The Role of Deconstructive Teaching in the Training of Laparoscopy

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ABSTRACT

Background and Objectives: Skills-lab training is crucial for the development of advanced laparoscopic skills. In this study, we examined whether a systematic deconstructive and comprehensive tutoring approach improves training results in laparoscopic suturing and intracorporeal knot tying.

Methods: Sixteen residents in obstetrics and gynecology participating in structured skills-lab laparoscopy training were randomized in 2 equal-sized groups receiving 1-on-1 tutoring either in the traditional method or according to the Peyton's 4-step approach, involving an additional training step, with the trainees instructing the tutor to perform the exercises. A validated assessment tool (revised Objective Structured Assessment of Technical Skills) and the number of completed square knots per training session and the mean time per knot were used to assess the efficacy of training in both groups.

Results: Trainees in Peyton's group achieved significantly higher revised Objective Structured Assessment of Technical Skills scores (28.6 vs 23.9 points; $P = .05$) and were able to improve their scores during autonomous training repetitions, in contrast to the trainees not in Peyton's group (difference +4.75 vs −4.29 points, $P = .02$). Additionally, they seemed to be able to perform a greater number of successful knots during the exercise and to complete each knot quicker with the later observations failing to reach the threshold of statistical significance.

Conclusion: Peyton's 4-step approach seemed to be superior for teaching laparoscopic skills to obstetrics and gynecology residents in the skills-lab setting and can be therefore proposed for training curricula.

Key Words: Laparoscopic training, Peyton's 4-step approach, Pelvitrainer.

INTRODUCTION

Laparoscopy has been performed for the diagnosis of various conditions for more than 100 y, with the oldest procedures dating back to 1901. The evolution of laparoscopy in gynecology from a limited diagnostic procedure to a major surgical tool has been a rather slow process until the mid-1980s when its role in surgery was clearly established.[1] Since then, there has been a revolution, with most major operations used to treat various benign and malignant gynecologic conditions being feasible with a minimally invasive approach. This enables shorter hospital stays, fewer complications, and less morbidity[2]. Therefore, acquiring laparoscopic skills is one of the major surgical challenges for residents in obstetrics and gynecology. Trainees must master various difficulties arising from loss of depth perception, altered tissue feedback, and the inability of manual intervention. Acquiring the needed complex psychomotor skills is difficult and must be trained in model settings.[3] Interestingly, skills-lab training has been shown to improve procedural skills in both novice and experienced surgeons.[4] For the basic skills such as hand eye coordination and camera navigation, the use of a surgical simulator may be helpful; however, haptic feedback is still best practiced in a box trainer.[5]

One of the most difficult tasks in laparoscopic surgery, which poses a challenge to gynecology residents in order to proceed safely to more complex procedures, is laparoscopic suturing and intracorporal knot tying. Hence, highly effective training models and instruction methods are needed to shorten the learning curve and enhance operative competence.[6,7] Traditional expert tutoring is therefore involved in a way that simulates surgical training in general. William Stewart Halsted, the first chief of surgery at Johns Hopkins Hospital, who transformed surgical education by creating the residency program, suggested the "see one, do one, teach

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one" model, which is based on promptly acquiring increasing amounts of responsibility that culminates in near-independence.[8] However, it remains unclear whether this training model is the optimal method for acquiring complex skills in a box trainer setting.

A novel widespread methodical teaching approach suggested by R. Peyton[9] adopts the deconstruction of teaching practical clinical skills in 4 steps:

1. Demonstration: The teacher performs the skill at normal pace without any comments providing a benchmark.
2. Deconstruction: The teacher repeats the procedure with an added explanation describing the necessary subsections.
3. Comprehension: The student describes every step and the teacher performs the procedure on instruction.
4. Execution: The student describes and executes the procedure step by step.

This approach aims to optimize how the students absorb, process, and retain knowledge. The first 2 steps are based on a traditional learning theory and the last step represents the actual implementation of the procedure analogous to the Halsted's model. The third step is crucial, because it helps to actively manipulate the information that is stored in the working memory. This manipulation seems to facilitate the transfer of the information to the long-term memory. The description of the procedure to the tutor enhances the mental correlation of the procedural motions, thus leading to more efficient learning and better reproduction.[10,11]

Indeed, the effectiveness of this teaching method has been validated in various settings. It has been proved superior to standard instruction for teaching complex spinal manipulation skills in the treatment of musculoskeletal disorders,[12] teaching gastric tube insertion to medical students,[10] and introducing physiotherapy students to passive mobilization.[13]

The 4-step approach has been shown to maximize consolidating new information and improve memorization through adequate instructor guidance in complex skills, which, however, do not require motor coordination, such as in echocardiography training.[14] Additionally, the feasibility and practicability of this model have been validated in the teaching of different skills.[15–17] In other, simpler model-trained procedures such as the external chest compression Peyton method did not seem to be beneficial.[18,19]

In the field of laparoscopy, the 4-step approach has been tested on medical students with promising results.[20] To date, there are no systematic trials involving residents in obstetrics and gynecology.

Our study was based on the hypothesis that in the field of teaching complex laparoscopic skills such as suturing and intracorporeal knot tying, the execution of all distinct training steps according to Peyton is superior to the traditional "see one, do one, teach one" model. This hypothesis was tested through comparison of the ability of 2 groups of trainees to tie knots after several training repetitions.

MATERIALS AND METHODS

This study was performed from October 2017 to July 2018 in the context of residency program laparoscopy training at the Department of Obstetrics and Gynecology of the University Hospital of Würzburg, Germany. The study was approved by the committee of the University Hospital of Würzburg (Ethik-Kommission der Medizinischen Fakultät Votum 2017101201). Eligibility criteria were full medical license and the status of resident in obstetrics and gynecology. The exclusion criterion was prior experience with laparoscopic suturing and intracorporal knot tying. From the total of 20 eligible candidates, 16 (1 man and 15 women, age range 27–37 years) enrolled in the study, after a written informed consent was obtained. All residents had a common initial skills-lab training in laparoscopy basics, and year in the residency program varied from first to fifth.

At the beginning, a 9-minute video tutorial of basic laparoscopic principles and skills was demonstrated, followed by small group (2 or 3 persons) explanatory teaching. The residents were then required to perform simple laparoscopic exercises such as camera navigation and hand-eye and bimanual coordination according to the European Society for Gynecological Endoscopy (ESGE) program and to the institutional standards. In this initial phase, the LYRA laparoscopic training station was used (Karl Storz SE & Co. KG, Tuttlingen, Germany) because it provides an excellent simulation of the female pelvis, the abdominal organs, and the abdominal wall. The residents were then given the chance to further improve their basic skills through assisting in various gynecological operations at our institution during a 6-month period.

After this period, the residents were randomly assigned by picking a ticket from a box (balanced randomization) in 2 equal-sized groups to receive their subsequent training in laparoscopic suturing and knot-tying training. The ESGE Laparoscopic Skills Testing and Training (LASTT) Model was used for the training. This model has the purpose of improving and testing the manual skills of laparoscopists in training.[21] The hands-on training occurs through 1-on-1 tutoring from an experienced mentor. Only 1 trainee was tutored during each training session. A specifically developed and validated box trainer is deployed in the open LASTT Training Station with the Tele Pack X LED 2D endoscopic video unit. We used 5-mm KOH macro needle holders and ClickLine single-use scissors (Karl Storz SE & Co. KG). The suturing was performed on the specifically for the LASTT model developed and validated pads SUTT1 (ID Trust Medical, Leuven, Belgium).

After an initial demonstration of a 7-minute video tutorial for laparoscopic suturing and intracorporal knot tying and immediately before the training, the instructor was notified about the group assignment of each trainee.

Group A (n = 8) trainees were instructed using the Peyton 4-step approach. Group B (n = 8) trainees were instructed according to the traditional Halsted principle of demonstration of the exercise followed by execution, thus omitting the third educational step. All residents were tutored 1-on-1 by the same instructor for 30 min.

During the training, the basic principles of introducing and manipulating the needle were demonstrated. The trainee was instructed to perform a "surgeon's square knot" by which a double throw sliding knot was followed by 2 single throw half-knots, each in the opposite direction ("locking").[22] A green nonabsorbable braided ethylene terephthalate 2–0 suture with a curved needle (Ethibond Excel' Ethicon, Inc.) was inserted with the right needle holder and adjusted with both needle holders with the needle tip 90° to 135° from the axis shaft. The needle was then driven through the suturing pad at an angle of approximately 60° from right to left, grasped with the left needle holder, and forwarded in a rotatory movement. The first clockwise double throw was performed around with the right instrument, and the needle tip was used to facilitate the loops. Subsequently, a counterclockwise throw was begun, and the knot was secured with a third clockwise throw. After controlling the knot closely with the camera, the suture was cut 0.5 to 1 cm from the knot with endoscopic scissors.

The trainees were then given 20 min alone to master laparoscopic suturing and intracorporal knot tying at the pelvi-trainer, having the ability to watch the video for a second time if they needed to. In order to achieve maximum efficiency, the spaced learning concept was applied,[23] allowing the trainees to rest for 15 min. After the break, the trainees were asked to perform 1 square knot, which was video recorded using the endoscope camera. The trainees were hereby assisted with the camera navigation through an experienced resident who did not comment or in any way help the trainees at any step. After a 10-minute break, the trainees performed consecutive square knots with time measurement of each knot for a period of 15 minutes. This procedure was repeated 5 times with 5-minute breaks between the repetitions. The time for each square knot and the total number of successful square knots including inserting and removing the needle were documented at each repetition. After an additional 10-minute break, the trainees were asked to repeat one square knot, which was video recorded.

Both videos, before and after the hands-on autonomous training, were anonymized and forwarded for evaluation to an experienced laparoscopic surgeon who was aware of neither the teaching method nor whether the videos were taken before or after the autonomous hands-on training repetitions. The revised Objective Structured Assessment of Technical Skills tool (OSATS)[24] was selected for the evaluation. This tool was validated with obstetrics and gynecology residents and has been shown to have an excellent reliability and ease of application. It can be used by a reviewer of video-recorded surgical simulation workshops to accurately assess the performance of the trainees at the field of laparoscopic suturing and intracorporal knot tying.

The number of successfully completed square knots at each repetition and the difference of the OSATS scores for each video sequence for every trainee in both Peyton and non-Peyton training groups were the primary endpoints in the study. Secondary endpoints were the speed of laparoscopic knotting of the trainees (measured in seconds to perform a successful knot) and the improvement of the OSATS scores after autonomous hands-on repetitions.

Nonparametric statistic tests were used. The number of knots in each group was compared by using the Mann-Whitney *U* test. OSATS scores were compared with the Wilcoxon signed ranks test and an ordinary least squares regression analysis was performed. $P = .05$ was the threshold for statistical significance. SPSS Statistics 17.0 (IBM Corp., Armonk, NY) was used.

One participant dropped out because of fatigue after the third repetition of autonomous box trainer exercising; therefore, the OSATS score was assessed in this case only once.

RESULTS

While all participants in both tutoring groups were able to perform laparoscopic suturing and knot tying, we observed immense differences in the perception of the tutoring among trainees, independently of the training method. The total number of knots the participants were able to perform is shown in **Table 1**, and the mean time needed for a successful knot is presented in **Table 2**. In addition, in order to evaluate the knot tying on a qualitative level, we calculated OSATS scores before and after 5 repetitions (**Table 3**).

Concerning a possible improvement after autonomous training following the initial tutoring, the OSATS score was assessed for the entire group. Regardless of the teaching method, no significant difference could be observed (23.5 vs 22.9 points; $P = .64$, **Figure 1**). When we examined the development of the OSATS score separately for each tutoring method, we observed a statistically significant improvement in the Peyton tutoring group (28.6 vs 23.9 points, $P = .05$; **Figure 2**). The OSATS score after practice is significantly higher in the Peyton group (28.6 vs 17.6 points, $P < .05$, calculated power 0.88). Age of the residents and year in the residency program did not affect the performance (data not shown).

To highlight the effect of the tutoring method on the qualitative score after the training repetitions, we compared the difference of the change (“difference-in-differences”) of the OSATS score between the Peyton and the non-Peyton group, revealing a significant difference in favor of the Peyton group (+4.75 vs −4.29 points, $P = .02$, calculated power 0.70). In addition to the nonparametric tests, this finding was confirmed in the ordinary least squares regression analysis. The difference in OSATS scores after training, regressed on the score before training (in order to account for individual differences in baseline ability), is highly significant ($P = .02$) and demonstrates that the Peyton method leads to a much stronger improvement in scores, compared with the non-Peyton group (**Figure 3**).

With regard to the initial mean OSATS scores before the training repetitions (**Figure 2**), we assumed that the Peyton group performed better. However, this observation was not significant (OSATS score 23.88 vs 21.88, $P = .915$). Furthermore, the number of successful knots was measured during each repetition of the autonomous training. In both the Peyton group as well as in the non-Peyton group, we observed an increase of successful knots between repetitions. However, due to the small number of participants, only borderline signifi-

Table 1.
Total Number of Complete Square Knots (n) Successfully Performed by Each Participant in Each of the 5 Repetitions (Sequences)

Participant	Group	Seq. 1 n	Seq. 2 n	Seq. 3 n	Seq. 4 n	Seq. 5 n
1	A	6	8	8	5	7
2	B	2	2	quit	quit	quit
3	A	4	4	3	3	3
4	A	6	6	6	5	7
5	B	3	4	5	6	6
6	B	3	4	5	2	8
7	B	0	1	1	1	3
8	A	5	5	7	7	6
9	A	2	3	2	2	4
10	B	2	2	2	2	3
11	A	1	1	2	4	3
12	B	3	5	5	6	5
13	A	3	4	4	4	4
14	B	1	3	3	3	0
15	A	2	2	3	3	2
16	B	0	1	1	2	0

Table 2.
Mean Time for the Completion of a Successful Knot by Each Participant. Failed: Failed to Perform a Successful Knot in 15 Minutes

		Mean time				
Participant	Group	Sequence 1	Sequence 2	Sequence 3	Sequence 4	Sequence 5
1	A	02:20	01:50	01:41	02:40	01:58
2	B	05:50	06:31	quit	quit	quit
3	A	03:21	02:53	04:21	03:09	04:03
4	A	02:19	02:14	02:23	02:05	02:09
5	B	05:01	03:45	02:31	02:21	02:26
6	B	04:36	03:03	03:26	03:37	01:59
7	B	Failed	04:10	14:00	11:58	04:59
8	A	02:53	02:22	02:01	02:07	02:14
9	A	07:07	04:24	05:18	04:19	03:47
10	B	07:01	04:30	04:58	04:08	04:27
11	A	05:02	06:43	05:22	03:18	04:05
12	B	04:44	02:59	02:28	02:25	02:40
13	A	04:05	03:08	03:43	03:46	02:52
14	B	10:32	04:01	04:11	04:46	Failed
15	A	07:35	06:21	03:31	04:22	05:42
16	B	Failed	10:07	06:35	06:06	Failed

Table 3.
OSATS Scores After the Tutoring in Both Groups, Before and After the Autonomous Repetitions of the Exercise

Participant	Group	OSATS Before Practice	OSATS After Practice
1	A	31	23
2	B	22	Quit
3	A	24	30
4	A	22	28
5	B	25	28
6	B	28	26
7	B	15	16
8	A	23	32
9	A	18	27
10	B	27	19
11	A	25	23
12	B	25	12
13	A	25	35
14	B	25	11
15	A	23	31
16	B	8	11

cance could be reached (P = .07). Additionally, the total number of performed knots tends to be higher in the Peyton group as compared to the non-Peyton group. Again, this observation failed to reach statistical significance (4.15 vs 2.88 completed knots per repetition, P = .11; **Figure 4**).

Interestingly, a positive correlation between number of successful knots and measured OSATS scores could be detected before the 5 autonomous repetitions (r = 0.60, P = .02). However, after having performed the training, this was not the case (r = 0.45, P = .09) (data not shown).

Finally, the time needed per knot did not decrease significantly after the training, regardless of the teaching groups. The trainees in the Peyton group tended to have shorter averages times, without this observation reaching the threshold of significance.

DISCUSSION

Reaching proficiency in performing laparoscopic surgery requires extensive training to acquire the necessary cognitive and psychomotor skills. Therefore, as time for practice is limited, the selection of the best possible training models is crucial. The current study demonstrates that

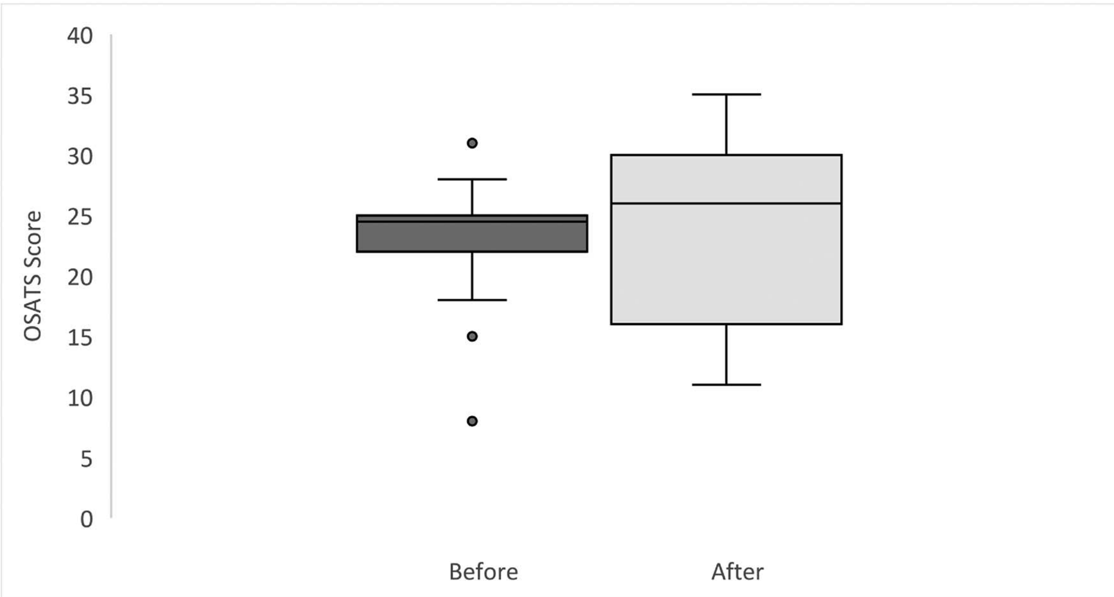

Figure 1. OSATS scores before and after training repetitions for all trainees, regardless of tutoring method: The training does not improve the score. Results are displayed as means ± standard deviations. The dots represent outliers ($P = 0.64$).

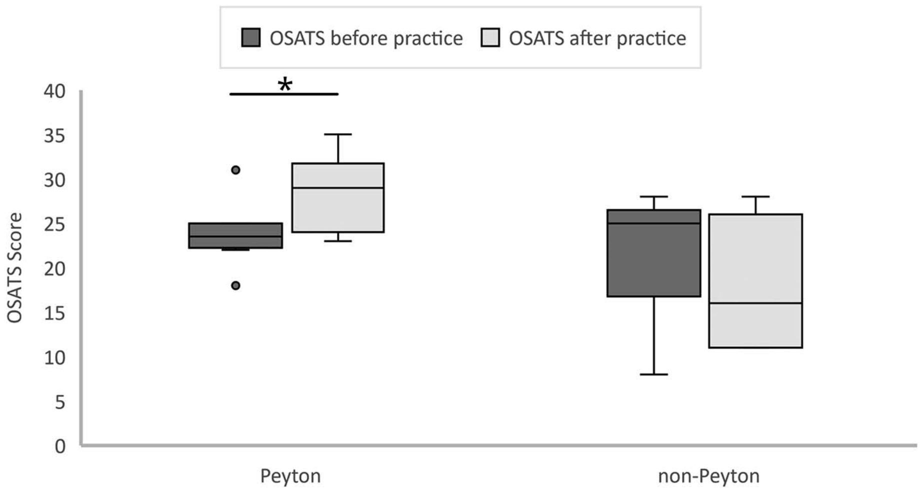

Figure 2. OSATS scores before (dark) and after (bright) the autonomous training repetitions: In the Peyton tutoring group, there is an improvement of the qualitative score. Results are displayed as mean ± standard deviation. The dots represent outliers ($P = .05$).

with a very brief instruction from an experienced laparoscopic surgeon, followed by hands-on training, even individuals with no prior exposure can successfully complete relatively complex tasks. The model was well accepted by the trainees and was rated as easily reproducible by the tutor.

We observed a lack of a significant change of the OSATS score (**Figure 1**), regardless of the tutoring group in our entire study population, after the autonomous training. This might be attributed to fatigue. Indeed, Platte et al.[25] proved that increasing physical fatigue in a laparoscopic box trainer setting led to significantly more errors. Here, we observed a trend of decreased OSATS scores after autonomous training in the non-Peyton training group, which is contradictory to one's expectation. One possible explanation is that whereas the deconstructive teaching

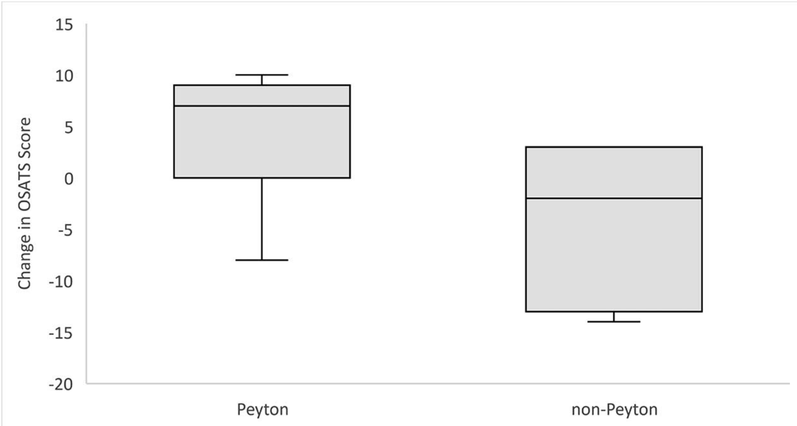

Figure 3. Difference in OSATS score during the autonomous training for each tutoring method. Peyton group trainees present an increase and non-Peyton trainees present a decrease in their OSATS score. Results are displayed as mean ± standard deviation ($P = .02$).

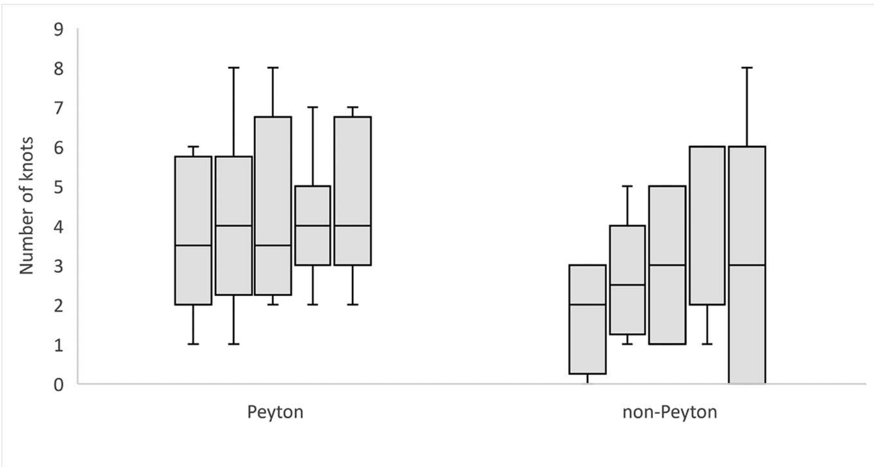

Figure 4. Number of successful knots during the 5 repetitions. In both groups, the number of knots is increasing, but the Peyton group trainees perform more knots ($P = .11$). Results are displayed as mean ± standard deviation.

improves the perception of the distinctive steps and thus the reproducibility over longer periods of time, mere repetition produces a limited result, as shown in the study of Krautter et al.[11]

In our study, the OSATS score was significantly increased in the Peyton tutoring group, as shown in **Figure 2**, indicating that the structured tutoring as proposed by Peyton[9] seems to improve the outcome on a qualitative level. This is in line with Romero et al., who observed an increase of the OSATS scores for laparoscopic suturing and intracorporal knot tying in a study performed with undergraduate medical students favoring the Peyton group.[20] However, this difference was limited to the first 3 sutures. A possible explanation is lack of the spaced learning concept in this study.[23] Additionally, confirming the expected benefit of the structured tutoring corresponding to Peyton, the difference in improvement of technical skills with regard to the qualitative level ("difference-in-differences") was highly significant in favor of the Peyton group (**Figure 3**). Therefore, it can be hypothesized that this approach really is superior to an unstructured proceeding.

The higher number of successful knots in any repetition in the Peyton training group (**Figure 4**), although not statistically significant, is also a clear indicator of the superiority of this approach. The increase in the number of knots performed in both groups during autonomous training, despite lower OSATS quality after the training in the non-

Peyton group underlines the importance of repetition to the acquisition of these complex skills, as published by Connor et al.[26] The strong correlation of laparoscopic suturing and knot tying speed expressed by number of successful knots with the OSATS qualitative scores demonstrates that there is a group among individuals with a similar background who are talented in this field. Quicker trainees achieve better quality. This is in accordance with the common perception in the field of surgical training and the findings of Groenier et al., who have demonstrated a strong link between perceptual speed and psychomotor ability in a laparoscopic trainer model.[27]

With regard to the speed expressed with time needed per successful knot (**Figure 5**) our results showed a discrete trend towards shorter duration by increased number of repetitions. We also observed a discrete trend towards lower times in the Peyton group, similar with the findings of Romero et al.[18]

The superiority of Peyton's 4-step approach is not the case in every model: Although it has been shown superior in transferring complex skills, Muenster et al. reported that any significant benefit of the deconstructive training approach could not be observed.[18] The authors suggest that this can be attributed to the simplicity of the training objectives in this study. Another possible explanation is the fact that the practical instruction took place in groups of 9 to 16 participants. This is well above the modification of Peyton's model for small group teaching suggested by Nikendei et al.[15] In our opinion, use of the larger teaching groups diminishes the effect of the crucial third step because it poses large difficulty in creating mental correlates of the procedural motions if both the person performing and the person instructing are trainees. The study of Schroeder et al. has similar limitations.[19] Skrzypek et al. proved that the 4-step approach can maximize the efficiency of training of a more complex procedure in a class setting.[14]

There seem to be several explanations for the superiority of the deconstructive tutoring method, as described by Peyton[9]: The observation step gives to the brain an overview of the task, a general orientation like the first look on the picture before solving a jigsaw puzzle. The deconstruction step according to Peyton has a positive effect to both the tutor and the trainee. Indeed, experienced tutors who perform an act flawlessly may fail to divide it into separate steps, which are necessary for someone who is inexperienced. When the tutor is required to describe the steps, they become conscious to him and, hence, the demonstration becomes more structured. For the trainees, the deconstruction step is important because they can recognize the vital steps (according to Peyton's "nodal points") of a complex procedure. The crucial third step enables the trainee to exactly comprehend the information. Simultaneously, it gives the tutor the chance to control the correct transfer of the information to the trainee. The final fourth step is common in both training models and facilitates independence of the trainee. The training repetitions facilitate the transition from the conscious to the unconscious competence.

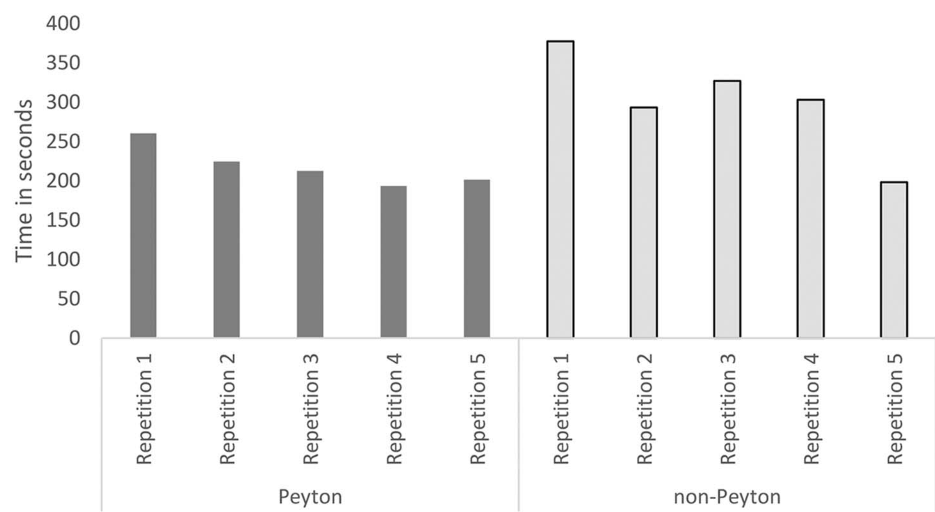

Figure 5. Average time in seconds needed for the completion of one successful knot during each training repetition in both tutoring groups. Both groups present a nonsignificant improvement during repetitions.

The strength of our study lies in the fact that we examined the impact of Peyton's 4-step approach on an advanced level of medical education. While most studies of this kind examine the effect of tutoring on medical students, we were able to demonstrate a significant impact on residents in obstetrics and gynecology. Additionally, this was done with a methodology that adheres to the latest recommendations for dry lab training in this field.

The small number of participants in this study is an obvious limitation, resulting from the early exposure of residents in obstetrics and gynecology to laparoscopic suturing and intracorporeal knot tying and the 1-on-1 tutoring by a single expert. Thus, the small number of participants is caused by the difficulty to find "knotting-naive individuals." A single-center study has a limited number of participants even in a tertiary center; however, it has the advantage of instruction of all individuals by single tutor under the exact same conditions. Nevertheless, our study could function as a pilot study for a multicenter collaboration, as the protocol is easy to implement, provided that tutors with a similar background agree on a common method of demonstration.

CONCLUSION

We have been able to show that Peyton's deconstructive and comprehensive approach is a promising training method for incorporation into laparoscopic training curricula. This method helps improve laparoscopic skills in a time-saving manner, since trainees tutored with this approach are able to achieve better technical skills assessment scores. This is the first study conducted with residents of obstetrics and gynecology and with an internationally validated testing and training model. In order to further evaluate the effectiveness of the complete training model for residents in obstetrics and gynecology, it has to be assessed in larger trials.

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