

# THE EVALUATION OF SURGICAL HAND RUBBING COMPLIANCE WITH THE USE OF FLUORESCENT ALCOHOL BASED HAND ANTISEPTIC ULTRAVIOLET LAMP METHOD

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## ABSTRACT

**Aims:** This study aims to evaluate the knowledge, attitude, and compliance of the students working in the sterile area of the operating room on the surgical hand preparation procedure using the ultraviolet lamp method.

**Methods:** The study was planned as a cross-sectional research and was carried out at the surgical technology department. This study was conducted with a total of 94 first- and second-year surgical technology students. The data was collected through "the introductory information, hand hygiene, and attitude form", and photographs were taken under a ultraviolet lamp after a surgical hand preparation procedure using fluorescent alcohol-based hand antiseptic. Compliance with surgical hand rubbing was evaluated based on the duration, technique, and efficiency of this procedure.

**Results:** The study was conducted on a total of 94 first- and second-year surgical technology students. Of the students, 67 (71.3%) were female, 52 (55.3%) were in the first year, and the most preferred surgical hand preparation procedure was surgical hand scrubbing (n=89, 94.7%). Only 19 (20.2%) of the students stated that they fully complied with the surgical hand preparation procedure. The students' knowledge was moderate, and their attitudes were positive. The median value for students' surgical hand preparation duration was 1.5 (1.24-2.51) minutes. The median alcohol-based hand antiseptic uncovered area percentage was larger for the left- and right-hand dorsal surfaces than the palmar surface. In both arms, the median percentage of the uncovered area was higher in the proximal than in the distal regions, whereas alcohol-based hand antiseptic intensity was lower in the proximal regions. The duration of surgical hand preparation was negatively correlated with the percentage of the area and positively correlated with the effectiveness of the procedure.

**Conclusion:** Students had a lack of knowledge and practice regarding the surgical hand rubbing/scrubbing procedure. Since the duration of surgical hand preparation was closely related to the technique and effectiveness, prolonging this period may improve the correct execution of this procedure. This is the first study to evaluate the effectiveness of UV lamps in surgical hand preparation procedures, and additional studies are needed.

**Keywords:** Alcohol-based hand rubs, operating room, students, surgical hand preparation, ultraviolet lamp

## INTRODUCTION

Surgical site infections (SSIs) are a serious problem that can cause prolonged and repeated hospitalizations, loss of labor, additional surgical procedures, increased treatment costs, and mortality (1, 2). The World Health Organization (WHO) has indicated that the incidence of SSIs is 11.2%, which means one

in three patients who underwent a surgical operation in low and middle-income countries have been affected by SSIs (1). In addition, this condition constitutes the second-most common cause of hospital-related infections in Europe and America (1).

According to the guidelines prepared by the WHO on the prevention of SSIs, preoperative surgical hand preparation takes place among factors that can be controlled (1, 2).



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Received: 19.07.2023 Accepted: 06.02.2024

**Cite this article as:** Köksoy Vayisoğlu S, Öncü E, Tubay Bağdatoğlu Ö et al. The evaluation of surgical hand rubbing compliance with the use of fluorescent alcohol based hand antiseptic ultraviolet lamp method. Turk Med Stud J 2024;11(1):13-22.



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Each person working in the sterile area of the operating room must perform the surgical hand preparation effectively to prevent contamination caused by medical personnel.

Surgical hand preparation may be carried out as surgical hand scrubbing (SHS) using antibacterial solutions and water or as surgical hand rubbing (SHR) using alcohol-based antiseptics (ABHA). Among these two methods, the preference for SHR is due to its ease of application as well as the absence of complications such as dryness on the hands, skin irritation, and allergic reactions due to SHS (3-6). However, studies carried out with medical personnel indicate that there are deficiencies in their knowledge and implementation of the SHR and SHS (7-9). Although it is stated that, along with medical personnel, students may also increase the risk of infection due to their lack of knowledge and skills, the number of studies evaluating the surgical hand preparation practices of students working in operating rooms is limited (10, 11).

The effectiveness of surgical hand preparation may be monitored using various methods. One of these methods is microbiological evaluation, in which bacteriological samples are taken from the surface of the hand and forearm before and after the procedure. Another one is the evaluation by the ultraviolet (UV) lamp method, which has been used frequently for hand washing control, yet there aren't any studies on its application for surgical hand preparation assessment in the literature. In this method, a disinfectant solution mixed with a fluorescent dye is used for surgical hand preparation, and the coverage of the hands and forearms is checked under a UV light lamp. The quality of the application of surgical hand preparation is suitable if all areas of the hands and forearms are covered homogeneously with the fluorescent hand rub solution (10-12).

In the evaluation of the compliance of the duration of SHR and SHS, the WHO guideline was accepted as a basis, and any duration under three minutes was evaluated as "unsuitable surgical hand rubbing" (1). Effective application of surgical hand preparation can be expected only from qualified and trained staff personnel (11). It is important for the operating room nurses, who are members of the professional staff that play a key role in transferring sufficient knowledge and skills to the students, to know the knowledge and technical application levels of the students on surgical hand preparation in terms of ensuring patient safety and eliminating deficiencies in this regard (13).

This study aims to objectively evaluate the surgical hand preparation performance of the students working in the sterile field in the operating room considering their knowledge, compliance, and attitude by using the UV lamp, which is preferred due to its advantages such as easy application, immediate and well-visible results, and low cost. This is the first study in the literature on the assessment of SHR compliance using the UV lamp method.

## MATERIAL AND METHODS

Ethical approval of this study was granted by the Mersin University Clinical Research Ethics Board (decision no: 128,

date: 20.03.2019), institutional permission was granted by the vocational school of health services, and written consent was given by the students.

The study was planned as a cross-sectional research and was carried out at the surgical technology (ST) Department of the Vocational School of Health Services of Mersin University in Türkiye between April 15 and April 30, 2019. Around 60% of the curriculum of the ST department, which lasts four semesters (two years), consists of surgery room practice, with students starting in their first year and working in the sterile area under the of surgery nurses. Students receive a four-hour surgical hand preparation training following WHO standards.

### Sample

The study was carried out with the participation of 94 ST students who attend their classes regularly, do not have any dermatological problems on their hands, and agreed to participate in the study among 103 registered students in the ST program during the spring semester of the 2018-2019 academic year.

### Measurement Tools

Research data was evaluated through Introductory Information, Hand Hygiene Information, and Attitude Form and "digital photographs" taken after SHR and SHS.

#### Introductory Information, Hand Hygiene Information, and Attitude Form

The content validity of the form, which was created through a literature review, was evaluated by a nurse who has served on an infection control committee and three instructors (4, 10, 13). The form consisted of 40 questions and four sections (Appendix 1). The first section included four questions about demographic information about the students and five questions about their evaluations of the surgery room in which they practice the surgical hand preparation procedure. In the second section, there were 10 questions regarding the purpose, duration, and steps of surgical hand preparation. Correct answers were given one point, and wrong answers were given zero points.

In the third section, there were 12 attitude statements regarding the necessity, difficulty, and effectiveness of surgical hand preparation (e.g., Following surgical hand preparation implementation steps one by one is annoying, surgical hand preparation is unnecessary when sterile gloves are worn). The responses were collected using a five-point Likert scale (absolutely disagree: one point, strongly agree: five points), and a total score was calculated based on the responses given to all questions. The lowest score that could be obtained was 12, and the highest score was 60. High scores were evaluated as a "positive attitude towards surgical hand preparation".

In the fourth section, there were nine questions about how often they complied with the principles of surgical hand asepsis during the surgery room implementation (e.g., I wash

my hands when entering and leaving the operating room, cut my nails short, and do not wear jewelry). For the evaluation of compliance with SHR and SHS, surgical hand preparation duration was measured, and photographs of the palmar and dorsal surfaces of the right and left hands and forearms were taken after surgical hand preparation under a UV lamp with a 12-megapixel camera (Nikon Digital Camera D3400, Nikon Corporation, Japan) in two shots. Photographs were evaluated in terms of the SHR and SHS technique (ABHA uncovered area) and effectiveness (ABHA intensity).

#### Study Protocol and Data Collection

Surveys were conducted in a classroom environment. It took about 15 minutes for the students to answer all the questions. The following day, the surgical hand preparation procedure was performed in the application laboratory under the supervision of two researchers. The training set was used to evaluate compliance with SHR and SHS. The set included ABHA with a fluorescent substance [two drops of phosphorous substance (disodium distyrylbiphenyl disulfonate) were added to 500 mL of ABHA] and a black box (76x43x43 cm) with a UV lamp. Students were admitted to the laboratories one by one so that they were not influenced by each other. Each student was asked to perform surgical hand preparation the same way they do during regular practice. The students performed the surgical hand preparation procedure using as much ABHA as they deemed sufficient. Without informing the students, a researcher whom the students did not know kept track of the time between the students taking ABHA and them finishing the implementation and declaring that they were ready.

The photographs were taken in a dark environment created with curtains at the student laboratory. Each student was given a code number, and the dorsal (D) and palmar (P) surfaces of their right (R) and left (L) hands (H) and forearms (FA) were photographed twice. After the photographing process, the areas uncovered by ABHA or where its intensity was low were shown to the student. Reminders were made regarding the steps they missed in the surgical hand preparation technique.

The photographs were evaluated visually on a computer by two independent researchers who were not involved in the photography process, according to the intensity of the areas covered by ABHA (bright blue areas). The evaluation criteria, which were described in our previous study, were used to determine the hand area (10). The surface area of a hand was calculated in cm<sup>2</sup> and converted into a percentage value. The dorsal/palmar area and percentages of a hand were determined as 14.5% for the thumb, 34.5% for the other fingers, 51% for the metacarpal area, and 100% for the total area (10).

A similar method was used for the evaluation of the forearm. The surface area of a forearm (the area between 2 cm above the wrist and elbow) was calculated in cm<sup>2</sup> and converted into a percentage value. Then, the lengths of the distal and

proximal regions were calculated by dividing the length of the forearm into two equal parts. After this calculation, 40% of the total forearm area was found to be the distal part and 60% of the proximal part. To make this evaluation more sensitive, the proximal and distal areas were divided into four equal regions. Each of the dorsal and palmar surfaces of the forearm was evaluated to be 100% in total. (Figure 1).

Fluorescent ABHA intensity was used to evaluate surgical hand preparation effectiveness. The areas with the highest brightness under the UV lamp were considered "three" and the areas that looked completely black and were not bright were evaluated as "zero" on a four-point scale.

Compliance with surgical hand preparation was evaluated under the duration, technique (ABHA uncovered area), and effectiveness (ABHA intensity) of surgical hand preparation sub-headings.

#### Statistical Analysis

The evaluation of the data was carried out in a computer environment (IBM SPSS Statistics 26.0). The inter-observer agreement (absolute agreement) was evaluated with the intraclass correlation coefficient (ICC) [95% confidence intervals, single measure 0.772 (0.409-0.892), degrees of freedom: 93, p<0.001]. The fact that ICC is between 0.75 and 0.90 has been considered good reliability (14).

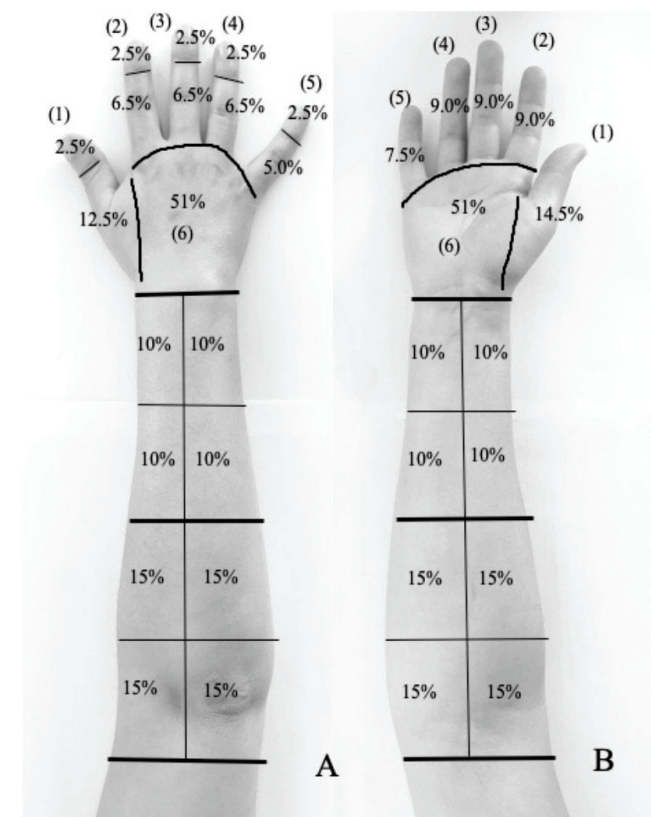


Figure 1: The surface area of a hand and forearm was calculated in cm<sup>2</sup> and converted into a percentage value. The dorsal (A) and palmar (B) areas and percentages of a hand were determined in the figure.

The normal distribution of the data was determined with the kurtosis and skewness coefficient. In descriptive statistics, number (percentage), mean  $\pm$  standard deviation, or median (25-75%) was used. Independent samples t-test, or Mann-Whitney U test were used in comparison of numeric variables between groups. The relationship between continuous data was determined by Spearman's rank correlation. The value of  $p < 0.05$  was accepted as significant. To calculate the percentage of the uncovered area, the ABHA-covered area score was subtracted from the surface area score and proportioned to the surface area score. For example, the dorsal hand 6<sup>th</sup> zone uncovered area is calculated as follows: [(51-ABHA covered area of the 6<sup>th</sup> zone)  $\times$  100  $\div$  51].

## RESULTS

The mean age of students was 20.83 $\pm$ 3.09 (18-38) years. When we look at the participants, 67 (71.3%) were women, 52 (55.3%) were in their first year, and 85 (90.4%) of them were right-handed. In the operating room where they regularly practice, there were 16 (17.0%) people who found inspections of hand preparation insufficient, 91 (96.8%) people who found the areas for surgical hand preparation adequate, and 68 (72.3%) people who thought the materials were often sufficient. While 89 (94.7%) of them preferred SHS and 5 (5.3%) of them preferred SHR for surgical hand preparation, 19 (20.2%) of the students stated that they fully comply with the surgical hand preparation procedure. Students' mean scores for knowledge were 5.03 $\pm$ 1.6 (1-8) and for attitude 47.05 $\pm$ 5.21 (29-60). In addition, the mean frequency of the behavior according to the principles of surgical hand asepsis was found to be 33.50 $\pm$ 3.69 (23-41) (Table 1).

### SHR Technique (ABHA Uncovered Area)

The median ABHA uncovered area percentage was larger for the left and right dorsal surfaces than the palmar surface, and the difference between the palmar and dorsal surfaces on the left hand was found to be statistically significant ( $z=219$ ,  $p=0.03$ ) (Figure 2).

There was a difference in the median percentage of ABHA uncovered area between the distal and proximal regions of both the right and left forearms ( $p < 0.001$ ). The median percentage of the uncovered area was higher in proximal areas (Figures 3, 4).

### Effectiveness of Surgical Hand Preparation (ABHA Intensity)

When the effectiveness of surgical hand preparation was evaluated according to the intensity level of fluorescent ABHA on areas, it was seen that the effectiveness decreased towards hand dorsal surfaces. However, there were no differences among ABHA intensity score medians. The effectiveness decreases from proximal to distal arm areas. There were differences among ABHA intensity score medians ( $p \leq 0.001$ ) (Figures 3, 4).

**Table 1: Introductory features of students and their views on the operating room.**

Features	n (%)
<b>Sex</b>	
Female	67 (71.3)
Male	27 (28.7)
<b>Year</b>	
First-year	52 (55.3)
Second-year	42 (44.7)
<b>Dominant hand</b>	
Right	85 (90.4)
Left	9 (9.6)
<b>Surgical hand preparation duration</b>	
Sufficient	16 (17.0)
Insufficient	78 (83.0)
<b>The most preferred surgical hand preparation procedure in the operating room practice</b>	
Surgical hand scrubbing	89 (94.7)
Surgical hand rubbing	5 (5.3)
<b>Evaluation of compliance with the surgical hand preparation procedure in practice (self-evaluation)</b>	
Never	1 (1.1)
Some	7 (7.4)
Highly	67 (71.3)
Fully	19 (20.2)
<b>Opinion on the adequacy of the areas of surgical hand preparation in the operating room</b>	
Adequate	91 (96.8)
Inadequate	3 (3.2)
<b>Opinion on the adequacy of surgical hand preparation materials in the operating room</b>	
Always	3 (3.2)
Mostly	68 (72.3)
Sometimes	20 (21.3)
Rarely	3 (3.2)
<b>Opinion on the adequacy of the compliance controls for surgical hand preparation in the operating room</b>	
Always	21 (22.3)
Mostly	31 (33.0)
Rarely	26 (27.7)
Inadequate	16 (17.0)
<b>Total</b>	<b>94 (100)</b>
<b>Mean <math>\pm</math> SD</b>	
Knowledge of surgical hand rubbing	5.03 $\pm$ 1.6 (1-8)
Attitude for surgical hand rubbing	47.05 $\pm$ 5.21 (29-60)
Behavior in accordance with the principles of surgical hand antisepsis	33.50 $\pm$ 3.69 (23-41)

SD: Standard deviation

**Duration of Surgical Hand Preparation**

The median duration of surgical hand preparation was 1.5 (1.24-2.51) minutes, and only 16 (17.0%) of the students were suitable to give sufficient time to this preparation. Although there was

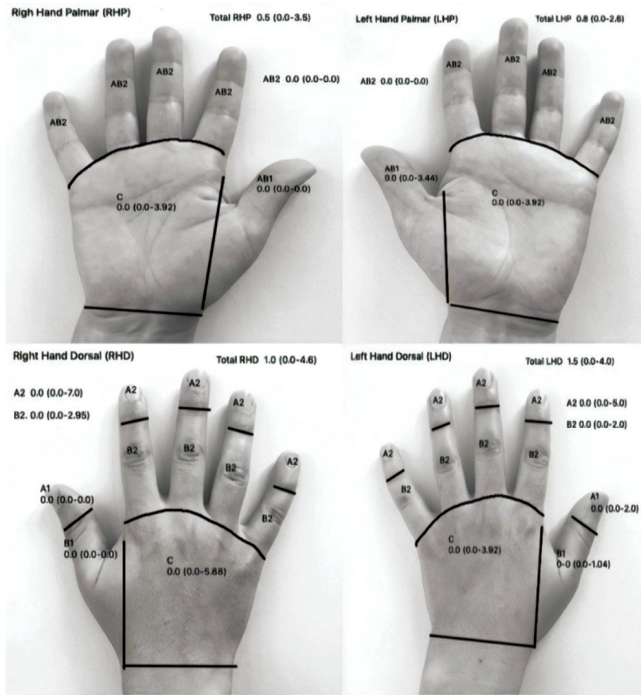
no statistical difference compared to gender in terms of the duration of surgical hand preparation median scores, it was higher among the students in their first year compared to those in their second year ( $u=662.0, p=0.001$ ) (Table 2). There was no significant correlation between surgical hand preparation duration and knowledge and attitude scores ( $p>0.05$ ).

**Relationship Between Duration, Technique, and Effectiveness of Surgical Hand Preparation**

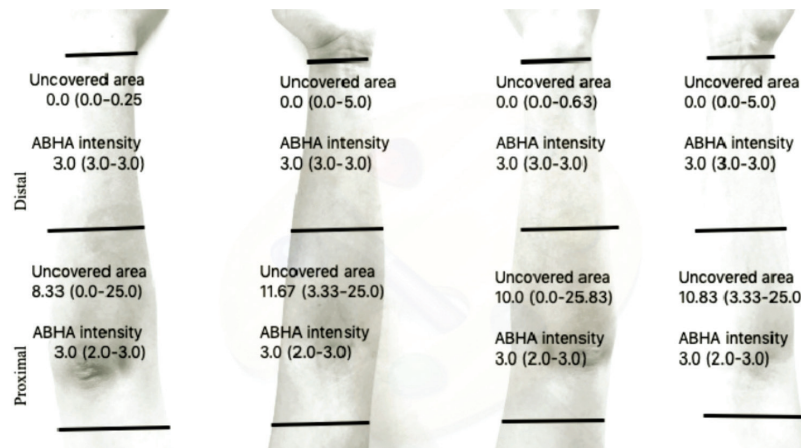
As the SHR and SHS duration decreased, the percentage of the uncovered area increased, whereas the duration of surgical hand preparation increased, and the effectiveness of the implementation increased. While there was no difference between first and second years in terms of knowledge, attitude, score medians, and ABHA intensity on hands and forearms, second years scored higher in terms of frequency of behavior appropriate to the surgical hand asepsis principles median scores ( $t=2.99, p=0.004$ ) (Table 2) and the median of ABHA uncovered area on the right hand (Table 3).

**DISCUSSION**

In this study, the knowledge, attitude, and compliance of ST students who practice in sterile areas in the operating room were evaluated. It was observed that the students answered approximately half of the knowledge questions regarding surgical hand preparation incorrectly, which shows that they lack information about the matter. It is also indicated that the operating room nurses and surgeons have insufficient knowledge in terms of the technique of surgical hand preparation, and only 3.1% of them correctly know the necessary duration for the surgical hand preparation (7, 15). The wrong examples they saw in implementation may have caused the students to have insufficient knowledge.



**Figure 2:** The distribution of median uncovered alcohol-based hand antiseptic area scores on the dorsal and palmar surfaces of hands [(RHP-RHD:  $z=1.73, p=0.09$ , total right hand 2.0 (0.3-3.6), LHP-LHD:  $z=2.19, p=0.03$ , total left hand 1.5 (0.3-3.8) ( $z=0.51, p=0.61$ )]. RHP: Right hand palmar, RHD: Right hand dorsal, LHP: Left hand palmar, LHD: Left hand dorsal



Total left forearm dorsal surface uncovered area: 5.5 (0.0-15.0) Distal-proximal uncovered area: $\leq 0.001/7.02$ ABHA intensity: $\leq 0.001/4.82$	Total left forearm palmar surface uncovered area: 8.5 (2.0-17.0) Distal-proximal uncovered area: $\leq 0.001/6.89$ ABHA intensity: $\leq 0.001/5.38$	Total right forearm dorsal surface uncovered area: 6.0 (0.8-19.0) Distal-proximal uncovered area: $\leq 0.001/6.78$ ABHA intensity: $\leq 0.001/4.95$	Total right forearm palmar surface uncovered area: 7.0 (2.0-19.0) Distal-proximal uncovered area: $\leq 0.001/7.10$ ABHA intensity: $\leq 0.001/4.95$
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**Figure 3:** The distribution of the median percentage of alcohol-based hand antiseptic uncovered areas on the forearm surfaces. ABHA: Alcohol-based antiseptics

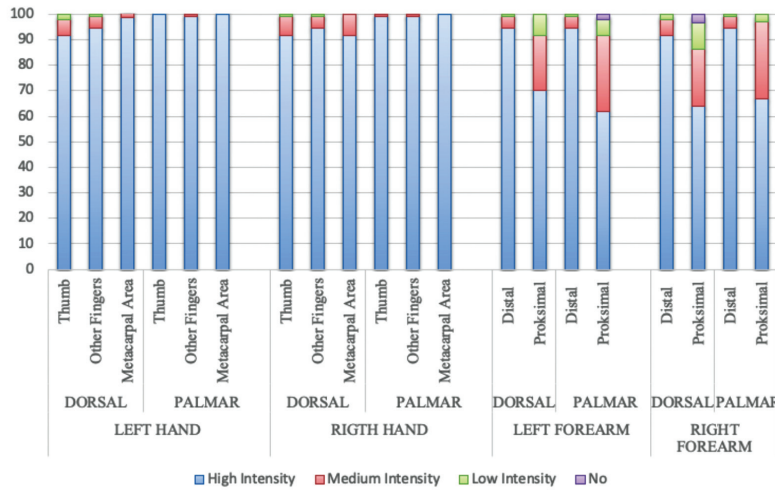


Figure 4: Intensity distribution of alcohol-based hand antiseptic on the hands and forearms.

Table 2: The distribution of median duration, knowledge, attitude, and behavior of surgical hand preparation in accordance with the principles of surgical hand antiseptics according to class and gender.

	Median knowledge scores of surgical hand preparation	Median attitude scores of surgical hand preparation	Median scores of behavior in accordance with the principles of surgical hand antiseptics	Median surgical hand preparation duration
First-year students	5.09±1.46	47.53±4.81	32.51±3.56	2.13 (1.34-3.09)
Second-year students	4.95±1.73	46.45±5.66	34.71±3.50	1.35 (1.162-2.11)
<b>t/df/p</b>	0.44/92/0.66	1.00/92/0.32	2.99/92/ <b>0.004</b>	U:662.0/ <b>0.001</b>
Female	5.13±1.58	47.50±4.94	33.71±3.53	1.45 (1.24-2.32)
Male	4.77±1.57	45.92±5.76	32.96±4.07	2.0 (1.24-3.13)
<b>t/df/p</b>	0.99/92/0.33	1.33/92/0.18	0.89/92/0.37	U:768.5/0.25

\*t: Student t-test, df: Degrees of freedom, u: Mann-Whiney U test, p: P-value

Table 3: The relationship between surgical hand preparation time, technique and effectiveness and the distribution of exposed areas in the hands according to classes.

		Hand (total)	Forearm (total)
Right	<b>Uncovered area</b> (Technique of surgical hand preparation)	r: -0.230 p: <b>0.026</b>	-0.189 0.067
	<b>ABHA intensity</b> (Effectiveness of surgical hand preparation)	r: -0.029 p: <b>0.784</b>	0.217 <b>0.036</b>
	<b>Uncovered area</b>		
	First-year students	Median (25-75%) 0.88 (0.14-3.26)	10.25 (5.0-17.0)
	Second-year students	Median (25-75%) 2.75 (1.67-4.06)	4.25 (0.88-19.13)
	U; p	790; <b>0.020</b>	896; 0.135
Left	<b>Uncovered area</b> (Technique of surgical hand preparation)	r: -0.235 p: <b>0.023</b>	-0.211 <b>0.041</b>
	<b>ABHA intensity</b> (Effectiveness of surgical hand preparation)	r: -0.134 p: <b>0.199</b>	0.302 <b>0.003</b>
	<b>Uncovered area</b>		
	First-year students	Median (25-75%) 1.25 (0-2.65)	9.0 (4.5-14.5)
	Second-year students	Median (25-75%) 2.0 (1.0-4.32)	4.5 (0-18.75)
	U;p	866.5; 0.084	902.5; 0.149

U: Mann-Whitney U test, r: Spearman's rank correlation test , p: P-value, ABHA: Alcohol-based antiseptics

Although the students' knowledge about surgical hand preparation was not at the desired level, the fact that they had a positive attitude about surgical hand preparation may be motivating in supporting their development and eliminating their lack of knowledge and practice on the subject.

It is stated that for compliance with surgical hand preparation, in-service training, an appropriate environment for hand preparation, sufficient materials, adequate inspections, and an institutional policy should exist (4). Although almost all the students participating in this study thought that the operating room environment was suitable for surgical hand preparation, three out of ten students stated that the materials were insufficient, and four students stated that there was a lack of supervision. In this context, in-house facilities and supervision can increase students' as well as the surgical team's knowledge of surgical hand preparation and help them apply the technique correctly.

Although direct observation is the gold standard for evaluating the surgical hand preparation technique, checklists were not used in this study to avoid influencing students (13). Instead, they were evaluated on the ABHA-uncovered areas with the help of a UV lamp. The application was strengthened by showing uncovered areas and areas with decreasing intensity to the students. Evaluation of suitability for hand hygiene with the help of a UV lamp does not show purification from pathogens, but it can be used in training as it allows visual inspection (9, 11, 16). Evaluation with UV lamps has been used mostly for hand washing control, but there is no study on surgical hand preparation assessment in the literature. Lehotsky et al. (12) reported that the UV-dye-based hand washing assessment method is a true and reliable indicator of correctly disinfected and pathogen-free areas on the hand surface. We think that the UV test method is easily applicable to and suitable for the evaluation of surgical hand preparation. It was suitable for revealing the errors and demonstrating the development of skills for the education and training of students (10, 11). Also, this method has immediate visual control over the surgical hand preparation. Therefore, direct feedback may support the correction of wrong practices.

While appropriate ABHA, sufficient time, and correct technique are required for effective surgical hand preparation, in the present study, ST students were found to have problems complying with the duration and technique of surgical hand preparation. Although one out of every five students thinks that he or she complies with the surgical hand preparation procedure, only one out of six students has been found to have a suitable duration for surgical hand preparation. Similarly, it has been reported that there are problems with the compliance of the operating room team with the duration of surgical hand preparation (7, 9, 17). Oriol et al. (3) reported that 10% of the personnel had a duration of under one minute for the surgical hand preparation procedure. Similar to this result, Jeyakumar (8) reported that this procedure lasted less than two minutes, and Laurikainen et al. (18) stated that more than half of the personnel did not comply with the three-minute duration.

Although studies are reporting that a 1.5-minute implementation is as effective as a 3-minute implementation in reducing the colonization of microorganisms, in the WHO guideline it is stated that the appropriate time for surgical hand preparation is between 3-5 minutes, and the company recommendation should be followed according to the ABHA content (1, 19, 20). In our study, it was observed that compliance with time was important since the uncovered areas increased when the duration of surgical hand preparation got shorter, and the students were more effective in implementing on their forearms when the duration of surgical hand preparation got longer. Although the of surgical hand preparation is important in order to fully implement the technique and ensure an adequate time of skin contact with ABHA, it has been observed that there are problems complying with the duration. Increasing interventional studies that will increase the compliance of students and health personnel in operating rooms with the duration of surgical hand preparation and ensure their dissemination in the field may contribute to the solution of the problem.

In our study, it was also observed that the duration was important but not solely sufficient. Effective surgical hand preparation was achieved by applying ABHA long enough and with the correct technique on the hands and forearms. The fact that although the SHR and SHS duration of the first-year students was longer, they had more uncovered areas on their forearms compared to second-year students. This result showed that the length of education increased compliance with the surgical hand preparation technique. It was reported that the increase in total employment and the increase in time spent in the operating room increased staff nurses' compliance with surgical hand preparation (7). In a study conducted with medical students, it was observed that surgical hand preparation compliance increased, and the areas uncovered by ABHA decreased in the last weeks of the theoretical and practical training given gradually throughout the term (11). On the contrary, studies are showing that working time in the operating room is not related to surgical hand preparation (8).

In our study, although the time spent in training increased compliance with surgical hand preparation, it was also observed that the students had deficiencies in the correct and effective application of the technique. Likewise, it is stated in the literature that operating room personnel have deficiencies in applying the technique regarding surgical hand preparation (4, 7, 8, 11). In one study, only 4 out of 34 surgical hand preparation procedures were reported to complete all steps correctly (4). In other studies, 48% of the nurses had insufficient surgical hand preparation techniques, and it was reported that the operating room personnel did not follow the forearm implementations adequately (7, 8, 18). In the study conducted by Schwartz et al. (4), it was shown that hand rubbing implementation, which is at the end of the surgical hand preparation implementation steps, was the most frequently skipped step. In another study, it was observed that participants allocated more time to hand rubbing

than they should have, but their forearm implementation duration and total duration were insufficient (8). The inadequacy of the operating room personnel to comply with the surgical hand preparation technique is important in terms of not being suitable role models for the students.

The World Health Organization recommends SHR or SHS methods for surgical hand preparation (1). Although the effectiveness of SHR is shown and its prevalence is increasing, almost all the students stated that they preferred to use SHS (21). The adequacy of the method, environment, and materials used by the surgical team in the practice environment may have been effective in satisfying this preference of the students who learned both methods in theoretical courses.

The fact that hand and forearm photographs could not be evaluated through a computer program in three dimensions is an important limitation of this study. For this reason, detailed guidance on the evaluation of the photographs has been prepared, the observers have been trained before the evaluation, and the inter-observer compliance has been evaluated statistically. However, the dry or moist hands and forearms, skin resistance differences, hairs on the arms, and the fluorescent material may have caused a difference. Also, since it is the only surgical technician school in our region and this study was carried out in that school, the number of people participating in this study was low.

## CONCLUSION

The results of this study show that using fluorescence-marked ABHA can be considered a good choice in evaluating compliance with surgical hand preparation. It was observed that ST students have deficiencies in compliance with their knowledge and practice about surgical hand preparation. The duration of surgical hand preparation is closely related to technique and effectiveness, and the time spent in practice can improve the students' application skills. It will be important for the operating room personnel, who are involved in the practical training of the students, to observe the students, give feedback to them, and be appropriate role models to increase compliance with surgical hand preparation and ensure patient safety in order to complete the deficiencies of the students in this regard. In future studies, it is recommended to evaluate the effect of interventional studies that aim to increase collaboration with personnel on student compliance.

**Ethics Committee Approval:** Ethical approval of this study was granted by the Mersin University Clinical Research Ethics Board (decision no: 128, date: 20.03.2019).

**Informed Consent:** Written consent was given by the students.

**Conflict of Interest:** The authors declared no conflict of interest.

**Author Contributions:** Surgical and Medical Practices: S.K.V., E.Ö., Ö.T.B., Z.K., Concept: S.K.V., E.Ö., Ö.T.B., Z.K., Design: S.K.V., E.Ö., Ö.T.B., Z.K., Data Collection or Processing: S.K.V., E.Ö., Ö.T.B., Z.K., Analysis or Interpretation: S.K.V., E.Ö., Ö.T.B., Z.K., Literature Search: S.K.V., E.Ö., Ö.T.B., Z.K., Writing: S.K.V., E.Ö., Ö.T.B., Z.K.

**Financial Disclosure:** The authors declared that this study received no financial support.

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## Appendix 1. Surgical Hand Preparation Evaluation Questionnaire

### Section 1.

1. Age.....

2. Sex

Female  Male

3. Grade

First year  Second year

4. Which is your dominant hand?

Right  Left

5. Do you think the inspections regarding surgical hand rubbing in the operating room are sufficient?

Yes  Mostly  Rarely  No

6. Are there sufficient materials for hand rubbing in the operating room?

Yes. If your answer is yes, how often?  Always  Mostly  Sometimes  Rarely  No, never

7. Are there sufficient areas for hand rubbing in the operating room?

Yes  No

8. How much of the recommended surgical hand rubbing procedure do you believe you can perform?

None  Some  Highly  Completely

9. Which one do you mostly prefer for surgical hand hygiene?

Surgical hand washing

Surgical hand rubbing (with alcohol-based antiseptics)

Surgical hand rubbing duration: .....second

### Section 2. Knowledge

Indicate whether each of the following statements is true	True	False	I don't know
1. The amount of antiseptic used for surgical hand rubbing is irrelevant.			
2. Surgical hand rubbing time with hand antiseptic is fixed.			
3. The active ingredient of the antiseptic solution used determines the duration of hand rubbing.			
4. The purpose of surgical hand rubbing is to eliminate only temporary flora.			
5. After surgical hand rubbing, wet areas can be dried with a sterile towel.			
6. In the surgical hand rubbing process, first all surfaces of the hands and then the forearm are rubbed with antiseptic solution.			
7. Surgical gloves prevent contamination even when surgical hand hygiene is not properly performed.			
8. Just rubbing your hands between two surgeries is sufficient.			
9. Surgical hand rubbing may be preferred as long as there is no visible contamination.			
10. Surgical hand rubbing should last at least 3 minutes before the first case of the day.			

### Section 3. Attitude

Please read each item and think about yourself and indicate how much you agree with the following statements regarding surgical hand preparation.

There is no right or wrong answer.

I strongly disagree

I disagree

I neither agree nor disagree

I agree

I strongly agree

1. It is very frustrating to have to follow the exact procedures for surgical hand rubbing.
2. It is unnecessary to follow the exact procedures for surgical hand rubbing.
3. It is unnecessary to perform surgical hand scrubbing up to the elbows.
4. It is a waste of time to follow the exact procedures related to surgical hand rubbing.
5. I believe it is a professional responsibility to comply with procedures regarding surgical hand rubbing.
6. Warnings regarding surgical hand hygiene in surgical hand washing areas draw my attention.
7. Surgical hand rubbing with alcohol-based hand antiseptic is more effective than surgical hand washing
8. Surgical hand rubbing with alcohol-based hand antiseptic is safer than surgical hand washing
9. Surgical hand rubbing with alcohol-based hand antiseptic is more comfortable than surgical hand washing
10. Surgical hand rubbing with alcohol-based hand antiseptic is easier than surgical hand washing
11. I don't believe in the effectiveness of surgical hand rubbing with alcohol-based hand antiseptic
12. If sterile gloves are used, I think surgical hand rub unnecessary.

### Section 4. Behavior

Please indicate how often you do the following behaviors.

Never

Rarely

Sometimes

Mostly

Always

1. When I enter the operating room from outside, I wash my hands with soap and water.
2. When I enter the operating room from outside, I rub my hands with alcohol-based hand antiseptic.
3. I wash my hands when leaving the operating room
4. I rub my hands with alcohol-based hand antiseptic when leaving the operating room.
5. I rub my hands with antiseptic for a longer time before the first surgery of the day.
6. Between surgeries, I only rub my hands with hand antiseptic.
7. I don't come to the operating room with jewelry such as rings, watches, etc.
8. On days when I will be in the operating room, my nails are always short.
9. I follow the recommended procedures for surgical hand rubbing step by step.