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Teaching Medical Students to Suture: Evaluation of a Modern Medical School Curriculum

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ABSTRACT

Background: Medical students are traditionally introduced to suturing in a simulated environment using animal products or synthetic materials. However, there is little evidence to support this pedagogy. Our study explored whether a modern suturing curriculum adequately prepares medical students and examined student preference for learning suturing skills.

Methods: Suturing performance was recorded and assessed by expert raters. Students also completed a survey that inquired about self-perceived knowledge and confidence in suturing, and preferred pedagogical methods.

Results: The majority (79%) of students that completed our suturing curriculum demonstrated competence in basic suturing techniques. There was no correlation between objective abilities and self-perceived knowledge or confidence. Students reported being significantly more confident suturing anesthetized patients and in simulated environments. Students reported a desire for earlier introduction to suturing and more frequent simulation training.

Conclusion: A modern medical school suturing curriculum, comprising online modules and in-person simulation-based learning, adequately develops basic suturing techniques. .

KEYWORDS

Suturing, Education, Curricula, Medical students

1 | INTRODUCTION

Medical students are introduced to procedural skills, such as suturing, during their preclinical years in preparation for their surgical and emergency medicine rotations during clerkship. (1) Learning to suture entails observation and deliberate practice, both in a real or simulated setting. (2, 3) Although it has taken many forms over the years, surgical skills training has gradually shifted away from learning on-the-job towards simulation-based training. (4) At present, there is no established standardized suturing curriculum or consensus regarding best curricular design. (5) While previously, medical students were taught to suture by the "see one, do one, teach one" adage, modern instruction utilizes animal products or synthetic materials in a simulation-based teaching environment. (1, 5-13)

Online modules or simulation-based training can positively impact learners' self-efficacy and objective proficiency in suturing abilities. (14-16) However, studies do not illustrate the effect of patient awareness on performance. In other words, it is unknown if learners will be more proficient when suturing a patient who is awake versus sedated. Such information can effectively guide the medical school curriculum to invest resources appropriately and, thus, supply medical students with the necessary environment for optimized learning. Furthermore, investigating the synergism of online modules and simulation-based exercises used in conjunction to train medical students and assess their level of confidence may be beneficial for the academic community.

The goal of the present study is to determine the effectiveness of a modern suturing curriculum, comprising of both online modules and in-person simulation-based learning, by discerning objective suturing competence, and self-perceived confidence and knowledge in suturing. Additionally, we aimed to elucidate medical students' perspectives on the benefit of each teaching modality, and to evaluate whether there is an association between self-efficacy and suturing abilities. Lastly, we sought to explore whether a patient's state of awareness has significant effects on a learner's ability to successfully complete a suturing task. The results of this study are intended to inform educational leaders on how best to improve medical students suturing skills.

2 | METHODS

Second-year medical students at the University of British Columbia medical school were recruited via email in the spring of 2019. Participants were offered a small monetary incentive for participating in the study. Students were anonymized upon enrolment and excluded if they were involved in the workings of the study. The experimental protocol was approved by local research ethics boards. All participants provided informed consent.

The suturing curriculum consisted of two 3-hour in-person hands-on teaching sessions and associated online learning modules, administered 2 months apart, prior to clerkship. The philosophy of such a curriculum is to introduce early and deliberate practice in which students can enhance their confidence and have the flexibility to practice at home via online modules. (10) Furthermore, the online modules can pose a solution to challenging logistical problems facing a traditional curriculum, such as recruiting facilitators and instructors. (17) These sessions were taught by clinical faculty from surgery, emergency medicine and family medicine departments. The initial in-person session introduced students to the basics of suturing, including equipment, tissue handling and basic suturing techniques, such as simple interrupted. The second session focused on more advanced suturing techniques, including vertical mattress, horizontal mattress, and running subcuticular. The majority of the second session was dedicated to having faculty observes learners' techniques and provide direct feedback.

Upon completion of this curriculum, participants were recorded completing both a simple interrupted (SI) and vertical mattress (VM) suture on pork hock with unlimited time under video recording. Their performance was scored using the modified 12-criteria OSATS by two senior surgical residents. The participants were concealed from the surgical residents; participant names,

genders and whether they had completed modules or not, for instance, were unbeknownst to the evaluators. The OSATS assesses the ability to safely, appropriately, and technically complete basic suturing skills using a combination of task-specific checklists and global rating scales. (18-20) OSATS were scored from 0-24 with a higher score indicating better performance.

Additionally, participants completed two surveys inquiring about suturing experience, confidence, knowledge, and preparedness. One survey was distributed after completion of the suturing curriculum but prior to clerkship and the second survey was distributed upon completion of 12 weeks of clerkship consisting of core surgical and medical rotations. Incomplete surveys were excluded from analysis.

Participant descriptive data and survey responses are reported in the standard format. We compared the mean (± standard deviation) OSATS score between SI and VM sutures. Using a paired sample t-test, we compared participants' confidence and knowledge between SI and VM sutures, confidence suturing awake versus anesthetized patients, and pre- and post-clerkship confidence. Using Chi-Square tests, we compared whether participant's confidence differed between simulated and clinical settings. The correlation between participants' perceived knowledge and confidence for SI and VM sutures were reported with R-square. We calculated Pearson correlation between SI and VM for perceived knowledge and confidence. Effect sizes were calculated using Cohen's d. (21) Qualitative survey analysis was completed via narrative analysis methods. All data analyses were conducted in SPSS Statistics (version 23.0, IBM Corp., Armonk, NY). Significance was set a priori at $p<0.05$. No corrections were made for multiple comparisons.

3 | RESULTS

Twenty-four second-year medical students (26.8 ± 3.0 years old) enrolled in the study and completed the objective evaluation of their suturing skills. An additional 39 students were involved in the survey aspects of the study but declined having their suturing skills assessed (total enrolment rate, 21.9%; pre-clinical survey, n=63; post-clinical survey, n=14).

In our video analysis, students were significantly better at performing SI (OSATS = 19.2 ± 1.9) than VM (OSATS = 18.2 ± 2.0) sutures ($p = 0.022$, Cohen's $d = 0.51$). Pearson's correlation was significant ($r = 0.58$, $p=0.003$) between participant performance on SI and VM sutures. There was no significant correlation between self-reported suturing confidence and/or knowledge and objective performance in SI or VM sutures (Figure 1). Students most commonly lost points on their OSATS score from the following aspects of evaluation: safe mounting of needle on driver, mounting and orientation of needle in driver, trajectory of needle through tissues, suture tension, and avoiding handling needle.

The vast majority (93.4%) of students reported at least one exposure to suturing prior to clerkship, however, only 20.5% reported having sutured a patient (Table 1). After completing the suturing curriculum, students reported a "moderate" mean preparedness (3.0 ± 0.8 out of 5) and a "moderate" mean overall confidence of (2.8 ± 0.8 out of 5). Participant's perceived knowledge and confidence was significantly ($p<0.001$) higher for SI than VM sutures (Figure 2).

Before starting clerkship, students were significantly more confident suturing an anesthetized patient compared to an awake patient ($p<0.001$, Cohen's $d = 0.86$), and were significantly more confident suturing in a simulated, rather than clinical, environment ($p=0.018$; Figure 2). The majority (94.7%) of students who stated they were unsure or not confident in performing SI sutures in a clinical setting were confident in a simulated setting. Similar results (81.2%) were found for VM sutures.

In our post-clerkship survey, we found no significant difference in overall confidence in suturing after 12 weeks of clerkship experience ($p=0.726$; Table 2). Participant's self-reported confidence in suturing was both "moderate" pre-clerkship (3.2 ± 0.9 out of 5) and post-clerkship (3.1 ± 0.7 out of 5).

When asked about their preferred methods of learning, students rated online videos as significantly ($p=0.009$) more beneficial than suture kits. There was no

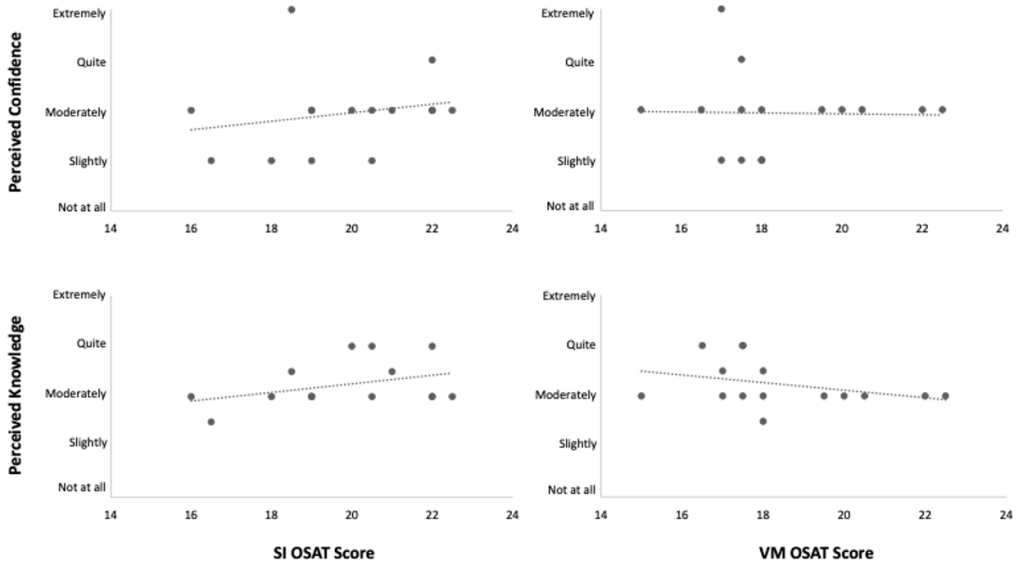

FIGURE 1 Correlation between objective suturing abilities (OSAT score) and self-reported confidence and knowledge for simple interrupted (SI) and vertical mattress (VM) sutures for medical students after completion of a modern suturing curriculum, comprising online modules and in-person simulation-based learning.

significant difference between teaching sessions and online videos (p=0.101) or suturing kits (p=0.157). Themes that emerged from qualitative data include preference for earlier suturing training, additional in-person teaching, advanced technical training opportunities, and practice tools. Students reported uncertainty about the transition from a simulated to clinical environment, yet viewed patients as the ideal learning model.

4 | DISCUSSION

This study assessed the effectiveness of a modern suturing curriculum in preparing medical students for clerkship and explored medical students preferred methods of learning suturing techniques. After completion of simulation-based suturing and online modules, the majority (79%) of students were competent in basic suturing techniques. Interestingly, there was no correlation between objective suturing abilities and students' self-perceived knowledge or confidence in suturing. Factors that increased student confidence while suturing included suturing in a simulated setting and suturing an anesthetized patient. In regards to pedagogy, students preferred in-person teaching sessions, online educational videos and early exposure to suture training during pre-clerkship years. These findings suggest that, although a suturing curriculum comprising online modules and in-person simulation-based learning adequately prepares students for clerkship, improvements can be made to increase student confidence in suturing. This is pertinent as student are frequently asked to suture during their clinical rotations and uncertainty in medical care is seen as detrimental to the physician-patient relationship. (22)

When suturing skills were objectively measured, we found no correlation between measurable suturing performance and self-reported knowledge or confidence suturing, indicating that subjective self-assessments were not reliable predictors of objective performance. Physician overconfidence increases diagnostic and medical management errors, which are associated with poor

Pre-clerkship Suturing Exposure						
Previous Experience (%)	**Nil** 6.6	**1-3 Occasions** 60.7	**4-6 Occasions** 26.0	**7+ Occasions** 6.6		
Previous Experience (%)	**Mandatory Teaching** 60.3	**Supplementary Teaching** 34.2	**Online Videos** 67.1	**Shadowing** 42.5	**Patient** 20.5	**Practice Material** 64.4
Experience Outside Curriculum (%)	**Nil** 27.9	**Little Bit** 55.7	**Moderate** 9.8	**Significant** 3.3	**Majority** 3.3	
Preparedness (%)	**Not at All** 0.0	**Slightly** 32.8	**Moderately** 44.3	**Quite** 18.0	**Extremely** 4.9	
Overall Confidence (%)	**Not at All** 3.3	**Slightly** 27.8	**Moderately** 52.5	**Quite** 13.1	**Extremely** 3.3	

TABLE 1 Medical students' exposure to and self-perceived knowledge and confidence in suturing prior to clerkship.

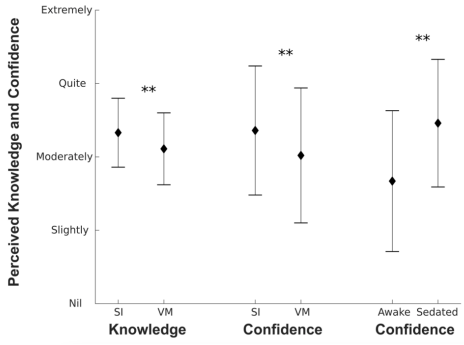

FIGURE 2 Medical students self-perceived knowledge and confidence in suturing simple interrupted (SI) and vertical mattress (VM) sutures, and in suturing awake and anesthetized patients, after completion of a modern suturing curriculum, comprising online modules and in-person simulation-based learning.

Benefit	Teaching Sessions	Suturing Kit	Online Videos
Nil (%)	0.0	0.0	0.0
Minimal (%)	7.7	45.5.	23.1
Moderate (%)	15.4	54.5	69.2
High (%)	76.9	0.0	7.7

TABLE 2 Medical students perceived benefit of different teaching modalities.

patient outcomes. (23, 24) Given the importance of accurate feedback in managing overconfidence and reducing the likelihood of future errors, providing medical students with objective feedback of suturing ability prior to clerkship may lead to greater self-awareness and less patient harm. (25)

Two themes emerged regarding where students most frequently made errors while suturing. Firstly, errors were commonly made in domains related to safety, such as mounting and orientation of needle in driver and avoiding handling needle. Secondly, errors were common in domains related to tissue handling, specifically the trajectory of needle through tissues and suture tension. In the clinical setting, errors in these domains can cause harm to both patients and students, through needlestick injuries or tissue damage and associated adverse healing. Students are more likely to damage tissue and are at increased risk of sharp injuries without proper

teaching. (26-29) Given that students are expected to suture patients during their clinical years, it is imperative that they have access to adequate training prior to clerkship to reduce risk of harm to patients or self.

Medical students were more confident suturing in a simulated, compared to a clinical, environment. Of those students who were unsure or lacked confidence suturing in a clinical environment, more than 80% stated they were confident in a simulated environment. Reduced confidence in a clinical setting is likely multifactorial, including limited supervision or feedback, concerns about causing poor patient outcomes, or concerns about preceptors' style of teaching. (26, 30, 31) Learning to suture in a clinical environment is stressful. It may lead to reduced skill acquisition, decreased confidence, and ultimately an avoidance of suturing in the future. (10, 32, 33) To reduce the likelihood of discontinued practice, medical schools should ensure ample opportunity to practice suturing in a supportive, simulated environment with adequate supervision and instruction. (10, 11, 32) A desire to learn suturing earlier in pre-clerkship training and having additional in-person training sessions were common themes that emerged from students. These themes complement previous literature that found medical students who learn suturing earlier in medical school and receive more training sessions report higher levels of confidence and have greater technical competence. (10, 11)

Within the clinical environment, medical students' confidence in suturing was impacted by the patients' level of consciousness. Students felt significantly more confident suturing an anesthetized, compared to an awake, patient. Malpas et al. (34) explain that there are two distinct components of completing a procedure: performing the technical aspect and communicating effectively with the patient. When suturing an anesthetized patient, medical students may feel that they can focus all of their attention on the task itself without the additional stress of exhibiting adequate relational skills. Although an anesthetized patient is ideal for offering an opportunity to focus solely on the technical task, it is crucial to consider the ethical implications of this, such as ensuring informed consent is obtained from the patient. (34-36) Suturing is a core competency of medical education, and suturing an anesthetized patient allows medical students to focus solely on improving their technique. (5) However, as highlighted by recent attention regarding pelvic examinations on anesthetized patients, to foster trust between patient and physicians, it is imperative that patients are informed that medical students may participate in their care. (37)

Medical students perceived in-person teaching sessions as the most beneficial teaching modality, and online educational videos to be more beneficial than suturing kits. Online educational videos provide an accessible, cost-effective and efficient alternative to in-person teaching. (30) However, frequent and deliberate practice in a simulated setting with direct observation remains the gold-standard during the skill acquisition phase of suturing. (10, 11, 38) Medical students rated suturing kits to be the least important tool for learning basic suturing skills; nonetheless, every student stated that they want access to a suturing kit. Suturing kits provide an important adjunct tool to reinforce foundation skills learned in education videos and in-person teaching sessions through dedicated practice outside of curricular time. (3)

A considerable limitation of this study is the lack of a Global Rating Scale (GRS) in objectively assessing students' performance. While students may score well on the OSATS, a novel GRS may be a better reflection of overall technical competence. For instance, this could take into consideration the number of attempts prior to success as well as other factors that the OSATS does not include. (39) Furthermore, although the OSATS assessment tool has been widely used, it has not undergone formal validation. (20, 40) Other limitations involve the inability to control for potential confounding variables such as prior medical training of varied forms.

In conclusion, we found that a modern suturing curriculum comprising online modules and in-person simulation-based learning adequately prepares medical students for clerkship. There was no correlation between objective suturing abilities and self-reported knowledge or confidence in suturing thereby emphasizing the importance of objective feedback prior to clerk-

ship in order to improve student self-awareness and reduce the risk of patient harm. Students were more confident while suturing an anesthetized patient which raises important ethical issues regarding informed consent within a teaching hospital or clinic. To improve medical students suturing curricula we recommend the use of online teaching videos as an adjunct teaching resource, early introduction to suturing, and simulation training prior to suturing in a clinical setting. Early and recurrent simulation training with direct expert feedback remains the gold-standard method to develop suturing skills.

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APPENDIX

Modified OSATS

Please rate the trainee's performance in the following areas **(1 – LOWEST, 5 – HIGHEST)**

Pre-procedure preparation				
1	2	3	4	5
Needed to be instructed on equipment gathering and patient positioning		Gathered equipment and helped position patient with some guidance; imperfect positioning		Assembled all equipment and positioned patient with no guidance required
Wound anesthesia				
1	2	3	4	5 N/A
Needed prompting and directed guidance to achieve wound anesthesia		Generally competent but somewhat inefficient and/or incomplete in anesthesia		Anesthetized wound completely and efficiently
Wound irrigation				
1	2	3	4	5
Needed frequent prompting and directed guidance to irrigate wound		Irrigated wound correctly with some prompting or is somewhat inefficient		Irrigated wound completely and efficiently without prompting or intervention
Use of Instruments				
1	2	3	4	5
Tentative or awkward positioning of instruments; poor use of instruments		Competent use of instruments but occasionally appears stiff or awkward		Fluid moves with instruments and no awkwardness
Time and motion				
1	2	3	4	5
Highly tentative, unsure of movements		Efficient, but somewhat tentative, with some unnecessary moves		Clear economy of movements and maximum efficiency
Needle Insertion and bite sizes				
1	2	3	4	5
Inappropriate needle positioning and bite sizes resulting in poor suture placement		Generally appropriate techniques with some room for correction		Appropriate needle angle and size and distance of bites every time
Knot tying				
1	2	3	4	5
Ties knots incorrectly, or needs frequent prompting on appropriate technique		Generally competent but somewhat inefficient and/or imperfect technique		Always tied knots efficiently using correct technique
Self-correction				
1	2	3	4	5
Oblivious to obvious deficiencies in repair, needs prompting to identify		Identifies imperfections in repair but unsure of how to correct		Performs perfect repair or independently and efficiently corrects imperfections
Overall Knowledge of Procedure				
1	2	3	4	5
Deficient knowledge. Needed specific instruction at most steps		Knew all important steps of procedure		Demonstrated familiarity with all aspects of procedure
Independence				
1	2	3	4	5
Needs frequent prompting and correction		Mostly independent needing only occasional guidance		Performs procedure with near-total independence
Overall performance				
1	2	3	4	5
Major intervention necessary to avoid cosmetic imperfection		Some prompting and redirection required to obtain acceptable cosmetic outcome		Outstanding cosmetic outcome achieved with minimal guidance
Post-procedure				
1				5
Needles and biohazards ignored or improperly discarded				Appropriately disposes of all hazardous materials & refuse

The Modified Objective Structured Assessment of Technical Skills (OSATS).