The Role of Manual Dexterity and Cognitive Functioning in Enhancing Resident Operative Autonomy

Saad Shebrain, MD, Gulrez Mahmood, MD, Gitonga Munene, MD, Lisa Miller, MD, John Collins, MD, and Robert Sawyer, MD

Department of Surgery, Western Michigan University Homer Stryker M.D. School of Medicine, Kalamazoo, Michigan

INTRODUCTION: Autonomy, both operative and nonoperative, is one of the most critical aspects of successful surgical training. Both surgeon and resident share the responsibility of achieving this goal. We hypothesize that operative autonomy is distinct and depends, for the most part, on the resident's manual dexterity, knowledge of, and preparation for the procedure.

METHODS: Over a period of 4 academic years, between July 2014 and June 2018, a total of 958 Global Rating Scale of Operative Performance evaluations were completed by 32 general and subspecialty faculty surgeons for 35 residents. Elective procedures were evaluated, including 165 (17.2%) by postgraduate year (PGY)1 residents, 253 (26.4%) by PGY2, 199 (20.8%) by PGY3, 147 (15.3%) by PGY4, and 194 (20.3%) by PGY5. The procedures evaluated were: 261 (27.2%) hernia repairs; 178 (18.6%) cholecystectomies; 102 (10.6%) colorectal and anal procedures; 73 (7.6%) vascular procedures; 56 (5.8%) thyroid and parathyroidectomies; 39 (4.1%) foregut (esophagus and stomach) procedures; 38 (4%) skin, soft tissue, and breast; 92 (10%) hepatopancreatic; 20 (2.1%) pediatric procedures; and 99 (10.3%) other procedures including amputations, cardiothoracic, and solid organs procedures. Each resident was scored from 1 to 5 (1 lowest, 5 highest) in each of the following categories of Global Rating Scale of Operative Performance: respect for tissue (RT), time and motion (T&M), instrument handling (IH), knowledge of the instrument (KI), flow of operation (FO) and resident's preparation for the procedure (RP). Resident operative autonomy (ROA) was assessed using the Zwisch scale, a 4-point scale describing faculty supervision behaviors associated with different degrees of resident autonomy (1: Show and Tell, 2: Active Help, 3: Passive Help, and 4: Supervision Only).

RESULTS: Correlation and ordinal regression analyses were conducted to examine the relationship between ROA and manual dexterity (RT, T&M, IH, and FO), and cognitive functioning (knowledge of instruments and resident preparation). Results indicated a positive correlation between ROA and RT ($r = 0.528$, $p < 0.001$), T&M ($r = 0.630$, $p < 0.001$), IH ($r = 0.597$, $p < 0.001$), KI ($r = 0.490$, $p < 0.001$), FO ($r = 0.637$, $p < 0.001$), and RP ($r = 0.525$, $p < 0.001$). Additionally, there was a weak inverse correlation between ROA and the number of years the surgeon had been in practice ($r = -0.127$, $p = 0.001$). The significant predictors of resident autonomy found by the ordinal logistic regression include time and motion ($p < 0.001$), flow of operation ($p < 0.001$), and resident's preparation for the procedure ($p < 0.001$).

CONCLUSIONS: Resident operative autonomy is a product of shared responsibility between the faculty and resident. However, residents' inherent and/or acquired skills and preparation for the operative procedures play a critical role. Residents should be advised to use available resources such as simulation to augment their skills preoperatively and to enhance their autonomy in the operating room. (J Surg Ed 76:e66–e76. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: Zwisch scale, operative autonomy, intraoperative evaluation

COMPETENCIES: Patient Care

INTRODUCTION

Operative autonomy is not an all-or-nothing event; the resident does not wake up one morning as an independent

Correspondence: Inquiries to Saad Shebrain, MD, Department of Surgery, Western Michigan University Homer Stryker M.D. School of Medicine, 1000 Oakland Drive, Kalamazoo, MI 49008; e-mail: saad.shebrain@med.wmich.edu

  1931-7204/$30.00
https://doi.org/10.1016/j.jsurg.2019.06.002

surgeon.[1] To develop operative autonomy by the end of their training, residents need to achieve graded autonomy as they progress through training. In past decades, senior residents proved their ability to operate independently by performing operations with limited or no supervision, often at night.[2] That time has passed now that the Accreditation Council for Graduate Medical Education instituted duty-hour limits in July 2013 as part of their comprehensive approach to promote high-quality education and safe patient care. However, with this ever-changing environment, the challenge is finding equivalent, if not better, alternatives to ensure resident operative competency and autonomy.

While the operating room remains primarily a master/apprentice-based learning environment for surgical residents, there are, currently, multiple competing demands on academic faculty that limit the opportunity for resident operative autonomy and challenge faculty to graduate residents fully proficient in operations.[3] These demands include, but are not limited to, duty-hour restriction; patient safety; psychological, legal, and financial malpractice threats; the expense of the operating room (surgical minute); increased scrutiny of outcomes from multiple databases; ongoing pressures for more clinical productivity; and improved quality. Since July 2012, the American Board of Surgery has required all chief surgical residents to have at least 6 operative and 6 clinical performance assessments conducted by the program director or other faculty members while in residency.[4] As a result of these requirements, there was a need to create valid, reliable, and feasible assessment tools to help surgery faculty enhance resident autonomy while still providing adequate supervision to ensure patient safety and quality.

Within the past decade, the format of surgical training programs has been restructured into competency-based curricula utilizing new methods for operative assessment,[5-9] such as formal technical skills exams in surgical skills laboratories,[10,11] videotape review of cases,[12] and the use of motion analysis devices.[13,14] While all of these methods have demonstrated the ability to objectively assess technical skills, they can be expensive and time-consuming to implement. Most studies assessing operative performance involve global assessment scales to grade some aspect of technical or overall technical abilities, task-specific checklists tailored to a specific procedure, or a combination of both.

The Objective Structured Assessment of Technical Skills (OSATS), a performance-based evaluation, is one of the most applied and accepted observational assessment tools. OSATS demonstrated high reliability and validity metrics in a skills laboratory setting on bench model simulations suggesting that this instrument could measure operative skills effectively.[10,15] OSATS has been incorporated in many residency programs, mainly by the specialties of general surgery and obstetrics and gynecology.[16,17]

Recently, a new but simple assessment instrument, the Zwisch scale, has been widely accepted and used by many training programs in the United States. The Zwisch scale is a 4-level, ordinal scale that describes the progression to autonomy. It provides a validated, reproducible framework to measure both faculties' operative guidance as well as resident intraoperative autonomy and performance in the operating room.[18] The Zwisch scale describes faculty supervision behavior associated with different degrees of resident autonomy. It can be used on a daily basis to document the amount of assistance required by a resident to successfully complete each case in the operating room.[3]

In addition to being reliable (repeatable) and valid (measures what it purports to measure), the Zwisch scale is feasible − that is, inexpensive and easy to implement by faculty without interrupting surgeon workflow. This helps increase faculty compliance and reduces recall bias, 2 limitations encountered with other tools. A study shows that deploying the Zwisch scale on a smartphone-based evaluation platform[18] allows the feasibility of continuous evaluation of resident autonomy immediately after completing the procedures. We hypothesize that operative autonomy is distinct and depends, for the most part, on the resident's manual dexterity (respect for tissue, time and motion, instrument handling, and flow of operation), knowledge of instruments, and preparation for the procedure. The purpose of our study was to evaluate the possible predictors of achieving operative autonomy among these domains of the OSATS.

METHODS

Participant/Setting

All categorical and nondesignated preliminary general surgery residents in a single general surgery residency program participated in this study. This study was approved by the institutional review board at Western Michigan University Homer Stryker M.D. School of Medicine, and all resident and faculty data were deidentified before analysis.

The original OSATS concept consists of a 3-part assessment form, including a task-specific checklist, a global rating scale, and a pass/fail judgment.[15] From this original concept, we adopted only the Global Rating Scale and combined it with the Zwisch scale to create a modified Global Rating Scale of Operative Performance evaluation, *m*-GRSOP (Table 1). One aim was to increase the efficiency and effectiveness of collecting operative assessments of surgery residents.

The Zwisch scale is a 4-level scale that represents progressive autonomy. It is used to grade the degree of

TABLE 1. *Modified* Global Rating Scale of Operative Performance

Respect for Tissue (RT)				
1	**2**	**3**	**4**	**5**
Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments		Careful handling of tissue, but occasionally caused inadvertent damage		Consistently handled tissues appropriately with minimal damage
Time and Motion (TM)				
1	**2**	**3**	**4**	**5**
Many unnecessary moves		Efficient time/motion but some unnecessary moves		Clear economy of movement and maximum efficiency
Instrument Handling (IH)				
1	**2**	**3**	**4**	**5**
Repeatedly makes tentative or awkward moves with instruments by inappropriate use of instruments		Competent use of instruments but occasionally appeared stiff or awkward		Fluid moves with instruments and no awkwardness
Knowledge of Instrument (KI)				
1	**2**	**3**	**4**	**5**
Frequently asked for wrong instrument or used inappropriate instrument		Knew names of most instruments and used appropriate instrument		Obviously familiar with the instruments and their names
Flow of Operation (FO)				
1	**2**	**3**	**4**	**5**
Frequently stopped operating and seemed unsure of next move		Demonstrated some forward planning with reasonable progression of procedure		Obviously planned course of operation with effortless flow from one move to next
The Resident's Preparation for this procedure (RP)				
1	**2**	**3**	**4**	**5**
Unacceptable (obviously did not know the patient, hadn't read about the disease state or the surgery)	Needs improvement (did not know some key elements about this patient, knew some random facts about the disease state, obvious gaps in preparation)	Satisfactory: (knew the patient well enough, has good overall fund of knowledge about the problem at hand, displayed obvious preparation for this case)	Above average: (told me some things I didn't even know about the patient, very good knowledge of pathophysiology and anatomy, read from several sources and found some good videos for the procedure)	Outstanding: (took the time to get to know the patient, looked up old op notes and films and reviewed with radiologist; showed mastery of the disease and looked up some articles about pros and cons of newer techniques, called me the night before to discuss)
Resident Autonomy (Zwisch scale)				
	1	**2**	**3**	**4**
	Show & Tell: Attending effectively did the case (even if resident was holding the instruments)	Smart Help (Active Help): Attending was actively assisting, coaching, creating tissue planes	Dumb Help (Passive Help): Attending let resident do the case and acted as a very good first assistant, giving pointers along the way	No Help (Supervision Only): Attending stood by while residents performed the case

guidance the attending surgeon provides to the trainee during most of the critical portions of the procedure. This scale has been described in detail in several studies.[2,3,18] In level 1, "Show and Tell," the attending surgeon performs the critical portion of procedure while explaining each step to the resident. In the next level, level 2, "Active Help," the attending surgeon actively guides the resident through the critical portion of the procedure. This is in contrast to level 3, "Passive Help," where the resident performs critical portions of the operation independently while the attending physician passively provides skilled assistance and intervenes only when necessary to make an important teaching point or to optimize patient safety. At level 4, "Supervision Only," attending surgeon presence is necessary only to guarantee patient safety. At this level, the resident has enough proficiency to perform the procedure independently using a less skilled assistant, while the attending surgeon does not need to be directly involved in the procedure other than to provide close supervision.[18]

In 2014, we implemented this new intraoperative evaluation form (m-GRSOP) in our program. Evaluations were assigned to faculty by the Program Director on a weekly basis. Both the attendings and residents received an email notification from our online evaluation system alerting them to the evaluation. The email contained a link that automatically opened the evaluation to be completed. Residents were asked to remind the attending about the evaluation and seek their feedback. After the procedure, the faculty surgeon used the link in their email to complete the evaluation electronically on the New Innovations website. Every effort was made to ensure evaluations encompassed a diverse, level-appropriate variety of cases assigned to residents. The actual operative case coverage by residents was assigned by the senior residents of the service. Each resident was scored by faculty, from 1 to 5 (1 lowest, 5 highest) in each of the following categories of m-GRSOP: respect for tissue (RT), time and motion (T&M), instrument handling (IH), knowledge of instrument (KI), flow of operation (FO) and resident's preparation for the procedure (RP). Resident Operative Autonomy (ROA) was assessed using the Zwisch scale with different degrees of resident autonomy (1: Show and Tell, 2: Active Help, 3: Passive Help, and 4: Supervision Only).

Statistical Analysis

Descriptive statistics including mean and standard deviation were used to analyze the distribution of cases, Zwisch scores, and procedure type. Spearman's rank-order correlation was used for the relationship between Zwisch level of autonomy and postgraduate year (PGY) of training and between the Zwisch rating and the individual item scores on the OSATS. Construct validity of the autonomy measure was assessed using a one-way analysis of variance (ANOVA) model with training level as the independent variable. A post-hoc test using Tukey's HSD (honestly significant difference) test for multiple comparison was performed. The chi-squared test was used to test for the association between Zwisch ratings and PGY level. For the ANOVA global hypotheses and the chi-squared test, an alpha level of 0.05 was used.

A cumulative odds ordinal logistic regression with proportional odds was run to determine the effect of domains in OSATS on autonomy score. The deviance goodness-of-fit test indicated that the model was a good fit to the observed data, χ^2 (693) = 1245.025, p = 1.000. The final model statistically significantly predicted the autonomy over and above the intercept-only model, χ^2 (6) = 529.148, p < 0.001. The model Nagelkerke pseudo-R^2 was 0.489. SPSS 25 software (IBM, Armonk, NY) was utilized for statistical analyses. Overall the model accounted for approximately 49% of the variance in the outcome, Nagelkerke's pseudo-R^2 = 0.49.

RESULTS

Thirty-two attendings completed intraoperative evaluations for 958 procedures performed by 35 residents during a 4-year period (July 2014 to June 2018). Procedures evaluated include general and subspecialty surgeries (Table 2), more than half of which (55%) were hernia repairs, cholecystectomies, and colorectal procedures. Cases were subjectively classified based on procedures into basic (e.g. open inguinal hernia repair, umbilical hernia repair, hemorrhoidectomy, etc.), advanced (e.g. laparoscopic cholecystectomy for symptomatic cholelithiasis, laparoscopic inguinal hernia repair, etc.), and complex procedures(e.g. carotid endarterectomy, pancreaticoduodenectomy, complex ventral hernia repair). Case difficulty was not collected in these evaluations.

For analysis, residents were divided into 5 groups based on PGY level of training (PGY1 through PGY5). Correlation and ordinal regression analyses were conducted to examine the relationship between resident operative autonomy, as assessed by the Zwisch scale, and manual dexterity (respect for tissue, time and motion, instrument handling, flow of operation) and cognitive functioning (knowledge of instruments and resident preparation), as assessed by *modified*-OSATS. Correlation analysis results indicated a positive correlation between ROA and RT (r = 0.528, p < 0.001), T&M (r = 0.630, p < 0.001), IH (r = 0.597, p < 0.001), KI (r = 0.490, p < 0.001), FO (r = 0.637, p < 0.001), and RP (r = 0.525, p < 0.001). Additionally, there was a weak inverse correlation between ROA and the number of years the surgeon had been in practice (r = −0.127, p = 0.001).

TABLE 2. Distribution of Surgical Procedures per Postgraduate Training Level

Procedures	PGY-1	PGY-2	PGY-3	PGY-4	PGY-5	Total
Amputation	9	9	1	3	0	22
Breast-axilla	4	19	8	4	3	38
Skin-soft tissue	34	16	9	2	3	64
Cholecystectomy	28	73	42	19	16	178
Colorectal surgery	4	11	18	22	31	86
Foregut surgery/small bowel	1	2	22	14	13	52
GI endoscopy	2	4	1	3	7	17
Hemorrhoidectomy/Sphincterotomy	5	7	3	1	0	16
Hepato-Bilio-Pancreatic	0	0	6	7	15	28
Hernias (IH,FH,UH,VH)	54	87	47	36	37	261
Pediatric surgery	12	2	2	2	2	20
Solid organ	1	0	0	1	10	12
Thoracic surgery	0	0	7	4	2	13
Thyroid-parathyroid surgery	0	7	13	11	25	56
Vascular-arterial	0	2	9	11	20	42
Vascular-HD access/Port-A-Cath	9	9	7	4	2	12
Miscellaneous (Laparotomy/Neck)	2	5	4	3	8	22
Total (per PGY Level)	**165**	**253**	**199**	**147**	**194**	**958**

IH, inguinal hernia; FH, femoral hernia; UH, umbilical hernia; VH, Ventral hernia.

Ordinal regression results indicate that an increase in one unit in time and motion was associated with 2.2 times increase in the odds of achieving higher autonomy (95% confidence interval [CI], 1.56 to 3.04), Wald $\chi^2(1) = 20.956$, $p < 0.0001$. An increase in one unit on flow of operation was associated with 2.6 times increase in odds of achieving higher autonomy (95% CI, 1.90 to 3.46), Wald χ^2 $(1) = 38.600$, $p < 0.001$. Additionally, an increase in one unit on resident's preparation for the procedure was associated with an increase in the odds of achieving higher autonomy of 1.5 times (95% CI, 1.22 to 1.87), Wald χ^2 $(1) = 14.256$, $p < 0.001$. An increase in one unit on both respect for tissue and instrument handling was associated with, respectively, a 1.07 ($p = 0.645$), and 1.20 ($p = 0.108$) times increase in the odds of achieving higher autonomy but was not statistically significant.

ANOVA results showed the Zwisch score significantly differed ($p < 0.001$) across level of training groups (Table 3). However, post-hoc analysis showed significant difference between all PGY levels ($p < 0.001$) except there was no significant difference between PGY4 and PGY5 ($p = 0.054$; Fig. 1). In addition, ANOVA results showed the *m*-OSATS score differed significantly ($p < 0.001$) across the level of training groups as well (Table 3). Additionally, a post-hoc analysis showed significant statistical difference between each PGY level ($p < 0.001$; Fig. 2).

The mean ± standard deviation Zwisch score for all cases was 2.71 ± 0.85 on a scale of 1 (show and tell) to 4 (supervision only). The mean score was highest for complex procedures, at 2.90 ± 0.80, followed by advanced procedures, at 2.64 ± 0.85, with the lowest allowed autonomy for basic procedures at 2.51 ± 0.93 ($p < 0.001$). While this was a surprising result, a possible explanation for this is that 83% of basic cases and 76% of advanced cases were performed by junior residents (PGY1-3). More than half (55%) of complex procedures were performed by senior (PGY4-5) residents (Table 4).

TABLE 3. Mean of Zwisch Score and *m*-OSATS for Postgraduate Level (PGY)

PGY Level (# Cases)	ZWISCH Score		OSATS Score	
	Mean (SD)	95% CI for Mean	Mean (SD)	95% CI for Mean
PGY-1 (163)	1.99 (0.73)	1.88 to 2.11	2.80 (0.73)	2.70 to 2.90
PGY-2 (253)	2.49 (0.85)	2.38 to 2.60	3.35 (0.70)	3.27 to 3.44
PGY-3 (199)	2.78 (0.74)	2.68 to 2.98	3.70 (0.56)	3.60 to 375
PGY-4 (147)	3.05 (073)	2.93 to 3.17	4.06 (0.64)	3.95 to 4.17
PGY-5 (194)	3.27 (0.71)	3.17 to 3.37	4.35 (0.66)	4.26 to 4.44
Total (956)	2.71 (0.88)	2.66 to 2.77	3.63 (0.84)	3.60 to 3.70

SD, standard deviation; CI, confidence interval for the mean.

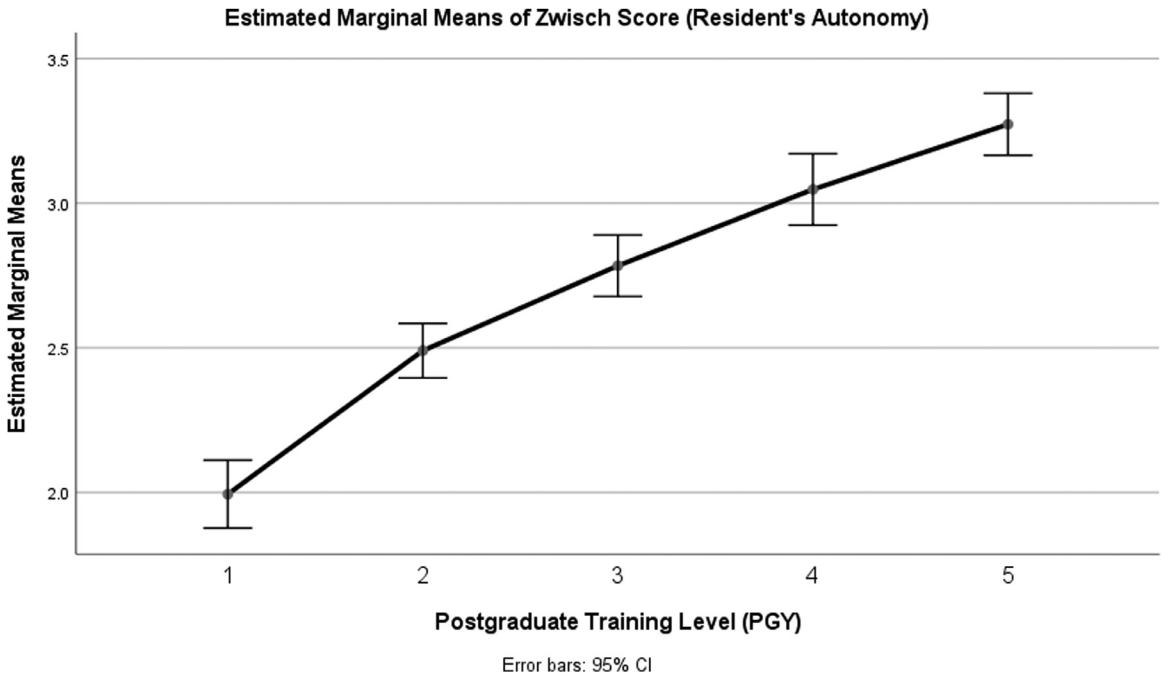

FIGURE 1. Increase in operative autonomy with increase in level of training.

The mean of the Zwisch score increased as residents advanced through training. Sixty-two percent (596/958) of operations were performed with higher autonomy ("Passive Help" or "Supervision Only"). Senior residents (PGY4-5) performed 341 cases total, 65% of which were complex. They demonstrated higher autonomy in 85% of these cases (Table 5). When looking at the data on the same resident across multiple years of training, we found a progressive increase in resident autonomy as he/she was promoted from one PGY level to the next. Six residents have evaluations covering 4 years, 6 residents have evaluations covering 3 years, and 5 residents have

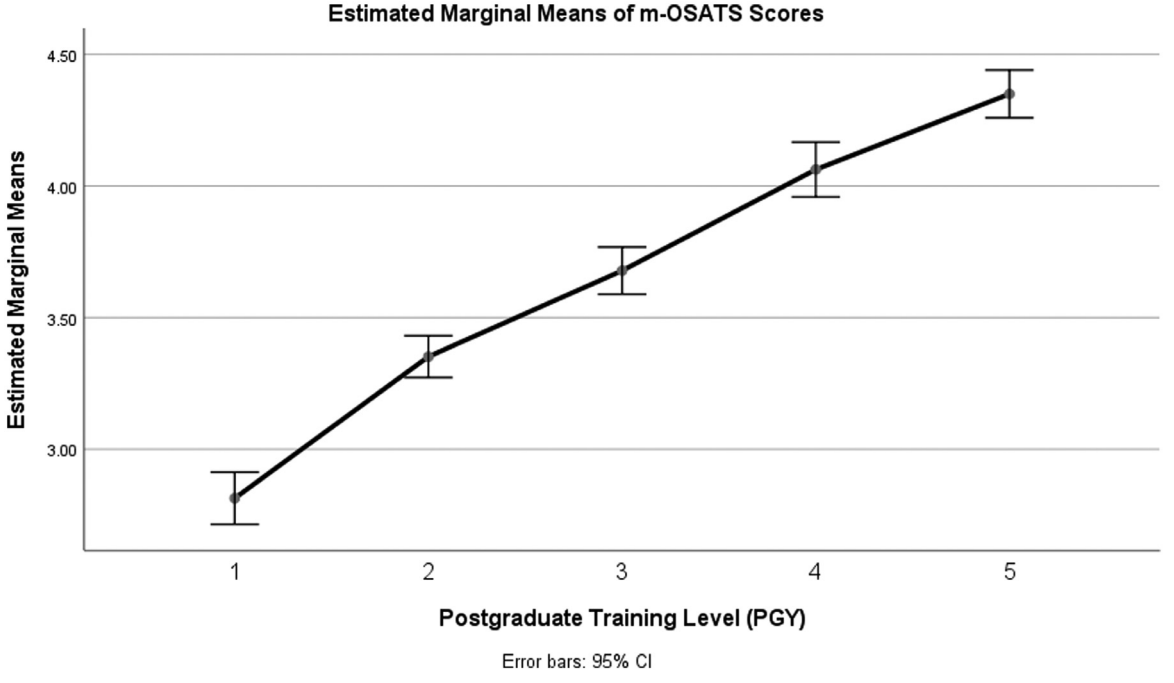

FIGURE 2. Increase in mean of *m*-OSATS scores with increase in level of training.

TABLE 4. Distribution of Procedures by Type and PGY Level

Postgraduate Training Level (PGY)	Type of Procedure			Total Cases per PGY Level
	Basic	***Advanced***	***Complex***	
PGY1, *n* (%)	97 (58.8)	51 (30.9)	17 (10.3)	165
PGY2, *n* (%)	92 (36.4)	98 (38.7)	63 (24.9)	253
PGY3, *n* (%)	36 (18.1)	65 (32.7)	98 (49.2)	199
PGY4, *n* (%)	25 (17.0)	38 (25.9)	84 (57.1)	147
PGY5, *n* (%)	22 (11.3)	31(16.0)	141(72.7)	194
Total cases per Type	**272 (28.4)**	**283 (29.5)**	**403 (42.1)**	**958**

evaluations covering 2 years. We also noticed some variations between individual residents, which can be explained by the resident's operative skills as well as the difficulty or complexity of the cases. The same resident may have variation in autonomy scores, which can be partly explained by the case complexity and/or difficulty, as well as the degree of the surgeon's willingness to allow the resident to perform the procedure. Figure 3 demonstrates the progressive increase in operative autonomy for the 6 residents over 4 years.

Our results indicate certain domains in the OSATS, specifically time and motion, flow of operation, and the resident's preparation for the procedure, most closely correlate with supervising surgeons' decisions regarding the level of autonomy granted to the trainee.

DISCUSSION

The aim of this study was to evaluate the possible predictors among the domains of the *m*-OSATS on achieving higher level of operative autonomy on the Zwisch. Our data show a strong correlation between the domains of the *m*-OSATS and the Zwisch scale in assessing resident operative autonomy. Two domains of manual dexterity (flow of operation and time and motion) and one cognitive functioning domain (the resident's preparation for the procedure) were found to positively influence granting residents operative autonomy.

With regard to resident's preparation, our findings could be used to counsel residents receiving low scores during early years of training and provide more mentoring and supervision. Additionally, emphasizing this to medical students during their last few months of medical school may positively impact them as they prepare for residency. It is important to consider the possible potential differences on the understanding of contents of this domain between surgeons and residents. In a study by Rose et al.[19], faculty and residents were asked to evaluate how adequate preoperative preparation was with respect to reading about the procedure, reviewing anatomy, and discussion with the supervising surgeon. Residents felt they were significantly more prepared than the faculty did, especially with respect to preoperative reading and reviewing pertinent anatomy. Pernar et al.[20] found that residents are often focused on the technical aspects of the procedure while faculty have additional goals for each operative teaching encounter, including preoperative and postoperative decision making.

The other 2 domains in the *m*-OSATS, flow of operation and time and motion, were found to significantly contribute to granting higher autonomy. These 2 domains improve as residents advance in their training, and they can be simply viewed as surrogates of resident experience. This result is in concordance with prior studies evaluating how the resident operative experience affects autonomy. Chen et al.[21] reported that residents with more years of surgical training were afforded more autonomy by the supervisor and that the quality of the trainees' performance was a determinant of the amount of autonomy afforded to them. Additionally, they observed that the amount of autonomy individual attending surgeons provided to residents in the operating room depended to a great extent on the attending surgeon.

George et al.[18] studied the guidance behavior of supervising surgeons who rated resident performances and found that the amount of autonomy afforded to residents increased with the number of years of training and that better operative performance led the supervising surgeon to afford the resident more autonomy.

The results of our study point to important domains influencing granting residents operative autonomy. Given the residents' work-hour restrictions, the faculty should clearly define their expectations, and provide guidance for residents. One of these expectations could be using surgical website platforms as educational resources while preparing for procedures. Many websites such as the Surgical Council on Resident Education (SCORE), the ACS video library, and surgical society websites provide focused materials, including videos of operative techniques that can increase resident preparedness. A resident knowing "how I do it" in the operating room and demonstrating

TABLE 5. Distribution of Zwisch Level per Postgraduate Training Level

Postgraduate Training Level (PGY)	Zwisch Scale				Total Cases per PGY Level
	1 Show and Tell	2 Active Help	3 Passive Help	4 Supervision Only	
PGY1, *n* (%)	41 (25.2)	87 (52.7)	34 (20.9)	3 (1.8)	165
PGY2, *n* (%)	36 (14.2)	81 (32.0)	112 (44.3)	24 (9.5)	253
PGY3, *n* (%)	8 (4.0)	56 (28.1)	106 (53.3)	29 (14.6)	199
PGY4, *n* (%)	4 (2.7)	24 (16.3)	80 (54.4)	39 (26.5)	147
PGY5, *n* (%)	2 (1.0)	23 (11.9)	89 (45.9)	80 (41.2)	194
Total cases per Zwisch scale (%)	**91 (9.5)**	**269 (28.1)**	**421(44.0)**	**175 (18.3)**	**958**

preparation increases attending confidence and willingness to allow autonomy.[2]

Challenges facing surgeons as educators include the need to periodically modify their teaching approach and create new curricula to balance limited training times while maintaining the surgical skills of their trainees at the highest possible levels. Roberts and colleagues[22] described 3 phases of an operative teaching model to increase autonomy. The first phase is called "briefing," and takes place before surgery. It involves a discussion of the resident's prior experience with the procedure and an agreement on what portions of the procedure the resident will be granted more autonomy and time to work through challenges. It also identifies areas where the attending will provide less autonomy to allow efficient and safe completion of the case. The second phase is called "intraoperative teaching," in which the supervising faculty divides operative procedures into steps, with residents performing specific, level-appropriate steps advancing gradually over time. The third phase, or the "debriefing" phase, involves the attending providing specific feedback about the parts of the work performed.

Modifying some factors related to the resident, the supervising surgeon, the nature of the tasks, and the circumstances surrounding the operation[23] would help enhance resident autonomy. A study by Hauer et al.[24] showed that trust is a critical determinant of a supervisor's decision regarding how much autonomy to provide to medical trainees and that 5 factors influence attending trust of residents: the characteristics of the supervisor, the trainee, the relationship between the two, the nature of the task, and the context in which the task is performed. Resident factors such as level of training, previous experience with the specific or similar procedures, previous experience with the supervising surgeon, communication skills, and self-confidence are important. A study by Torbeck et al.[25] showed that surgical supervisors vary the amount of autonomy afforded to trainees at various points in the performance depending on the criticality/risk of the procedural step being performed. In fact, factors that may limit granted autonomy include difficulty of the case where errors have major consequences and are difficult to recover from.

We found a weak inverse correlation between the number of years the surgeon has been in practice and granting resident operative autonomy. It was an interesting finding. However, one explanation may be that the younger surgeons work with and supervise more senior residents than junior residents and that the procedures performed are more basic and advanced rather than complex cases.

Our study has limitations. The major limitation lies in the dependency on voluntary faculty participation. Although we send an email with a link to these evaluation

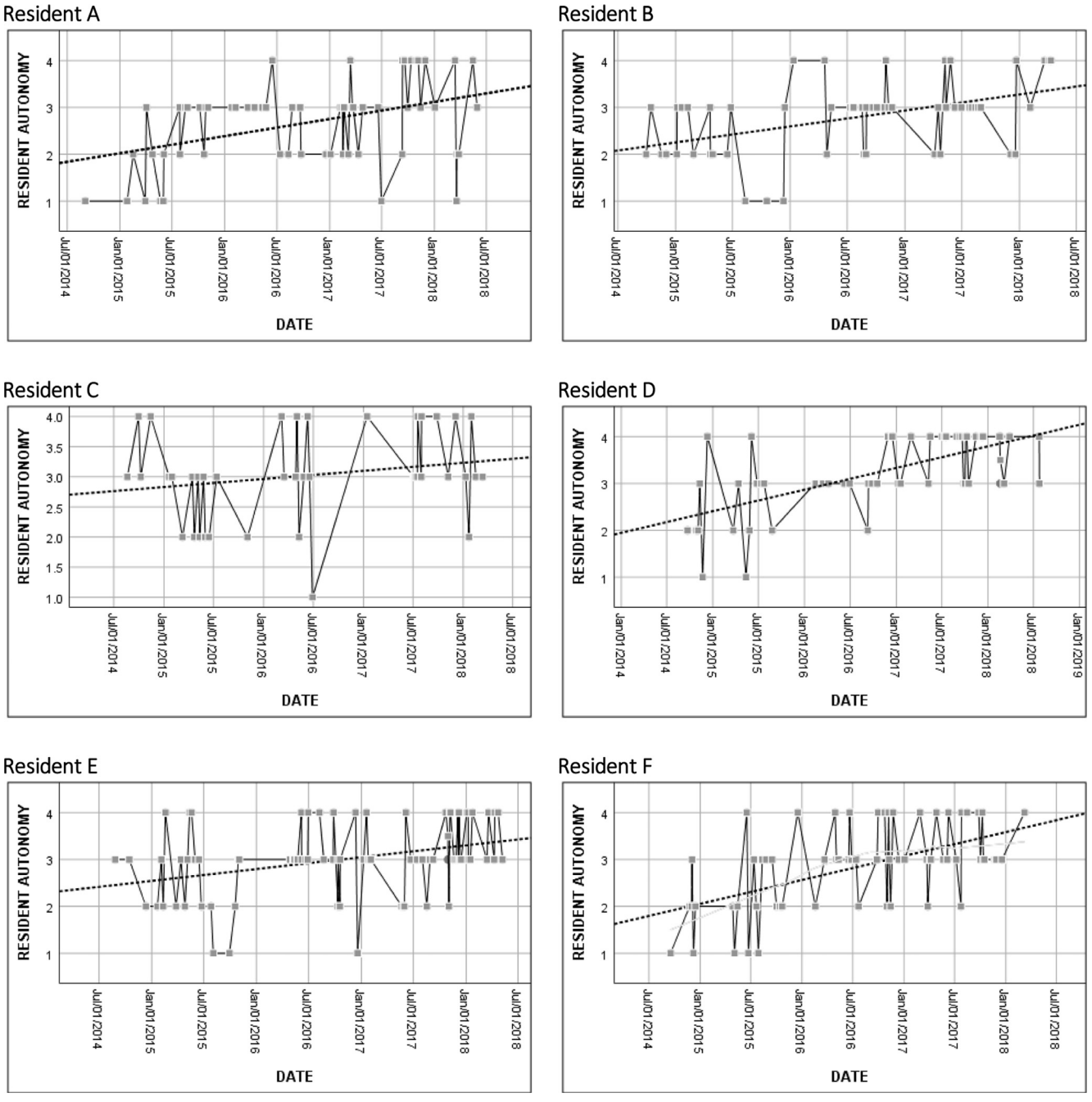

FIGURE 3. Progressive increase in resident autonomy over a 4-year period.

assignments every week, many faculty don't complete all evaluations assigned. Faculty with an academic interest in teaching completes these evaluations in a timely fashion. Some studies suggest faculty development efforts should be made to remind faculty that the provision of safe, graduated autonomy is critical in assuring the resident's ability to perform procedures independently by the completion of his/her training. Attending surgeons who frequently achieve this goal should be acknowledged, while attending surgeons who do not often provide residents with appropriate autonomy may benefit from faculty development efforts.[26]

Another limitation is potential selection bias. All of these evaluations were completed for elective and nonemergent or nonurgent cases. It would be interesting to see how ratings on the Zwisch scale of autonomy would be affected under stressful conditions such as emergency trauma surgery and abdominal catastrophe

operations. Additionally, this selection bias could contribute to the relatively small sample. In the future, we will include evaluations for emergency procedures. Finally, while assessment of case difficulty is an important aspect of granting autonomy, unfortunately, the modified evaluation form we used does not address this point. As we know, case difficulty could potentially affect the degree of how much operative autonomy is granted, and in the future, we will incorporate case difficulty in the evaluation.

CONCLUSION

Resident operative autonomy is a product of shared responsibility between the faculty and resident. In our study, we have found that residents' inherent and/or acquired skills and preparation for operative procedures play a critical role in granting more autonomy in the operating room, as measured by the Zwisch scale. Residents currently in training and incoming surgical interns should be advised to use available resources such as simulation to potentially augment their skills preoperatively in order to gain autonomy in the operating room.

ACKNOWLEDGMENT

We would like to thank Duncan Vos, MS, for providing feedback on the statistical analyses, and Mary Goggins Farley and Cynthia Shattuck for their participation in collecting and maintaining the integrity of the data.

REFERENCES

1. Meyerson SL, Teitelbaum EN, George BC, Schuller MC, DaRosa DA, Fryer JP. Defining the autonomy gap: when expectations do not meet reality in the operating room. *J Surg Educ*. 2014;71:e64–e72. https://doi.org/10.1016/j.jsurg.2014.05.002.
2. Meyerson SL, Sternbach JM, Zwischenberger JB, Bender EM. Resident autonomy in the operating room: expectations versus reality. *Ann Thorac Surg*. 2017;104:1062–1068. https://doi.org/10.1016/j.athoracsur.2017.05.034.
3. DaRosa DA, Zwischenberger JB, Meyerson SL, et al. A theory-based model for teaching and assessing residents in the operating room. *J Surg Educ*. 2013;70:24–30. https://doi.org/10.1016/j.jsurg.2012.07.007.
4. http://www.absurgery.org/default.jsp?certgsqe_training
5. Kim MJ, Williams RG, Boehler ML, et al. Refining the evaluation of operating room performance. *J Surg Educ*. 2009;66:352–356.
6. Doyle JD, Webber EM, Sidhu RS. A universal global rating scale for the evaluation of technical skills in the operating room. *Am J Surg*. 2007;193:551–555. Discussion 555.
7. Aggarwal R, Grantcharov T, Moorthy K, et al. Toward feasible, valid, and reliable video-based assessments of technical surgical skills in the operating room. *Ann Surg*. 2008;247:372–379.
8. Larson JL, Williams RG, Ketchum J, et al. Feasibility, reliability, and validity of an operative performance rating system for evaluating surgery residents. *Surgery*. 2005;138:640–647. Discussion:647-649.
9. Wohaibi EM, Earle DB, Ansanitis FE, et al. A new web-based operative skills assessment tool effectively tracks progression in surgical resident performance. *J Surg Educ*. 2007;64:333–341.
10. Reznick R, Regehr G, MacRae H, et al. Testing technical skill via an innovative "bench station" examination. *Am J Surg*. 1997;173:226–230.
11. Mackay S, Datta V, Chang A, et al. Multiple Objective Measures of Skill (MOMS): a new approach to the assessment of technical ability in surgical trainees. *Ann Surg*. 2003;238:291–300.
12. Dath D, Regehr G, Birch D, et al. Toward reliable operative assessment: the reliability and feasibility of videotaped assessment of laparoscopic technical skills. *Surg Endosc*. 2004;18:1800–1804.
13. Datta V, Chang A, Mackay S, et al. The relationship between motion analysis and surgical technical assessments. *Am J Surg*. 2002;184:70–73.
14. Smith SG, Torkington J, Brown TJ, et al. Motion analysis. *Surg Endosc*. 2002;16:640–645.
15. Martin JA, Regehr G, Reznick R, et al. Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg*. 1997;84:273–278.
16. Hopmans CJ, den Hoed PT, van der Laan L, et al. Assessment of surgery residents' operative skills in the operating theater using a modified Objective Structured Assessment of Technical Skills (OSATS): a prospective multicenter study. *Surgery*. 2014;156:1078–1088. https://doi.org/10.1016/j.surg.2014.04.052.
17. Boehler ML, Schwind CJ, Rogers DA, et al. A theory-based curriculum for enhancing surgical skillfulness. *J Am Coll Surg*. 2007;205:492–497.

18. George BC, Teitelbaum EN, Meyerson SL, Schuller MC, DaRosa DA, Fryer JP. Reliability, validity and feasibility of the Zwisch scale for the assessment of intra-operative performance. *J Surg Educ*. 2014;71:e90–e96.

19. Rose JS, Waibel BH, Schenarts PJ. Disparity between resident and faculty surgeons' perceptions of preoperative preparation,intraoperative teaching, and postoperative feedback. *J Surg Educ*. 2011;68:459–464.

20. Pernar LI, Breen E, Ashley SW, Peyre SE. Preoperative learning goals set by surgical residents and faculty. *J Surg Res*. 2011;170:1–5. https://doi.org/10.1016/j.jss.2011.01.022.

21. Chen XP, Williams RG, Sanfey HA, Dunnington GL. How do supervising surgeons evaluate guidance provided in the operating room? *Am J Surg*. 2012;203:44–48.

22. Roberts NK, Williams RG, Kim MJ, Dunnington GL. The briefing, intraoperative teaching, debriefing model for teaching in the operating room. *J Am Coll Surg*. 2009;208:299–303. https://doi.org/10.1016/j.jamcollsurg.2008.10.024.

23. Sterkenburg A, Barach P, Kalkman C, Gielen M, ten Cate O. When do supervising physicians decide to entrust residents with unsupervised tasks? *Acad Med*. 2010;85:1408–1417. https://doi.org/10.1097/ACM.0b013e3181eab0ec.

24. Hauer KE, Ten Cate O, Boscardin C, Irby DM, Iobst W, O'Sullivan PS. Understanding trust as an essential element of trainee supervision and learning in the workplace. *Adv Health Sci Educ Theory Pract*. 2014;19:435–456. https://doi.org/10.1007/s10459-013-9474-4.

25. Torbeck L, Williams RG, Choi J, Schmitz CC, Chipman JG, Dunnington GL. How much guidance is given in the operating room? Factors influencing faculty self-reports, resident perceptions, and faculty/resident agreement. *Surgery*. 2014;156:797–803. https://doi.org/10.1016/j.surg.2014.06.069.

26. Williams RG, George BC, Meyerson SL, et al. What factors influence attending surgeon decisions about resident autonomy in the operating room? *Surgery*. 2017;162:1314–1319. https://doi.org/10.1016/j.surg.2017.07.028.

SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jsurg.2019.06.002.