gateway to reconstructive microsurgery. This may explain a shift in general surgeons performing microvascular free flap breast reconstruction. This cumulative case load required plays a role in complications. Limited data exist on performance experienced by large academic centers versus smaller centers (a proxy for hospital volume), but the consensus is that academic centers with larger volumes tend to have less complication rates.[14–16] Much of this, however, is likely procedure based.[17] Additional data are required to determine the exact or specific cumulative case load required to decrease other complication rates (SSIs, reoperations, and readmissions). The surgical specialty with the higher case load tends to have less reoperations. In our cumulative frequency analysis, this trend is significant for SSIs (Table 6 and Fig. 3). Lower surgical volumes are associated with longer operative durations, a risk factor for SSI.[18]

Some studies in the past have suggested that case volume is not a proxy for successful outcome and modern plastic surgery training programs produce competency in their trainees, as evidenced by no changes in microsurgery outcomes in 3 microsurgeons with various levels of experience over 7 years.[19] The majority of the literature, however, suggests that higher case volumes lead to better outcomes, which is intuitive. This is seen at hospital volume level,[14,15,20–22] individual level,[14,15,23] procedure and perceived difficulty level,[17] and in free flap outcomes.[23]

Most of the above studies use hospital or surgeon volumes, as evidenced by meta-analysis data.[16] However, herein, a new cumulative specialty volume is proposed. As seen in Figure 3 and Table 6, CMLT is defined as cumulative frequency stratified by CPT code and surgical specialty. This is needed to avoid confounders or effect modification by surgical specialty and is crucial in analysis of procedures performed by multiple different specialties. Our study has confirmed the importance of volumes on surgical outcomes. In addition, this strengthens our conclusion that once another specialty amasses enough case volume, resulting outcomes may very well be similar.

Limitations

There are limitations to this research, mainly related to the nature of NSQIP. NSQIP is a representative sample, coded by humans doing retrospective chart reviews and prospective follow-up protocols. Coding incongruency can happen, and subtle descriptions may differ site to site. NSQIP allows only one entry for specialty per case, even when multiple procedures are performed and multiple specialties are involved. It does not include all cases that may be important to plastic surgeons, including trauma (eg, lower extremity trauma free flap surgery is not included in this study) and burn reconstruction. It also does not capture flap failure or thrombosis as an outcome, and, thus, the cause of reoperations cannot be clearly elicited. It also only captures 30-day outcomes, which although would include most flap failures, does not capture functional or patient-reported outcomes which are a critical element to outcome performance reporting.

Conclusions and Recommendation

The subject of surgical outcomes by surgical subspecialty must be approached with caution, and studies on the matter are scarce in the literature. Regardless, the outcomes of this study are important in an environment of quality and pay for performance metrics and surgeon-tracked outcomes. The rate of microsurgery complications including readmission, reoperation, and SSI is similar between specialties in our study. Plastic surgery is at risk—plastic surgeons should protect caseloads to maintain relevancy. System-based outcome measures are an important additional methodology to report, measure, and manage complications. In fact, the ideal outcome measure would include surgeon-reported, patient-reported, and even system-reported outcomes such as NSQIP. Finally, because plastic surgeons do not have direct control on patient referrals and are increasingly not geographically hospital based, these factors impose an increased risk on the sustainability of our specialty as it currently exists, particularly in the setting of our present research, which implies statistically equivalent free flap outcomes irrespective of specialty doing the procedure.

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REFERENCES

1. Lee M, Haller HS, Gosain AK. Evolution of practice patterns in plastic surgery using current procedural terminology mapping: a 9-year analysis of cases submitted by primary and recertification candidates to the American Board of Plastic Surgery. *Plastic Reconstr Surg.* 2015;135:631e–637e.
2. Reid CM, Brandel MG, Gosman AA. Comparison of surgeon specialty in open ventral hernia repair. *Ann Plast Surg.* 2017;78(5 Suppl 4):S212–S216.
3. Lieber BA, Henry JK, Agarwal N, et al. Impact of surgical specialty on outcomes following carotid endarterectomy. *Neurosurgery.* 2017;80:217–225.
4. Saarinen AJ, Helenius I. Paediatric supracondylar humeral fractures: the effect of the surgical specialty on the outcomes. *J Child Orthop.* 2019;13:40–46.
5. Obeid T, Locham S, Arhuidese I, et al. Sartorius muscle flaps: perioperative outcomes based on surgical specialty. *Ann Vasc Surg.* 2017;43:226–231.
6. Scott RD II. *The Direct Medical Costs of Healthcare-Associated Infections in U.S. Hospitals and the Benefits of Prevention.* 2009. Available at: http://www.cdc.gov/hai/pdfs/hai/scott_costpaper.pdf. Accessed July 15, 2019.
7. Wes AM, Mazzaferro D, Naran S, et al. Craniosynostosis surgery: does hospital case volume impact outcomes or cost? *Plast Reconstr Surg.* 2017;140:711e–718e.
8. Schmidt CM, Turrini O, Parikh P, et al. Effect of hospital volume, surgeon experience, and surgeon volume on patient outcomes after pancreaticoduodenectomy: a single-institution experience. *Arch Surg.* 2010;145:634–640.
9. American College of Surgeons. *ACS NSQIP Pediatrics Participant Use File User's Guide.* Available at: http://www.pediatric.acsnsqip.org/acsNsqipDataPed/jsp/pdf/PEDS_ACS_NSQIP_PUF_UserGuide_2013.pdf. Accessed July 15, 2019.
10. Zhang JX, Song D, Bedford J, et al. What is the best way to measure surgical quality? Comparing the American College of Surgeons National Surgical Quality Improvement Program versus Traditional Morbidity and Mortality Conferences. *Plast Reconstr Surg.* 2016;137:1242–1250.
11. Drinane J, Drinane J, Nair L, et al. Head and neck reconstruction: does surgical specialty affect complication rates? *J Reconstr Microsurg.* 2019;35:e1–e2.
12. Butala P, Cheung MC, Wilk A, et al. Abstract 23: comparison of early outcomes between plastic surgeons and otolaryngologists performing head and neck free flap reconstruction: based on the American College of Surgeons National Surgical Quality Improvement Program. *Plast Reconstr Surg.* 2014;133:989–990.
13. Offodile AC II, Aherrera AS, Wenger J, et al. Impact of specialty training on the association between flap size and incidence of complications following microvascular head and neck reconstruction for cancer. *J Reconstr Microsurg.* 2015;31:348–354.
14. Wouters MWJM, Gooiker GA, van Sandick JW, et al. The volume-outcome relation in the surgical treatment of esophageal cancer. *Cancer.* 2012;118:1754–1763.
15. Kandil E, Noureldine SI, Abbas A, et al. The impact of surgical volume on patient outcomes following thyroid surgery. *Surgery.* 2013;154:1346–1353.
16. Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Ann Intern Med.* 2002;137:511–520.
17. Luft HS, Bunker JP, Enthoven AC. Should operations be regionalized? The empirical relation between surgical volume and mortality. 1979. *Clin Orthop Relat Res.* 2007;457:3–9.
18. Muilwijk J, van den Hof S, Wille JC. Associations between surgical site infection risk and hospital operation volume and surgeon operation volume among hospitals in the Dutch nosocomial infection surveillance network. *Infect Control Hosp Epidemiol.* 2007;28:557–563.
19. Kreymerman P, Silverman AL, Rebecca AM, et al. Contradicting an established mantra. *Plast Reconstr Surg.* 2012;130:507e–512e.
20. Cheung MC, Koniaris LG, Perez EA, et al. Impact of hospital volume on surgical outcome for head and neck cancer. *Ann Surg Oncol.* 2009;16:1001–1009.
21. Nocon CC, Ajmani GS, Bhayani MK. Association of facility volume with positive margin rate in the surgical treatment of head and neck cancer. *JAMA Otolaryngol Head Neck Surg.* 2018;144:1090.
22. Hauch A, Al-Qurayshi Z, Randolph G, et al. Total thyroidectomy is associated with increased risk of complications for low- and high-volume surgeons. *Ann Surg Oncol.* 2014;21:3844–3852.
23. Klosterman T, Siu E, Tatum S. Free flap reconstruction experience and outcomes at a low-volume institution over 20 years. *JAMA Otolaryngol Head Neck Surg.* 2015;152:832–837.