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GYNECOLOGIC ONCOLOGY

Introduction of a learning model for type 1 loop excision of the transformation zone of the uterine cervix in undergraduate medical students: a prospective cohort study

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Abstract

Purpose We address the impact of applying loop electrosurgical excision procedure (LEEP) under direct colposcopic vision teaching to our undergraduates using a self-developed simulation model and a standardized assessment to evaluate the progress of learning.

Methods The undergraduate teaching module was composed of a theoretical course on cervical dysplasia, colposcopy, electrosurgery and excisional procedures of the uterine cervix. This was followed by hands-on practical rounds. During the hands-on practice the students performed five "type 1" LEEP under direct colposcopic vision on the self-developed simulator. Based on specimen fragmentation and excision accuracy a score system was established. The students were asked to answer a course evaluation questionnaire.

Results The accuracy of the excisions showed a statistically significant improvement during the five training procedures (excision depth 7.34 ± 1.60–8.54 ± 1.67 mm, $p = 0.0041$; deviation from target cone thickness 0.88 ± 1.16–0.13 ± 0.94 mm, $p = 0.0116$). The fragmentation of the conus decreased (2.57 ± 1.26–1.29 ± 0.60 pieces, $p < 0.0001$). All this led to a general improvement of the LEEP score (2.59 ± 1.93–0.84 ± 1.03, $p = 0.001$). The student's questionnaire revealed a subjective satisfaction and improvement of their knowledge in pathomechanism, diagnosis and therapy of cervical pathologies.

Conclusion Undergraduate surgical training, in cervical excisional procedure, is a successful method in improving the students' perception and management of cervical pathologies.

Keywords Simulation training · Teaching · LEEP · LLETZ · Cone biopsy · Colposcopy

Introduction

Simulation in undergraduate medical education is an active learning method. Nonetheless, an investigation of which simulations are most appropriate or have the most impact in improving the medical education was never conducted [1]. Until this skill teaching project was introduced, undergraduate students from the University of Saarland could only observe colposcopic examinations, diagnostic and therapeutic procedures of cervical precancerous lesions. Despite presenting descriptive colposcopic images, we noted a lack of interest in many students.

With more stringent ethical requirements, undergraduate practical teaching of operative treatment of cervical pathologies has become more difficult. The conflict of interest between medical students' education and ethics is pronounced, especially at vaginal and speculum examinations [2]. Not all patients agree for co-observation by a student during colposcopy. Due to the specialized and intimate nature of the colposcopic examination, access to the undergraduate students is limited.

Using simulation models for cervical punch biopsy improves learning when compared to theoretical courses only [3]. Simple materials such as plastic tube, cardboard box, and sausages or meat pieces have also been utilized to construct a simulation model for loop electrosurgical excision procedure (LEEP) [3–9]. The simulation-based training

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allowed participants to also improve their surgical performance [3, 7–9].

The aim of our study is to provide undergraduate medical students with a better understanding of colposcopy, the diagnosis and treatment of cervical precancerous lesions. This is accomplished by a simulator model for loop excision of the transformation zone.

To determine the surgical improvement in LEEP performance by students, we developed a standardized assessment system.

Methods

Study population

This prospective cohort study is conducted on undergraduate medical students of the University of Saarland. The study group was enrolled in the department of obstetrics and gynecology in 2017/2018 academic year. Participation in the clinical round and our course were the only requirements for eligibility. We informed the students about the study in detail. Informed consent was obtained from all participants before the simulation training. The participation was voluntary and anonymous. The study was approved by the Ethics Committee of Saarland (no: 259/17).

Simulator design

Our tabletop model with a bi-valved, self-retaining speculum is similar to the narrow space of the vagina. A stone plate forms a stable surface; the Styrofoam plate is easy to adapt to the contours of the speculum. Single-handed speculum with smoke extractor is ideal for LEEP in local anesthesia and, thus, provides very realistic conditions. We simulated the cervix using a sausage. The cervical canal is demarcated by injecting a dye into the sausage. This enabled a better assessment of the shape and thickness of the excised cone. The sausage is placed directly on the neutral electrode and can be fixed with a Velcro (Fig. 1). This allowed a quick reloading of the model. LEEP was carried out with an ERBE Vio300 D (Erbe, Tübingen, Germany) with a 20-mm loop electrode (Medimex, Limburg, Germany) under colposcopic vision (Olympus OCS-500, Olympus Europa, Hamburg, Germany). The procedure was presented on a monitor for the rest of the students.

Simulation procedure

We introduced the course with a 45-min interactive session discussing case-related cervical pathologies, colposcopy, excisional treatment and technical and safety aspects of electrosurgery. The students then shifted to the hands-on training using our self-designed simulator. The simulation training is comprised of five practical practice sessions aiming at simulating a "type 1" excision [10, 11]. The aim is to achieve a cone thickness between 8 and 10 mm measured at the cervical canal, with a single cut. One tutor (ZT) evaluated this skill practice. All exercises took place outside of regular course hours and outside working hours.

Evaluation of technical skills: the LEEP score

The specimens were measured by a digital caliper at the dyed cervical canal according to recommendations of the International Federation for Cervical Pathology and

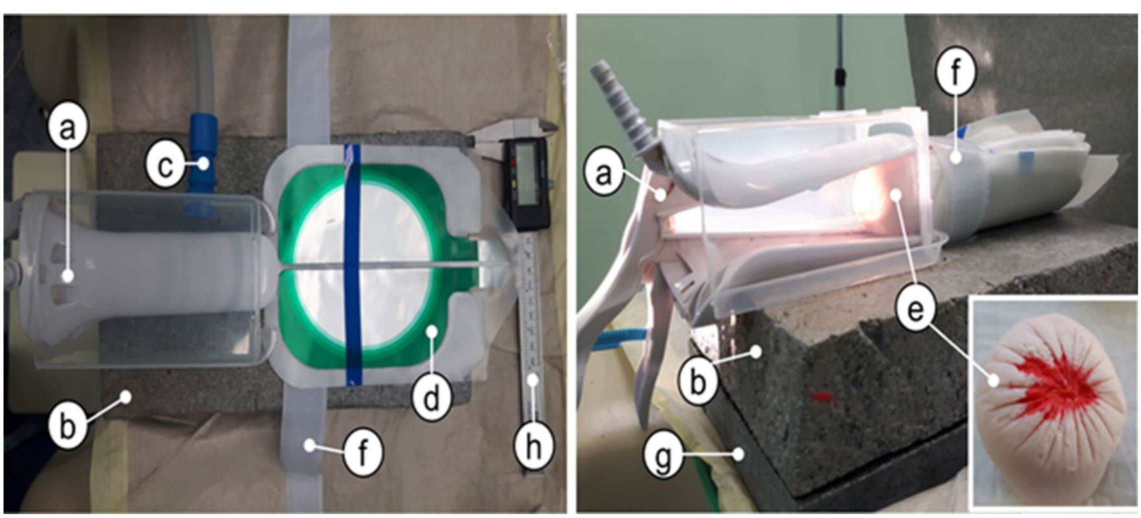

Fig. 1 LEEP simulator. **a** Speculum, **b** styrofoam plate, **c** smoke extractor, **d** neutral electrode, **e** sausage, **f** velcro, **g** stone plate, **h** colposcope, **i**caliper

Colposcopy in 2011 [10]. Depending on the depth and shape of the specimen, the students were given the choice whether to perform subsequent resections or not. The thickness of each specimen was added to calculate the total thickness.

The deviation from the target area shows how many mm was the total thickness of the specimen too deep or too shallow. The deviation from the desired cutting depth was calculated as follows: depth between 8 and 10 mm deviation = 0, with flatter (less than 8 mm) cuts, depth of cut minus 8 mm (for example, at 7 mm depth deviation = 7–8 mm = − 1 mm); for deep (more than 10 mm) cuts, depth of cut minus 10 mm (for example, at 12 mm depth deviation = 12–10 mm = 2 mm). To achieve the target depth of 8–10 mm, subsequent resections were allowed. We defined the number of excidates as the fragmentation of the cone. To determine the fragmentation and the depth of cut together, we established a LEEP score (Fig. 2). The LEEP score results from fragmentation and deviation. With the simple addition of the two parameters the best score would be 1. To be able to represent the score better, we decided to subtract 1 point; thus, the best grade becomes 0. For example, a 9-mm-thick conus (deviation = 0) with one cut (fragmentation = 1) minus 1 = 0. If

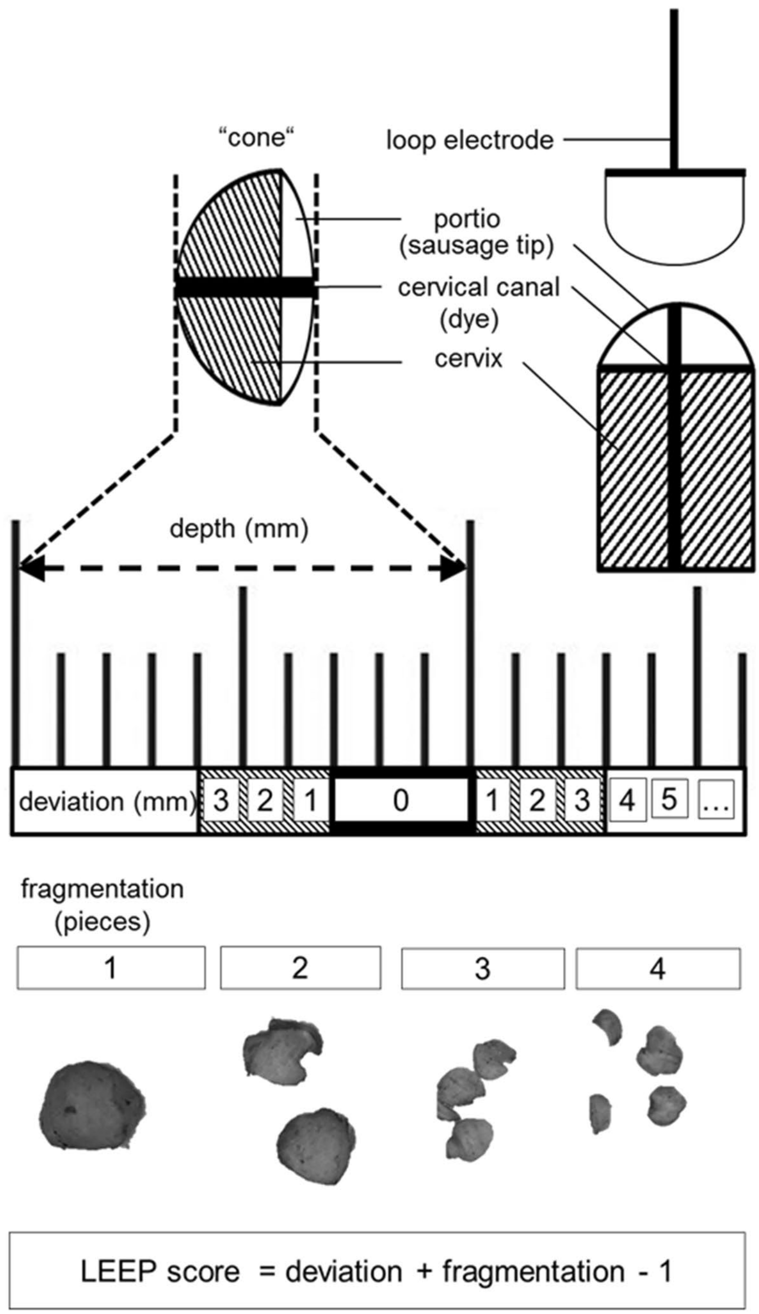

Fig. 2 The determination of the cone thickness and fragmentation, calculation of deviation and LEEP score

there is a deviation from the target depth or fragmentation of the conus, the score increases.

Curriculum evaluation

Following the course, we asked the students to evaluate the course using a standardized questionnaire as shown in Fig. 3. The Likert scale is an ordered scale used to assess attitudes by providing a spectrum of responses, for which the respondents select levels to which they 'agree' or 'disagree' [12]. Questionnaire respondents choose one option best fitting with their opinion. We chose a typical, five-point Likert scale with following categories: "1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree or 5 = strongly disagree". Considering our scale, the closer the median to 1, the more positive is the evaluation.

Statistical analysis

All variables are analyzed descriptively using mean and standard deviation for continuous variables and frequency counts for categorical variables.

The null hypothesis, that there was no change between the first and the fifths exercise, was tested using the paired *t* test for the approximately normally distributed variable "excision depth" and the Wilcoxon signed rank test for "deviation", "fragmentation" and "LEEP score". A comparison-wise two-sided significance level α of 5% is used.

All subjects providing data on the first and the fifths exercise are included in the statistical analyzes.

Results

Study population

The course was offered for 54 students, of which 32 (59.3%) participated. The students completed a total of 146 LEEP under direct colposcopic vision. Two students performed only one and two students performed only two exercises. Only the results of 28 students who did all 5 exercises were included in the statistical analyzes.

LEEP parameter

The results of the excisions are delineated in Table 1. Initially, the students did not cut deep enough and, therefore, needed more attempts to reach the desired depth. Later, as the depth of cut became increasingly more precise, fewer passes per excision were necessary. We found a significant

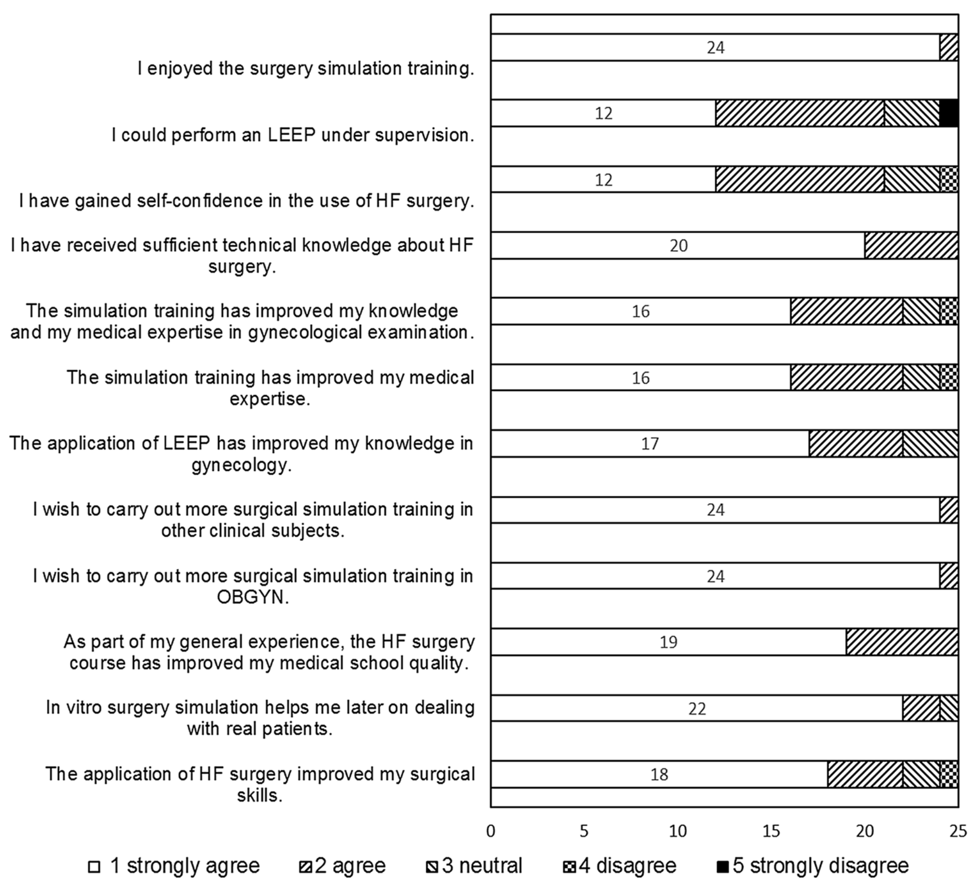

Fig. 3 Student questionnaire and evaluation. Bar chart represents the percentage of students in each answer category (1–5) and the number of students who strongly agreed. *HF surgery* high-frequency electrosurgery, *LEEP* loop electrosurgical excision procedure, *OBGYN* obstetrics and gynecology

Table 1 Main results

Simulation	Mean ± SD					p (1 vs 0.5)
$N = 28$	1	2	3	4	5	
Excision depth (mm)	7.34 ± 1.60	7.98 ± 2.21	8.14 ± 2.17	8.07 ± 1.53	8.54 ± 1.67	0.0041*
Deviation (mm)	0.88 ± 1.16	0.60 ± 1.41	0.60 ± 1.05	0.45 ± 1.01	0.13 ± 0.94	0.0116**
Fragmentation (pieces)	2.57 ± 1.26	1.71 ± 0.76	1.46 ± 0.69	1.21 ± 0.42	1.29 ± 0.60	< 0.0001**
LEEP score	2.59 ± 1.93	1.75 ± 1.43	1.54 ± 1.25	0.80 ± 1.41	0.84 ± 1.03	0.001**

p values compared first versus fifth repetition and were calculated using the paired t test (*) or Wilcoxon signed rank test (**)

reduction in deviation to the required 8- to 10-mm resection depth (0.88 vs. 0.13 mm, $p = 0.009$), lower number of resectates (2.57 vs. 1.29, $p < 0.0001$), and an improvement in the LEEP score (2.59 vs. 0.84, $p = 0.001$) between the first and last exercise.

Student evaluation

Figure 3 presents the results of the student questionnaire, and the mean Likert scores. For determining the reliability of the survey, internal consistency (Cronbach α) was used. The Cronbach α coefficient of the survey was 0.891 and the range of this coefficient for each item was 0.861–0.894. This indicated strong internal consistency and a high level of reliability.

Discussion

To our knowledge, we are the first to describe an undergraduate skill practice course for “type 1” LEEP using a self-designed simulator. Our simulator is designed for LEEP under local anesthesia, using direct colposcopic vision, similar to a model published by Wilson et al. [13]. We were able to show that simulation exercises improve students’ technical skills in implementing LEEP. The learning curve shows a linear improvement throughout the five repetitions regarding accuracy and fragmentation.

Recent LEEP simulation studies measured participants’ technical skills with Objective Structured Assessment of Technical Skills (OSATS) [9]. In addition to a procedure checklist (yes/no), the observer can also grade individual aspects of the procedure (e.g., unnecessary moves, instrument handling, knowledge of the instruments, flow of operation, etc.) on a five-point scale [9, 14]. This method allows a good assessment of trainee progress in the execution of the surgical procedure. However, it does not determine the main prognostic parameters (depth and fragmentation) for recurrence and late obstetric complications. In our study, we focus on the measurement of excision depth and the number of resections performed to achieve proper cone thickness. These parameters are significant to the patient’s oncological and obstetrical outcome. While an insufficient depth of excision increases the risk of post treatment disease, an excessive excision depth raises the risk of preterm birth in subsequent pregnancies [15, 16].

Good knowledge about the instruments is essential for surgical procedures. Prior to the practical course, we show the students the size of the loop electrode, especially how deep the loop must be embedded in the tissue to get the correct depth of excision. According to the students, this part of the course was the most helpful in performing a correct excision.

The direct feedback after each cut allowed the participants to correct their incision in case of a flat cone. However, several students stopped at a lower depth of cut to avoid too high total depth. Too flat excisions resulted in an increased number of subsequent resections to reach the required minimum excision depth (Fig. 4).

Only 53.9% of the students participated in the simulation training. Low participation rates of students in simulation training were also described by other authors [9]. One of these reasons may be the course’s schedule. All students had to complete the course after the official study time. Although we did not systematically evaluate this, according to the students’ statements, students who were more interested in other disciplines also participated in lower numbers. In addition, no incentives were offered for participation.

Integrating a simulation lab into undergraduate training is a challenging task. The course design must specify the objectives (the knowledge and skills to be learned) of the intended simulation exercise [17]. On the other hand, the costs of the instruments, premises and personal resource (teaching staff) pose a big challenge in the face of the decreasing budgets for undergraduate education and the critical financial situation of university hospitals [18].

Yet, these "investments" can be worthwhile later on in different levels [17]. A direct consequence of the undergraduate simulation exercises is the increased patient safety, and reducing medical errors as already demonstrated in simulation training on shoulder dystocia [19]. Van de Ven et al. calculated that through team training of shoulder dystocia, cost reduction in the patient care can be achieved, by reducing adverse neonatal outcome [20]. Undergraduate

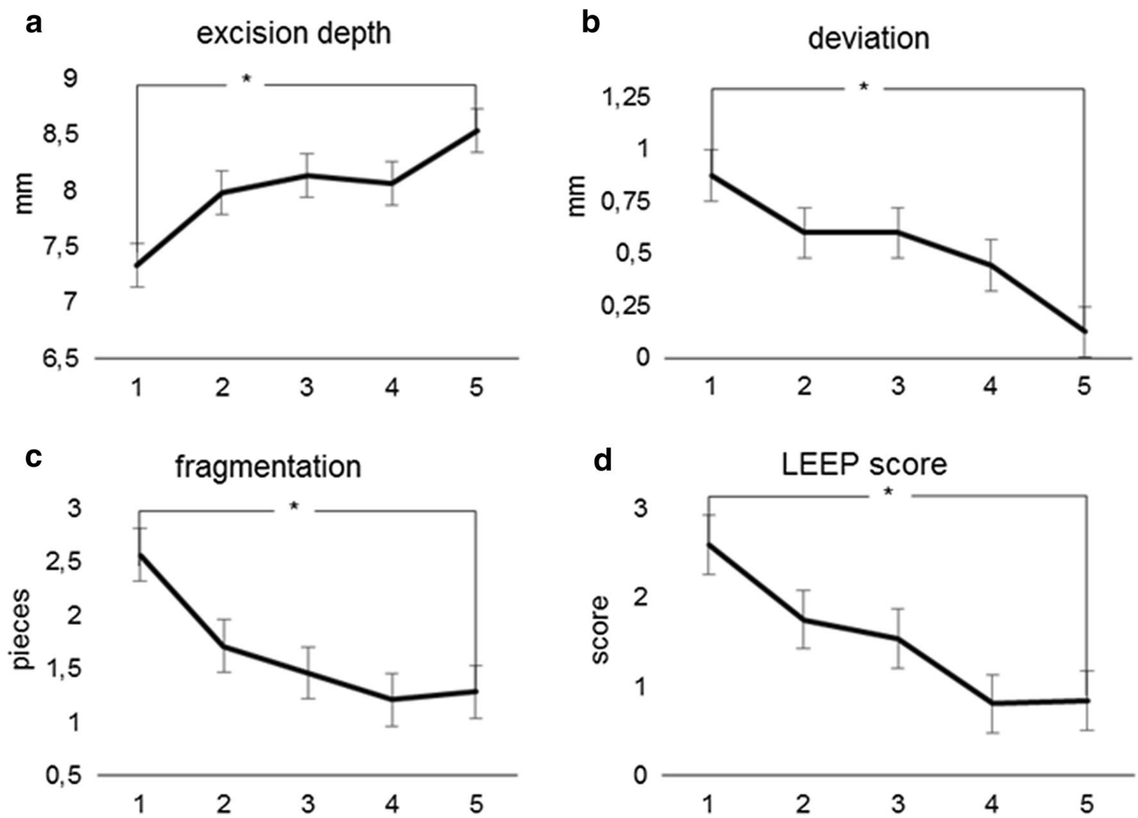

Fig. 4 Comparison of **a** excision depth, **b** deviation to target depth, **c** cone fragmentation and **d** LEEP score according to number of simulation repetitions (1–5) (*$p < 0.05$; **$p < 0.01$; **$p < 0.001$. Error bars represent the standard error of mean)

simulation-based surgical exercises can also impact later career choices. Several studies have investigated the reason for choosing an operative discipline by medical students [21–23]. In addition to role models, participation in surgical clerkship, involvement in surgical procedures, simulation training positively influence the choice for a surgical specialty [21–24]. Due to the declining numbers of residents, surgical disciplines may benefit from simulation trainings [21, 22, 25, 26]. Simulation training increase awareness of the surgical discipline and help to recruit new surgical students. Lee et al. were able to show the positive effects on the later career choice of participants 6 months–3 years after an endovascular skill simulation course [27].

Therefore, beside the scientific value of the course, we aimed at raising the interests of the participants. The students in our study were satisfied and requested further simulation courses in obstetrics and gynecology, as well as in other subjects. The practical exercises improved the students understanding of the pathomechanism, diagnosis and therapy of cervical precancerous lesions. The highest approval was given for questions about satisfaction with the course and whether the students want more simulation exercises in the curriculum. However, fewer students felt comfortable with the question if they would perform a LEEP on the patient (Fig. 3). In a cervical biopsy simulation, Manley et al. show that the participants most valued the possibility of practicing to deal with complications of a true biopsy. Before turning to a real patient, the simulation can reduce anxiety and increase self-confidence [3].

These courses cannot replace a real patient; however, practicing the procedure of excising cervical pathologies on the simulator prevents ethical disparities. It also acts as an alternative for students to learn when patients refuse to allow students to attend procedures. Simulation training is a safe way to apply previously acquired knowledge, and fits well in bloom's revised taxonomy of learning [17, 28, 29]. Didactic teaching methods only reach the basic levels of "remembering" and "understanding" of the cognitive processes [28]. According to Ericsson, expert performance like in music starts always with playing an instrument, but needs instructions from a teacher to avoid playing the same mistakes. In simulation training, it is important to mentor and give feedback to facilitate the learning process and to keep the trainees' motivation to improve themselves [30].

Although our study is relatively small, the number of participants is sufficient to show a statistically significant improvement in students' skills. If we would repeat the exercises after some time,probably no such learning curve would be seen. Skill retention is an important question for surgical training. Connor et al. stated that after an initial training of a simple task, lapses in practice did not impair the execution [31]. This requires further investigation along with minimum number of simulation exercises needed to safely perform the LEEP on patients. That the LEEP score at the fourth and fifth exercise is the same suggests that it may come to a plateau, reaching no further improvement (Fig. 4). This may mean that the minimum number of exercises can be at least 4–5, but this hypothesis must also be confirmed by further studies.

Conclusion

Using a simulator improves medical students' technical surgical skills in loop electrosurgical excisional procedures. Simulation training increases students' knowledge and foster the understanding for pathomechanism, diagnosis and therapy of cervical precancerous lesions. Students strive for more simulation training in gynecology and other medical fields. We introduced in our department the LEEP training in the clinical round week after this pilot study to enable our students to gain a better understanding of the diagnosis and therapy of cervical pathologies.

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Author contributions FZT: project development, data collection and analysis, manuscript writing. JCR: review and editing. CG: data analysis, review and editing. SF: data collection, review and editing. IJ-B: review and editing. EFS: review and editing. AH: review and editing.

Compliance with ethical standards

Ethical approval The study was approved by the Ethics Committee of Saarland (no: 259/17)

Conflict of interest We declare that we have no conflict of interest.

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