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ORIGINAL RESEARCH

Identifying the Optimal Refresher Training Interval for Suturing Skill Retention among Preclinical Medical Students: A Randomized Pilot Study

Kaitlin Lipner[1], Danielle Kerrigan[2], Brian Drury[1], Brian Clyne[1]

ABSTRACT

OPEN ACCESS

Background: Distributed practice is ideal for teaching procedural skills, yet the optimal time interval between learning sessions remains unclear. We employed a distributed practice model to determine the interval that maximizes skill retention among medical students performing a horizontal mattress suture.

Methods: We taught participants the skill and assessed their proficiency using two previously validated scoring tools. Participants returned at two weeks, one month, or three months for retesting. At their second session, students either received a brief refresher module prior to testing or completed immediate testing without a refresher. Learners also completed a survey.

Results: Thirty-one students completed the study. At two weeks, we found no statistical difference between the refresher and immediate-testing groups ($p = 0.86$; CI 0.2–0.6). At one month, the difference remained nonsignificant ($p = 0.13$; CI 0.1–0.4), although confidence intervals narrowed. At three months, we observed a statistically significant difference between groups (adjusted $p < 0.0001$; CI 0.06–0.2). Survey results indicated no significant differences ($p = 0.14$), suggesting a homogeneous distribution of learners.

Conclusion: For educators designing suturing curricula, our findings suggest that scheduling a refresher session within one to three months of initial instruction represents a reasonable and actionable starting point for optimizing long-term retention of the horizontal mattress suture.

AUTHOR AFFILIATIONS

[1] Department of Emergency Medicine, Warren Alpert Medical School of Brown University, Providence, Rhode Island, USA

[2] Department of Emergency Medicine, University of California, San Francisco Fresno, Fresno, California, USA

Kaitlin Lipner (Corresponding Author)
Email: kaitlinvlipner@gmail.com

Danielle Kerrigan
Email: danielle.kerrigan1@gmail.com

Brian Drury
Email: briandrury2718@gmail.com

Brian Clyne
Email: bclyne@brownhealth.org

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Introduction

The American Association of Medical Colleges' (AAMC's) Core Entrustable Professional Activities (EPAs) for Entering Residency includes the expectation that all MD graduates can "Perform General Procedures of a Physician."[1] Consequently, medical schools are obligated to incorporate procedural teaching into their curricula. Due to competing curricular priorities, procedural skills training may receive limited attention, perhaps being taught via a single session. This approach has raised concern among medical educators about skill decay[2-5] as multiple studies have found single-session "massed practice" to be less effective for skill retention over time.[4,6-8]

Suturing is one of the most commonly taught procedures in medical school, and numerous studies have demonstrated measurable decay in suturing skills occurring within weeks to months of initial training.[2,5,9] The "performance curve" of learning suggests that repeated, distributed practice is critical to maximizing skill retention.[10] Distributed practice (also referred to as maintenance training or spaced training) aligns with educational theories such as deliberate practice[5,7,8,11-14] and has consistently been found superior to massed practice for promoting skill retention.[7,15-17]

While distributed practice may be a superior method to deliver a procedural skills curriculum, the optimal time interval between teaching sessions remains unclear. Experts have suggested that the ideal teaching interval depends on the complexity of the task.[11,18] We aimed to determine the optimal interval between horizontal mattress suture training sessions to maximize retention among preclinical medical students. These findings may inform the design of future procedural skills curricula that incorporate distributed practice, supporting medical schools in building programs that are as efficient as they are effective amid ever-increasing curricular demands.

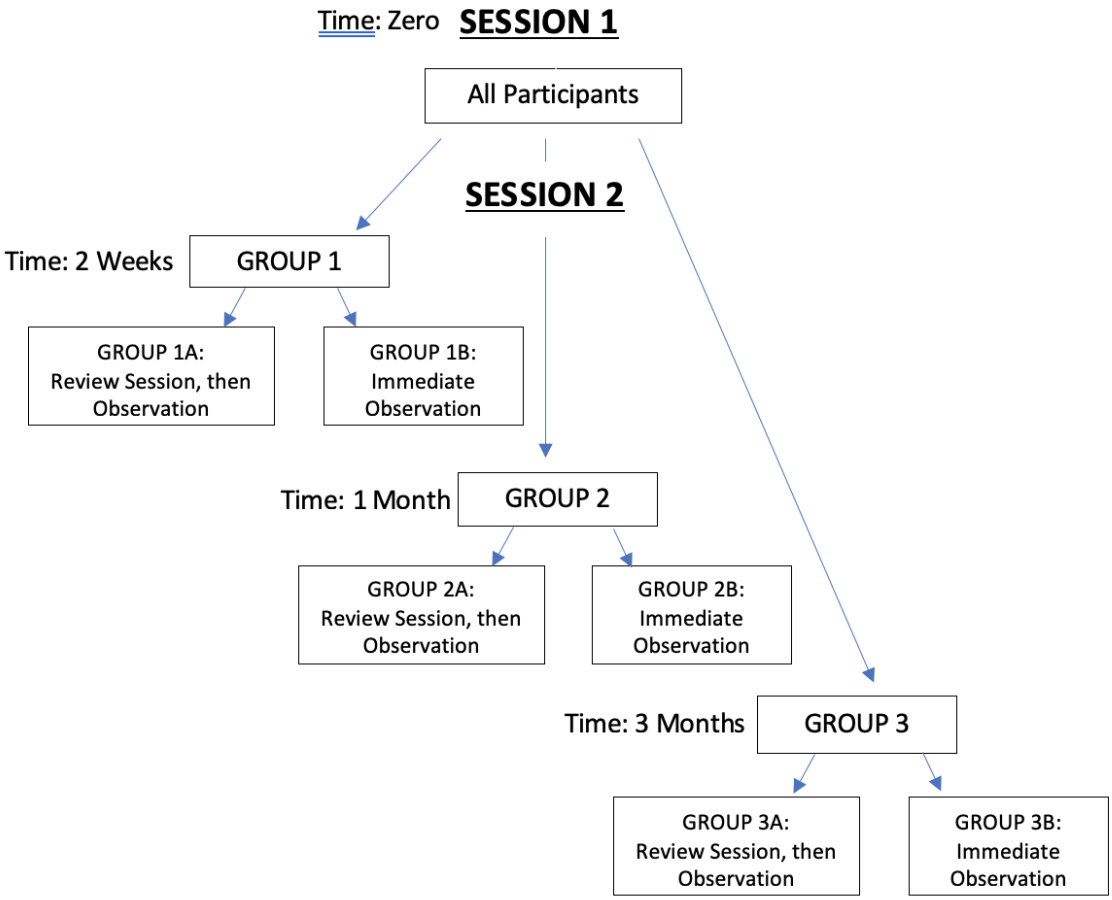
METHODS

Study Design: We designed a randomized controlled study to evaluate the effect of refresher training on skill retention in horizontal mattress suturing.

Setting: We conducted this study at the Warren Alpert Medical School of Brown University with preclinical student volunteers.

Sample Size and Sampling Methods: Thirty-one students completed the study. We randomized participants into either the refresher group (Intervention, n = 14) or the immediate-testing group (Control, n = 17). We further randomized participants to testing intervals of two weeks (n = 11), one month (n = 10), or three months (n = 10) (Appendix A).

Appendix A



Study Protocol: All participants attended an initial session consisting of 30 minutes of teaching and 30 minutes of independent practice. As trainers (authors KL and DK), we provided real-time feedback to students during the session. At the end of training, we assessed proficiency using the Suture Task Checklist[19] and the Global Rating Scale[20] (Appendices B & C).

Appendix B

Suture Task Checklist	Yes	No
Enquires re: tetanus status		
Mentions anesthetic		
Sterile technique (gloves)		
Mentions need for irrigation		
Selection of appropriate instruments and suture		

Suture Task Checklist	Yes	No
Correct placement of needle in needle driver		
Perpendicular penetration and exit		
Bite no closer than 0.5cm		
Equal bites on either side of the wound		
Curvature of the needle followed		
Smooth passage of needle, no hesitancy		
Completes a horizontal mattress with correct technique		
Instrument tie technique		
Initial double wrap throw		
Square knot		
At least 3 knots		
Leaves 0.5cm after cutting suture		
Minimum 3 sutures		
Stitch parallel to wound edge		
Adequate eversion of wound edge		

Appendix C

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

Numerical Code Session (one, 2 wks, 1mo or 3mo)

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	2	3	4	5
Needles and biohazards ignored or improperly discarded				Appropriately disposes of all hazardous materials & refuse

We performed all assessments without blinding, and a single rater evaluated each student.
Participants returned at their assigned interval for a second session. We subdivided them into either a refresher group, which received a brief module before retesting, or a non-refresher group, which completed immediate testing (see Appendix A). We again used the Suture Task Checklist and Global Rating Scale to assess proficiency. Each participant also completed a survey about prior suturing experience and time spent practicing the skill between sessions (Appendix D).

Appendix D

Survey

Numerical Code_____Session _____ (2 wks, 1mo or 3mo)

1. Prior to medical school and/or prior to your participation in this study, how many times did you practice suturing?
    a) Never
    b) 1-4 times
    c) 5-9 times
    d) 10-14 times
    e) 15 times or more

2. How many times do you estimate that you practiced suturing between session 1 and session 2 of this study?
    a) Never
    b) 1-4 times
    c) 5-9 times
    d) 10-14 times
    e) More than 15 times
3. I am currently learning something in one of my medical school classes that is relevant to suturing.
    a) Strongly disagree
    b) Disagree
    c) Neutral
    d) Agree
    e) Strongly agree
4. I am motivated to learn how to perform suturing well.
    a) Strongly disagree
    b) Disagree
    c) Neutral
    d) Agree
    e) Strongly agree
5. I believe this skill is worth learning and is relevant to my future residency/specialty training.
    a) Strongly disagree
    b) Disagree
    c) Neutral
    d) Agree
    e) Strongly agree
6. I have participated in a suturing class or training session before my participation in this study.
    a) Strongly disagree
    b) Disagree
    c) Neutral
    d) Agree
    e) Strongly agree
7. I would rate my own level of dexterity as:
    a) Very poor
    b) Poor
    c) Neither poor nor good
    d) Good
    e) Very good

Outcome Measures: We measured suturing proficiency using two previously validated assessment tools: the Suture Task Checklist19 and the Global Rating Scale.20 We also collected survey data to capture prior experience and interim practice behaviors.

Data Analysis: After collecting data, we evaluated de-identified results using a general estimating model. We calculated adjusted p-values with a linear model and a sandwich procedure to evaluate maximum likelihood estimation. We conducted all analyses using Statistical Analysis System (SAS) software.

Ethics Approval and Consent: We obtained written informed consent from all participants. The Institutional Review Board at Brown University reviewed the study and deemed it exempt.

RESULTS

Thirty-six learners initially enrolled, and five did not complete the second session. Thirty-one participants completed the study. These students were evenly and randomly distributed between refresher and immediate-testing groups across all time intervals.

Using the Suture Task Checklist, we found no statistical difference at two weeks (adjusted p = 0.86; CI 0.2–0.6) between the refresher group (n = 5) and the immediate-testing group (n = 6) (Figure 1).

Figure 1

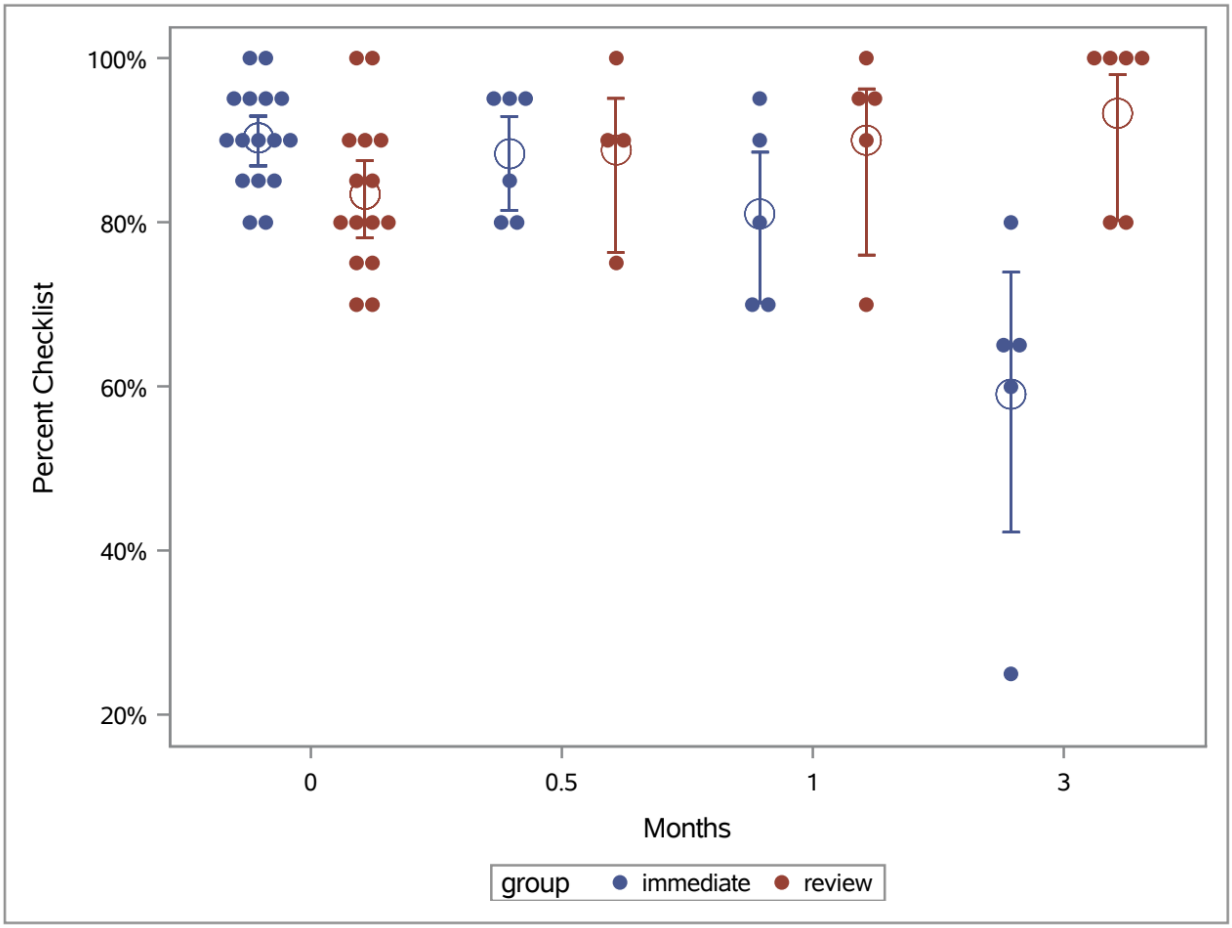


Fig. 1 Average mean scores with confidence intervals for each individual group, immediate-testing group (blue) and refresher-group (red), on the Suture Task Checklist, which objectively evaluated students' ability to perform a suturing task.

At one month, the difference remained nonsignificant (adjusted p = 0.13), but the confidence interval narrowed (CI 0.1–0.4). At three months, we found a statistically significant difference (adjusted p < 0.0001;

CI 0.06–0.2) between the refresher group (n = 5) and the immediate-testing group (n = 6). We observed similar results when using the Global Rating Scale (Figure 2).

Figure 2

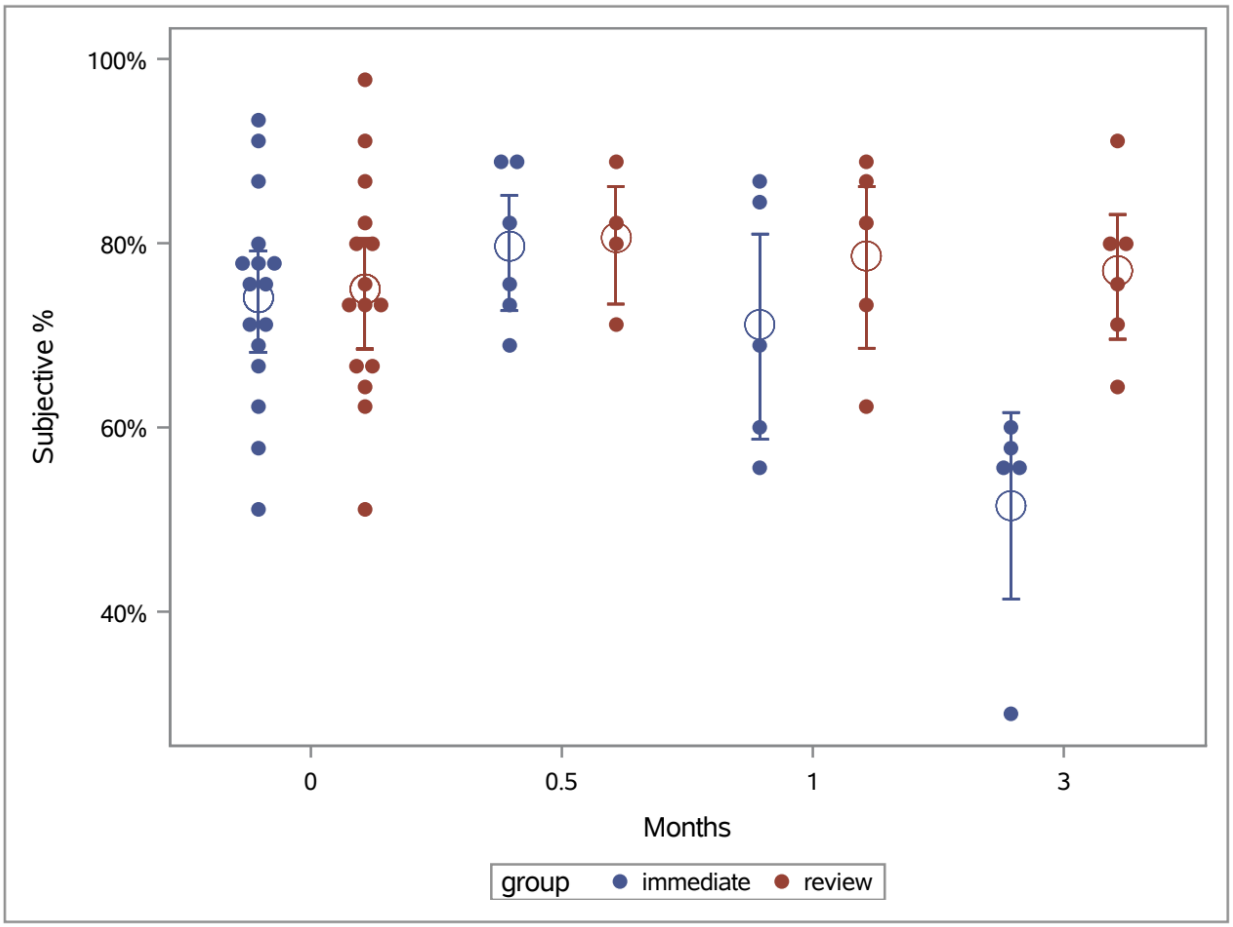


Fig. 2 Average mean scores with confidence intervals for each individual group, immediate-testing group (blue) and refresher-group (red), on the Global Rating Scale which attempted to subjectively evaluate students' ability to perform a suture.

Survey results revealed no significant differences in prior suturing exposure or interim practice between groups (p = 0.14), indicating that we studied a homogeneous population of learners.

DISCUSSION

Our findings build on established evidence that distributed practice supports procedural skill retention,[7, 15–17] and we add to the literature by examining the specific time interval at which refresher training sessions begin to demonstrate measurable benefit for the horizontal mattress suture. By the three-month follow up, students who did not receive a refresher demonstrated substantial skill decay, and we found a statistically significant difference between the refresher and immediate-testing groups, consistent with prior research showing procedural degradation after this interval.[21,22] Interestingly, Joosten et al. in 2021 observed little procedural skill loss in the first six weeks following minimally invasive surgical skills training, with significant decay emerging by six months.[23] Our finding of minimal decay at two weeks is consistent with this pattern, and our observed significant decay at three months contributes a data point within that interval, though direct comparison is limited given the differences in procedures studied.

At two weeks and one month, we observed no statistically significant difference between refresher and immediate-testing groups, although confidence intervals narrowed at one month, suggesting a meaningful difference may emerge with a larger sample. We could also attribute the lack of statistical significance at earlier intervals to the likelihood that the benefit of a refresher module only becomes detectable once sufficient skill decay has accumulated.

While our findings suggest that three months may be the critical interval, with one month showing a trend toward significance, the optimal interval remains an open question and our results should be interpreted with that uncertainty in mind. Investigators have previously recognized how challenging it is to define this interval. A systematic review by Fahl et al. examining spacing in simulator-based psychomotor training found that while spacing across consecutive days seemed most effective, ultimately the heterogeneity across studies prevents identification of a single optimal spacing.[24] With this understanding, our findings suggest that the one to three month window identified in our study represents a reasonable and actionable starting point, but should be understood as a preliminary estimate.

Our study has several limitations worth integrating into the interpretation of these results. The sample size was small, with as few as five participants per subgroup at the three-month interval, which limits the statistical power of that finding despite its significance. A study of comparable scope noted similar constraints, observing that small samples in surgical skills training research make it difficult to draw broad conclusions from any single study.[23] We did not blind assessors, participants varied in prior suturing experience, and five students practiced independently between sessions, all of which could have influenced retention scores in either direction. Finally, these findings apply specifically to the horizontal mattress suture. Each suture technique involves distinct motor patterns and instrument mechanics, and it cannot be assumed that an optimal training interval for one technique generalizes to another. Future studies with larger samples, blinded assessment, and additional tested intervals within the one to three month range would help to clarify the optimal interval for refresher training in suturing curricula.

CONCLUSION

In an environment of ever-increasing curricular demands, institutions cannot afford to allocate time to refresher sessions that do not meaningfully contribute to long-term skill retention. For educators designing a suturing curriculum, our findings begin to address this challenge by suggesting that scheduling a refresher session within one to three months of initial instruction represents a reasonable and actionable starting point.

These findings apply specifically to the horizontal mattress suture and should not be assumed to generalize across suture types or other procedural skills. Future work should explore additional intervals within the one-to-three-month range to more precisely define the optimal timing, and should incorporate larger samples and blinded assessment to strengthen the conclusions.

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The authors report there are no conflicts of interest.

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AI Usage Attestation:

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