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The Impact of Surgical Trainee Participation on Sinus Surgery Outcomes

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Objectives/Hypothesis: To determine the effect of otolaryngology trainee participation on clinical outcomes in patients who undergo endoscopic sinus surgery (ESS) for chronic rhinosinusitis.

Study Design: Secondary analysis of prospectively collected data.

Methods: Patients enrolled in a sinus surgery outcomes study between May 2011 and March 2013 were stratified into two groups—those who were operated on by an attending alone and those operated on by an attending with a trainee present (resident, fellow, or both). Patients completed quality of life (QOL) surveys including the Chronic Sinusitis Survey (CSS), 22-item Sino-Nasal Outcome Test (SNOT-22), and EuroQol 5-dimension survey preoperatively and 1 year postoperatively. Operative time, estimated blood loss (EBL), complication rates, and survey scores were compared between groups.

Results: The study population consisted of 452 patients. The attending alone (n = 119) and trainee (n = 333) groups were statistically comparable in terms of patient demographics, disease severity, and extent of surgery. Mean operative time was significantly shorter in the attending-alone group (80.0 vs. 90.6 minutes, $P < .01$). Mean EBL (105 mL attending vs. 117 mL trainee, $P = .39$) and complication rates (3.3% attending vs. 0.6% trainee, $P = .07$) were similar between groups. Observed changes in QOL measures following ESS were comparable between groups, although absolute improvement in the SNOT-22 scores (19.0 attending vs. 24.5 trainee, $P = .05$) did show a trend toward greater improvement in the trainee group.

Conclusions: Trainee participation in ESS is associated with prolongation in surgical time; however, such participation was not found to adversely affect patient safety or clinical outcomes.

Key Words: Quality of life, allergy/rhinology, outcomes/cost-effectiveness, adult rhinology.

Level of Evidence: 2b

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INTRODUCTION

Academic medical centers have a dual mission to provide high-quality patient care while also training healthcare providers, including future surgeons. Trainee participation in surgical procedures is a necessary part of postgraduate training, but may present a concern to patients who fear being "practiced upon." Prospective outcomes data demonstrating the impact of trainees in the operating room setting may allay such concerns.

The American College of Surgeons implemented the National Surgical Quality Improvement Program (NSQIP) in 2004 as a quality-improvement initiative, and as such, intraoperative and 30-day postoperative morbidity and mortality data are recorded. NSQIP has been employed to evaluate the role of surgical trainees on surgical outcomes. Reports from this database have shown mixed outcomes data with several studies finding increased operative time[1–4] and postoperative morbidity[2,4–10] when trainees are involved with general surgery cases, whereas other analyses have shown resident involvement to decrease mortality rates.[5–7,11] Only one study has used NSQIP to evaluate the role of otolaryngologic trainees on surgical outcomes.[12]

In the field of otolaryngology, published studies on the effect of trainees on patient outcomes are largely limited to retrospective reviews. When residents are involved in otolaryngologic surgeries, longer operative times have been reported for tympanoplasty[13] transsphenoidal approaches to the pituitary,[14] thyroidectomy, and parathyroidectomy,[12] as well as tonsillectomy, adenoidectomy, and myringotomy with tube placement.[15] Free flap surgery[16] and tympanoplasty[13,17] performed with resident assistance did not result in increased complications; however, an increased rate of intraoperative cerebrospinal fluid (CSF) leaks was found during otolaryngologist-assisted transsphenoidal pituitary surgery when residents were involved.[14]

Although several prospective studies have demonstrated the benefit of endoscopic sinus surgery (ESS) on patients' quality of life (QOL) in the chronic rhinosinusitis (CRS) population,[18–21] the impact of otolaryngology trainees on objective outcomes after ESS has not been

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reported. The purpose of this study was to evaluate the effect of trainee participation on clinical outcomes in sinus surgery at an academic medical center.

MATERIALS AND METHODS

Study Design

The study population was comprised of patients with CRS who underwent ESS at the Massachusetts Eye and Ear Infirmary between February 2011 and February 2013. Subjects were enrolled on the day of surgery in a consecutive, prospective fashion from 10 different otolaryngologic practices: four academic based and six community based. Patient demographics, comorbidities, and preoperative computed tomography (CT) scores were recorded. This study represents a secondary analysis of a subset of patients enrolled in an ongoing prospective and previously reported study of QOL outcomes after ESS.[18,22,23]

Inclusion criteria for the study included age greater than 18 years and a diagnosis of CRS as defined by the American Academy of Otolaryngology Head and Neck Surgery.[24] Subjects were excluded if they had a diagnosis of neoplasm, trauma, CSF leak, or if surgery included external frontal sinus procedures. Patients with preoperative data who did not complete 12-month follow-up surveys were analyzed separately as nonresponders.

Trainee involvement was determined by review of the operative note. Patients were assigned to one of two groups—those that underwent surgery with an attending alone or those who underwent surgery with an attending and a trainee (resident, fellow, or both). A *resident* was defined as an otolaryngology trainee in the second to fifth year of postgraduate year (PGY) education (PGY-2–PGY-5). A *fellow* was defined as an otolaryngology trainee having completed a 5-year residency, and having entered a sixth year of postgraduate education in Rhinology (PGY-6). Surgeries selected for resident and fellow participation were selected on a daily basis by the individual trainee from the list of scheduled cases.

Surgery length and estimated blood loss (EBL) were extracted from the operating room record. When EBL was defined as minimal by the nursing staff, a value of 25 mL was assigned. Complications were defined as the intraoperative occurrence of, or any unscheduled patient follow-up visit to the clinic or emergency room in the first 30 days for epistaxis, orbital injury, or CSF leak. Institutional review board approval was obtained from the Human Subjects Committee of the Massachusetts Eye and Ear infirmary.

Patients completed three instruments that have been validated for the study of CRS—the EuroQol 5-dimension survey (EQ-5D), Chronic Sinusitis Survey (CSS), and the 22-item Sino-Nasal Outcome Test (SNOT-22—on the day of surgery (baseline) and at 1 year postoperatively. Each patient was given a 2-month window to complete 12-month follow-up data. Data collection was performed by mail, phone, or electronic survey in a Health Insurance Portability and Accountability Act–compliant manner. An online survey firm (DataStar, Waltham, MA) was employed to create and administer an Internet-based system for patients to securely enter their responses to QOL questionnaires.[25]

QOL Instruments

The EQ-5D is a general quality-of-life instrument that collects data from five health domains: mobility, self-care, usual activity, pain/discomfort, and anxiety/depression. A sixth question asks about the patients' "health today" along a 0 to 100 visual analog scale (VAS). The EQ-5D health utility value (HUV) represents a composite of patients' answers to the five domain questions. HUVs are constructed from country-specific population surveys.[26] A US-specific dataset is created and validated to allow for translation of indirect health valuation (EQ-5D survey response) into HUVs.[27,28]

The EQ-5D VAS is scored on a 0 to 100 scale (0 = the worst health imaginable, 100 = the best possible health), and the EQ-5D HUV is scored on a 0 to 1.0 scale (0 = worst health, 1.0 = best health). In contrast, the SNOT-22 is scored in an inverse fashion on a 0 to 110 scale (0 = no symptoms, 110 = maximal symptoms). To facilitate intersurvey comparison, CSS scores were normalized to a 0 to 100 scale, where 0 is the worst possible score (maximal symptoms/medication usage) and 100 the best (no symptoms or medication usage), as has been previously described.[19]

Statistical Analysis

Demographic data were compared between the attending and trainee groups using two independent sample t tests for variables including age, gender, and smoking. χ^2 tests were used for categorical variables including ethnicity, surgeon, and type of diagnosis. Pre- and postoperative outcome measures, including CSS, EQ-5D HUV and VAS, and SNOT-22 scores, were compared between the attending and trainee groups using two-sided paired t tests. The absolute change in QOL values was calculated by subtracting the 12-month value from the preoperative value; these outcomes were also compared between the attending and trainee groups with two-sample independent t tests. In addition, a Wilcoxon rank sum test was used to compare non-normative median EBL data between the attending and trainee groups. Linear multivariate analysis was performed to examine the association between outcomes under study including length of surgery; EBL; absolute change in CSS, EQ-5D HUV and VAS, and SNOT-22 scores with the variable of interest; and the presence of trainees while controlling for baseline characteristics of patients. Variables controlled for included: the surgeon performing the procedure, age, gender, ethnicity, asthma, revision surgery, aspirin allergy, smoking status, Lund-Mackay CT score, surgical procedures performed, and preoperative QOL values. Demographics and baseline CSS, EQ-5D, and SNOT-22 scores for patients who did not respond at 1 year were compared to those who did using χ^2 and two-sample independent t tests to assess for response bias. Statistical significance was set at a P value of $<.05$ using two-sided tests.

RESULTS

The study population consisted of 452 patients. There were 119 patients who were operated on by an attending alone and 333 operated on by an attending plus an otolaryngology trainee. A total of 22 residents and five fellows comprised the trainee group. The use of image guidance, rate of revision surgery, and extent of surgery did not differ significantly between the two groups. Similarly, patient characteristics, including Lund-Mackay score, smoking status, history of asthma, history of polyps, and history of aspirin allergy did not differ significantly between the attending and trainee groups (Table I). Ten attending surgeons participated in the study, with four in academic practice and six in community-based private practice. In the academic group, 41.7% of cases were performed by an attending alone, whereas 12.2% of cases were performed by an

TABLE I.
Demographic Data and Operative Details (n = 452).

	All Patients	Attending Alone	Attending With Trainees	*P* Value
No.	452	119	333	
Age, yr, mean (SD)	47.4 (14.7)	47.6 (13.7)	47.3 (15.1)	.849
Gender, % male	46.7	53.8	44.1	.089
Race, % Caucasian	91.6	90.8	91.9	.739
Active smokers, %	8.6	11.8	7.5	.219
Asthma, %	33.6	31.9	34.2	.732
Aspirin allergy, %	8.0	7.6	8.1	>.999
Prior ESS, %	46.2	39.5	48.6	.107
Nasal polyps, %	45.6	46.2	45.3	.955
CT stage, mean (SD)	11.1 (5.4)	11.3 (5.4)	11.0 (5.4)	.501
Image guidance, %	83.0	78.2	84.7	.138
Procedures performed, %				
Maxillary antrostomy	94.7	95.0	94.6	>.999
Ethmoidectomy	95.1	93.3	95.8	.397
Sphenoidotomy	65.6	62.2	66.7	.441
Frontal sinusotomy	63.1	55.5	65.8	.059
Septoplasty	56.9	58.0	55.3	.684
Frontal sinus drillout	3.8	1.7	4.5	.267

CT = computed tomography; ESS = endoscopic sinus surgery; SD = standard deviation.

attending alone in the community-based private practice group. Both junior and senior level attendings operated with and without trainees.

The mean duration of surgery was significantly shorter for the attending than the trainee group (80.0 vs. 90.6 minutes, respectively, $P < .001$), as shown in Figure 1. EBL data were available in 433 out of 452 patients. The mean EBL did not differ significantly ($P = .39$) between the attending-alone and the trainee groups (105 mL vs. 117 mL, respectively, $P = .39$). In addition, because the EBL data were non-normative, median EBL was compared between groups and was found to be similar (50.0 for both groups, $P = .771$). There was a trend toward higher complications in the attending group (4/119 cases, 3.3%) versus the trainee group (2/333 cases, 0.6%), but this result did not reach statistical significance ($P = .073$) (Table II). Postoperative epistaxis comprised all of the complications. Bleeding was managed with either packing in the emergency room (n = 3) or with operative intervention (n = 3). There were no incidences of orbital injury or CSF leak in either group.

Of the 452 enrolled patients who provided baseline data, 309 responded at 1 year, for a follow-up rate of 68.3%. There were no significant differences between the attending or trainee groups at baseline for the CSS, EQ-5D HUV, or SNOT-22 scores. However, the EQ-5D VAS was significantly higher (better) at baseline in the attending group when compared to the trainee group (76.7 vs. 72.5, respectively, $P = .029$). The CSS, EQ-5D HUV and VAS, and SNOT-22 scores all demonstrated significant improvement 1 year after surgery when compared to preoperative values in both groups ($P < .001$). When univariate analysis was performed, the trainee group had a significantly higher mean absolute change than the attending group for the EQ-5D VAS (7.9 vs. 2.3, respectively, $P = .02$), as well as the EQ-5D HUV (0.07 vs. 0.03, respectively, $P = .008$), as shown in Table III. The absolute change in CSS was not significantly different between the attending and trainee groups. The absolute change in SNOT-22 was greater in the trainee group (24.5) than the attending group (19), but did not reach statistical significance ($P = .051$). When linear multivariate analysis was performed for absolute change in

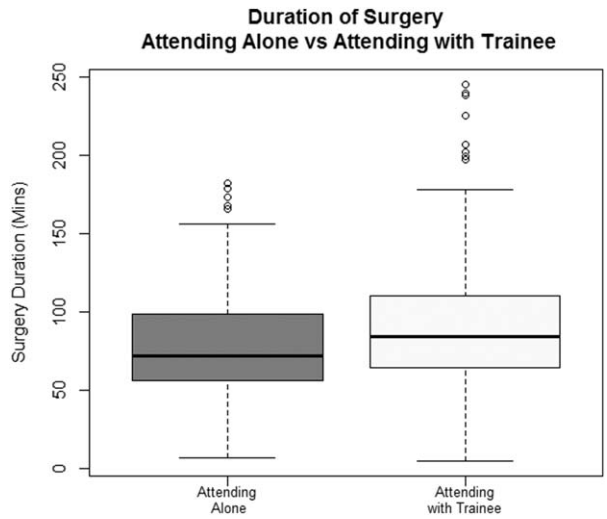

Fig. 1. Surgical duration stratified into attending-alone and attending with trainee groups. The mean surgical duration was 10.6 minutes longer in the attending with trainee group ($P < .001$).

TABLE II.
Complications, Estimated Blood Loss, and Surgical Duration (n = 452).

	All Patients	Attending Alone	Attending with Trainees	*P* Value
Surgery duration, min, mean (SD)	87.8 (38.6)	80.0 (37.1)	90.6 (38.8)	**<.001**
Estimated blood loss, mL, median (interquartile range)	50.0 (120.0)	50.0 (52.5)	50.0 (120.0)	.771
Estimated blood loss, mL, mean (SD)	114.0 (132.4)	105.0 (131.4)	117.3 (132.8)	.39
Complications, n (%)	6 (1.3%)	4 (3.3%)	2 (0.6%)	.073

SD = standard deviation.
Bold values are significant.

QOL instruments, controlling for confounding variables of the attending and trainee groups, the presence of trainees did not significantly impact EBL ($P = .904$), change in EQ-5D VAS ($P = .529$), change in EQ-5D HUV ($P = .210$), change in CSS ($P = .896$), or change in SNOT-22 ($P = .050$) (Fig. 2).

Demographics, comorbidities, and operative details for responders were compared to patients who did not respond to 12-month follow-up surveys. Responders were found to be more likely to be older ($P = .005$) and nonsmokers ($P < .001$) when compared to nonresponders. At baseline, responders had significantly higher EQ-5D HUV values when compared to nonresponders ($P = .013$); otherwise, baseline QOL scores were not significantly different.

DISCUSSION

William Halsted is credited with many novel contributions to the field of surgery, including the establishment of the hierarchical system in America of surgical education. In the late 19th century, he introduced a multiyear training program at Johns Hopkins Hospital with graduated autonomy, where the acquired knowledge of the senior surgeons was passed down to trainees.[29] More than 100 years later, the dual missions of an academic hospital to provide exemplary patient care and train future surgeons remains a potential cause for concern for patients.

In the current prospective study, trainee participation in ESS was found to prolong operative time by roughly 10 minutes. Similar findings have been reported for housestaff involvement in a variety of otolaryngologic and general surgical procedures.[1,12]

In this study, patient QOL improved 1 year after sinus surgery in all four QOL indices employed. Comparable improvements in these QOL measurements were observed whether the surgery was performed by an attending alone or with trainee participation. Similarly, several studies evaluating clinical outcomes in nonotolaryngologic procedures have demonstrated that resident participation has not negatively affected surgical outcomes, including weight loss in bariatric surgery[30] or nodal yields in colorectal surgery.[31]

TABLE III.
Quality-of-Life Outcomes After Sinus Surgery (n = 309).

	All Patients	Attending Alone	Attending With Trainee	*P* Value
CSS, mean (SD)				
Baseline	46.8 (20.2)	47.1 (18.7)	46.6 (20.7)	
1 year	72.9 (21.4)	71.8 (22.6)	73.3 (21.0)	
Absolute change	26.2 (25.0)	24.4 (28.8)	26.8 (23.5)	.896
SNOT-22, mean (SD)				
Baseline	48.0 (20.5)	47.9 (18.9)	48.0 (21.1)	
1 year	24.9 (20.1)	28.9 (21.3)	23.6 (19.5)	
Absolute change	−23.1 (20.5)	−19.0 (22.5)	−24.5 (19.5)	.050
EQ-5D VAS, mean (SD)				
Baseline	73.7 (16.1)	76.7 (13.8)	72.5 (16.7)	
1 year	80.1 (17.0)	79.1 (19.1)	80.4 (16.2)	
Absolute change	6.4 (17.8)	2.3 (17.8)	7.9 (17.5)	.529
EQ-5D HUV, mean (SD)				
Baseline	0.82 (0.12)	0.83 (0.11)	0.82 (0.12)	
1 year	0.88 (0.11)	0.86 (0.11)	0.89 (0.11)	
Absolute change	0.06 (0.11)	0.03 (0.11)	0.07 (0.11)	.210

Note that an increase in scores for CSS, EQ-5D HUV, and VAS signifies an improvement in quality of life, whereas a decrease in SNOT-22 signifies an improvement in quality of life.
CSS = Chronic Sinusitis Survey; EQ-5D = EuroQol 5-dimension survey; HUV = health utility value; SD = standard deviation; SNOT-22 = 22-item Sino-Nasal Outcome Test; VAS = visual analog scale.

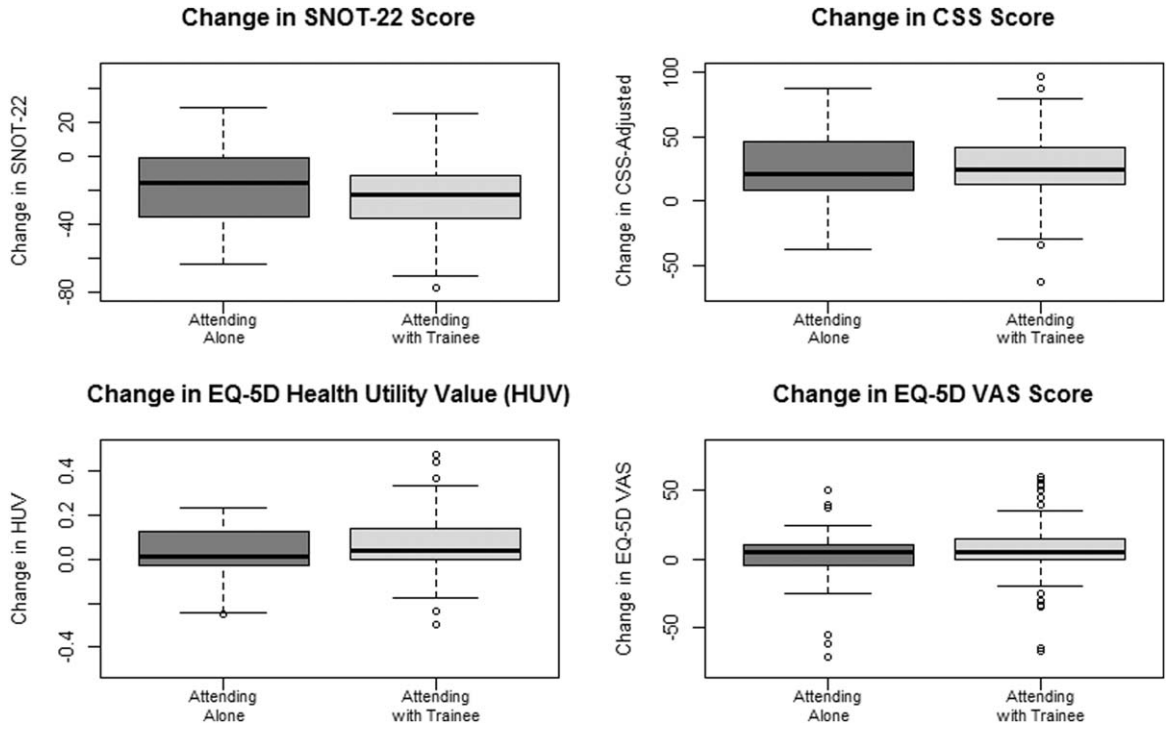

Fig. 2. Absolute change in score for SNOT-22, CSS, EQ-5D VAS, and EQ-5D HUV (clockwise from upper left) from baseline to 1 year after sinus surgery. Note that positive values for absolute change in CSS, EQ-5D HUV, and EQ-5D VAS represent an improvement in QOL, whereas negative values for SNOT-22 represent an improvement in QOL. CSS = Chronic Sinusitis Survey; EQ-5D = EuroQol 5-dimension survey; HUV = health utility value; QOL = quality of life; SNOT-22 = 22-item Sino-Nasal Outcome Test; VAS = visual analog scale.

Despite the fact that the current study was performed in a large teaching hospital, no major intraoperative complications occurred in the 452 patients who comprised the study population. Although ESS is a single-operator surgery, because it is routinely performed with videoendoscopy, a trainee's progress is easily monitored on the video screen, allowing for real-time feedback by the attending surgeon. The addition of an image-guidance system during the surgical procedure may provide an additional layer of safety by providing confirmation of the sinonasal landmarks to reassure both the trainee and attending surgeon alike.[32]

The trainee group in this study had a lower rate of postoperative complications compared to the attending group, although this difference did not reach statistical significance. Complications were limited to postoperative epistaxis in less than 4% of patients. The observed complication rates were consistent with those for sinus surgery reported in the contemporary literature.[33]

Multiple evaluations of the NSQIP by general surgeons have found an increase in 30-day complication rates associated with resident involvement in a broad array of general surgery procedures.[2,4–10,34] Increased morbidity associated with resident operative involvement has been seen in orthopedics,[35,36] plastic surgery,[37,38] and urology.[39] It has been proposed that increased postoperative morbidity may result from the prolonged operative time associated with resident involvement by way of surgical site infections and venous thromboembolic events from stasis, not necessarily from operative error.[40] Alternatively, other studies have found resident involvement to be beneficial or to have no effect on patient morbidity. Six NSQIP studies found that resident involvement in general surgery procedures decreased[5–7,11] or did not change[2,4] mortality rates.

In the current study, mean and median EBL were not significantly different between the attending and trainee groups. Dedhia et al. similarly found no difference in EBL between attending and trainee groups during otolaryngologist-assisted transsphenoidal pituitary surgery.[14] Although these findings are encouraging, it is difficult to draw conclusions from them, as blood loss during endoscopic sinus surgery is typically low and may be difficult to accurately assess.

A limitation of this study includes the secondary analysis of prospectively collected data. Trainees chose the surgical cases in which they participated, which may have introduced a selection bias. The observed trend toward worse preoperative QOL scores in the trainee group supports the notion that trainees chose to participate in the surgical care of patients with more severe disease. More research is needed in the assessment of patient outcomes in academic medical centers to fully delineate the impact of surgical training on patient care. Future directions for such research include comparison of longer-term outcome and trainee educational level.

CONCLUSION

The participation of otolaryngology trainees in endoscopic sinus surgery appears safe. Trainee involvement

in ESS does lead to increased operative time; however, complication rates, blood loss, and clinical outcomes are not statistically different when compared to the results of attending surgeons' without trainees.

BIBLIOGRAPHY

1. Papandria D, Rhee D, Ortega G, et al. Assessing trainee impact on operative time for common general surgical procedures in ACS-NSQIP. *J Surg Educ* 2012;69:149–155.
2. Kiran RP, Ahmed Ali U, Coffey JC, Vogel JD, Pokala N, Fazio VW. Impact of resident participation in surgical operations on postoperative outcomes: National Surgical Quality Improvement Program. *Ann Surg* 2012;256:469–475.
3. Hernández-Irizarry R, Zendejas B, Ali SM, Lohse CM, Farley DR. Impact of resident participation on laparoscopic inguinal hernia repairs: are residents slowing us down? *J Surg Educ* 2012;69:746–752.
4. Davis SS Jr, Husain FA, Lin E, Nandipati KC, Perez S, Sweeney JF. Resident participation in index laparoscopic general surgical cases: impact of the learning environment on surgical outcomes. *J Am Coll Surg* 2013; 216:96–104.
5. Tseng WH, Jin L, Canter RJ, et al. Surgical resident involvement is safe for common elective general surgery procedures. *J Am Coll Surg* 2011; 213:19–26.
6. Castleberry AW, Clary BM, Migaly J, et al. Resident education in the era of patient safety: a nationwide analysis of outcomes and complications in resident-assisted oncologic surgery. *Ann Surg Oncol* 2013;20:3715–3724.
7. Raval MV, Wang X, Cohen ME, et al. The influence of resident involvement on surgical outcomes. *J Am Coll Surg* 2011;212:889–898.
8. Scarborough JE, Bennett KM, Pappas TN. Defining the impact of resident participation on outcomes after appendectomy. *Ann Surg* 2012;255:577–582.
9. Iannuzzi JC, Chandra A, Rickles AS, et al. Resident involvement is associated with worse outcomes after major lower extremity amputation. *J Vasc Surg* 2013;58:827–831.
10. Advani V, Ahad S, Gonczy C, Markwell S, Hassan I. Does resident involvement effect surgical times and complication rates during laparoscopic appendectomy for uncomplicated appendicitis? An analysis of 16,849 cases from the ACS-NSQIP. *Am J Surg* 2012;203:347–351.
11. Jan A, Riggs DR, Orlando KL, Khan FJ. Surgical outcomes based on resident involvement: what is the impact on vascular surgery patients? *J Surg Educ* 2012;69:638–642.
12. Monteiro R, Mino JS, Siperstein AE. Trends and disparities in education between specialities in thyroid and parathyroid surgery: an analysis of 55,402 NSQIP patients. *Surgery* 2013;154:720–729.
13. Liu CY, Yu E, Shiao A, Wang M. Learning curve of tympanoplasty type I. *Auris Nasus Larynx* 2009;36:26–29.
14. Dedhia RC, Lord CA, Pinheiro-Neto CD, et al. Endoscopic endonasal pituitary surgery: impact of surgical education on operation length and patient morbidity. *J Neurol Surg B Skull Base* 2012;73:405–409.
15. Puram SV, Kozin ED, Sethi R, et al. Impact of resident surgeons on procedure length based on common pediatric otolaryngology cases. *Laryngoscope* 2015;125:991–997.
16. Patel UA, Lin AC. Flap outcomes when training residents in microvascular anastomosis in the head and neck. *Am J Otolaryngol* 2013;34:407–410.
17. Charlett SD, Scott A, Richardson H, Hawthorne MR, Banerjee A. Audiometric outcomes of tympanoplasty with hydroxylapatite prosthesis: consultant versus trainees. *Otol Neurotol* 2007;28:678–681.
18. Smith TL, Litvack JR, Hwang PH, et al. Determinants of outcomes of sinus surgery: a multi-institutional prospective cohort study. *Otolaryngol Head Neck Surg* 2010;142:55–63.
19. Gliklich R, Metson R. Effect of sinus surgery on quality of life. *Otolaryngol Head Neck Surg* 1997;117:12–17.
20. Remenschneider AK, D'Amico L, Litvack JR, et al. Long-term outcomes in sinus surgery: a new tool for measuring health-related quality of life. *Otolaryngol Head Neck Surg* 2014;151:164–170.
21. Poetker DM, Mendolia-Loffredo S, Smith TL. Outcomes of endoscopic sinus surgery for chronic rhinosinusitis associated with sinonasal polyps. *Am J Rhinol* 2007;21:84–88.
22. Remenschneider AK, D'Amico L, Gray ST, Holbrook EH, Gliklich RE, Metson R. TheEQ-5D—a new tool for studying clinical outcomes in chronic rhinosinusitis. *Laryngoscope* 2015;125:7–15.
23. Remenschneider AK, Scangas G, Meier JC, Gray ST, Holbrook EH, Metson R. EQ-5D-derived health utility values in patients undergoing surgery for chronic rhinosinusitis. *Laryngoscope* 2015;125:1056–1061.
24. Rosenfeld RM, Andes D, Bhattacharyya N, et al. Clinical practice guideline: adult sinusitis. *Otolaryngol Head Neck Surg* 2007;137:365–377.
25. Meier JC, Remenschneider AK, D'Amico L, Holbrook EH, Gray ST, Metson R. A new model for collection of clinical outcomes data in patients with chronic rhinosinusitis. *Int Forum Allergy Rhinol* 2014;4:411–415.
26. Shaw JW, Johnson JA, Coons SJ. US valuation of the EQ-5D health states: development and testing of the D1 valuation model. *Med Care* 2005;43:203–220.
27. Dolan P. Modeling valuations for EuroQol health states. *Med Care* 1997; 35:1095–1108.
28. EQ-5D-5L value sets. Available at: http://www.euroqol.org/about-eq-5d/valuation-of-eq-5d-5l-value-sets.html. Accessed May 27, 2014.
29. Cameron JL. William Stewart Halsted. *Ann Surg* 1997;22:445–458.
30. Fanous M, Carlin A. Surgical resident participation in laparoscopic Roux-en-Y bypass: is it safe? *Surgery* 2012;152:21–25.
31. Montroni I, Ghignone F, Rosati G, et al. The challenge of education in colorectal cancer surgery: a comparison of early oncological results, morbidity, and mortality between residents and attending surgeons performing an open right colectomy. *J Surg Educ* 2014;71:254–261.
32. Metson R, Coszena MJ, Cunningham MJ, Randolph GW. Physician experience with an optical image guided system for sinus surgery. *Laryngoscope* 2000;110:972–976.
33. Ramakrishnan VR, Kingdom TT, Nayak JV, Hwang PH, Orlandi RR. Nationwide incidence of major complications in endoscopic sinus surgery. *Int Forum Allergy Rhinol* 2012;2:34–39.
34. Iannuzzi JC, Rickles AS, Deeb AP, Sharma A, Fleming FJ, Monson JR. Outcomes associated with resident involvement in partial colectomy. *Dis Colon Rectum* 2013;56:212–218.
35. Pugely AJ, Gao Y, Martin CT, Callaghan JJ, Weinstein SL, Marsh JL. The Effect of resident participation on short-term outcomes after orthopaedic surgery. *Clin Orthop Relat Res* 2014;472:2290–2300.
36. Schoenfeld AJ, Serrano JA, Waterman BR, Bader JO, Belmont PJ Jr. The impact of resident involvement on post-operative morbidity and mortality following orthopaedic procedures: a study of 43,343 cases. *Arch Orthop Trauma Surg* 2013;133:1483–1491.
37. Fischer JP, Wes AM, Kovach SJ. The impact of surgical resident participation in breast reduction surgery—outcome analysis from the 2005–2011 ACS-NSQIP datasets. *J Plast Surg Hand Surg* 2014;48:315–321.
38. Jordan SW, Mioton LM, Smetona J, et al. Resident involvement and plastic surgery outcomes: an analysis of 10,356 patients from the American College of Surgeons National Surgical Quality Improvement Program database. *Plast Reconstr Surg* 2013;131:763–773.
39. Kern SQ, Lustik MB, McMann LP, Thibault GP, Sterbis JR. Comparison of outcomes after minimally invasive versus open partial nephrectomy with respect to trainee involvement utilizing the American College of Surgeons National Surgical Quality Improvement Program. *J Endourol* 2014;28:40–47.
40. Krell RW, Birkmeyer NJ, Reames BN, Carlin AM, Birkmeyer JD, Finks JF; Michigan Bariatric Surgery Collaborative. Effects of resident involvement on complication rates after laparoscopic gastric bypass. *J Am Coll Surg* 2014;218:253–260.