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# A proficiency-based surgical boot camp May not provide trainees with a durable foundation in fundamental surgical skills

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## ABSTRACT

**Background:** Pre-internship boot camps have become popular platforms to rapidly teach skills to surgical interns. This study aimed to analyze psychomotor skill retention four months after completing a boot camp program.

**Methods:** Surgical interns (n = 20) took a baseline pre-test and then trained to proficiency (based on time and errors) for 5 knot tying, 4 simple suturing, and 2 running suturing tasks during a three-day boot camp. Three months later, all interns took a retention test.

**Results:** Proficiency scores significantly improved on all task types from pre-test to post test and significantly regressed on all task types from post-test to retention test. Normalized scores decreased as the tasks became more complex (knot tying = 93.5, simple suturing = 89.1, running suturing = 85.2, p = 0.05).

**Conclusions:** Boot camp style training can rapidly teach fundamental surgical skills to novices; however, skills regress significantly over time with a greater degree of regression seen on more complex skills.

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## Background

Intern prep courses or “boot camps” have become common platforms to ease the transition from medical school to residency. The goal of these courses is to ensure that new physicians are competent to perform the basic tasks necessary to excel as an intern. If interns master fundamental skills before or during orientation, they can theoretically function more efficiently on the wards and focus on developing complex skills earlier in their training. Some medical schools have begun the practice of offering specialty specific boot camps to senior medical students prior to graduation.<sup>12</sup> Additionally, many residency Program Directors now choose to incorporate these curricula into intern orientation.<sup>3–5</sup>

Available literature on boot camp style training consistently shows that boot camp participants are more confident in their ability to perform basic tasks after completing training.<sup>16–8</sup> Additionally, some studies have found that boot camp training is superior to traditional curricula when participants are compared to a control group of typical learners.<sup>49</sup> These comparative studies suggest that boot camps can not only increase learners’ confidence

but also improve their objective performance scores on clinical skills exams.

Since 2006, our institution has hosted an open knot tying and suturing course for General Surgery interns during their first few months of training.<sup>10,11</sup> Participants in the course undergo proficiency-based simulation training in a variety of fundamental suturing and knot tying tasks. This curriculum was developed based on interviews with faculty and residents regarding what operative skills all surgical interns should possess. From the interviews, our simulation team selected clinically-relevant, level-appropriate exercises for surgical interns that would teach these fundamental skills. Complete details regarding the development and validation of this course have been previously published.<sup>10</sup>

Historically, the course was administered over the initial 8–10 weeks of intern year; however, for the most recent academic year, we compressed the course into a three-day boot camp during orientation (Fig. 1). We chose to make this change to our curriculum for several reasons. First, our interns’ rotations are heterogeneous in regard to operative exposure, and some months (e.g. outpatient surgery) provide daily experience as primary surgeon while others (e.g. Surgical ICU) provide very little operating room exposure. We felt that interns who rotated on heavily operative services during their early months of training would benefit from the new compressed curriculum. Further, the initial months of intern year are

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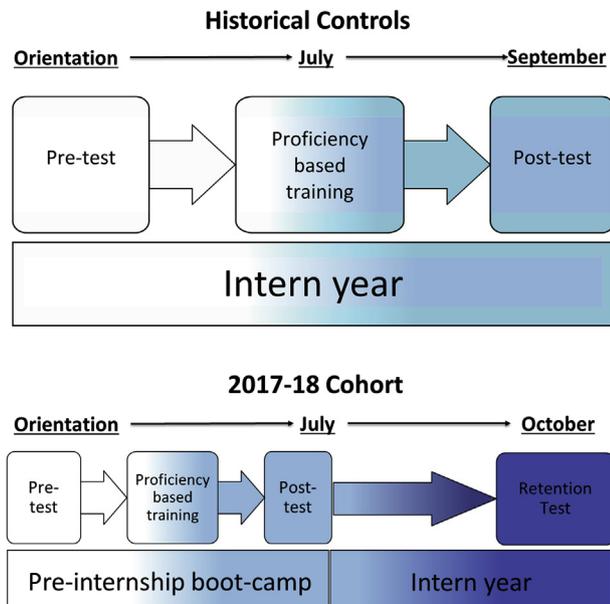


Fig. 1. Boot Camp Curriculum vs. Historical Controls.

often hectic for trainees, and they may not always have the physical or mental energy to regularly engage in self-directed suturing practice. Thus, we hypothesized that compressing the curriculum into orientation week would capture learners when they were most eager, motivated, and available to practice. The aims of this study were to assess both whether this proficiency-based training was feasible in an accelerated format and whether skills acquired during boot camp were durable over time.

## Methods

General Surgery preliminary and categorical interns ( $n = 23$ ) participated in a boot camp training program during pre-internship orientation. All training was hosted by the UT Southwestern Simulation Center. The training started with a baseline pre-test of 11 fundamental suturing and knot tying skills. Over the next three days, participants were instructed to engage in self-directed practice and train to proficiency standards for each of the 11 tasks. Proficiency standards were based on time and errors with proficiency thresholds established based on previously published trials with expert surgeons.<sup>10</sup> Interns were required to perform and document repetitions of each task until they reached proficiency on two consecutive repetitions. Once this was accomplished on all 11 tasks, participants were eligible to take the post-test. Post-tests were performed cold (no warm up allowed) and were proctored by simulation support staff. Any intern who failed to demonstrate proficiency in all tasks on the post-test was required to complete additional training and repeat a post-test. All tasks and their respective proficiency standards are shown in Table 1.

After completing their first 3 months of clinical training, all participants were required to return to the skills lab to take another post-test (hereafter referred to as “retention test”) on all 11 skills to assess the durability of the skills acquired in boot camp. During the 3 months of clinical rotations between the post-test and retention test, interns did not have any mandatory simulation training or scheduled practice in suturing or knot tying; however, all interns had 24 hour access to the simulation laboratory to engage in optional self-directed practice as they saw fit. Interns were informed of the retention test via an email from the Program Director four weeks in advance of testing. In the same email, the

Program Director stated that the goal of the retention test was to assess the durability of basic skills in real clinical practice, so interns were encouraged to continue with “business as usual” leading up to the retention test. This was done in an effort to minimize the Hawthorne Effect.

After all testing was complete, we compiled proficiency score data for the pre-test, post-test, and retention test for all interns and all tasks. Raw scores were converted to normalized scores with the proficiency level for each task set at 100 points. For the purpose of analysis, tasks were classified into three different task types—knot tying (5 tasks), interrupted suturing (4 tasks), and running suturing (2 tasks). The classification of these tasks is shown in Table 1.

Our primary outcomes of interest were feasibility and durability of boot camp style training for acquisition of basic psychomotor tasks. To assess feasibility of an accelerated program, we compared normalized post-test scores from the boot camp participants to a historical control group of the previous two year’s categorical interns ( $n = 26$ ) using independent samples t-tests. To evaluate durability of the boot camp program, participants’ normalized pre, post, and retention scores were compared with ANOVA. For initial analyses,  $p < 0.05$  was considered significant. Post-hoc repeated measures t-tests were performed for any significant differences detected with ANOVA with significant  $p$  values adjusted using a Bonferroni correction for multiple comparisons.

Secondary outcomes included whether retention of skills varied based on task complexity or operative experience. To analyze the effects of task complexity, we compared normalized retention test scores for knot tying vs. interrupted suturing vs. running suturing using ANOVA. To determine the effects of operative experience, we obtained ACGME case log data for each participant and performed a linear regression of retention scores vs. case volumes at the time of retention testing. Microsoft Excel 2013 with the Data Analysis ToolPak was used for all statistical analyses.

## Results

### Feasibility data

Complete data were available for 20 boot camp participants and 26 historical controls. All historical controls completed the curriculum in the required timeframe and passed their post-test on the first attempt. Despite the compressed time frame, all boot camp participants also successfully completed the proficiency based training and passed the post-test during on their first attempt. When compared to historical controls, boot camp participants had statistically similar post-test scores for knot tying and running suturing skills and statistically superior post-test scores on interrupted suturing skills (Table 2). Data for the number of training repetitions and the time spent on training were not recorded.

### Durability data

As expected, boot camp participants demonstrated significant improvements in their proficiency scores from pre-test to post-test for all task types; however, boot camp participants also showed significant regression in their proficiency scores from post-test to retention test for all task types (Fig. 2). The majority of interns failed to maintain proficiency on all skill types. Only five participants (25%) remained proficient in knot tying on the retention test while one (5%) remained proficient in interrupted suturing and two (10%) remained proficient in running suturing. Notably, four participants (20%) saw their scores on one or more task types regress back to the baseline levels seen on their pre-test.

Task complexity did not affect scores on the post test, but did affect retention. Based on normalized score, interns’ average skill

**Table 1**  
Proficiency-based training tasks.

Task Type	Task	Proficiency Standard
Knot tying	2 handed tie, no tension	10 s with no errors
	1 handed tie, no tension	10 s with no errors
	2 handed surgeons knot under tension	13 s with no errors
	2 handed slip knot under tension	15 s with no errors
	1 handed slip knot under tension	15 s with no errors
Interrupted Suturing	Simple interrupted suture	18 s with no errors
	Horizontal mattress suture	31 s with no errors
	Vertical mattress suture	31 s with no errors
	Interrupted subcuticular suture	33 s with no errors
	Simple running suture	165 s with no errors
Running Suturing	Simple running suture	165 s with no errors
	Running subcuticular suture	204 s with no errors

**Table 2**  
Post-test Scores for Boot Camp Participants vs. Historical Controls.

Task Type	Historical Control mean $\pm$ SD (n = 26)	Boot Camp mean $\pm$ SD (n = 20)	p value
Knot tying	106 $\pm$ 1.7	105.7 $\pm$ 2.5	0.66
Interrupted Suturing	103.1 $\pm$ 1.6	104.7 $\pm$ 2.4	0.01
Running Suturing	105.1 $\pm$ 3.9	104.5 $\pm$ 3.2	0.55

level at the time of their post-test was similar for knot tying (105.7), interrupted suturing (104.7) and running suturing (104.5). However, on the retention test, interns' percent proficiency decayed in a stepwise fashion as task complexity increased with the highest normalized scores seen in knot tying (93.5) followed by interrupted suturing (89.1) and finally running suturing (85.2). This phenomenon is illustrated in Fig. 3. These changes in normalized scores represent an average skill loss of 11.5% for knot tying, 14.9% for interrupted suturing, and 18.5% for running suturing.

Interns had limited operative exposure as primary surgeon between post-test and retention test [median 16 major cases (IQR 9–27)]. Including cases performed as first assistant, interns' had performed a median of 30 total procedures (IQR 22–50) at the time of their retention test. We observed a weakly positive but statistically significant correlation between increased total procedures and higher retention test scores for knot tying tasks (Pearson's  $r = 0.46$ ,  $p = 0.02$ ). There was also a weak correlation between procedure volume and retention of running suturing skills, but this did not reach statistical significance (Pearson's  $r = 0.36$ ,  $p = 0.059$ ). Procedure volume did not correlate with retention of interrupted suturing skills (Pearson's  $r = -0.06$ ,  $p = 0.41$ ).

## Discussion

This was a single institution study designed to assess whether proficiency-based training in fundamental knot tying and suturing skills was feasible in an accelerated boot camp format and whether skills acquired were durable over time. Our data demonstrated good feasibility for initial skill acquisition. Although boot camp participants had far less time available for self-directed, proficiency-based practice compared to historical controls (3 days vs. 8–10 weeks respectively), all members of the boot camp cohort were able to achieve a passing score on the post-test, and mean post-test scores in the boot camp cohort were equal to or better than scores seen in historical controls. Unfortunately, our data showed poor durability as boot camp participants saw a significant decrement in their skills 3 months after training with increasing skill decay observed as tasks became more complex. Operative exposure between the post-test and retention test showed a weak correlation in preservation of knot tying skills but not interrupted or running suturing skills.

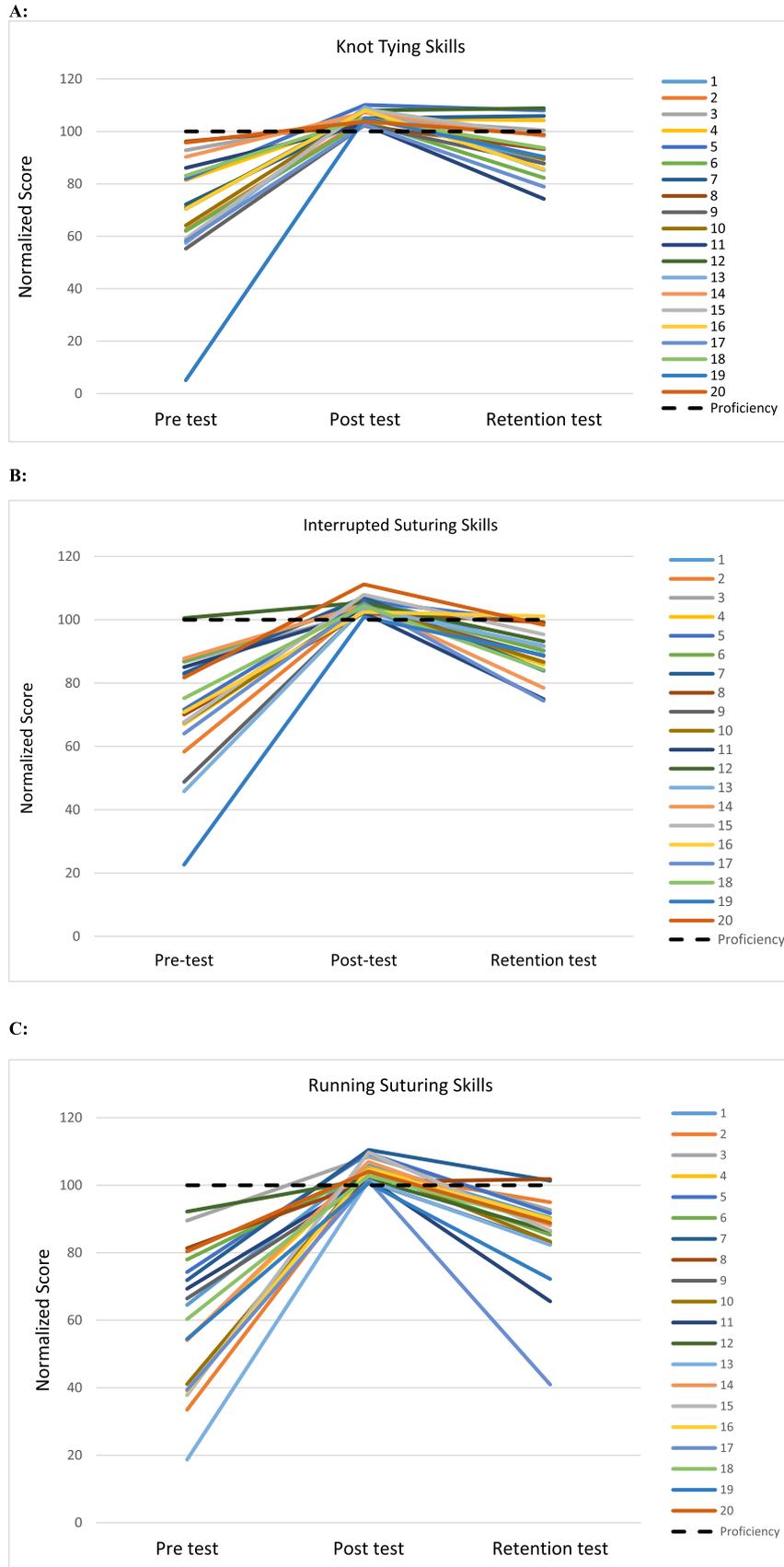
Our results on feasibility are consistent with existing literature

on boot camp curricula. Currently, there is level 2 evidence to support the effectiveness of boot camp curricula for rapid acquisition of clinical skills including a meta-analysis published by Blackmore and colleagues in 2014 which analyzed 16 studies of medical education boot camps.<sup>12</sup> This included 6 prospective cohort studies that measured clinical skills in a pre-test/post-test format. Analysis of these studies demonstrated immediate improvements in clinical skills in boot camp participants with a large effect size (expressed as Cohen's  $d$ ) of 1.78 (95% CI 1.33–2.22). None of these studies included long term follow-up of participants to evaluate retention.

Existing data on the durability of skills acquired in boot camp are limited. One study by Heskin and associates published in 2015 showed that a skills boot camp for surgical interns in Ireland improved participants' technical skills compared to historical controls, and this improvement was durable one year later.<sup>13</sup> Importantly, participants in this study received skills kits to take home at the conclusion of the boot camp for additional self-directed practice. They also returned to the simulation center on five occasions at 8-week intervals for additional mentored practice on the skills taught during the initial boot camp.

Another study of surgical interns in the UK published by Singh and colleagues in 2015 demonstrated that interns who underwent an “immersive simulation week” prior to intern year had superior surgical technical skills compared to control interns.<sup>14</sup> Follow up at 1, 4, and 6 months showed almost complete retention of technical skills in the simulation group as well as continued superiority, although at a lower effect size, compared to controls. In contrast to our participants who logged a median of 30 procedures in 3 months, the interns in this analysis had a robust exposure to procedures with a median of 71 procedures logged during the first month of training and a median of 20–30 procedures logged *per week* in the months that followed.

The absence of the additional practice sessions associated with Heskin's data or robust procedural exposure seen in Singh's publication likely contributed to the lack of durability in our cohort. Much of our understanding of skill retention comes from work done by Anders Ericsson on maintenance of expert performance.<sup>15,16</sup> According to Ericsson, a key component of achieving superior reproducible performance is regular, deliberate practice, which includes the following four key elements:



**Fig. 2.** Each line represents a participant's performance on individual skills over time. Normalized scores (y-axis) are calculated based on time to task completion and number of errors committed (e.g. air knot). Skills are grouped into three categories (A) knot tying, (B) interrupted suturing, and (C) running suturing.

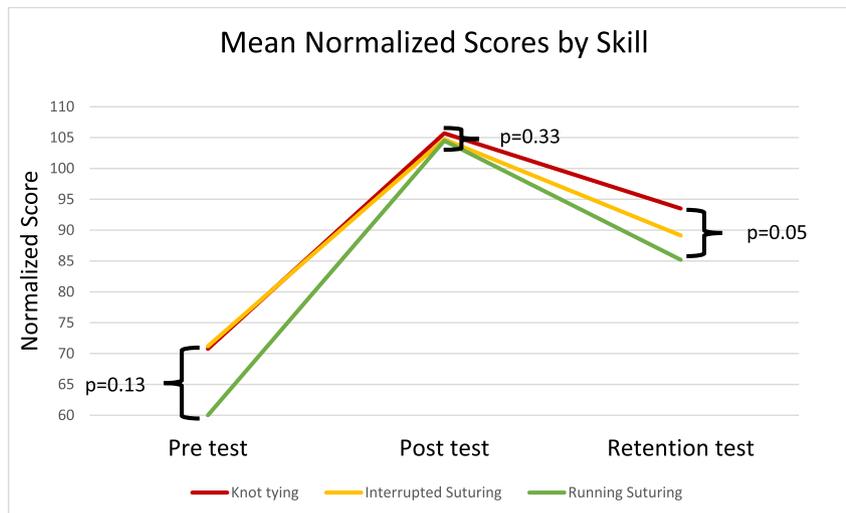


Fig. 3. Group means on pre, post, and retention test compared across skill types. Brackets indicate p value for ANOVA of means at various time points.

- 1) A task with a well-defined goal
- 2) A learner motivated to improve
- 3) Feedback on performance
- 4) Opportunities for repetition and gradual refinements of performance

Boot camps provide these elements in a compressed time frame—referred to as massed practice—which allows for rapid skill acquisition but inadequate opportunity for reinforcement. The alternative method, distributed practice, involves methodical training over multiple shorter sessions. The longer training sessions associated with massed practice may lead to higher rates of physical and mental fatigue during training.<sup>17</sup> This fatigue can be overcome if the learners are highly motivated to learn the material, which may explain why new interns still performed well on their post-test in our study. However, several randomized trials of massed practice vs. distributed practice of surgical skills show superior retention with distributed practice.<sup>18,19</sup> This is likely related to the learning phenomenon known as consolidation, which allows cognitive information and motor skills to move from short term to long term memory. Consolidation is known to occur during periods of inactivity between training or study sessions. With massed practice, trainees have fewer opportunities for consolidation compared to distributed practice, so less consolidation occurs, and retention suffers.<sup>20</sup>

In surgical interns, distributed practice could take the form of regular operative experience. However, in our study, operative case volume was only weakly associated with retention of knot tying skills and was not significantly associated with retention of interrupted or running suturing skills. We hypothesize that two factors were primarily responsible for the absence of a stronger association. First, our interns' low case volumes (median 16 cases as primary surgeon and 30 cases total) were likely insufficient to provide the amount of practice necessary to maintain skills. Furthermore, intern-appropriate cases may not have provided adequate repetitions of suturing and knot tying skills.

Our study is unique from other boot camp studies in that it includes not only immediate post-test data but also long term retention data. Some readers may question whether the lower proficiency scores observed on our retention test actually translate to meaningful changes in clinical abilities. For context, the average boot camp participants' knot tying normalized scores fell from 105.7 on the post-test to 93.5 on the retention test. In real practice

this would equate to completing a one-handed knot under no tension in 7 s on the post-test but needing 13 s on the retention test. Similarly, interrupted suturing normalized scores fell from 104.7 on the post-test to 89.1 proficiency on the retention test. This equates completing a simple interrupted suture in 13 s on the post-test but needing 29 s on the retention test. Finally, running suturing normalized scores fell from 104.5 on the post-test to 85.2 on the retention test. This equates to interns completing a 10 cm running subcuticular closure in 3 min 13 s on the post-test but needing 4 min 30 s on the retention test. Considering that an intern level case such as open inguinal hernia may require multiple knots, interrupted sutures, and layers of running suture, these observed differences in task performance would have a profound effect on operating room efficiency.

We do not have retention test data from our historical cohort of interns who trained to proficiency with a distributed practice model. However, anecdotal feedback from faculty suggests that the boot camp participants seemed noticeably less prepared in the operating room compared to prior cohorts. Because of this feedback and the evidence cited above, our program is planning to revert to a distributed practice model for future cohorts of interns. For programs that choose to continue with a massed practice curriculum in a boot camp format, we recommend supplementing the boot camp training with additional mandatory practice sessions or frequent exposure to procedures. Practice sessions could take the form of self-directed practice at home or mentored practice during scheduled protected time. At our institution, we plan to continue measuring retention in future cohorts of interns to assess whether further curricular modifications are needed to maintain expert performance in our trainees.

## Conclusions

Fundamental surgical skills can be rapidly acquired in a boot camp curriculum but will be poorly retained in the absence of regular deliberate practice. A model of distributed practice in place of or in addition to boot camp training should be considered to ensure retention of skills.

## Conflicts of interest

Drs. Weis, Farr, Abdelfattah, Hogg and Scott have no conflicts of interest to disclose related to this manuscript.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.amjsurg.2018.07.040>.

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