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Hand Scrub Methods and Their Effect on Bacterial Flora

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Abstract

Background: Hand disinfection is a critical component of infection control in surgery. Various solutions and techniques are used for hand scrubbing, but these often produce conflicting results.

Objectives: This study aims to compare the effectiveness of four different hand scrubbing techniques in reducing hand bacterial colonies.

Methods: A total of 30 participants were selected through convenience sampling based on specific criteria. They were randomly assigned to perform one of four hand scrub techniques: (1) Iodine scrub alone; (2) Decocept alone; (3) a combination of iodine scrub followed by Decocept; and (4) a combination of Decocept followed by an iodine soak. Microorganism cultures were taken before, immediately after, and one hour after scrubbing. Staff satisfaction was measured after each method using the Visual Analog Scale (VAS).

Results: The study examined the effectiveness of the four scrubbing techniques in reducing skin microorganism levels. Coagulase-negative *Staphylococcus* was the most frequently detected microorganism, appearing in the majority of cases, with no significant variation between the groups. While all scrubbing methods reduced microbial counts, no statistically significant differences were found between the techniques.

Conclusions: The use of Decocept alone may be considered a viable alternative to other hand scrubbing methods in operating rooms.

Keywords: Surgical Scrubbing, Betadine, Decocept, Bacterial Colony

1. Background

Failure to adhere to proper health protocols in healthcare settings not only jeopardizes patient safety but also presents a significant challenge to medical centers (1). Studies show that approximately 10% of infections in these facilities result from inadequate compliance with health guidelines. These infections, ranging from minor to severe, lead to prolonged hospital stays, increased treatment costs, and, in severe cases, can result in disability or death. Consequently, hospitals experience increased workloads, requiring additional care and resources to manage these preventable complications, which places a considerable burden on nursing staff (2). Efforts to prevent these infections, which stem from poor adherence to health protocols, have become a primary goal for nursing teams. Numerous solutions have been proposed, focusing on effectiveness, simplicity, and cost-efficiency. One standout strategy involves preventing the transmission of microbial agents and diseases from healthcare staff to patients through meticulous hand hygiene practices (3).

Hand hygiene is globally recognized as a priority, playing a crucial role in reducing infection rates in healthcare environments. The Centers for Disease Control and Prevention (CDC) have developed a comprehensive and regularly updated guide incorporating the latest research in this field (4). This resource underscores the importance of proper hand hygiene, particularly during invasive medical procedures and specific nursing practices that compromise the skin's natural barrier. Failure to maintain adequate hand hygiene in these situations significantly increases the risk of infection transmission. The Association of Operating Room Nurses has highlighted the ongoing need to study hand scrubbing techniques to improve clinical care practices (5). As a result, ensuring hand disinfection before nursing procedures has become mandatory to minimize hand-based microorganisms. Despite the use of sterile gloves, statistics show that surgical gloves are punctured in nearly 18.6% of cases, further emphasizing the need to reduce microbial loads on healthcare workers' hands (6).

Hand disinfection is a crucial aspect of hygiene and infection control, aiming to eliminate transient skin flora and reduce resident microorganisms. This can be achieved using either alcohol-based solutions or non-alcoholic alternatives. Alcohol-based solutions, which contain ethanol or isopropanol, are highly effective against a broad spectrum of microbes and evaporate quickly, leaving no residue. Non-alcoholic options include antimicrobial soaps such as betadine scrub, chlorhexidine gluconate, hexachlorophene, and Hibitan. Chlorhexidine gluconate disrupts microbial cell membranes, while hexachlorophene is effective against Gram-positive bacteria but carries a potential risk of neurotoxicity. Hibitan, also based on chlorhexidine, is commonly used in healthcare settings due to its broad-spectrum antimicrobial activity and long-lasting effect (7).

Hand hygiene plays a pivotal role in infection prevention, and various methods have been developed to evaluate the effectiveness of hand hygiene products. Recent studies have explored multiple approaches, including in vitro, ex vivo, and in vivo methods, to test the efficacy of hand sanitizers and wash-off products against pathogens such as *Serratia marcescens*, *Escherichia coli*, and *Staphylococcus aureus* (8).

In vitro testing of hand sanitizers has demonstrated a substantial bacterial reduction, achieving at least a 5-log reduction in microbial counts. However, the high level of efficacy observed in controlled laboratory settings does not always translate to similar effectiveness in more realistic scenarios. Specifically, in vivo and ex vivo studies have shown that hand sanitizers, particularly those with low alcohol content, exhibit reduced antibacterial effectiveness. Similarly, in vitro testing of hand wash products has revealed less than a 1-log decrease in bacterial counts against *E. coli*, likely due to factors such as bubble formation and product viscosity. In contrast, in vivo and ex vivo studies have shown more significant bacterial reductions, highlighting that these methods may provide a more accurate assessment of the antibacterial performance of hand hygiene products.

To evaluate hand antisepsis protocols, primary outcome measures, such as the reduction in bacterial counts immediately (LogR-I) and three hours (LogR-3h) after application, are used. The LogR-I is calculated by the logarithmic difference between pre- and immediate post-application bacterial counts on the same hand, while LogR-3h measures the logarithmic difference between pre- and post-3-hour bacterial counts on a different hand. These measures are essential for evaluating both the immediate and sustained effects of antiseptic protocols, in accordance with EN 12791 standards. Additionally, secondary outcomes include comparing logarithmic values for pre- and post-application bacterial counts across different experimental protocols, providing a comprehensive evaluation of antiseptic efficacy (9).

The choice between alcohol-based solutions and non-alcoholic alternatives depends on various factors, including the specific pathogens targeted, skin condition, and the context of use. While alcohol-based solutions provide rapid disinfection, some individuals may prefer or require non-alcoholic options due to skin sensitivity or concerns regarding microbial resistance. Understanding the unique features and effectiveness of these disinfection methods is crucial for selecting the most appropriate solution in various contexts, ultimately contributing to effective hand hygiene practices and reducing the risk of infectious transmission (10).

2. Objectives

Given the critical role of hand scrubbing in preventing hospital-acquired infections, this study aims to compare four different hand scrubbing techniques to evaluate their effectiveness in reducing hand bacterial colonies.

3. Methods

3.1. Research Type and Study Population

This study was designed as a pre- and post-intervention clinical trial involving a single group. The study population comprised members of the surgical team in the operating rooms at Kosar Hospital, affiliated with Semnan University of Medical Sciences.

3.2. Sample Size

A confidence level of 95% and statistical power of 90% were used in the calculations for the sample size, utilizing a two-tailed test. Based on the results generated from Stata11, the initial sample size was determined to be 25 individuals. To account for potential sample attrition, the final sample size was adjusted to 30 participants, with each participant undergoing hand scrubbing using all four methods.

3.3. Criteria for Study Inclusion and Exclusion

Criteria for study inclusion: (1) Complete willingness to participate in this study; (2) short and clean fingernails; (3) no use of antibiotics at least one week prior to each sampling; (4) no nail polish during the study period; (5) performing the first scrub on the day of the study.

Criteria for study exclusion: (1) Presence of cuts, wounds, or scratches on the hands; (2) skin diseases or excessive sweating of the hands; (3) skin sensitivity to disinfectants; (4) dermatitis; (5) surgical procedures lasting less than one hour; (6) emergency surgical procedures.

3.4. Sampling Method

The samples for this study were selected after obtaining ethical committee approval, and the research project was approved by the ethics committee of Semnan University of Medical Sciences (approval code: IR.SEMUMS.REC.1400.100) and was registered at the Iranian Registry of Clinical Trials (registration code: IRCT201104300006342N12). Utilizing the convenience sampling method and considering the inclusion and exclusion criteria, individuals were chosen from among the members of the surgical team working at Kosar Hospital, affiliated with Semnan University of Medical Sciences. Following the explanation of the study objectives and obtaining informed consent, individuals were sequentially enrolled in the study until the desired sample size was reached. After identifying eligible participants, these individuals were randomly allocated to four scrubbing methods. Randomization was determined using random numbers in Excel, specifying which method each participant would perform from the first to the fourth attempts.

This clinical trial was conducted after providing explanations to the research participants and obtaining written consent from them. For all participants, a demographic information questionnaire was completed, which included details such as age, gender, education level, occupation (surgeon, surgical assistant, nurse, operating room technician), and work experience in the operating room. Before starting the interventions, the participants were instructed on hand washing and disinfection methods according to standard protocols. Prior to the first non-emergency surgical procedure of the day, a baseline skin culture sample was taken from each participant.

All participants performed scrubbing using the four randomly selected methods, which included:

(1) Povidone-iodine scrub: Scrub hands with 10 mL of Povidone-Iodine solution (5.7% Povidone-Iodine manufactured by Aria Co.) for 3 minutes, followed by rinsing.

(2) Decocept scrub: Scrub hands with 10 mL of Decocept solution (manufactured by Samen Daroo Co., containing 7.44% 2-propanol, 9.21% 1-propanol, and 0.1% benzalkonium chloride) for 3 minutes.

(3) Betadine-Decocept scrub: Scrub hands with 10 mL of betadine for 3 minutes, followed by immersing the hands in 5 mL of Decocept solution.

(4) Decocept-betadine scrub: Scrub hands with 10 mL of Decocept for 3 minutes, followed by immersing the hands in 3 mL of betadine solution.

3.5. Organism Identification Method

Samples were collected using sterile swabs over a 10 × 10 square centimeter area. The swab was moistened in a nutrient agar medium and then used to collect samples from the designated points. After collection, the swab was placed in 1.5 mL of nutrient agar medium in sterile containers and rotated inside the medium for 20 seconds. The samples were then vortexed for 2 minutes and incubated for 24 hours at a temperature of 35°C (11). Following incubation, the presence or absence of turbidity in the nutrient agar culture medium was recorded to assess bacterial growth. Samples exhibiting growth were transferred onto McConkey agar (MAC), eosin methylene blue agar (EMB), and blood agar, and incubated for another 24 hours at 35°C. Upon observing bacterial growth, an initial screening for Gram-positive and Gram-negative bacteria was conducted using Gram staining. Differential tests for Gram-negative and Gram-positive bacteria were then performed based on their growth in the mentioned culture media, following preliminary categorization according to their growth characteristics (12).

3.6. Data Analysis

Data analysis was performed using SPSS software, version 23 (SPSS for Windows 11.5). The Shapiro-Wilk test was used to assess the normal distribution of continuous variables. Data were reported as mean ± standard deviation for normally distributed variables or as median ± 95% central range for non-normally distributed variables. Group differences were evaluated using either ANOVA for parametric data or the Kruskal-Wallis test for non-parametric data. Paired *t*-tests were employed for dependent parametric variables, while the Wilcoxon test was used for non-parametric variables. Repeated measures ANOVA was applied to compare different time points within a single group. A P-value of less than 0.05 was considered statistically significant in all tests.

4. Results

The mean age of the participants in the study was 30.43 ± 6.98 years (minimum: 21, maximum: 42, median: 33 years). The majority (86.7%) of the participants fell within the middle-aged category (30 - 59 years old). The mean body mass index (BMI) of the participants was 23.64 ± 1.93 kg/m^2 (minimum: 20.31, maximum: 27.34, median: 23.73 kg/m^2).

Tables 1-3 provide a detailed distribution of the microorganism types cultured from samples. The distribution of the number of microorganisms grown across different time points and groups is displayed in Table 4. According to the data in Table 4, there were no statistically significant differences in the number of microorganisms grown across the groups at any of the time points: Before scrub (P = 0.234), immediately after scrub (P = 0.174), or one hour after scrub (P = 0.068).

5. Discussion

Selecting the optimal hand scrubbing technique for operating room staff stands as a critical concern in contemporary operating room patient care (13). Enhancing medical understanding by comparing four scrub methods regarding bacterial colony presence on hands holds the promise of determining the most effective approach, particularly for operating room personnel reliant on these solutions. Their choice of hand scrubs aids in making informed decisions to prevent complications arising from incorrect practices or unsuitable methods, especially given the limited scope of existing studies in this domain (14). To address these gaps and discrepancies, this study aimed to assess four scrub methods (betadine, Decocept, betadine followed by Decocept, and Decocept followed by betadine) concerning bacterial colony levels on hands. The objective was to contribute to the knowledge base for optimal hand scrubbing in operating rooms, ultimately reducing associated hospital complications and facilitating informed decision-making.

In a study carried out in Turkey by Parlak et al. The purpose of the study was to compare the effects on bacterial counts of various surgical hand scrub durations and techniques. Participants in the study, which involved 180 surgical nurses and surgeons, were split into four groups: While groups III and IV scrubbed for two minutes, group III used a nail brush and group IV did not, groups I and II scrubbed for one minute and group II did not use one. Before and after scrubbing, as well as following surgery, bacterial counts were recorded. The two-minute scrub with a nail brush in group III had a considerably higher bacterial count than the two-minute scrub without a nail brush in group IV, according to the results. Following scrubbing and surgery, there was not a significant difference in the number of bacteria between groups II and IV. A one-minute scrub was found to be just as effective as a two-minute scrub in eliminating bacteria, and the study also found that using a nail brush during cleaning increased the number of bacteria (15).

This study explored the effectiveness of various hand disinfectants, comparing alcohol-based solutions with betadine to assess their impact on bacterial growth during hand scrubbing. A variety of researchers contributed to this body of work, each offering distinct perspectives on the efficacy of these disinfectants. Notably, most studies reached a similar conclusion: There was no significant difference between betadine and alcohol-based solutions in reducing bacterial growth (16). While the general consensus highlighted their comparable effectiveness, there were some nuances worth considering. The majority of research findings suggested that both betadine and alcohol-based solutions performed equally well in curbing bacterial growth. However, one particular study stood out by showing a notable reduction in bacterial growth with an alcohol-based solution compared to betadine (17). Despite this, the study acknowledged its limited sample size, calling for further research to validate the findings. Overall, the collective results pointed to a trend of equivalence between betadine and alcohol-based solutions in their ability to control bacterial growth during hand scrubbing. Although there was a slight deviation in one study, the overall conclusion suggested similar efficacy, underscoring the need for more comprehensive research to confirm these observations and identify any subtle differences between these disinfectants.

In a study involving forty nurses, those who experienced hand irritation had a higher colonization of specific species compared to those who did not, though their overall microbial counts were not significantly higher. Notably, there was a greater likelihood of *Staphylococcus hominis* colonization, with

Table 1. The Distribution of Microorganism Types Cultured (Pre-intervention)

Result of Cultivation	Studied Group, No. (%)				P-Value
	Betadine	Decocept	Betadine Followed by Decocept	Decocept Followed by Betadine	
Staphylococcus epidermidis	9 (30)	8 (26.7)	9 (30)	9 (30)	0.968
Staphylococcus aureus	3 (10)	3 (10)	3 (10)	3 (10)	
Coagulase negative *Staphylococcus*	17 (56.7)	18 (60)	18 (60)	18 (60)	
Negative culture	1 (3.3)	1 (3.3)	-	-	
Total	30 (100)	30 (100)	30 (100)	30 (100)	-

Table 2. The Distribution of Microorganism Types Cultured (Immediately Post-intervention)

Result of Cultivation	Studied Group, No. (%)				P-Value
	Betadine	Decocept	Betadine Followed by Decocept	Decocept Followed by Betadine	
Staphylococcus epidermidis	7 (23.3)	5 (16.7)	4 (13.3)	4 (13.3)	0.344
Staphylococcus aureus	3 (10)	1 (3.3)	-	1 (3.3)	
Coagulase negative *Staphylococcus*	7 (23.3)	3 (10)	4 (13.3)	7 (23.3)	
Negative culture	13 (43.3)	21 (70)	22 (73.3)	18 (60)	
Total	30 (100)	30 (100)	30 (100)	30 (100)	-

Table 3. The Distribution of Microorganism Types Cultured (One-hour Post-intervention)

Result of Cultivation	Studied Group, No. (%)				P-Value
	Betadine	Decocept	Betadine Followed by Decocept	Decocept Followed by Betadine	
Staphylococcus epidermidis	2 (6.7)	5 (16.7)	5 (16.7)	3 (10)	0.218
Staphylococcus aureus	-	1 (3.3)	-	3 (10)	
Coagulase negative *Staphylococcus*	8 (26.7)	3 (10)	7 (23.3)	4 (13.3)	
Negative culture	20 (66.7)	21 (70)	18 (60)	20 (66.7)	
Total	30 (100)	30 (100)	30 (100)	30 (100)	-

59% of these strains being methicillin-resistant. Nurses with injured hands also had a higher, albeit not statistically significant, incidence of *Staphylococcus aureus* colonization. Additionally, these nurses exhibited higher, though non-significant, rates of *Enterococci*, *Candida*, and gram-negative bacteria. However, the groups showed no difference in the resistance of coagulase-negative staphylococci to antibiotics. The findings highlight the need for improved hand hygiene practices, such as stricter regulations, careful use of gloves and hand protectors, and enhanced monitoring (18).

The study also examined participant satisfaction with different hand disinfection methods, revealing significant differences in satisfaction levels. Although alcohol-based solutions and betadine demonstrated similar efficacy in reducing bacterial growth, participants expressed a preference for alcohol-based solutions due to their lower incidence of side effects and comparable effectiveness. This preference aligns with findings from other studies that favored alternatives like betadine, particularly because of its skin effects and color-altering issues. However, a study conducted in India found higher staff satisfaction with betadine, attributed to its perceived effectiveness, despite similar results in terms of complications and skin injuries (19). These variations in staff preferences across studies may be influenced by demographic differences in the populations studied.

This study, though methodologically sound, was not without its limitations, as is often the case with research endeavors. One key limitation lies in the fact that numerous known and unknown variables could have impacted the study's outcomes. The complexity of these factors means that a single study cannot account for every aspect, emphasizing the need for broader, more extensive investigations in larger populations to draw more definitive conclusions.

Table 4. Mean and Standard Deviation of Microorganisms in Four Methods of Scrub

Variables	Studied Group (Mean ± SD)				P-Value [a]
	Betadine	Decocept	Betadine Followed by Decocept	Decocept Followed by Betadine	
Before scrub	34800 ± 14183.5	27872 ± 20134.1	32213.3 ± 14942.5	24560 ± 17245.5	0.234
Immediate after scrub	13560 ± 9020.5	9760 ± 6278.8	17526.7 ± 29576.8	9120 ± 8596.4	0.174
1-hour after scrub	2273.7 ± 3714.6	5664 ± 3521.1	6586.7 ± 7185.7	600 ± 1200	0.068
P-value [b]	0.043	0.035	0.009	0.036	-

[a] ANOVA.

[b] Repeated measure ANOVA.

Two specific constraints were the cross-sectional design and the relatively small sample size. These limitations naturally restrict the range and depth of insights. However, the researchers made concerted efforts to mitigate these constraints wherever possible. Rigorous measures were implemented to control and minimize the influence of these limitations, with the aim of producing precise and reliable results. The researchers also made efforts to generalize the findings to the extent possible, within the study's inherent scope.

Acknowledging these limitations, alongside the efforts to address them, enhances the transparency and credibility of the research. It further underscores the need for additional studies employing more comprehensive methodologies and larger sample sizes to validate and build upon these findings, ultimately contributing to a stronger scientific understanding in this field.

5.1. Conclusions

The results of the study revealed an intriguing pattern: Although there was no significant difference between the methods regarding the type and number of microorganisms at different times, the Decocept hand scrubbing method was notably more popular among participants. This trend suggests that Decocept could be considered a feasible and potentially better alternative in operating rooms. The high levels of satisfaction associated with Decocept alone raise the possibility that it could become a reliable and respected technique in the surgical environment. It's important to proceed cautiously with this conclusion, as further research is necessary to fully understand how these findings can be applied. Clearly, more comprehensive studies are required to confirm and expand upon these preliminary results. Although the initial outcomes are promising, larger and more thorough investigations are essential to verify the feasibility and reliability of using Decocept as an alternative handwashing technique in operating rooms. Such follow-up studies could provide a more in-depth understanding and potentially support its broader application in clinical settings.

Footnotes

Authors' Contribution: Study concept and design, and critical revision of the manuscript for important intellectual content: M. E., S. A., M. R. A., and A. A. G.; acquisition of data: S. A.; analysis and interpretation of data: M. E., M. R. A., and A. A. G.; drafting of the manuscript, and administrative, technical, and material support: M. E.; statistical analysis: M. E. and A. A. G.; study supervision: A. A. G.

Clinical Trial Registration Code: IRCT201104300006342N12 .

Conflict of Interests Statement: We declare that one of our authors (Majid Eslami) is of the editorial board. The journal confirmed that the author with CoI was excluded from all review processes.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: IR.SEMUMS.REC.1400.100 .

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Informed Consent: This clinical trial was conducted after providing explanations to the research participants and obtaining written consent from them.

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