Pre-education Enhances the Success of Manual Training for Orthopedic Surgery Residents

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INTRODUCTION: Surgical skill training is difficult due to limited resources and the associated risks in the clinical setting. There have been many studies that have looked at optimizing resident skill techniques out of the operating room to optimize intraoperative teaching. Specifically, as seen in spine surgery performing a laminectomy with a high-speed drill is difficult and requires many hours of training and guidance before a resident can feel comfortable to adequately complete the laminectomy with minimal risk of adverse effects.

OBJECTIVE: The objective of this study is to assess if pre-education of residents prior to using the high-speed drill will significantly increase their comfort level, as well as increase the success of laminectomy.

DESIGN, SETTING AND PARTICIPANTS: This was done by a prospective cohort study in evaluating 20 orthopedic surgical residents via the objective structured assessment of technical skills and global rating scale.

RESULTS: Results showed that residents who had pre-education were in fact more successful in completing the laminectomy with the high-speed drill.

CONCLUSIONS: Pre-education, whether via a didactic or simulator-based model are both beneficial to resident's knowledge and surgical skill attainment however the simulator based model did not deem the group more successful in completing the laminectomy with the high-speed drill. Certain technical skills still require unreplaceable hands-on practice to become proficient. (J Surg Ed 76:1433–1439. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

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INTRODUCTION

Educating surgical residents has been always a challenge. From skin suturing to meticulous complex procedures, the training of safe, highly skilled future surgeons is a difficult task. Formalized surgical education and training in the United States was first described and promulgated by Sir William Halsted in 1889.[4] Unfortunately the Halstedian apprenticeship model appears inadequate due to work hour restrictions, increasing complexity of surgical techniques, and increasing societal expectations for good outcomes.

One of the most common spine pathologies that orthopedic residents encounter during their training is cervical stenosis secondary to cervical spondylosis. Symptomatic patients suffering from multiple stenotic spinal levels, will need a multilevel laminectomy to alleviate their symptoms. A laminectomy involves the removal of bone in the posterior aspect of the vertebra (the lamina) to decompress the neural elements. The use of high-speed burrs during laminectomies is a mainstay use and allows for efficient and safe decompression. However, as can be expected, precision and expertise is required to prevent the occurrence of adverse effects when using a high-speed burr near the spinal cord. While this skill is practiced during orthopedic residency, there is a large variation in the comfort levels and skill sets each resident possesses upon completing their training. This may be in part related to the number of cases the residents executes independently but also the gap of time between the use of the drill.

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For example, when residents are off service on other orthopedic subspecialties there may be large periods of time when they have no exposure to the use of a drill and their drilling skills will decline over time. That being said, simulation using saw bones is the ideal way of teaching residents the basics of doing these procedures in order to perform them in the clinical setting. To this date, there is no validated method that confirms the optimal manual teaching of orthopedic residents for this skill set. For this reason, our study has been designed to assess this and potentially showcase a model that can be utilized for all surgical specialties.

Two global assessment tools have been previously used and validated in multiple surgical subspecialties: Global Rating Scale of Operative Performance (GRS) as well as the Objective Structured Assessment of Technical Skills (OSATS).[1-3,5] However, they have yet to be utilized to assess orthopedic spine surgical skills. Using these assessment tools, the objective of this study was to assess if pre-education of residents prior to using the high-speed drill will significantly increase their comfort level, as well as increase the success of laminectomy with less adverse events.

MATERIALS AND METHODS

After the institutional review board approval, a prospective cohort study was used to analyze a group of 20 orthopedic residents and their ability to perform a laminectomy on a cervical spine "sawbones" model. All residents were recruited from the orthopedic residency program at McGill University. The study was performed at the Shriners Simulation center and participants were consented to participate in the study and for use of the results. None of the residents had training in manual handling skills prior to the assessment.

The residents were randomized into two groups and secluded from each other. Group A (study group) were given a 30-minute didactic session by an Orthopedic Spine staff on the various components of the Stryker CORE (Consolidated Operating Room Equipment) Powered Instrument Driver (model number 5400-050-000), the Stryker Pi Drive Plus Motor (model number 5407-300-000) and various burrs. Specifically, information regarding how to appropriately operate the burr and how to perform the laminectomy while minimizing adverse side effects. Group B (control group) were given no didactic session and were not given formal instructions as to how to operate the drill or how to perform a laminectomy (Fig. 1).

The residents were then brought individually into the simulation center and were given **three** attempts to perform a laminectomy at three consecutive levels. The spinal cord was simulated via a fluid filled insert (Fig. 2) that would indicate a dural tear/CSF leak if the drill encroached onto "the canal," signifying an adverse event.

The resident's technique during performing the laminectomy was observed by an Orthopedic spine staff and evaluated via GRS[2] **(Appendix 1)** as well as OSATS[1,3] **(Appendix 2)**. No instruction or feedback was given by the observer to either group during skill evaluation. Images of the completed laminectomies were taken from both groups to quantify the completed laminectomy and assess resident competency (Fig. 3).

After the resident's experience, standardized feedback questionnaire was filled out by the residents regarding their comfort level and competency **(Appendix 3).**

STATISTICAL ANALYSIS

Categorical variables were presented as a number and percentage. Continuous variables were conducted to

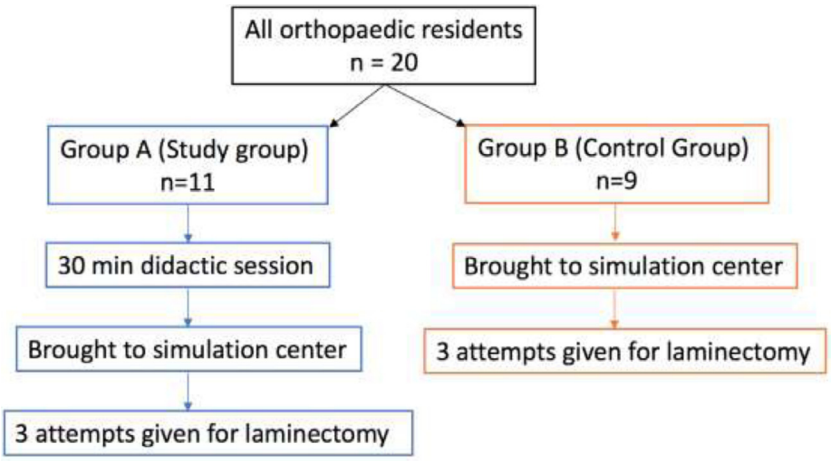

FIGURE 1. Study model and outline of study groups A (study group) and B (control group). Group A received a didactic teaching session, whereas group B only performed a laminectomy without a didactic session.

FIGURE 2. Sample of synbone cervical spine model, with visible dura simulation insert.

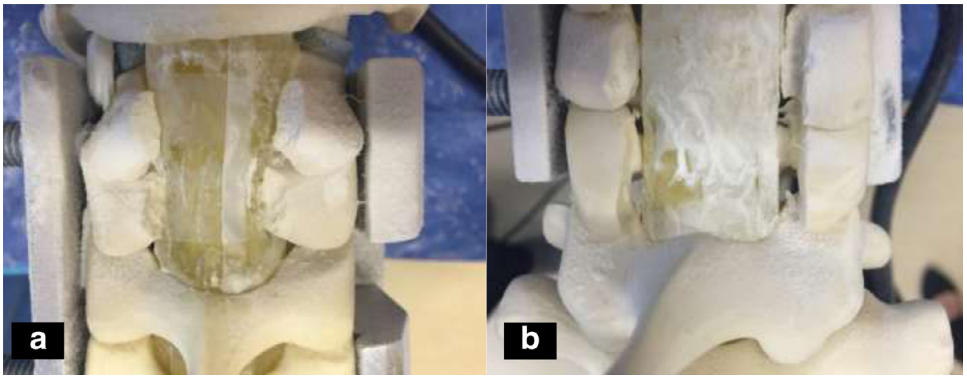

FIGURE 3. (a) An example of an insufficient C2-C3 laminectomy. (b) An example of a sufficient C5-C6 laminectomy.

Kolmogorov-Smirnov test and presented as mean and standard deviation or median and interquartile interval, depending on the distribution. Group comparisons were performed with Student's *t* test and Fisher exact test, for continuous and categorical variables, respectively. In order to evaluate the influence of resident level (i.e., Junior versus Senior) on the overall GRS, multiple linear regression was performed including resident level as a confounder. Bootstrapping analysis was used to calculate the distribution and the confidence intervals (CI 95%). Bootstrapping is a distribution-independent resampling method for data with insufficient sample size, and it was performed with 1000 replicates and stratified by level of training (i.e., Junior versus Senior). p values are based on two-sided tests, and values lower than 0.05 were considered significant. All statistical analyses were performed with SPSS version 20 (IBM Corp, Armonk, New York).

RESULTS

A total of 11 orthopedic residents were enrolled to the didactic session (Group A – Study Group) and 9 did not receive any specific training before performing the laminectomies (Group B – Control Group). The distribution

TABLE 1. Group Comparisons of Global Rating Scale of Operative Performance (GRS)

GRS	Control Group	Study Group	p	Mean Difference	CI 95%
Respect for Tissues	4.22 (±1.09)	4.64 (±0.67)	0.312	0.41	−0.26-1.09
Time and motion	3.44 (±1.01)	3.73 (±1.27)	0.596	0.28	−0.70-1.22
Instrument Handling	3.22 (±0.83)	3.82 (±0.87)	0.139	0.59	−0.13-1.33
Knowledge of Instruments	3.00 (±1.11)	4.09 (±0.94)	0.029	1.09	0.24-1.90
Flow of Operation	2.22 (±1.48)	3.73 (±1.19)	0.021	1.50	0.28-2.56
Knowledge of Specific Procedure	2.67 (±1.32)	3.91 (±0.83)	0.019	1.24	0.21-2.22
Overall (6 – 30)	**18.7 (±5.65)**	**23.9 (±4.15)**	**0.031**	**5.13**	**0.70-9.20**

Bolded values were used to differentiate the overall result from the subresults section.

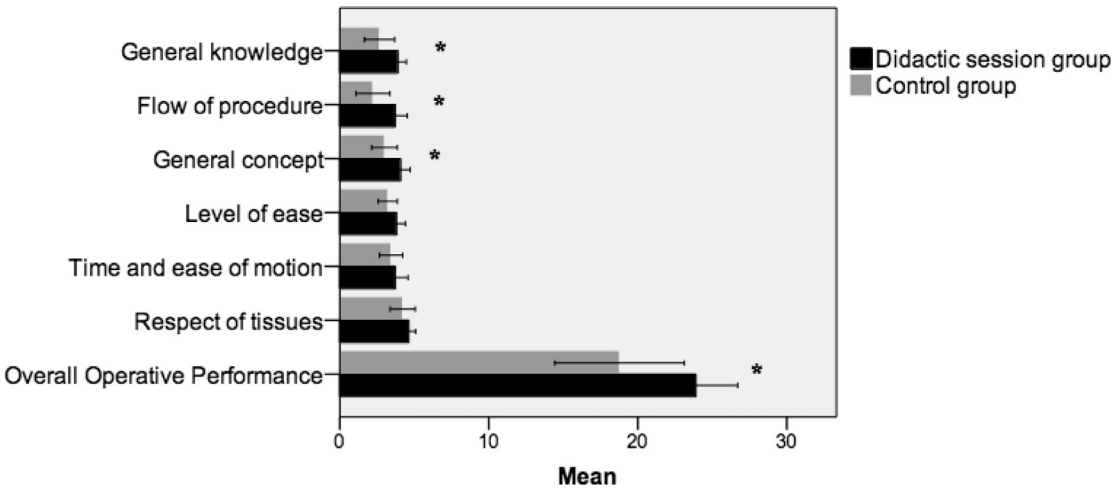

FIGURE 4. Comparison of global rating scale of operative performance between the groups. *p < 0.05.

of Junior and Senior residents was similar between the groups: 5 × 6 (45.5% × 54.5%), in the Study Group and 4 × 5 (44.4% × 55.6%) in the Control Group (p = 1.00).

Results of the GRS clearly show that the didactic session improved overall laminectomy performance by Orthopedic Residents (Mean difference in overall GRS = 5.13, CI 95% 0.70-9.20, p = 0.031; Table 1, Fig. 4). More specifically, there was a trend toward the Study Group being better than the Control Group for "Respect for Tissues"; "Time and motion" and "Instrument Handling." There was a significant difference in favor of the Study Group being better than the Control Group for "Knowledge of Instruments," "Flow of Operation," "Knowledge of Specific Procedure," and "Overall."

Multiple linear regression showed that pre-education (Study versus Control Group: B = 5.17, CI 95%: 0.83-9.50, p = 0.035) enhances the overall operative performance independently of the level of training (Junior versus Senior Residents: B = 4.17, CI 95%: 0.48-7.56, p = 0.056). Results of the OSATS are presented in Figure 5. There was a trend toward the Study Group being better than the Control Group for "Adequate instrument handling." However, there was no difference between Study Group and the Control Group for "efficiency"; and "adequate complete decompression."

The results of the satisfaction feedback questionnaire are shown in Table 2. A statistically significant difference was observed in the answers about feeling safe and confident in performing the specific procedure. On both questions, the study group reported higher scores. In other words, there was a trend toward the Study Group being better than the Control Group for "Did you find you had enough allotted time?" and "Would additional pre-

TABLE 2. Group Comparison of the Self-Reported Satisfaction Questionnaire

	Study Group	Control Group	p	Mean Difference	CI 95%
Did you feel comfortable operating the drill?	4.40 (±0.89)	4.11 (±0.60)	0.48	−0.10	−1.3-1.12
Did you feel as though you would be able to perform this surgery on your own?	4.00 (±0.70)	2.33 (±1.00)	**0.007**	−1.65	−3.11-0.18
Do you feel as though you were being safe?	4.60 (±0.54)	3.44 (±0.88)	**0.02**	−0.95	−2.08-0.18
Did you find you had enough allotted time?	3.20 (±1.78)	4.22 (0.66)	0.27	0.75	−1.55-3.05
Would additional pre-education increase your success?	3.40 (±1.14)	4.40 (0.52)	0.20	1.35	−0.54-1.84
Do you now feel more comfortable to complete this task in the OR after this simulation?	4.00 (±0.70)	4.22 (±0.66)	0.56	−0.05	−1.18-1.08
Overall Satisfaction	4.75 (±0.50)	4.67 (±0.70)	0.83	−0.15	−1.34-1.04

Bolded values indicates significance - P <0.05.

education increase your success?" There was a significant difference in favor of the Study Group being better than the Control Group for "Did you feel as though you would be able to perform this surgery on your own?" and "Do you feel as though you were being safe?" However, there was no difference between the Study Group and the Control Group for "Did you feel comfortable operating the drill?" "Do you now feel more comfortable to complete this task in the OR after this simulation?" or "Overall Satisfaction." These results suggest that the didactic session was effective in increasing the confidence of the residents on cervical laminectomy surgical technique. Satisfaction with the simulation was similar on both groups.

DISCUSSION

Training competent and skillful surgeons are the main objectives during a surgical residency which is a difficult task to achieve due to limited resources and the associated risks. There have been many studies that have looked at optimizing resident skill techniques out of the operating room to optimize intraoperative teaching. Specifically, as seen in spine surgery performing a laminectomy with a high-speed drill is difficult and requires many hours of training and guidance before a resident can feel comfortable to adequately complete the laminectomy with minimal risk of adverse effects.

Assessment of orthopedic residents using OSATS and GRS showed that residents with pre-education had a statistically significant better knowledge of instruments, flow of operation, and knowledge about the laminectomy technique ($p = 0.035$). However, it was noted that there was no statistically significant difference in adequate instrument handling ($p = 0.285$), efficiency ($p = 1.00$), and adequate complete decompression ($p = 0.642$). Although due to the small number of study participants, the study is not powered correctly to safely retain the null hypothesis. Despite the possibility of a type II error, the diverging results of the GRS and OSATS outcome measure require an examination of the outcome measures themselves.

The GRS contains evaluated components that are easily instructed during the didactic session and can be explained on a theoretical level (i.e., General concepts and general knowledge). However, the outcome measure subcomponents that actually measure task efficiency, respect of tissue, ease of motion, or most importantly task completion are not adequately aided by having a didactic teaching session.

The results of this study have shown that the technical operation of spinal decompression was not improved in the Study Group, however the surgeons felt more confident

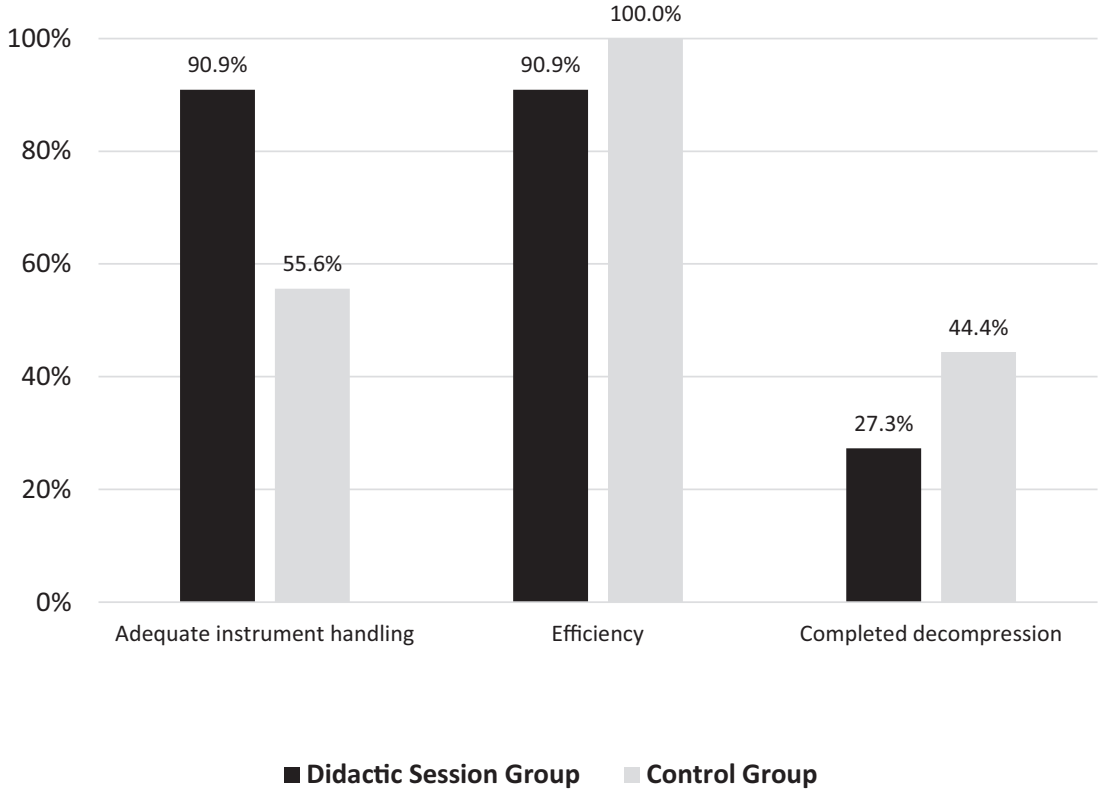

FIGURE 5. Results of the objective structured assessment of technical skills (OSATS).

and better respected the soft tissues. Although this was not part of our study, it was our impression that carrying out the technical exercise may improve the surgical outcomes and this should be evaluated in the future.

Fundamentally, our results suggest that a trainee needs hands-on practice to improve upon the more technical subcomponents of the GRS score and the OSATs score. The observation that hands-on practice is required to improve technical skills is self-evident, but the more striking observation is that a simple 30-minute didactic lesson prior to a surgical task can have a large effect on outcome measures of surgical competency. We consider a relatively short task specific teaching session to not be resource intensive and can be easy to implement as adjunct to training.

There are a few limitations of the study. These include intraobserver bias during the evaluation process, even with structured evaluation forms. In addition, amongst all residency levels there is variability in exposure to laminectomy and comfort level of the residents with performing such a technique intraoperatively. However, as this can be a confounding factor, when performing our statistical analysis, it was shown this did not affect our statistical significance.

CONCLUSION

Surgical education is a challenging process and surgical educators face the challenge of having to innovate creative methods to teach future surgeons efficiently and safely. In our study, we used validated assessment tools, GRS, and OSATS to verify if pre-education plays a role in the success of teaching surgical technical skills. Our results showed that pre-education does in fact improve the understanding of the surgical technique and flow of the operation, however it did not deem the group more successful in completing the laminectomy with the high-speed drill. Certain technical skills, while they can be explained during

APPENDIX 1. HIGH SPEED BURR – GLOBAL RATING SCALE OF OPERATIVE PERFORMANCE

please select one score per objective

Please circle: Group 1 **or** Group 2 **and** R1 R2 R3 R4 R5

Objective	1	2	3	4	5
Respect for tissues	Frequently used unnecessary force or caused damage by use of inappropriate use of instruments		Careful handling of tissue but occasionally caused inadvertent damage		Consistently handled tissues appropriately with minimal damage
Time and motion (max 15 min/2 levels)	Many unnecessary movements		Efficient time/motion but some unnecessary moves		Clear economy of movement and maximum efficiency
Instrument handling	Repeatedly makes tentative or awkward moves with instruments by inappropriate use of instruments		Competent use of instruments but occasionally appeared awkward or stiff		Fluid moves with instruments and no awkwardness
Knowledge of instruments	Frequently asked for wrong instrument or used inappropriate equipment		Knew names of most instruments and used appropriates instruments		Obviously familiar with the instruments and their names
Flow of operation	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 the next
Knowledge of specific procedure	Deficient knowledge. Needed specific instructions at most steps		Knew all important steps of operation		Demonstrated familiarity with all aspects of operation
Overall performance	Poor		Average		Superior

APPENDIX 2. HIGH SPEED BURR – OBJECTIVE STRUCTURED ASSESSMENT OF TECHNICAL SKILL (OSATS)

please select one score per objective

Please circle: Group 1 **or** Group 2 **and** R1 R2 R3 R4 R5

Objective	Component of Task	Correct	Incorrect
Completed decompression	Entire decompression is completed, no additional remnants could be excised		
Efficiency	Completed in allotted time (15 min/2 levels)		
Instrument handling	Did not plunge, did not breach the dura or other vital structures		

% completed of 1st level: _____
% completed of 2nd level:_____

APPENDIX 3. HIGH SPEED BURR – RESIDENT SATISFACTION QUESTIONNAIRE

please select one score per objective

Please circle: Group 1 **or** Group 2 **and** R1 R2 R3 R4 R5

	1: Not at all	2: Less	3: Somewhat	4: More	5: Definitely
Did you feel comfortable operating the drill?	1	2	3	4	5
Did you feel as though you would be able to perform this surgery on your own?	1	2	3	4	5
Do you feel as though you were being safe?	1	2	3	4	5
Did you find you had enough allotted time?	1	2	3	4	5
Would additional pre-education increase your success?	1	2	3	4	5
Do you now feel more comfortable to complete this task in the OR after this simulation?	1	2	3	4	5
Overall satisfaction	Poor		Average		Superior

didactic sessions, require, unreplaceable hands-on practice to become proficient.

Pre-education, whether via a didactic or simulator-based model are beneficial to resident surgical skill attainment and their intraoperative success, with the supplementation of hands-on technical skill practice.

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