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CLINICAL ARTICLE

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The impact of resident involvement in breast reconstruction surgery outcomes by modality: An analysis of 4,500 cases

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Background: The goal of this study was to determine the impact of resident involvement on various methods of breast reconstruction via an American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) retrospective analysis.

Methods: We performed a retrospective analysis of the ACS NSQIP database to identify patients undergoing breast reconstruction by free flap, implant, latissimus dorsi (LD), and transverse rectus abdominis myocutaneous (TRAM) flap reconstruction modalities. Primary outcomes measured include major and wound complications.

Results: A total of 4,500 cases were included in this analysis, of which residents participated in 1,743 (38.7%). Major complications occurred in 7.2% of all cases, and wound complications occurred in 3.3% of all cases. BMI was positively correlated with major complications in free flap, implant, and TRAM reconstruction groups. Wound complications were associated with BMI in free flap, implant, and TRAM reconstruction, with steroid use in implant and TRAM reconstruction, and with a history of bleeding disorder in LD reconstruction. Resident involvement did not reach significance in any reconstruction group as an independent factor for major or wound complications.

Conclusions: Resident involvement is safe and effective across implant, free flap, LD, and TRAM based methods of breast reconstruction with similar major and wound complication rates. Participation of trainees in these surgical cases is imperative for future patient care.

1 | INTRODUCTION

Surgical training is a critical aspect of academic medical centers, which must ensure both high quality patient care and training future competent and safe surgeons. With increased focus on medical errors, adverse events, and patient outcomes (Cuschieri, 2003), the influence of resident participation on these metrics is an area requiring investigation. The involvement of trainees in patient care has raised concerns about their experience and abilities, prompting some patients to request that residents not participate in their care (Cowles et al., 2001).

The literature has examined resident involvement in patient outcomes among different subspecialties and procedure types. While some of these studies resulted in poorer outcomes with resident involvement (Advani, Ahad, Gonczy, Markwell, Hassan, 2012; Davis, Husain, Lin, Nandipati, Perez, Sweeney, 2013; Hernández-Irizarry, Zendejas, Ali, Lohse, Farley, 2012; Iannuzzi et al., 2013a,b; Kern, Lustik, McMann, Thibault, Sterbis, 2014; Papandria et al., 2012; Schoenfeld, Serrano, Waterman, Bader, Belmont, 2013), others reported no detrimental results (Jordan et al., 2012; Chatterjee et al., 2015; Jan, Riggs, Orlando, Khan, 2012; Saliba et al., 2016; Kiran et al., 2012; Hirche et al., 2015). The impact of resident involvement in breast surgery (Chatterjee et al., 2015) and breast reduction surgery (Fischer, Wes, Kovach, 2014) has been studied. However, there is a void regarding resident impact on the various methods of breast reconstruction. This study aims to explore the impact of trainee involvement in breast reconstruction via an American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) retrospective analysis.

2 | METHODS

2.1 | Data source

We obtained database files for the years 2005–2014 from the ACS NSQIP website (http://www.acsnsqip.org/). This database is comprised of data regarding pre-operative comorbidities, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes in

TABLE 1 CPT codes

Category	CPT code	Frequency (*n*)	Procedure
Latissimus Dorsi	19361	407	Breast reconstruction with latissimus dorsi flap, without prosthetic implant
TRAM	19367	328	Breast reconstruction with transverse rectus abdominis myocutaneous flap (TRAM), single pedicle, including closure of donor site
	19368	62	Breast reconstruction with transverse rectus abdominis myocutaneous ap (TRAM), single pedicle, including closure of donor site; with microvascular anastomosis (supercharging)
	19369	35	Breast reconstruction with transverse rectus abdominis myocutaneous ap (TRAM), double pedicle, including closure of donor site
Free flap	19364	497	Breast reconstruction with free flap
Implant	19340	672	Immediate insertion of breast prosthesis following mastopexy, mastectomy or in reconstruction
	19342	878	Delayed insertion of breast prosthesis following mastopexy, mastectomy or in reconstruction
	19357	1621	Breast reconstruction, immediate or delayed, with tissue expander, including subsequent expansion

surgeries performed at participating institutions. The details for data collection methods are available through the program (Data Collection, Analysis, and Reporting, 2016). This study was approved by our IRB board and conducted in accordance with the principles outlined in the Declaration of Helsinki.

2.2 | Patient selection

We performed a retrospective analysis on all patients undergoing procedures with breast reconstruction with between 2005 and 2014. The following American Medical Association Current Procedural Terminology (CPT) codes were screened as both primary and secondary operations to identify patients undergoing breast reconstruction: 19340, 19342, 19357, 19361, 19364, and 19367 through 19369 (Table 1). Latissimus dorsi (LD) reconstruction was coded as 19361, transverse rectus abdominis myocutaneous (TRAM) flap reconstruction was coded as 19367 through 19369, free flap reconstruction was coded as 19364, and implant-based reconstruction was coded as 19340, 19342 and 19357.

2.3 | Statistical analysis

Descriptive statistics and complication profiles were calculated for the study population. Primary outcomes measured include major and wound complications. Major complications included deep wound infection or unplanned return to the operating room. Wound complications were comprised of superficial infections or wound dehiscence. Demographic data included age, body mass index (BMI), and gender.

Univariate analysis was carried out by χ^2 and *t* tests on categorical and continuous variables, respectively. Significance was defined with a *P* value of <0.05. Factors included in the multivariate analysis included those variables with a *P* value <0.1 from the univariate analysis in addition to perceived clinical pertinence. Factors were excluded from multivariate regression analysis if the number of cases per instance was <10. Multivariate analysis was performed to determine the effect of comorbidities on complication rate. All analyses were performed using SPSS version 24.0 (IBM Corp., Armonk, N.Y.).

3 | RESULTS

A total of 17,070 cases were initially identified. After removing cases with incomplete data regarding resident involvement including patient data from the years 2013 and 2014, 4,500 cases remained. Attendings conducted 2,757 (61.3%) cases without resident involvement and residents participated in 1,743 (38.7%) cases. Major complications resulted in 7.2% of all cases, and wound complications resulted in 3.3% of all cases.

Patient baseline preoperative data is presented in Table 2. Characteristics that reached statistically significant difference between the groups include the following: lower BMI in resident-involved implant (26.2 vs 26.7, $P = 0.03$), lower proportion of patients with ASA of 3 or higher in resident-involved LD reconstruction (57.4% vs 68.6%, $P = 0.03$), fewer patients with smoking history in resident-involved implant-based reconstruction (10.5% vs 13.7%, $P = 0.01$), greater proportion of patients with radiotherapy within 90 days prior to the operation in resident-involved latissimus reconstruction (2.2% vs 0.0%, $P = 0.01$), longer operative time with resident-involvement in implant-based reconstruction (152.5 vs 135.6 minutes, $P < 0.001$), LD reconstruction (273.2 vs 242.4 minutes, $P = 0.01$), and free flap reconstruction (545.1 vs 471.9 minutes, $P < 0.001$), and longer hospital stay with resident-involved implant (1.2 vs 0.8 days, $P < 0.001$) and latissimus-based reconstruction (5.5 vs 2.8 days, $P = 0.01$).

No statistical significance was observed between groups with regards to clinical factors including age, obesity, or alcohol consumption. Comorbidities that did not demonstrate statistically significant

TABLE 2 Univariate analysis of patient demographics and preoperative, perioperative, and postoperative variables

	Free flap ($n = 497$)			Implant ($n = 3{,}171$)			Latissimus dorsi flap ($n = 407$)			TRAM flap ($n = 425$)		
Variable	Attending ($n = 167$)	Resident ($n = 330$)	*P* values	Attending ($n = 2{,}039$)	Resident ($n = 1{,}132$)	*P* values	Attending ($n = 271$)	Resident ($n = 136$)	*P* values	Attending ($n = 280$)	Resident ($n = 145$)	*P* values
Age, years (mean ± SD)	51.5 ± 9.4	50.1 ± 9.2	0.10	52.0 ± 11.2	51.2 ± 11.1	0.06	53.1 ± 10.4	51.8 ± 11.7	0.28	52.2 ± 9.0	51.9 ± 9.0	0.42
BMI (mean ± SD)	29.3 ± 7.1	29.6 ± 5.4	0.55	26.7 ± 7.0	26.2 ± 6.6	0.03*	28.3 ± 7.3	28.8 ± 7.4	0.52	29.2 ± 5.3	28.8 ± 6.8	0.52
Obese, BMI ≥ 30, *n* (%)	78 (46.7)	145 (43.9)	0.56	511 (25.1)	264 (23.3)	0.28	93 (34.3)	50 (36.8)	0.63	117 (41.8)	49 (33.8)	0.11
ASA ≥ 3, *n* (%)[a]	51 (30.5)	127 (38.5)	0.08	439 (21.5)	217 (19.2)	0.12	186 (68.6)	78 (57.4)	0.03*	85 (31.4)	58 (42.6)	0.46
Smoking, *n* (%)	13 (7.8)	25 (7.6)	0.93	279 (13.7)	119 (10.5)	0.01*	36 (13.3)	19 (14.0)	0.85	41 (14.6)	18 (12.4)	0.53
EtOH, *n* (%)	2 (1.2)	3 (0.9)	0.76	42 (2.1)	16 (1.4)	0.29	5 (1.8)	3 (2.2)	0.79	2 (0.7)	3 (2.1)	0.19
Preoperative Comorbidities												
Cardiac comorbidities, *n* (%)	1 (0.6)	3 (0.9)	0.72	19 (0.9)	11 (1.0)	0.91	5 (1.5)	0 (0.0)	0.15	2 (0.7)	1 (0.7)	0.98
Pulmonary comorbidities, *n* (%)	1 (0.6)	2 (0.6)	0.99	21 (1.0)	8 (0.7)	0.36	4 (1.5)	2 (1.5)	0.99	1 (0.4)	1 (0.7)	0.64
Diabetes, *n* (%)	11 (6.6)	17 (5.2)	0.51	106 (5.2)	53 (4.7)	0.52	22 (8.1)	16 (11.8)	0.23	12 (4.3)	5 (3.4)	0.68
Hypertension, *n* (%)	48 (28.7)	80 (24.2)	0.28	506 (24.8)	258 (22.8)	0.20	78 (28.8)	43 (31.6)	0.56	82 (29.3)	37 (25.5)	0.41
Wound/wound infection, *n* (%)	0 (0.0)	2 (0.6)	0.31	17 (0.8)	11 (1.0)	0.69	11 (4.1)	10 (7.4)	0.16	6 (2.1)	6 (4.1)	0.24
Steroid use, *n* (%)	3 (1.8)	4 (1.2)	0.60	16 (0.8)	15 (1.3)	0.14	6 (2.2)	2 (1.5)	0.61	2 (0.7)	1 (0.7)	0.98
Bleeding Disorder, *n* (%)	2 (1.2)	4 (1.2)	0.99	12 (0.6)	11 (1.0)	0.22	1 (0.4)	1 (0.7)	0.62	3 (1.1)	1 (0.7)	0.70
Chemotherapy 30 days, *n* (%)	11 (6.6)	20 (6.1)	0.82	142 (7.0)	58 (5.1)	0.12	25 (9.2)	14 (10.3)	0.69	15 (5.7)	9 (6.2)	0.73
Radiotherapy 30 days, *n* (%)	3 (1.8)	4 (1.2)	0.60	15 (0.7)	11 (1.0)	0.37	0 (0.0)	3 (2.2)	0.01*	3 (1.1)	4 (2.8)	0.17
Disseminated cancer, *n* (%)	0 (0.0)	5 (1.5)	0.11	19 (0.9)	11 (1.0)	0.99	3 (1.1)	4 (2.9)	0.18	3 (1.1)	3 (2.1)	0.41
Prior Operation 30 days, *n* (%)	5 (3.0)	7 (2.1)	0.55	33 (1.6)	12 (1.1)	0.28	4 (1.5)	4 (2.9)	0.31	12 (4.3)	11 (7.6)	0.16
Operative time, minutes (mean ± SD)	471.9 ± 200.0	545.1 ± 186.5	<0.001*	135.6 ± 88.7	152.5 ± 109.1	<0.001*	242.4 ± 117.3	273.2 ± 117.7	0.01*	321.5 (154.4)	320.7 (178.3)	0.95
Length of Hospital Stay, days (mean ± SD)	4.9 ± 4.8	4.9 ± 2.1	0.87	0.8 ± 2.0	1.2 ± 3.6	<0.001*	2.8 ± 5.8	5.5 ± 24.8	0.01*	4.3 ± 4.9	4.4 ± 2.6	0.82
Post-operative complications												
Wound complications, *n* (%)	6 (3.6)	19 (5.8)	0.30	42 (2.1)	33 (2.9)	0.13	8 (3.0)	3 (2.2)	0.66	27 (9.6)	10 (6.9)	0.34
Major complications, *n* (%)	25 (15.0)	55 (16.7)	0.63	88 (4.3)	69 (6.1)	0.03*	23 (8.5)	7 (5.1)	0.22	36 (12.9)	19 (13.1)	0.94

[a]In comparison to ASA class of 1 or 2.

Cardiac history includes history of angina, congestive heart failure, myocardial infarction within past 6 months of operation, history of percutaneous coronary intervention, and history of cardiac surgery. Pulmonary history includes history of chronic obstructive pulmonary disease, current pneumonia, and ventilator dependence. Wound complication includes superficial infection or wound dehiscence. Major complication includes deep wound infection or unplanned return to OR.

TABLE 3 Multivariate analysis for major complications

Factor	Free flap		Implant		LD		TRAM	
	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Age	1.00 (0.98 – 1.03)	0.85	1.00 (0.98 – 1.01)	0.73	1.00 (0.96 – 1.04)	0.83	1.00 (0.96 – 1.03)	0.83
BMI	1.06 (1.02 – 1.11)	0.01*	1.03 (1.01 – 1.05)	0.02*	1.01 (0.95 – 1.07)	0.80	1.08 (1.03 – 1.14)	0.003*
Diabetes	0.32 (0.71 – 1.47)	0.14	1.03 (0.51 – 2.06)	0.94	3.72 (1.17 – 11.82)	0.03*	0.42 (0.09 – 2.03)	0.42
Smoker	1.92 (0.86 – 4.28)	0.11	1.58 (1.01 – 2.47)	0.05*	1.68 (0.61 – 4.59)	0.31	1.02 (0.44 – 2.36)	0.97
ASA 3 or 4[a]	1.54 (0.91 – 2.61)	0.11	1.22 (0.82 – 1.82)	0.33	1.45 (0.62 – 3.39)	0.39	1.10 (0.54 – 2.26)	0.79
Steroid	1.48 (0.16 – 13.61)	0.73	3.37 (1.24 – 9.19)	0.02*	2.56 (0.28 – 23.61)	0.41	2.27 (0.18 – 28.17)	0.52
Chemotherapy	0.14 (0.02 – 1.07)	0.06	1.01 (0.53 – 1.93)	0.98	0.89 (0.19 – 4.14)	0.89	1.13 (0.31 – 4.21)	0.85
Hypertension	0.84 (0.46 – 1.53)	0.56	1.28 (0.84 – 1.95)	0.26	0.39 (0.13 – 1.17)	0.09	1.70 (0.87 – 3.32)	0.12
CVA	-	-	2.62 (0.56 – 12.32)	0.22	4.27 (0.36 – 60.00)	0.25	-	-
Bleeding disorder	-	-	0.90 (0.12 – 6.84)	0.92	18.41 (0.97 – 350.46)	0.05	1.22 (0.12 – 12.89)	0.87
Total operation time	1.00 (0.999 – 1.001)	0.79	1.003 (1.001 – 1.004)	<0.001*	1.002 (0.999 – 1.005)	0.23	1.002 (1.000– 1.003)	0.07
Resident involvement	1.06 (0.62 – 1.81)	0.84	1.34 (0.95 – 1.88)	0.10	0.50 (0.20 – 1.25)	0.14	1.06 (0.57 – 1.97)	0.85

[a]In comparison to ASA class of 1 or 2.

TABLE 4 Multivariate analysis for wound complications

Factor	Free flap		Implant		LD		TRAM	
	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Age	1.00 (0.97 – 1.03)	0.95	1.00 (0.98 – 1.02)	0.79	1.02 (0.95 – 1.09)	0.61	1.04 (0.99 – 1.08)	0.12
BMI	1.06 (1.01 – 1.11)	0.01*	1.04 (1.01 – 1.07)	0.01*	1.04 (0.95 – 1.14)	0.45	1.17 (1.05 – 1.19)	<0.001*
COPD	3.24 (0.27 – 38.92)	0.36	-	-	-	-	-	-
ASA 3 or 4[a]	1.43 (0.85 – 2.39)	0.18	0.94 (0.51 – 1.74)	0.84	2.37 (0.57 – 9.93)	0.24	0.80 (0.33 – 1.96)	0.63
Steroid	0.83 (0.10 – 7.16)	0.86	4.29 (1.25 – 14.75)	0.02*	-	-	24.39 (1.79 – 331.47)	0.02*
Hypertension	0.78 (0.43 – 1.44)	0.43	0.79 (0.41 – 1.52)	0.49	0.44 (0.07 – 2.68)	0.37	1.07 (0.48 – 2.39)	0.86
Bleeding Disorder	-	-	-	-	65.60 (2.84 – 1516.41)	0.01*	-	-
CVA	-	-	3.69 (0.46 – 29.72)	0.22	10.86 (0.90 – 131.09)	0.06	-	-
Total Operation Time	1.00 (0.999 – 1.001)	0.80	1.00 (0.997 – 1.002)	0.68	1.001 (0.995 – 1.006)	0.83	1.00 (0.998 – 1.002)	0.92
Resident Involvement	1.06 (0.62 – 1.81)	0.82	1.31 (0.80 – 2.14)	0.28	0.42 (0.80 – 2.26)	0.42	0.68 (0.31 – 1.49)	0.33

[a]In comparison to ASA class of 1 or 2.

differences between the groups include: cardiac comorbidities, pulmonary comorbidities, diabetes, hypertension, preoperative wound infection, steroid use, bleeding disorder, chemotherapy within 30 days preoperatively, disseminated cancer, and undergoing another operation within 30 days preoperatively.

On multivariate analysis (Table 3), BMI was positively correlated with major complications in free flap, implant, and TRAM reconstruction groups. Smoking, steroid use, and operative time demonstrated significant association with major complications under implant-based reconstruction, and diabetes was associated with major complications in LD reconstructions.

On multivariate analysis (Table 4), factors that demonstrated statistically significant association with wound complications included BMI in free flap, implant, and TRAM reconstruction, steroid use in implant and TRAM reconstruction, and history of bleeding disorder in LD reconstruction. Resident involvement did not reach significance in any reconstruction group as an independent factor of major or wound complications.

The distribution of breast reconstruction modality by year of operation is illustrated in Table 5. TRAM reconstructions steadily decreased from 2005 to 2012, while free flap and implant-based reconstructions steadily increased over the years.

4 | DISCUSSION

This study examines the complications across four modalities of breast reconstruction with and without resident involvement. The analysis suggests resident involvement in breast reconstruction is safe, as there is no significant difference in major or wound complication rates with trainee participation compared to attending-only involvement. The data presented here provides valuable information for surgeons in both preoperative decision making and counseling patients about the risks of undergoing breast reconstruction.

Surgical resident training is crucial in the training of future physicians, but recent focus on patient outcomes has resulted in scrutinization of resident impact in patient care. Other studies examining the influence of resident involvement in breast surgery have produced mixed results. Fischer et al. reported a significant increase in surgical morbidity with resident participation in breast reduction surgery (Fischer, Wes, Kovach, 2014). Similarly, Jordan and colleagues examined 2006 through 2010 NSQIP data with respect to reconstructive plastic surgery cases and found that resident involvement resulted in modestly increased morbidity and similar or decreased mortality (Jordan et al., 2012). On the other hand, the analysis by Chatterjee et al. demonstrated no significant difference in complication rates with trainee participation in breast cancer surgery including partial and complete mastectomy (Chatterjee et al., 2015). Patel and colleagues examined resident involvement in reduction mammoplasty and demonstrated that resident participation did not negatively influence outcomes (Patel et al., 2010). Sebai et al. also reported no increased morbidity, reoperation, or readmission with resident involvement in immediate breast reconstruction (Sebai et al., 2016).

TABLE 5 Breast reconstruction modality by year of operation

Year of operation	Free (*n* = 497)	Implant (*n* = 3171)	LD (*n* = 407)	TRAM (*n* = 425)	Total
2005	0 (0.0)	12 (54.5)	2 (9.1)	8 (36.4)	22
2006	4 (7.0)	37 (64.9)	3 (5.3)	13 (22.8)	57
2007	5 (2.6)	133 (70.4)	17 (9.0)	34 (18.0)	189
2008	14 (3.6)	276 (70.2)	35 (8.9)	68 (17.3)	393
2009	49 (7.7)	457 (71.4)	65 (10.2)	69 (10.8)	640
2010	87 (9.9)	593 (67.3)	105 (11.9)	96 (10.9)	881
2011	148 (14.0)	739 (69.8)	94 (8.9)	77 (7.3)	1058
2012	190 (15.1)	924 (73.3)	86 (6.8)	60 (4.8)	1260

In our dataset, breast reconstruction procedures involving residents were on average more complex as demonstrated by perioperative risk factors including lower ASA for LD group, use of radiotherapy, longer average operative times, and average length of hospitalization. Cases with resident involvement are generally performed at academic teaching hospitals, which leads to a case mix bias as discussed above. In spite of these biases that would favor increased complications, we found no statistically significant difference in complication profiles regardless of resident involvement in free flap, implant, TRAM, or LD-based reconstructions. These results support the involvement of plastic surgery residents in breast reconstruction with no perceived detrimental effect on major or wound complications.

The complication rates between reconstruction modalities are variable in the literature. Some studies demonstrate lower complication rates with free flap and autologous reconstruction compared to implant (Fischer et al., 2013; Kroll and Baldwin, 1992), whereas others demonstrate the opposite (Mioton et al., 2013). It appears that free flap performance improves over time (Fischer et al., 2013). Our data demonstrated lower major and wound complications with implant based reconstruction, however this analysis was limited by 30-day complications. Explanations for the lower rates of complications are multifactorial, possibly owing to donor site morbidity, operative time, and medical comorbidity differences between the groups (Mioton et al., 2013). Furthermore, autologous reconstruction methods are prone to higher complication rates in the immediate postoperative period but decrease with time, in contrast to complication profiles in implant reconstruction methods (Rusby, Waters, Nightengale, England, 2010).

Operative time has been demonstrated as an independent predictor of complications in breast reconstruction (Mioton et al., 2013). After multivariate analysis, prolonged operative time was correlated to increased major complications in the implant based reconstruction group. Resident involvement was correlated to prolonged operative time in free flap and implant reconstruction groups, but no statistically significant differences were noted in LD and TRAM groups as demonstrated in Table 2. The teaching and training of residents contributes to the overall length of the case. ASA in resident LD group was lower. Additionally, the length of hospital stay was longer in resident-involved implant and latissimus breast reconstructions, which likely creates an added risk of both occurrence and detection of complications. This variation in average length of stay may also be due to case mix variations at teaching versus non-teaching hospitals. However, because of the nature of the NSQIP data set, no specific conclusion can be drawn regarding the increased operative times or hospital length of stay.

Similar to other studies, high BMI was associated with poorer outcomes (Fischer, Wes, Kanchwala, Kovach, 2014; Hanwright et al., 2013; Bonomi, Salval, Settembrini, Gregorelli, Musumarra, 2012). Specifically, our analysis demonstrated increasing BMI was associated with both major and wound complications across free flap, implant, and TRAM groups. LD reconstruction did not demonstrate significantly increased major or wound complications after multivariate analysis, consistent with findings in the literature highlighting the latissimus flap as a superior option in obese patients (Hanwright et al., 2013; Bonomi, Salval, Settembrini, Gregorelli, Musumarra, 2012). Consistent with other studies (Mioton et al., 2013), the implant reconstruction group had a lower average BMI compared with autologous reconstruction groups. High BMI should not be considered an absolute contraindication to breast reconstruction, however these high-risk patients are more prone to postoperative complications; therefore, surgeons and anesthesiologists should be vigilant of this comorbidity. With adequate precautions, complication rates in this patient group can be minimized.

Recent trends in breast reconstruction have favored implant-based reconstructions over autologous tissue (Cemal et al., 2013; Jagsi et al., 2014; Gurunluoglu, Gurunluoglu, Williams, Tebockhorst, 2013). This is in part due to increasing frequency of bilateral mastectomy, but implants have also been increasingly used for all mastectomy types (Cemal et al., 2013). The results presented herein demonstrate a similar trend of increasing implant use, yet the mixture of autologous breast reconstruction types has varied as well. TRAM reconstructions sharply decreased from 2005 to 2012, whereas free flaps steadily increased in usage. In recent years, the popularity of perforator flaps, particularly the deep inferior epigastric perforator (DIEP) flap, has increased because of donor site morbidity advantages when compared to the TRAM flap (Tran, Buchel, Convery, 2007). The popularity of the DIEP flap likely contributes to the increase in free flap reconstructions, as it has the unique properties of removing abdominal excess tissues with minimal donor-site morbidity (Gurunluoglu et al., 2013).

Free flap reconstructions averaged significantly longer operative times in cases with residents. The prolonged operative times can be attributed to the training of residents the "increased complexity" is expected due to case mix variations at academic institutions, but since the data does not clearly show this, we should exclude it. However, it must also be taken into consideration that microsurgical free flap transfer is rarely performed by a single surgeon. The presence of multiple surgeons, one or more residents, or physician assistants (PA) is a more common occurrence. Unfortunately, these operative characteristics were not able to be analyzed in the dataset.

This analysis is not without limitations. Due to the nature of our NSQIP data, our results can only demonstrate the impact of the presence of a resident rather than the specific level of involvement. The level of training in terms of PGY level was also not able to be determined because of incomplete data. The increase in operative length with a trainee present may be due to multiple factors including increased complexity of cases, slower operative speed of trainees, or time spent instructing. Additionally, the NSQIP database tracks outcomes in a 30-day window postoperatively, which would not capture long-term complications which are critical in the assessment of breast reconstruction success, particularly with implant reconstruction (Cordeiro, McCarthy, 2006). Moreover, the data does not allow for determination of unilateral or bilateral reconstructions. We were additionally restricted by usage of CPT codes, resulting in omission of Healthcare Common Procedure Coding System (HCPCS) codes in both academic center and private hospitals. Such codes relevant to the study would include gluteal artery perforator (GAP) flaps (s2066), deep inferior epigastric perforator (DIEP) flaps (s2068), and stacked DIEP flaps (s2067). The absence of S codes in the database may greatly reduce the volume captured in this study, as the use of S codes vary by geography and payer mix. The database does not include certain endpoints of interest including hematoma, seroma, or fat necrosis which are common complications in autologous breast reconstruction. Microsurgical free flap, LD, and TRAM reconstructions were represented in smaller proportions than implant-based methods, which may have constrained the ability to detect statistically significant variations in the less common reconstruction modalities. Lastly, institution information is anonymized such that we were unable to control for hospital-level effects. This may introduce a bias because of differences in case mix related to academic centers that are more likely to involve residents.

5 | CONCLUSION

Resident involvement in breast reconstruction does not lead to increased complications. However, resident involvement is associated with increased average operative time in free flap, implant, and LD reconstruction groups and prolonged length of hospitalization in implant-based reconstructions. Resident involvement is safe and effective across implant, free flap, LD, and TRAM based methods with no significant difference in complication rates. Participation of trainees in these surgical cases is crucial for future patient care.

DISCLOSURE

American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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