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Does Realism Matter? A Randomized Controlled Trial Comparing Models for Medical Student Suture Education

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Background: We hypothesized that medical students trained in suturing using high-fidelity models (cadaveric tissue) would demonstrate greater proficiency when compared with those trained using low-fidelity models (synthetic tissue).
Methods: Forty-three medical students were randomized into 2 groups. Group 1 consisted of students taught to perform simple interrupted sutures using synthetic tissue, and group 2 consisted of those taught using human cadaveric tissue. Suturing proficiency was measured pre- and postinstruction using the Global Rating Scale and by measuring suture accuracy. Perceived confidence in suturing was measured on a scale of 0–100.
Results: Perceived confidence was measured as an average of 8.26 out of 100 pretraining and significantly improved after training (56.91 out of 100); however, there was no significant difference when comparing confidence between groups posttraining (57.65 cadaveric versus 56.05 synthetic; $P = 0.78$), nor in the measured confidence change pre- and posttraining ($P = 0.53$). Posttraining, participants displayed a significant improvement in the number of adequately placed sutures; however, there was no significant difference posttraining when comparing groups (2.43 cadaveric versus 2.75 synthetic; $P = 0.48$). The change in adequate suture placement pre- and posttraining did not reach statistical significance between groups ($P = 0.27$). After instruction, participants demonstrated a significant improvement in total suture performance scores; however, there was no significant difference when comparing groups (30.04 cadaveric versus 29.80 synthetic; $P = 0.90$), nor in the total change pre- and posttraining ($P = 0.74$).
Conclusions: Training medium fidelity (tissue versus synthetic) does not significantly influence a student's overall suturing performance. However, formal instruction significantly improves objective competence and perceived confidence. Regardless of the model, surgical departments should emphasize medical student exposure to basic surgical skills education. *(Plast Reconstr Surg Glob Open 2020;8:e2738; doi: 10.1097/GOX.0000000000002738; Published online 22 April 2020.)*

INTRODUCTION

Within the operating room, suturing is often the highest-level skill that a medical student may perform without direct supervision. Yet, providing primary instruction on the proper suturing techniques within the actual operating room is often difficult. It is, therefore, necessary for surgical departments to adequately educate students on proper suturing techniques before their operating room experience. In recent years, increased attention has been paid toward determining what is the most optimal method of suture and surgical training.[1–3] However, the majority of this research focuses on the education of surgical residents and establishing the best method of objective assessment.[4–7] In addition, these models often rely on advanced tasks and are above the level expected of medical students

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and beyond what many physicians are expected to perform in their professional practice. There is a paucity of literature that examines what the optimal method of suture training is for the preclinical student.

An important consideration in simulations for surgical training is the fidelity or "realism" of the teaching model. Simulation is an effective method of improving outcomes but has limitations related to cost and time.[8] Limited data exist on how the selection of suture training medium (ie, synthetic versus animal versus cadaveric tissue) influences medical student education and proficiency in suturing. Previous studies examining this concept have found that there is no difference in measured surgical skill proficiency after training with low- or high-fidelity models.[9–11] Despite this, the belief persists that more realistic training models will offer an enhanced experience and improve practical competence. A predominant limitation to previous studies examining this question is that the high-fidelity models studied do not match the "gold-standard" of human tissue. In select institutions, access to ultra-high-fidelity (fresh cadaveric) tissue is often made available to medical students and residents for simulation and training purposes. The question remains whether high-fidelity models, such as cadaveric tissue, offer an advantage in surgical education and whether attempts should be made to utilize these materials when available for medical student education. The goal of this study is to assess whether medical students who are trained to suture on fresh human cadaveric tissue achieve a higher level of suturing proficiency when compared with students who are trained on low-fidelity or synthetic models. We hypothesized that students who are trained on fresh human cadaveric tissue would achieve a higher level of measured proficiency.

METHODS

Participants

Forty-three first-year (preclinical) medical students at the Duke University School of Medicine were recruited via a class-wide e-mail. Each participant signed an informed consent for an experience that was reviewed by the Institutional Review Board at Duke University and was exempt from further review per federal regulations due to its educational nature. All participants completed a questionnaire to determine baseline characteristics and assess previous suturing experience. Students with previous suturing experience were excluded from this study.

Study Design

Each participant watched an approximately 4-minute video, which detailed the technique for placing simple, interrupted sutures with instrument ties. (**See Video [online],** which demonstrates the technique for placing a simple, interrupted suture before any formal instruction or evaluation.)

After watching the video as a group, each student was assigned a "pretest," where she/he was allocated 5 minutes to place up to 5 simple, interrupted sutures within a 10-cm linear incision within fresh (not fixed) human

cadaveric tissue. The surgical field was uniformly draped to ensure consistency across participants (Fig. 1). The quality of the 5 pretest sutures was then evaluated for adequacy and scored by a blinded board-certified plastic surgeon. To evaluate suturing adequacy, the Global Rating Scale was used in both the pre- and posttest periods by the blinded scorer. This scale was part of the Objective Structured Assessment of Technical Skills, which was a validated assessment tool for grading overall technical proficiency.[12] The Global Rating Scale objectively evaluates participants in 8 main areas based on a minimum score of 1 and a maximum score of 5, for a total maximum score of 40. This scale has been previously validated and studied specifically in the context of medical student suture instruction.[13] Students were then dismissed and returned 2 days later to be randomized into 1 of 2 groups. Group 1 consisted of students who received instruction on performing simple, interrupted sutures using synthetic tissue. Group 2 consisted of students who received instruction with the same set of teachers using human cadaveric tissue. All students were matched with an instructor with a 1:4 (or greater) instructor-to-student ratio. Each training session lasted 1 hour, and instruction was provided by 3 plastic surgery residents at the postgraduate year 3 level from a credentialed plastic surgery training program. A sample training setup for each medium is represented in Figure 2. Following this training session, each student then

Fig. 1. Sample suture setup. Each student was provided a block of skin through which a 10-cm incision was made. Draping with a surgical towel was uniform. Each student was provided a pair of Adson forceps, a pair of scissors, a needle driver, and a 4-0 nylon suture. Additional suture material was available on request.
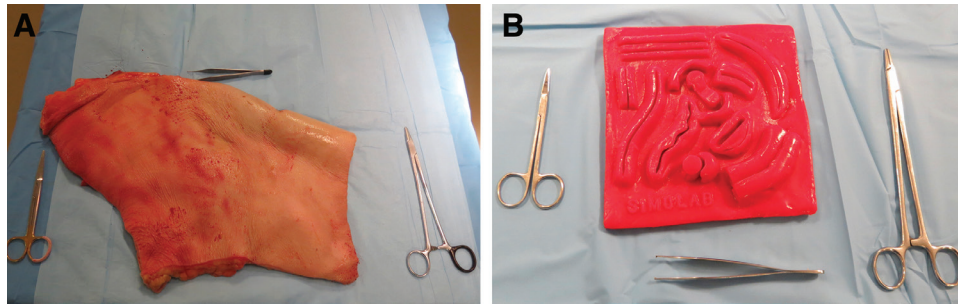
Fig. 2. Training setup for human (A) and synthetic tissue (B).

participated in a posttraining test, *on human tissue*, which utilized conditions identical to those of the pretest scenario to objectively determine how suturing proficiency improved following instruction on a low- or high-fidelity model, according to scores derived from the Global Rating Scale. The study design is depicted in Figure 3. All testing was performed in a Human Fresh Tissue Laboratory.

Study Outcomes

The primary outcome of this study was the change in an individual's total score as graded by the Global Rating Scale before and after suture training. The maximum score an individual could achieve was 40. Secondary outcomes of this study included the number of inadequately placed sutures (eg, air knot, different distances from left to right, incorrect distance from the previous suture, incorrect stitch used, knot was not square, knot was not perpendicular, or the tissue was not approximated), the number of attempted sutures pre- and postteaching, and the student's confidence pre- and postteaching. Students' levels of confidence were assessed by asking them to personally rank their confidence before and after teaching on a scale of 0–100. The Global Rating Scale and criteria used to judge suture adequacy are presented in SDC. (**See figure, Supplementary Digital Content,** which displays a depiction of the Global Rating Scale to score a student's overall suture performance in addition to the criteria used to judge suture adequacy, **http://links.lww.com/PRSGO/B355**.)

Statistical Analysis

Variables were compared using χ^2 tests for nominal variables and Student t tests for continuous variables. An α value of $P < 0.05$ was used for significance. For power analysis of student performance, using an effect size of 0.4 and a power of 0.80, the minimum sample size is 16.71 students per group.
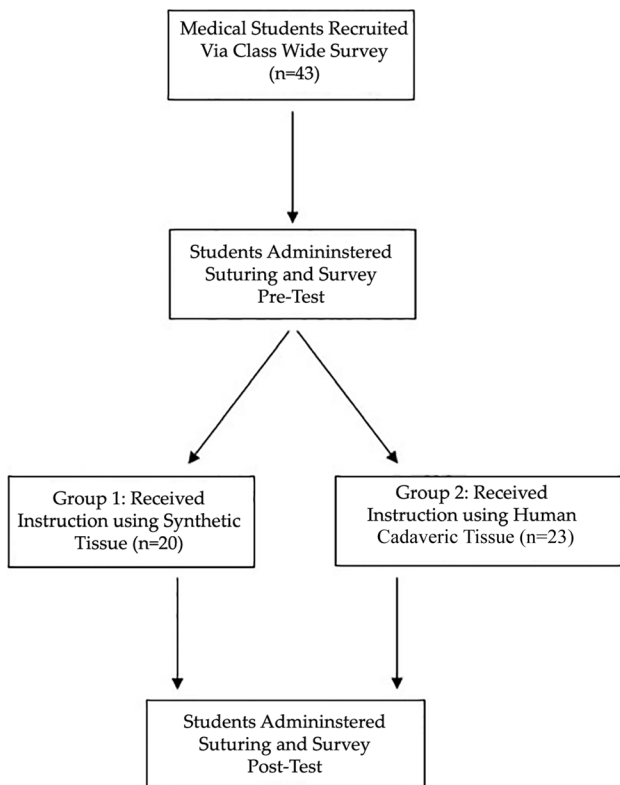
RESULTS

Subject Demographics

A total of 43 first-year medical students participated in this study. No participants were excluded from the final analysis. The mean age of the study cohort was 23.9 years, and most participants were female and of white race (Table 1). There were no significant differences in demographic characteristics following randomization into the 2-study cohorts of synthetic or cadaveric tissue.

Pre- and Posttest Comparisons between High- and Low-fidelity Training Groups

Participants were evaluated for improvement on 4 domains pre- and postteaching. These included the

Medical Students Recruited
Via Class Wide Survey
(n=43)

↓

Students Admininstered
Suturing and Survey
Pre-Test

↓

Group 1: Received Instruction using Synthetic Tissue (n=20)   Group 2: Received Instruction using Human Cadaveric Tissue (n=23)

↓

Students Admininstered
Suturing and Survey
Post-Test

Fig. 3. Inclusion and exclusion criteria of the study cohort.

Table 1. Demographic Characteristics of the Study Cohort

Variable	Cadaveric (n = 23)	Synthetic (n = 20)	P
Age (y)	23.64	24.07	0.46
Sex (female), %	60.9	60.0	0.95
Race, %			
Asian	26.09	30.00	0.78
Black or African American	8.70	10.00	0.88
Native Hawaiian or other Pacific Islander	4.35	0	0.26
White	65.22	65.00	0.98

following: the total number of attempted sutures within the allotted 5 minutes, participant confidence levels, the number of adequately placed sutures, and the overall suture performance score (derived from the Global Rating Scale). Before suture training, students were able to place an average of 0.96 sutures, with the cadaveric group placing 1.00 adequate sutures and the synthetic group placing 0.80 adequate sutures ($P = 0.58$). After suture training, there was no significant difference in the number of sutures participants could place if they were trained on cadaveric versus synthetic tissue (2.343 versus 2.75; $P = 0.48$), and the calculated improvement pre- and posttraining was not significantly different between groups ($P = 0.97$). An example of a student's work that represents 5 out of 5 target sutures is presented in Figure 4. To determine how an individual's confidence level improved following formal instruction, we assessed perceived confidence on a scale of 1–100 as it pertained to suturing before and following suture training. Average self-reported confidence was 8.26 out of 100 before training. Following formal instruction, participants displayed a significantly improved level of perceived confidence (56.91 out of 100; $P < 0.01$) without a significant difference in confidence levels when comparing those who trained on cadaveric or synthetic tissue (57.65 versus 56.05; $P = 0.78$) or in the measured change between groups before and following instruction ($P = 0.53$). Pretraining, the average number of adequately placed sutures was 0.91 among the entire study cohort. Following training, the cohort as a whole displayed a significant improvement in the number of adequately placed sutures; however, there was no significant difference in the number of adequately placed sutures posttraining between groups (2.43 versus 2.75; $P = 0.48$). The reasons
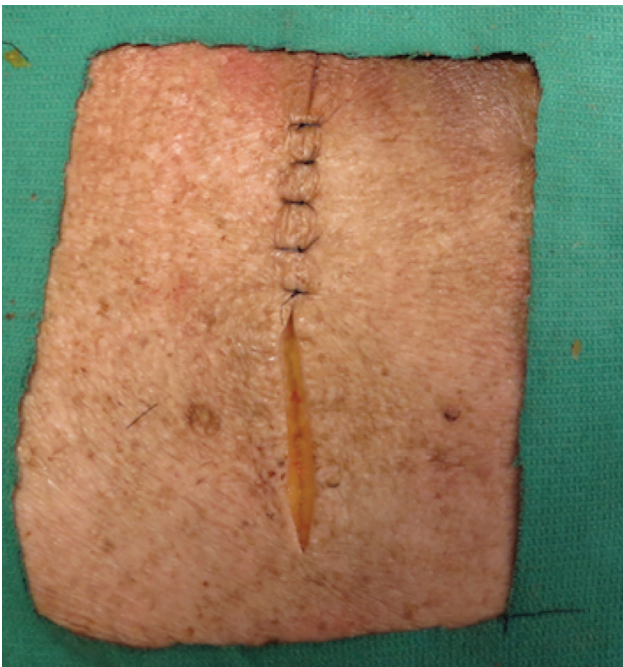
for why a suture is judged to be adequate or inadequate are presented in Table 2. Finally, overall suture performance scores, as determined from the Global Rating Scale, were compared across groups before and after training. The average total score was 13.81 before suture training. Both groups demonstrated a significant improvement in total suture performance scores following formal instruction; however, there was no significant difference in scores when comparing those who trained on cadaveric versus synthetic tissue (30.04 versus 29.80; $P = 0.90$), and the total change across groups was not significant ($P = 0.74$). The results across tested domains are presented in Figure 5.

DISCUSSION

There has been a renewed focus by surgery departments nationwide to revitalize medical students' interest and participation in surgery throughout their medical school education.[14,15] Often, one of the most engaging tasks a student may participate in while in the operating room is suturing. However, factors such as limited time make it difficult to provide direct instruction to students while in the operating room, emphasizing the importance of suturing instruction before the first operating room experience. Some surgery departments can provide students with regular access to *ultra*-high-fidelity media (ie, fresh human cadaveric tissue), whereas others have more restricted dedicated resources toward medical student education and are limited in supplying low-fidelity synthetic models for suturing instruction (eg, animal parts from grocery stores, foam templates). Our study demonstrates that there was no significant difference in suturing proficiency after medical students trained on either high- or low-fidelity models. More importantly, this study demonstrates that following formal instruction, suturing skill significantly increased with respect to the total number of sutures attempted, the number of adequate sutures placed, and the total suture performance score. Finally, all participants demonstrated a significant increase in their perceived confidence level with respect to suturing following formal instruction. These results emphasize the importance of formal surgical instruction in basic suturing skills, irrespective of low- or high-fidelity training media, early in medical student education.

Our study design was specifically chosen to assess whether the training medium that a medical student is exposed to influences his or her gained competency with respect to suturing. This question has been previously explored in the context of surgical training using animal models to evaluate elliptical excisions, suturing, and microvascular anastomoses. These authors found that there is no significant difference in proficiency whether someone trained on a high- or low-fidelity model.[9–11] Our study revealed similar results in the context of medical student education, finding that irrespective of the medium used for suture training, students demonstrated a significant improvement in suturing skills following formal instruction. Cadaveric models, as used in this study, present several obstacles for regular use in surgical education, including financial constraints, limited availability, and


Fig. 4. This student's product on the "posttraining test" received the maximum score (5 out of 5) for suture adequacy.

Table 2. Sutures Judged to Be Inadequate across the Study Cohort

Error	Postcadaveric	Presynthetic	Postcadaveric	Postsynthetic
Air knot	2	2	1	1
Different distance from left to right	2	2	1	2
Incorrect distance from previous suture	6	4	9	11
Incorrect stitch	1	0	0	0
Knot was not square	4	10	7	3
Knot was not perpendicular	1	0	0	0
Tissue was not approximated	0	0	1	0
Multiple above errors in one attempt	5	8	5	1
Total	21	26	24	18

the need for specialized facilities.[16] In contrast to high-fidelity models, low-fidelity models provide many inherent advantages to medical student education, including widespread availability, financial feasibility, reproducibility, and increased safety.[11] Despite these advantages, there is a prevalent perception among trainees that low-fidelity models do not provide an equivalent training environment due to a perceived lack of realism.[17] Even using cadaveric tissue to provide the most realistic environment possible to trainees, our results support those of previous studies suggesting that with respect to surgical skills training, it is the instruction and repetition that have the greatest impact on improved performance, rather than to the training medium used.[4,5,12] Surgery departments should emphasize repeated instruction at spaced intervals over the acquisition of high-fidelity materials to increase skill and perceived confidence in medical student surgical education.[1,5]

Regardless of what suture medium was used during training, students demonstrated a significant
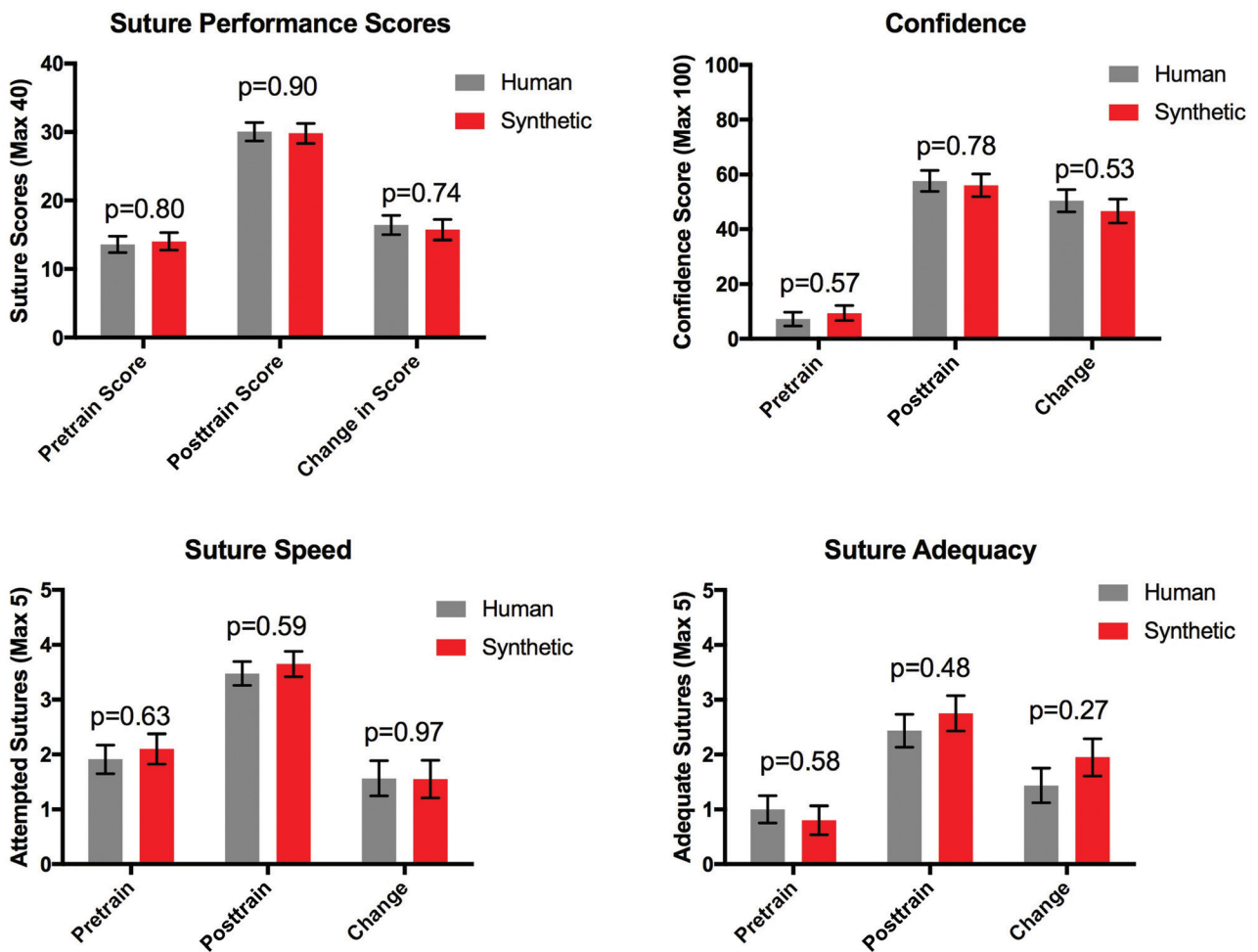
Fig. 5. Measured change in surgical proficiency across the study cohort. All students demonstrated a significant improvement in suturing proficiency and perceived confidence following formal instruction, and there was no difference in the measured change in improvement when comparing those trained on low- vs high-fidelity models. Max indicates maximum.

improvement across all tested domains in the posttraining period. In addition to an objective improvement in suturing, all participants noted an increase in their perceived confidence in suturing. Similar results were yielded in previous studies showing that following surgical training on bench-top models, there was a perceived increase in confidence when students performed skills in a clinical setting.[9,10,18] Confidence in basic surgical skills becomes increasingly important throughout a medical student's education, where applicants applying to competitive surgical subspecialties will often participate in multiple subinternships. Although operating room performance, as a medical student, was often not seen to be a deciding factor in an applicant's "fit" to a residency program,[19] it is self-evident that medical students ideally demonstrate a basic level of competence in the operating room while on their surgical subinternships. As shown by Clanton et al[20] and Leopold et al,[21] a trainee's level of confidence following formal instruction in a task independently correlated with an improved performance in a surgical skill. The results of this study emphasize the need for surgical departments to invest in providing formal instruction in basic surgical skills throughout a medical student's preclinical years. These tasks can be delegated through student-led surgical interest groups to increase students' interest in surgery, confidence, and ultimate performance once they begin their surgical rotations and subinternships.[22–24]

Study Limitations

Most notably, the design of this study precluded our ability to assess the value of implementing regular suture teaching sessions throughout the preclinical years. Therefore, we were unable to determine the value of repeated and spaced learning and at which point, if any, measurable improvement in suturing begins to plateau with instruction of a bench-top model. Furthermore, we were only able to assess the performance of first-year medical students at our institution, rather than focusing on a longitudinal examination of how regularly spaced formal teaching sessions may improve the skill retention and basic competency. Additionally, the task performed, while the most basic suture technique, may not match the task asked of the surgery student. For instance, the subcuticular stitch may be more commonly performed during a clerkship. Training on more advanced maneuvers would have introduced confounders over the hours of training necessary to learn the task and does not represent the basic fundamentals of tissue handling and approximation that physicians of many fields must perform.

CONCLUSIONS

Suturing is one of the most advanced procedural skills that a medical student will be allowed to participate in while in the operating room during his or her clinical rotations. A lack of competence in basic procedural skills can compromise hands-on learning opportunities for medical students while on their clinical rotations. The results of this study suggest that formal instruction in surgical skills (ie, suturing) significantly improves a student's objective competence and perceived confidence, which translates into improved performance while participating in the surgery clerkship and subinternships. Importantly, the results of this study emphasize that the fidelity of the medium used to train students on suturing does not influence the overall performance. Even if using low-fidelity cost-effective materials, surgical departments should emphasize regular and continued exposure of medical students to basic surgical skills education to foster increased interest in surgery and improve competence later in training.

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