Performance on the Plastic Surgery In-Service Examination Can Predict Success on the American Board of Plastic Surgery Written Examination

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Background: Originally developed for resident self-assessment, the Plastic Surgery In-Service Examination has been administered for over 45 years. The Accreditation Council for Graduate Medical Education requires that at least 70 percent of graduates pass the American Board of Plastic Surgery Written Examination on their first attempt. This study evaluates the role of In-Service Exam scores in predicting Written Exam success.

Methods: In-Service Exam scores from 2009 to 2015 were collected from the National Board of Medical Examiners. Data included residency training track, training year, and examination year. Written Exam data were gathered from the American Board of Plastic Surgery. Multivariate analysis was performed and receiver operating characteristic curves were used to identify optimal In-Service Exam score cut-points for Written Exam success.

Results: Data from 1364 residents were included. Residents who failed the Written Exam had significantly lower In-Service Exam scores than those who passed ($p < 0.001$). Independent residents were 7.0 times more likely to fail compared with integrated/combined residents ($p < 0.001$). Residents who scored above the optimal cut-points were significantly more likely to pass the Written Exam. The optimal cut-point score for independent residents was the thirty-sixth percentile and the twenty-second percentile for integrated/combined residents.

Conclusions: Plastic Surgery In-Service Exam scores can predict success on the American Board of Plastic Surgery Written Exam. Residents who score below the cut-points are at an increased risk of failing. These data can help identify residents at risk for early intervention. (*Plast. Reconstr. Surg.* 143: 1099e, 2019.)

Originally developed as a self-evaluation for residents, the Plastic Surgery In-Service Examination has been administered for over 45 years. It was created by the Academic Plastic Surgery Forum travel club and initially presented at the American Association of Plastic Surgeons meeting in 1972. By 1974, the examination was widely adopted throughout residency training programs in the United States. Over

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time, the In-Service Exam has been expanded and offered to surgeons in practice as a self-assessment and CME tool. Among residency training programs, it is generally used to predict a resident's readiness to pass the American Board of Plastic Surgery Written Examination.

The Accreditation Council for Graduate Medical Education Plastic Surgery Residency Review Committee requires that at least 70 percent of plastic surgery graduates pass the Written Exam on their first attempt.[1] Programs that fail to meet this threshold may be at risk of probation or loss of accreditation. Thus, any objective measure that can predict successful board certification could be of great value to training programs. Predicting at-risk residents would allow for early focused educational efforts to maximize the likelihood of Written Exam success and minimize the risks to training programs.

To date, there have been no identified predictors of success on the American Board of Plastic Surgery Written Exam. The goal of this study was to analyze In-Service Exam scores as a predictor for success on the American Board of Plastic Surgery Written Exam.

METHODS

In-Service Exam scores from all residents between 2009 to 2015 were gathered from the National Board of Medical Examiners. The National Board of Medical Examiners is responsible for coordinating the creation of the examination for the American Society of Plastic Surgeons and administering the examination annually. Data collected included training track [independent, integrated, or combined (3 + 3) programs], year of examination, year in training, total examination percentage correct, subsection percentage correct, and total examination score percentile versus peers (same training track and year). Percentile data on individual examination sections were not available. Demographic data were not available. Percentage correct scores were used to correlate the percentile versus peers score (same training track and year) based on respective annual norm charts that are released with the In-Service Exam each year. Percentile versus peers data were used to allow residents to correlate their scores to readily available data (norm charts).

American Board of Plastic Surgery Written Exam pass/fail data were collected on all examinees from 2009 to 2015 from the American Board of Plastic Surgery. Written Exam examinees with incomplete data were excluded. Written Exam data were joined with the In-Service Exam data using resident/examinee name.

The total number of plastic surgery resident graduates was estimated based on annual published works by Brotherton and Etzel.[2] These data represent the number of new residents starting plastic surgery residency per year over the 7-year study period (2009 to 2015) and approximates the number of residents graduating from plastic surgery residency programs throughout the same study period.

Statistical Analysis

Summary statistics were calculated. Quantitative data are expressed as the mean ± SD, and nominal data are expressed as a percentage. Differences between those who passed on their first attempt and those who did not with regard to total and individual In-Service Exam scores were analyzed using multiple regression, using the test year as a covariate. For these analyses, clustering on the individuals was used to control for nonindependence. Multivariate logistic regression was also performed, with passing the Written Exam as the dependent variable, with program type (integrated or combined versus. independent; reference variable was integrated/combined) and percentile comparison of the In-Service Exam score versus peers as the independent variables.

Receiver operating characteristic curve analyses were performed to determine optimal cut-points for predicting success or failure on the Written Exam, based up scores on the In-Service Exam. Two types of receiver operating characteristic curve analyses were performed. In the first, all of the In-Service Exam scores in the data set were used. In the second, only the In-Service Exam score from the last year of training was used. These analyses were performed on all residents, and separately for the subsets of integrated/combined residents and independent residents.

The cut-points for the receiver operating characteristic curve analyses were determined using the Youden J statistic.[3] Sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, and area under the curve were determined for each of the receiver operating characteristic curve analyses. Failure rates above and below the respective cut-points were calculated. Relative risk of failure was assessed for those scoring below the respective cut-point relative to those scoring above. Significance was assessed at $p < 0.05$. All analyses were performed using Stata Version 15.0 (StatCorp, College Station, Texas).

RESULTS

Data were analyzed from 1364 residents (2009 to 2015). This accounts for 96.1 percent of estimated graduates during the study period. Fifty-five percent (n = 747) were residents trained in integrated/combined programs and 45 percent (n = 617) were residents trained in independent programs. Sixty-one graduates failed the American Board of Plastic Surgery Written Exam on their first attempt during the study period, for an overall Written Exam pass rate of 95.5 percent.

All In-Service Exam scores were analyzed for residents that passed (n = 3848 In-Service Exam scores from 1302 examinees) and failed (n = 153 In-Service Exam scores from 61 examinees) the Written Exam on the first attempt. In-Service Exam scores from multiple test years were available for most residents (mean, 2.9 In-Service Exam scores per Written Exam examinee). Residents that passed the Written Exam scored significantly higher on every section of the In-Service Exam (Table 1).

A multivariate analysis was performed, including both program type and In-Service Exam performance against peers as independent variables to predict passing the Written Exam. Residents graduating from independent programs were 7.0 times more likely to fail the Written Exam compared with those graduating from integrated or combined programs ($p < 0.001$). In addition, the mean In-Service Exam percentile score was significantly higher for those that passed the Written Exam compared to those that failed on the first attempt (48.1 ± 27.7 versus 18.2 ± 17.7; $p < 0.001$). Residents who scored 10 percentile points higher than their peers on the In-Service Exam were 1.7 times less likely to fail the Written Exam ($p < 0.001$).

Receiver operating characteristic curve analysis was then performed based on percentile versus peers scores for all of the residents, integrated/combined residents, and the independent resident group. Analyzing all In-Service Exam scores available for residents, those that scored above the twenty-fourth percentile relative to their peers were less likely to fail the Written Exam than those residents scoring below the cutpoint (1.4 percent versus 10.3 percent; relative risk, 7.5; $p < 0.001$). Integrated/combined residents scoring above the twenty-second percentile were less likely to fail the Written Exam than those that scored below (0.4 percent versus 7.1 percent; relative risk, 20.0; $p < 0.001$). Independent resident scores were also analyzed. Those scoring above the thirty-sixth percentile compared to their peers were less likely to fail the Written Exam (2.3 percent versus 13.6 percent; relative risk, 6.0; $p < 0.001$) (Table 2).

Residents were also analyzed based on the In-Service Exam score from their last year of residency training (Table 3). Including all residents, those that scored above the thirty-first percentile compared to their peers in their final year of training were more likely to pass the Written Exam (1.1 percent failure versus 12.2 percent; relative risk, 11.6; $p < 0.001$). Integrated/combined residents that scored above the twenty-fourth percentile in their final year of training (0.2 percent failure versus 8.3 percent; relative risk; 47.5; $p < 0.001$) and independent residents scoring above the thirty-first percentile in their final year of training were more likely to be successful on their first attempt at the Written Exam (2.2 percent failure versus 17.5 percent; relative risk, 8.0; $p < 0.001$).

Of the 61 individuals who failed on their first attempt, 42 (68.9 percent) eventually passed within the study period. Of the 42 graduates who eventually passed, 34 (81 percent) failed the Written Exam one time, six (14.3 percent) failed twice, one (2.4 percent) failed three times, and one (2.4 percent) failed four times.

Table 1. Total and Individual Section In-Service Exam Scores of Those That Did and Did Not Pass the American Board of Plastic Surgery Written Exam on Their First Attempt*

	Fail on First Attempt (n = 153)	Pass on First Attempt (n = 3848)	p
Comprehensive	63.7 ± 8.7	69.9 ± 9.4	<0.001
Hand and lower extremity	61.8 ± 9.0	68.4 ± 9.9	<0.001
Craniomaxillofacial	58.3 ± 9.9	66.9 ± 11.0	<0.001
Breast and cosmetic	56.0 ± 9.1	62.7 ± 10.7	<0.001
Overall score	60.1 ± 6.4	67.0 ± 7.8	<0.001

*Scores are displayed as percentage correct (mean ± SD).

DISCUSSION

This study is the first to demonstrate a significant and direct correlation between In-Service Exam scores and American Board of Plastic Surgery Written Exam outcomes. Residents scoring above specific percentile cut-points are significantly more likely to be successful on the Written Exam.

To become board-certified by the American Board of Plastic Surgery, graduates of accredited training programs must pass the Written Exam followed by successful completion of the oral examination. During training, plastic surgery

Table 2. In-Service Exam Optimal Cut-Points for All Residents, Independent Residents, and Integrated Residents Taking the American Board of Plastic Surgery Written Exam Based on All Available In-Service Exam Scores

	ISE Cutpoint (Percentile vs. Peers)	Se (%)	Sp (%)	PLR	NLR	AUC (%)	% Failing if Scored above Cut-Point	% Failing if Scored below Cut-Point	RR* (95% CI)	*p*
Integrated/combined	22nd	79.3	84.8	5.2	0.2	87.1	0.4	7.1	20.0 (9.0–44.5)	<0.001
Independent	36th	59.3	82.2	3.3	0.5	77.5	2.3	13.6	6.0 (3.7–9.7)	<0.001
All residents	24th	74.5	73.9	2.9	0.4	81.4	1.4	10.3	7.5 (5.3–10.7)	<0.001

ISE, In-Service Examination; Se, sensitivity; Sp, specificity; PLR, positive likelihood ratio; NLR, negative likelihood ratio; AUC, area under the curve; RR, relative risk.
*Represents relative risk of failure if scoring below the ISE cut-point, compared with those scoring above the In-Service Exam cut-point.

Table 3. In-Service Exam Optimal Cut-Points for All Residents, Independent Residents, and Integrated Residents Taking the American Board of Plastic Surgery Written Exam Based on the In-Service Exam Score in the Resident's Final Year of Training

	ISE Cutpoint (percentile vs. peers)	Se (%)	Sp (%)	PLR	NLR	AUC (%)	% Failing if Scored above Cut-Point (%)	% Failing if Scored below Cut-Point (%)	RR* (95% CI)	*p*
Integrated/combined	24th	77.5	93.8	12.4	0.2	91.3	0.2	8.3	47.5 (6.3–357.1)	<0.001
Independent	31st	70.3	80.0	3.5	0.4	81.9	2.2	17.5	8.0 (3.9–16.2)	<0.001
All residents	31st	71.9	83.6	4.4	0.3	84.6	1.1	12.2	11.6 (5.9–22.6)	<0.001

ISE, In-Service Examination; Se, sensitivity; Sp, specificity; PLR, positive likelihood ratio; NLR, negative likelihood ratio; AUC, area under the curve; RR, relative risk.
*Represents relative risk of failure if scoring below the ISE cut-point, compared to those scoring above the In-Service Exam cut-point.

residents in the United States take the In-Service Exam annually. Both the Written Exam and the In-Service Exam are multiple-choice examinations that cover the wide spectrum of plastic surgery knowledge. Although the sources of content are not necessarily the same, it seems intuitive that In-Service Exam scores could be used to predict success on the Written Exam. This study confirms that hypothesis.

Several studies in other disciplines have recognized in-training examination scores as a positive predictor of success on written board examinations, including orthopedic surgery, general surgery, urology, and cardiology.[4–10] In general surgery training, Shellito et al. found that the American Board of Surgery In-Training Exam scores higher than the fiftieth percentile in postgraduate years 1 and 3 and higher than the thirty-third percentile in postgraduate years 4 and 5 predicted passing the American Board of Surgery Qualifying Examination.[4] De Virgilio et al. studied 607 graduating residents taking their general surgery boards.[11] On multivariate analysis, scoring below the thirty-fifth percentile on the American Board of Surgery In-Training Exam at any time during residency was associated with an increased risk of failing the written American Board of Surgery Qualifying Examination. In orthopedics, Dougherty et al. reviewed 202 resident files and found a stepwise increase in correlation from postgraduate year 2 through postgraduate year 5 between the Orthopaedic In-Training Exam scores and American Board of Orthopaedic Surgery Written Exam scores.[7] Those who averaged in the twenty-seventh percentile or lower on the Orthopaedic In-Training Exam had a 57 percent chance of failing the American Board of Orthopaedic Surgery Part I Written Exam. Similar results were seen among data analyzed by Klein et al. in 2004.[5] Within their institution, they found statistically significant cutpoints based on year in training. The relative risk of failing the American Board of Orthopaedic Surgery Part I was 92 if the resident scored below the identified cutpoint.

Other criteria have been evaluated as predictors of board examination success with variable results. Shellito et al. analyzed subjective and objective measures to help better predict written board examination success in general surgery graduates.[4] They noted a positive correlation between one subjective measure (residents that received awards) and several objective criteria. The objective criteria included United States Medical Licensing Examination scores (Step 1 and 2), medical school rank (top one-third), and American Board of Surgery In-Training Exam scores. Similar correlations between United States Medical Licensing Examination scores and board examination success have been seen in orthopedic residents. Dougherty et al. found a significant,

positive correlation between the United States Medical Licensing Examination Step 1 examination and the American Board of Orthopaedic Surgery Written Exam.[6] On multivariate analysis, de Virgilio et al. found an odds ratio of 0.36 (95 percent CI, 0.21 to 0.62) for success on the American Board of Surgery Qualifying Examination if the examinee scored below 200 on the United States Medical Licensing Examination Step 1 exam.[11] The authors noted the usefulness of United States Medical Licensing Examination Step 1 scores in the surgical resident selection process. Future research will attempt to correlate medical student characteristics, including United States Medical Licensing Examination score, to written examination pass rates to assist programs in resident selection and minimize the risk of Written Exam failure.

Program directors attempt to identify medical students and residents that they feel will excel throughout plastic surgery residency and successfully complete board certification. Some of these criteria include letters of recommendation, Dean's Letters, clerkship scores, and United States Medical Licensing Examination scores. Many program directors have lost faith in these metrics and, to date, no subjective or objective criteria have been identified to predict success in residency or board-certification within plastic surgery.

Identifying residents at risk of failing the American Board of Plastic Surgery Written Exam or Oral Exam can be equally challenging. Historically, the In-Service Exam has been considered to be a predictor for identifying at-risk residents to allow for focused attention, intense study plans, or mandated board review courses. In-Service Exam score thresholds for these interventions have been chosen arbitrarily, as no published data have been available to guide these practices. Program directors now have In-Service Exam percentile cut-points to aid in determining at-risk residents and providing early intervention as necessary. Interventions in the form of intensive study programs or mandatory board review courses have been advocated in other specialties, including general surgery. Borman found that a mandatory intervention program in the form of faculty mentoring, personal learning plans, Qualifying Examination review videos, and monthly evaluations did improve American Board of Surgery In-Training Exam scores and American Board of Surgery Qualifying Examination success in residents with low American Board of Surgery In-Training Exam scores.[12] Similar data are not available within plastic surgery training.

This study identified independent residents as being at a higher risk for failure of the Written Exam by seven-fold. In addition, independent residents scored lower on the In-Service Exam compared to those residents within integrated and combined programs. This is consistent with other published data on In-Service Exam scores.[13] Silvestre et al. analyzed In-Service Exam score data for 4 consecutive years and noted integrated residents scored higher than those training in independent programs. They also found similar differences when comparing integrated residents in their final 3 years of training (years 4 through 6) to independent residents. However, they were unable to discern between residents training in combined programs (3 + 3) and those within independent programs because of the classification of residents in their data source. This would have likely increased the disparity between integrated and independent residents' scores. Furthermore, they were unable to perform analyses on the In-Service Exam subsections, again because of their data source.

The authors posed several potential explanations for the discrepancy in In-Service Exam scores, including higher United States Medical Licensing Examination scores and a higher proportion of Alpha Omega Alpha Honor Medical Society members among integrated residents. We agree that these are likely influencing factors. In 2012, Roostaeian et al. published their survey results, in part, from plastic surgery residency program directors.[14] The program directors completing their survey indicated that integrated and combined residents were superior in knowledge compared with the independent residents. They speculate that this is likely attributable to the increased exposure to plastic surgery and possibly increased longitudinal evaluation of performance, allowing for adjustments in training direction as dictated by the residents' knowledge and skills. Their survey data also noted a perceived technical superiority among independent residents compared with those of the integrated or combined pathways, a result that is likely attributable to the minimum 5 years of surgical training before plastic surgery residency. Guo et al. compared qualitative educational metrics between residents completing the independent and integrated pathways at the Harvard Combined Plastic Surgery Training Program.[15] They noted several significant differences between the two groups. Most notably, integrated residents had higher United States Medical Licensing Examination Step 1 scores, graduated from a higher-tiered medical school, and had a

greater number of preresidency publications. They did not, however, show a statistically significant difference in In-Service Exam scores between the two groups. This is likely attributable to low power, as there were less than 25 residents in each group of this single-institution study.

Given these data, we would also suggest that those programs offering an independent training pathway consider providing an accelerated and intensive educational opportunity to their independent residents. Often, residents that are eligible will consider dual board certification, thus studying for a general surgery board examination and simultaneously training in plastic surgery. We would emphasize that this study only predicts success on the American Board of Plastic Surgery Written Exam. It does not imply a difference in board-certification rates or surgical skills/judgment between training pathways.

This study has multiple limitations. There were evolving numbers of integrated and independent residency programs, with a trend toward more integrated and fewer independent programs as time progressed. In addition, the minimum residency time requirements for plastic surgery training was increased during the study period (from 5 years to 6 years for integrated/combined and from 2 years to 3 years for independent programs). Both of these factors could have impacted our results. Furthermore, the combined training track consisting of 3 years as a general surgery resident followed by 2 to 3 years of plastic surgery residency was phased out during the study period. Through this transition, most of the combined programs transitioned into integrated programs and it is likely that the data from the combined residents are similar to those within the integrated pathway. Because of these similarities, it is unlikely that there were any large changes among integrated and combined residents. Data evaluating the residents' mean In-Service Exam score throughout their training are somewhat limited. Because of the confined study period (2009 to 2015), some residents had only one In-Service Exam score, whereas others had up to six. The discrepancies in these data likely did not significantly impact the study's conclusions, as they are similar to the results analyzing the In-Service Exam score from the residents' final year of training.

Data analysis through receiver operating characteristic curves also has limitations. This includes a potential risk for underestimating the practical significance of the cut-point. Although optimizing specificity, they are not tailored to identifying *catastrophic* events such as Written Exam failure and the impact that would have on a training program. However, the Written Exam failure rates we identified for those scoring above the identified In-Service Exam cut-points were quite low (0.2 to 2.4 percent) and we feel have practical significance.

Because the In-Service Exam is written on a yearly basis, its difficulty and distribution of topic questions are variable. Therefore, the normative data for the In-Service Exam change annually. The National Board of Medical Examiners and the In-Service Exam Committee apply rigorous metrics to ensure that examination questions are discriminatory.

It is important to emphasize that individuals who failed the Written Exam ultimately went on to pass at a high rate. Of those, over 80 percent passed on their second attempt. Many factors can alter performance of a Written Exam, including stress/anxiety, time constraints, and personal health variability. Such factors were not investigated for this study.

CONCLUSIONS

The Plastic Surgery In-Service Examination can be used as a predictor of success on the American Board of Plastic Surgery Written Examination. Program directors now have statistically significant cut-points for identifying residents at risk of failure on the American Board of Plastic Surgery Written Exam, allowing for early interventions and actions. Those programs offering an independent training pathway might consider providing an accelerated and intensive educational opportunity to their independent residents. It is our goal that these data be used to increase Written Exam pass rates and decrease the potential for noncompliance with Accreditation Council for Graduate Medical Education Written Exam pass rate requirements.

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