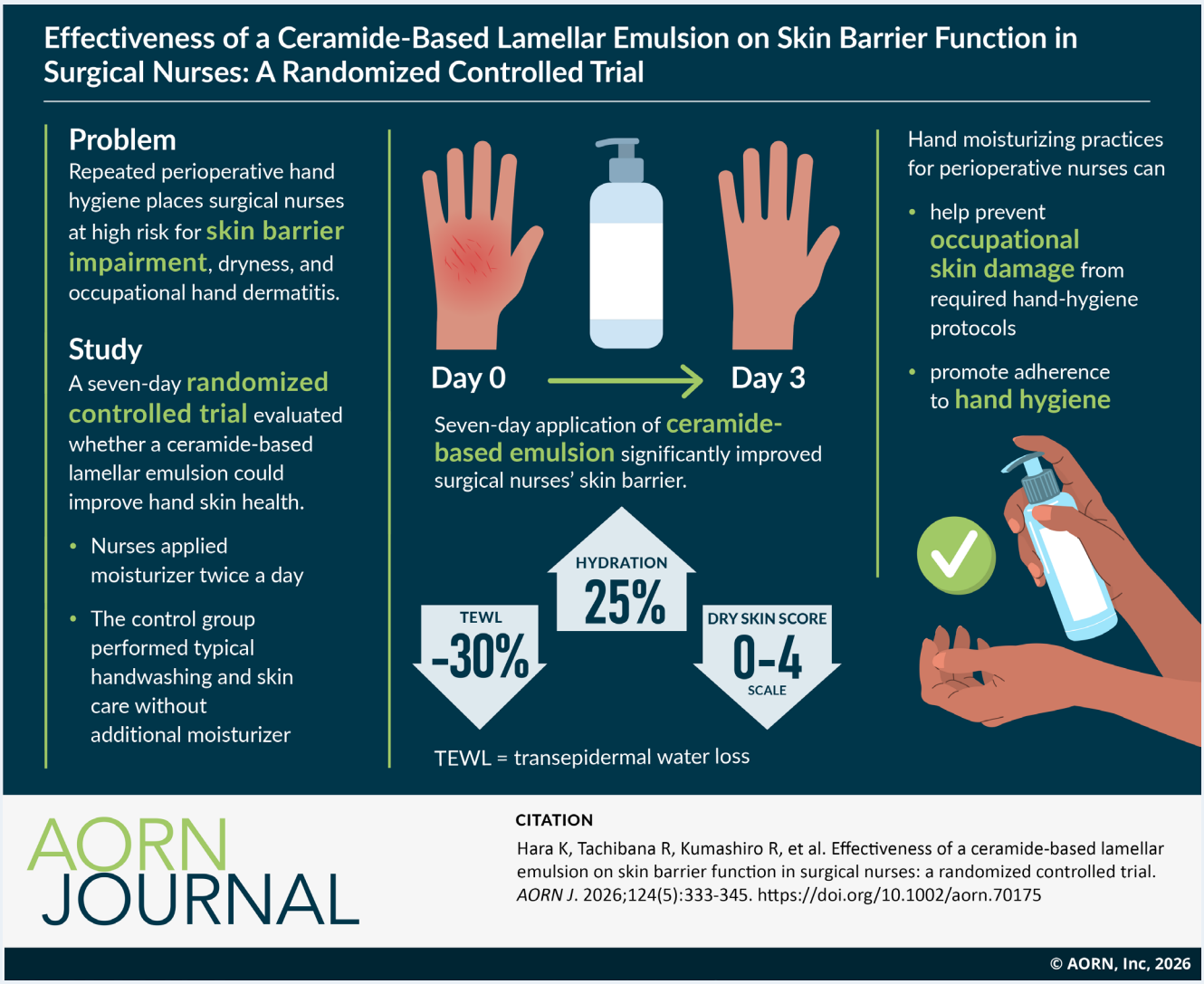
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RESEARCH

Effectiveness of a Ceramide-Based Lamellar Emulsion on Skin Barrier Function in Surgical Nurses: A Randomized Controlled Trial

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ABSTRACT



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Surgical nurses frequently perform perioperative hand hygiene, predisposing them to hand dryness and skin barrier impairment. This single-center randomized controlled trial evaluated a ceramide-based lamellar emulsion for improving hand skin barrier function among surgical nurses. Thirty-five nurses were assigned to an intervention group (n = 18) applying the emulsion twice daily for seven days or a control group (n = 17) receiving usual care. Transepidermal water loss, stratum corneum hydration, skin surface pH, and dry skin scores were assessed at baseline and follow-up. Transepidermal water loss significantly decreased in the intervention group from day 1 and remained lower than in the control group. Hydration increased and dry skin scores improved in the intervention group, whereas minimal changes occurred in the control group. Short-term use of the emulsion improved barrier function and may help reduce occupational skin damage in perioperative nurses. These findings support integrating moisturizing protocols into perioperative hand hygiene.

Key words: *skin barrier*, *ceramide moisturizer*, *perioperative hand hygiene*, *surgical nurses*, *occupational hand dermatitis (OHD).*

Surgical nurses play a central role in maintaining patient safety and ensuring the smooth execution of perioperative procedures.[1,2] Among their diverse professional responsibilities, the maintenance of asepsis of the surgical field and surgical instruments is fundamental to preventing surgical site infections and ensuring procedural integrity. In this context, surgical nurses perform surgical hand antisepsis using alcohol-based hand rubs or surgical scrub products, in accordance with institutional perioperative policies and applicable guidelines.[3-6] These practices are supported by the AORN *Guidelines for Perioperative Practice*, which emphasizes evidence-based hand hygiene and occupational skin protection for perioperative personnel.[7]

Depending on surgical schedules, staffing patterns, and case volume, surgical personnel—including both nurses and surgeons—may be required to perform perioperative hand hygiene multiple times per day. Although such repeated hand hygiene practices are indispensable for infection control, they also expose the skin of the hands to frequent mechanical friction and chemical irritation. As a result, perioperative staff are particularly vulnerable to occupational skin disorders associated with cumulative exposure to antiseptic agents.[8]

Repeated exposure to antiseptic solutions is a well-recognized cause of irritant contact dermatitis, which represents one of the most common occupational skin disorders among health care workers.[9,10] Researchers of one study that was conducted in a Japanese hospital reported that approximately 35% of nurses experience occupational hand dermatitis (OHD), with the highest prevalence observed among surgical nurses.[11] Perioperative hand hygiene procedures, including surgical scrubbing, have been independently reported to cause significant skin irritancy.[12] Similar trends have been reported internationally, indicating that occupational skin disorders among perioperative staff constitute a global occupational health issue rather than a context-specific problem.[10,13]

In severe cases, OHD may lead to persistent discomfort, pain, and fissuring of the skin, potentially impairing manual dexterity and job performance.[13,14] Furthermore, chronic or refractory symptoms may necessitate temporary or permanent reassignment to nonclinical duties, thereby affecting workforce sustainability and continuity of perioperative care.[13] These occupational consequences underscore the importance of effective preventive strategies to protect the skin health of surgical nurses.

LITERATURE REVIEW

Skin barrier impairment associated with OHD is characterized by increased transepidermal water loss (TEWL), reduced stratum corneum hydration, and alterations in skin surface pH. These physiological changes contribute to chronic xerosis, inflammation, and heightened susceptibility to irritants and allergens.[15-18] From a preventive perspective, maintaining skin barrier integrity is therefore a critical component of occupational health management for health care workers engaged in frequent hand hygiene practices.

Previous studies have demonstrated that preventive skin care interventions, particularly the regular use of

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moisturizers, play a key role in preserving skin integrity and reducing the incidence and severity of OHD.[19,20] However, the effectiveness of moisturizers varies depending on their formulation and their ability to replicate the structural and functional properties of the native skin barrier.

In recent years, moisturizers containing skin-identical ceramides—especially those engineered with lamellar structures—have received increasing attention due to their capacity to restore and reinforce the skin barrier.[21,22] These lamellar-structured ceramides are designed to mimic the organization of natural intercellular lipids in the human stratum corneum, thereby enhancing hydration, reducing TEWL, and improving overall barrier function.[23-25] Such formulations have been widely adopted in cosmetic and dermocosmetic applications, with accumulating evidence supporting their physiological relevance.

Despite this growing body of research, no randomized controlled trial (RCT) has specifically evaluated the effects of a lamellar-structured, ceramide-containing emulsion (hereafter referred to as a lamellar emulsion) on the hand skin condition of OR personnel. This represents a critical evidence gap, as surgical nurses constitute an occupational group uniquely exposed to repeated and intensive skin stress due to mandatory perioperative hand hygiene and prolonged glove use.

Therefore, this RCT aimed to investigate the effects of a lamellar emulsion on the hand skin barrier function of surgical nurses. Transepidermal water loss was selected as the primary outcome, while stratum corneum hydration, skin surface pH, and a clinical dry skin score were designated as secondary outcomes. It was hypothesized that regular use of the lamellar emulsion over a short-term, seven-day intervention period would lead to measurable improvements in key skin barrier parameters and contribute to the prevention of occupationally related hand skin disorders among perioperative nurses.

CONCEPTUAL FRAMEWORK

This study was guided by a skin barrier restoration framework grounded in occupational dermatology and perioperative infection prevention. Perioperative hand hygiene repeatedly disrupts the stratum corneum lipid matrix, leading to increased TEWL and reduced hydration. Lamellar ceramide-based formulations are designed to structurally mimic native intercellular lipids and support rapid barrier repair. In perioperative nursing, maintaining skin integrity is directly linked to sustained adherence to perioperative hand hygiene practices and occupational well-being. Therefore, restoration of barrier physiology serves as both a biological and professional health outcome.

PURPOSE AND RESEARCH QUESTIONS

The purpose of this RCT was to evaluate the differences in hand skin barrier function between surgical nurses who used a lamellar-structured, ceramide-containing emulsion and those who received usual care over a seven-day period. To address the objective, the following research questions were formulated.

- What differences in TEWL were observed between surgical nurses using the lamellar ceramide emulsion and those receiving usual care over seven days?
- What differences in stratum corneum hydration, skin surface pH, and clinical dry skin scores were observed between the two groups over the seven-day period?

METHODS

This single-center, open-label, parallel-group RCT was conducted at the Department of Operation Center, NHO Nagasaki Medical Center, in a clinical environment operating under the AORN *Guidelines for Perioperative Practice*. The trial period spanned from October to December 2024 and was designed and reported in accordance with the CONSORT (Consolidated Standards of Reporting Trials) 2025 guidelines.[26] To minimize the potential influence of seasonal variation on skin condition, all participant recruitment, allocation procedures, and outcome assessments were completed within this defined period under stable environmental conditions.

Participants were randomly assigned to either an intervention group, which received a lamellar-structured, ceramide-containing emulsion, or a control group, which received no additional moisturizer beyond usual care (ie, each participant's self-directed routine hand care practices without a standardized protocol or product). The primary outcome of the trial was TEWL, reflecting skin barrier function. Secondary outcomes included stratum corneum hydration, skin surface pH, and a clinical dry skin score assessed in accordance with validated guidance from the

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European Group on Efficacy Measurement of Cosmetics and Other Topical Products.[27]

No invasive procedures or biological sampling were performed during the study period. All participants continued their routine perioperative hand hygiene practices. The use of any additional hand moisturizers outside the allocated intervention was strictly prohibited. The trial was prospectively registered with the University Hospital Medical Information Network. No external funding or commercial sponsorship was obtained for this study.

Protection of Participants' Rights

This study was approved by the Ethics Committee of the NHO Nagasaki Medical Center on September 17, 2024 (Approval No. 2024058). The study was conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants before enrollment. Participation was voluntary, and participants were free to withdraw at any time without consequence. No financial compensation or material incentives were offered. All data were collected anonymously using participant identification codes; personal identifiers were removed before analysis and were not accessible to parties outside the research team. Data are stored securely at the principal investigator's institution and will be retained for a minimum of five years in accordance with institutional requirements.

Setting and Participants

The study population comprised surgical nurses employed in the Department of Operation Center, NHO Nagasaki Medical Center. Participants included both scrub (instrument) nurses and RN circulators, both of whom perform perioperative hand hygiene as part of their routine clinical duties. Performing the scrub role was not a requirement for study participation; both roles were eligible to enroll. Eligible participants were identified through departmental staff lists and approached directly by the research team.

Inclusion criteria were as follows:

- currently practicing surgical nurses, regardless of age, sex, or years of professional experience; and
- provision of written informed consent after both verbal and written explanation of the study.

Exclusion criteria included

- managerial staff (eg, head nurses) who do not routinely perform perioperative hand hygiene;
- current use of topical corticosteroids on the hands;
- a history of adult atopic dermatitis, with childhood remission permitted; and
- any medical, occupational, or logistical condition deemed unsuitable for participation by the investigators for reasons of safety or operational feasibility.

All eligible nurses were approached in person, provided with written study information, and given sufficient time to consider participation before providing consent. No financial compensation or material incentives were offered.

Intervention and Control Conditions

Participants allocated to the intervention group received a lamellar-structured emulsion containing the synthetic pseudo-ceramide cetyl-PG hydroxyethyl palmitamide (RemoisLamellar Moisturizing Milk; ALCARE Co, Ltd). The formulation additionally contained glycerin and sodium hyaluronate as humectants, and dimethicone as an occlusive agent. The emulsion was designed to mimic the lamellar lipid bilayer structure of the stratum corneum, thereby supporting rapid restoration of the skin barrier and enhanced moisture retention.[23,24,28]

The seven-day intervention period included both working days and rest days in accordance with participants' standard nursing shift schedule (five working days and two rest days per week). On working days, participants performed perioperative hand hygiene as required by their clinical duties. On rest days, occupational hand hygiene was not performed; however, emulsion application was continued twice daily as per the protocol, and daily application records were maintained.

Participants in the intervention group were instructed to apply the emulsion to both hands twice daily, at approximately 7 AM and 9 PM, for seven consecutive days. Participants allocated to the control group continued their usual hand care practices and did not receive any additional moisturizer from the study team.

Before study commencement, the selected emulsion was assessed for compatibility with the surgical hand

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antisepsis products and glove types routinely used at the study institution, in accordance with the AORN *Guidelines for Perioperative Practice* recommendation to verify compatibility of skin care products with hand hygiene agents and glove materials. No adverse compatibility effects were identified.

Emulsion application was performed at home (outside the workplace). Each participant was provided with a standardized daily record sheet and was instructed to document the date and time of each application. Adherence was additionally confirmed verbally by the research team at each assessment visit. The application times of 7 AM and 9 PM were selected to correspond with participants' morning waking routine (before occupational hand hygiene exposure) and presleep routine (after all occupational hand hygiene had been completed for the day), thereby addressing both the pre-exposure and postexposure phases of the occupational skin care cycle.

Skin assessments were conducted on days 0 (baseline), 1, 3, and 7. At each assessment visit, adherence to the intervention protocol was verbally confirmed. To quantify occupational exposure during the study period, participants also recorded the number of perioperative hand hygiene procedures performed per shift throughout the intervention period.

Outcome Measures

The primary outcome was TEWL, measured at the dorsal web space between the thumb and index finger of the dominant hand. Measurements were obtained using a closed-chamber evaporimeter (VapoScan VT100RS; ASCH Japan Co, Ltd).

Secondary outcomes included the following:

- Stratum corneum hydration, measured using a corneometer (Mobile Moisture HP19-M; Integral Corp).
- Skin surface pH, measured using a calibrated pH meter (HI981037; Hanna Instruments).
- Clinical dry skin score, assessed from standardized dermoscopic photographs (DZ-D100; Casio Computer Co, Ltd) by a plastic surgeon blinded to group allocation, in accordance with guidance from the European Group on Efficacy Measurement of Cosmetics and Other Topical Products.[27]

All measurements were conducted under controlled environmental conditions, with room temperature maintained at 25 °C (77 °F) and relative humidity at 50%. Participants underwent a 10-minute acclimatization period before each assessment, and all measurements were performed at approximately 9 AM to minimize the influence of diurnal variation.[15,29]

All skin biophysical measurements (TEWL, stratum corneum hydration, and skin surface pH) were performed by the principal investigator (K.H.) at each scheduled assessment visit. Clinical dry skin scores were independently assessed from standardized dermoscopic photographs by an external plastic surgeon who remained blinded to group allocation throughout the entire study period and had no involvement in participant recruitment, intervention delivery, or data analysis.

Sample Size and Randomization

The sample size was estimated with reference to a previous trial evaluating a ceramide-based moisturizing intervention.[24] Assuming a between-group difference in TEWL of 8.0 g/m^2/h and a standard deviation of 6.0 g/m^2/h, a minimum of 13 participants per group was required to achieve 80% statistical power with a two-sided α level of .05. Considering workforce availability (N = 40) and potential participant attrition, the target sample size was set at 20 participants per group, yielding a total planned sample size of 40 participants.

Randomization was performed using a stratified block method based on work schedules, with participants categorized into blocks A and B. A computer-generated random sequence created in Microsoft Excel (Microsoft Corp) was used for allocation. Within each block, the first half of the sequence was assigned to the intervention group, and the remaining participants were allocated to the control group.

Blinding

This trial employed an open-label design; therefore, participants and onsite investigators were not blinded to group allocation. However, clinical dry skin scores were independently assessed by a plastic surgeon who remained blinded throughout the study period and had no involvement in participant recruitment, intervention delivery, or data analysis.

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Statistical Analysis

Continuous variables were summarized as mean ± standard deviation or median (interquartile range [IQR]), as appropriate. Categorical variables were summarized as frequencies and percentages (n, %).

Between-group comparisons at each assessment time point were conducted using the Student *t* test or the Mann-Whitney test, depending on data distribution and sample size considerations. Within-group changes over time were analyzed using the Wilcoxon signed rank test. To account for multiple within-group comparisons across time points, a Bonferroni adjustment was applied. Statistical significance was two-sided and set at $P < .05$. All statistical analyses were performed using JMP Pro 18 (SAS Institute Inc).

RESULTS

The trial was completed as scheduled without early termination. A total of 35 surgical nurses were enrolled and completed the study, with 18 participants allocated to the intervention group and 17 to the control group (Figure 1). The median age (IQR) was 38.5 (27.0 to 51.0) years in the intervention group and 32.0 (26.0 to 41.0) years in the control group. There were no statistically significant differences in baseline demographic or occupational characteristics between the two groups (Table 1).

Primary Outcome

At baseline (preintervention), no statistically significant difference in TEWL was observed between the groups (median [IQR]: 15.8 [11.8 to 17.9] g/m^2/h in the intervention group versus 19.4 [12.9 to 29.5] g/m^2/h in the control group; $P = .135$), indicating comparable skin barrier function at enrollment.

On day 1, TEWL decreased to 10.0 (7.9 to 13.5) g/m^2/h in the intervention group, whereas the control group

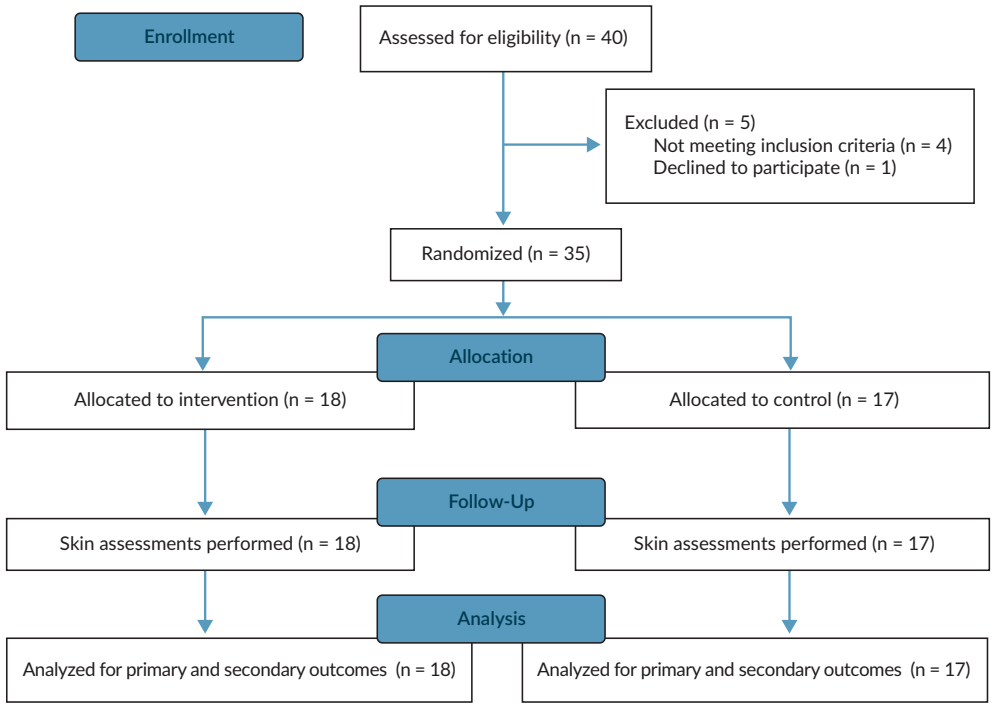


Figure 1. Flow diagram of participant enrollment and allocation. A total of 35 surgical nurses were assessed for eligibility and randomly assigned to either the intervention group (n = 18) or the control group (n = 17) according to the CONSORT (Consolidated Standards of Reporting Trials) 2025 guidelines. All participants completed the seven-day follow-up, and their data were included in the final analysis. *Adapted under CC BY 4.0 from Hopewell S, Chan AW, Collins GS, et al. CONSORT 2025 Statement: updated guideline for reporting randomised trials*. BMJ. 2025; 388:e081123. https://doi.org/10.1136/bmj-2024-081123

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Table 1. Baseline Participant Characteristics and Surgical Hand Antisepsis Method Practices

Variable	Intervention Group	Control Group	*P* Value
Age, y (IQR)	38.5 (27.0-51.0)	32.0 (26.0-41.0)	.173
OR experience, y (IQR)	14.5 (7.2-21.5)	7.0 (2.0-16.0)	.120
Surgical hand antisepsis method, N (%)			.443
Surgical scrub technique	3 (16.7)	5 (29.4)	
Surgical rubbing technique	15 (83.3)	12 (70.6)	
Number of surgical hand antisepsis procedures, median (IQR)			
Day 0	1.0 (0.0-1.0)	1.0 (0.0-1.0)	.646
Day 1	1.0 (1.0-2.0)	1.0 (0.0-2.0)	.375
Day 2	1.0 (0.0-1.0)	1.0 (1.0-2.0)	.182
Day 3	0.0 (0.0-1.8)	1.0 (0.0-2.0)	.292
Day 4	0.0 (0.0-1.0)	1.0 (0.0-1.0)	.555
Day 5	0.0 (0.0-0.0)	0.0 (0.0-0.0)	.128
Day 6	0.0 (0.0-0.8)	0.0 (0.0-1.0)	.416

IQR = interquartile range.
NOTES. Values are presented as median (IQR) or number (%). Comparisons of continuous variables were performed using the Mann-Whitney test. Categorical variables were compared using the chi-square or Fisher exact test, as appropriate. No significant differences were found between groups in hand antisepsis frequency.

showed a value of 15.4 (8.4 to 29.6) g/m^2/h, resulting in a statistically significant between-group difference (P = .017). On day 3 and day 7, TEWL remained significantly lower in the intervention group (8.2 [6.2 to 10.5] g/m^2/h and 7.8 [6.4 to 10.3] g/m^2/h, respectively) compared with the control group (19.0 [17.2 to 21.2] g/m^2/h and 18.0 [14.5 to 24.4] g/m^2/h, respectively; both P < .001) (Table 2).

At day 1, the absolute between-group difference in TEWL was 5.4 g/m^2/h (95% confidence interval [CI], 0.9 to 10.3), corresponding to a 35.1% relative reduction in the intervention group compared with the control group. At day 3, the absolute difference increased to 10.8 g/m^2/h (95% CI, 8.3 to 13.4), representing a 56.8% relative reduction. At day 7, the absolute difference was 10.2 g/m^2/h (95% CI, 5.5 to 16.3), corresponding to a 56.7% relative reduction in TEWL in the intervention group compared with the control group.

Within-group analyses using the Wilcoxon signed rank test with Bonferroni adjustment demonstrated significant reductions in TEWL from baseline to day 1, day 3, and day 7 in the intervention group (all adjusted P < .001). In contrast, no statistically significant changes in TEWL were observed at any time point in the control group.

Secondary Outcomes

In the intervention group, stratum corneum hydration increased progressively over the study period, whereas no improvement was observed in the control group. Between-group comparisons showed significantly higher hydration levels in the intervention group on day 1 (P = .048), day 3 (P = .020), and day 7 (P = .002).

Skin surface pH remained stable throughout the study period in both groups, with no statistically significant between-group differences at any assessment point. Skin temperature and ambient humidity exhibited minor fluctuations during the measurement period; however, these parameters did not differ significantly between groups.

Clinical assessment based on high-resolution dermoscopic photographs (DERMO mode, ×5 magnification) demonstrated clinically observable improvement in hand skin condition in the intervention group by day 7. Figure 2 presents a representative case illustrating the progressive resolution of visible dryness from baseline to day 7.

Table 2. Changes in Skin Physiological Parameters Over Time

Variable	Time Point	Intervention Group	Control Group	*P* Value
Stratum corneum moisture	Baseline	38.9 (31.9-47.2)	39.2 (32.0-42.4)	.428
	Day 1	49.6 (40.0-58.5)	41.2 (35.4-48.4)	.048[a]
	Day 3	50.6 (39.1-60.1)	37.8 (32.6-41.2)	.020[a]
	Day 7	50.0 (44.3-63.4)	35.0 (28.0-47.6)	.002[a]
Skin pH	Baseline	5.9 (5.7-6.4)	5.9 (5.8-6.1)	.703
	Day 1	6.0 (5.6-6.2)	5.9 (5.7-6.2)	.742
	Day 3	5.8 (5.5-6.3)	6.0 (5.5-6.2)	.648
	Day 7	5.9 (5.3-6.4)	6.2 (5.7-6.3)	.482
Skin temperature	Baseline	25.1 (24.8-25.4)	25.3 (24.6-25.9)	.349
	Day 1	25.1 (24.8-25.4)	25.2 (24.9-25.7)	.407
	Day 3	24.9 (24.5-25.3)	25.4 (24.8-25.8)	.087
	Day 7	25.0 (24.7-25.4)	25.4 (24.8-25.8)	.300
Humidity	Baseline	62.8 (45.9-69.3)	65.1 (48.9-69.9)	.551
	Day 1	60.5 (49.3-73.1)	51.5 (49.0-68.0)	.537
	Day 3	57.4 (43.5-69.5)	55.8 (50.2-64.7)	.980
	Day 7	60.6 (43.0-73.1)	55.6 (44.5-63.7)	.412
TEWL	Baseline	15.8 (11.8-17.9)	19.4 (12.9-29.5)	.135
	Day 1	10.0 (7.9-13.5)	15.4 (8.4-29.6)	.017[a]
	Day 3	8.2 (6.2-10.5)	19.0 (17.2-21.2)	<.001[a]
	Day 7	7.8 (6.4-10.3)	18.0 (14.5-24.4)	<.001[a]

TEWL = transepidermal water loss.
NOTES. Values are presented as median (interquartile range). Comparisons between intervention and control groups at each time point were performed using the Mann-Whitney test.
[a]*P* < .05.

Quantitative scoring of the clinical images revealed a marked and statistically significant progressive reduction in dry skin scores in the intervention group from baseline through day 7 (all adjusted *P* < .001), whereas no statistically significant changes were observed in the control group (Table 3).

Adverse Events

No adverse events related to the emulsion were reported during the study period. The intervention was completed by all participants.

DISCUSSION

This RCT demonstrated that a seven-day application of a lamellar-structured, ceramide-containing emulsion substantially improved hand skin barrier function in surgical nurses. The key findings of this study showed that, compared with usual care, the intervention group exhibited marked reductions in TEWL, increased stratum corneum hydration, and improved clinical dry skin scores, whereas no statistically significant changes were observed in the control group. Collectively, these findings indicate that lamellar ceramide–based moisturizers can provide rapid and clinically relevant restoration of the skin barrier in nurses exposed to intensive and repeated perioperative hand hygiene.

Baseline TEWL values in the present sample (15.8 to 19.4 g/m^2/h) were slightly higher than those reported in healthy volunteers,[28,30] suggesting mild preexisting occupational skin barrier impairment at enrollment. The subsequent rapid improvement after lamellar emulsion use indicates that this formulation may offer effective short-term

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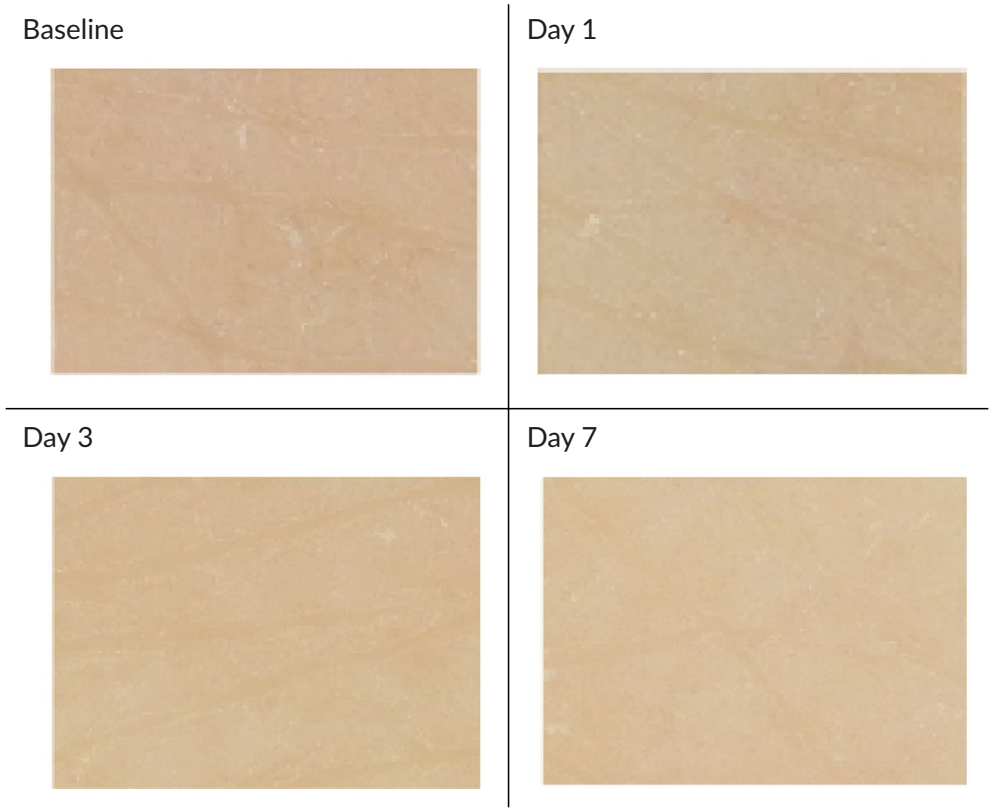


Figure 2. Representative case from the intervention group showing progressive visual improvement in hand skin condition over time. Serial high-resolution dermoscopic images were captured using a DZ-D100 camera (DERMO mode; ×5 magnification) at baseline (preintervention) and on days 1, 3, and 7. A gradual reduction in visible dryness, scaling, and roughness is evident, consistent with clinical improvement after application of the lamellar-structured ceramide-containing emulsion.

barrier support for perioperative staff who require immediate protection while continuing high-frequency perioperative hand hygiene. Importantly, the intervention was compatible with routine perioperative workflows and did not require additional training or modification of hand hygiene practices, supporting its feasibility for real-world implementation.

Table 3. Changes in Overall Dry Skin Scores in the Intervention and Control Groups

Time Point	Intervention Group (n = 18)	Control Group (n = 17)	*P* Value
Baseline	2.0 (1.0-3.0)	2.0 (1.0-2.5)	.869
Day 1	1.0 (0.0-2.0)	2.0 (1.0-2.0)	.246
Day 3	0.0 (0.0-1.0)	2.0 (1.0-2.0)	<.001
Day 7	0.0 (0.0-1.0)	2.0 (1.0-2.0)	<.001

NOTES. Data are presented as median (interquartile range). Comparisons between groups were made using the Mann-Whitney test. Dry skin scores were assessed by a blinded plastic surgeon using standardized dermoscopic images. Lower scores indicate less visible dry skin.

Interpretation in Relation to Previous Studies

Transepidermal water loss is widely recognized as a sensitive indicator of impaired skin barrier function, reflecting increased water loss and disruption of the intercellular lipid matrix.[15-17] In the present study, TEWL decreased significantly as early as day 1 and continued to improve through day 7 in the intervention group. In contrast, conventional moisturizers often require two to eight weeks of continuous use before measurable reductions in TEWL are observed.[29,31] The early response observed in this trial may be attributable to the lamellar structure of the emulsion, which closely mimics the multilamellar lipid architecture of the stratum corneum

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Key Takeaways

- Repeated perioperative hand hygiene places surgical nurses at high risk for skin barrier impairment, dryness, and occupational hand dermatitis. A seven-day randomized controlled trial evaluated whether a ceramide-based lamellar emulsion could improve hand skin health in this high-risk population.
- Nurses who applied the ceramide-based lamellar emulsion twice daily experienced significant reductions in transepidermal water loss by day 1, with benefits maintained through day 7. Participants receiving usual care showed no significant improvement in skin barrier function during the study period.
- Use of the emulsion increased stratum corneum hydration and significantly improved clinical dry skin scores. Improvements were confirmed through standardized dermoscopic imaging that was evaluated by a plastic surgeon who remained blinded to group assignment.
- No adverse events related to the emulsion were reported during the trial. Findings support incorporating evidence-based moisturizing protocols into perioperative hand care practices to help prevent occupational skin damage and promote adherence to hand hygiene.

and is thought to integrate efficiently into a disrupted lipid matrix.[23,32] In addition, the inclusion of skin-identical pseudo-ceramides may accelerate lipid replenishment and barrier repair.[24,25]

The occupational context of these findings is particularly relevant. Surgical nurses routinely perform frequent perioperative hand hygiene using soaps, brushes, and alcohol-based hand rubs.[3-6] Repetitive exposure to these agents is a major contributor to irritant contact dermatitis, and the prevalence of OHD among perioperative staff is substantial.[11,12,33] Compromised skin barrier function can result in pain, fissuring, and pruritus, and may discourage adherence to recommended hand hygiene practices.[20] From this perspective, the reductions in TEWL and improvements in clinical dry skin scores observed in this study are not only physiologically meaningful but also directly relevant to occupational health, nurse comfort, and infection prevention.

Strengths and Limitations

A notable strength of this study is the comprehensive assessment of skin barrier recovery, combining objective biophysical measures (TEWL and hydration) with blinded evaluation of clinical dry skin scores. All measurements were conducted under standardized environmental conditions (25 °C [77 °F], 50% relative humidity), which enhances internal validity. Moreover, the pragmatic trial design—conducted within an active operating department and reflecting real-world perioperative hand hygiene practices—supports the clinical relevance and potential transferability of the findings to similar perioperative settings.

Several limitations should be considered. First, this was a single-center study with a relatively short intervention period. Although the short-term improvements observed are encouraging, long-term adherence, sustainability of effects, and potential recurrence after discontinuation were not assessed. Additionally, the sample size was insufficient to support subgroup analyses by hand antisepsis method (surgical scrub technique versus surgical rubbing technique). Future studies with larger samples should examine whether skin barrier outcomes differ by antisepsis technique, as scrub-based and rub-based methods may impose differing degrees of mechanical and chemical stress on the skin. Second, participants were not blinded to group allocation, which may have influenced subjective perceptions; however, primary and secondary outcomes were objective or assessed by a blinded rater, reducing the risk of bias. Third, usual home skin care practices in the control group were not standardized, introducing variability that may have attenuated between-group differences. Fourth, the study was conducted in a single Japanese tertiary hospital, and differences in environmental conditions, hand hygiene products, and staffing patterns may limit generalizability to other settings. Finally, antimicrobial activity of surgical hand antisepsis was not assessed in either group. Because emollient barrier products may theoretically affect the persistence of antimicrobial efficacy after perioperative hand hygiene, future studies should evaluate whether twice-daily application

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of ceramide-based emulsions alters residual antimicrobial activity.

Implications for Perioperative Nursing

Despite these limitations, the findings have important implications for perioperative nursing and management. Maintaining hand skin integrity is closely linked to nurse comfort, work capacity, and adherence to infection prevention measures. Occupational hand dermatitis has been associated with absenteeism, reduced productivity, and job modification.[19] The present results suggest that incorporating a lamellar ceramide–based moisturizer into perioperative hand care routines may represent an evidence-based, low-burden strategy to protect nurses' skin, support sustained hand hygiene, and contribute to a safer working environment. Given that the mechanisms of skin barrier damage and repair are similar across populations, and that frequent perioperative hand hygiene is common in operating departments worldwide, these findings are likely to be relevant across diverse health care systems.

Recommendations for Future Research

Future research should evaluate the long-term effectiveness and acceptability of lamellar ceramide–based regimens, including their effects on OHD incidence, work productivity, and cost-effectiveness. Multicenter and international studies are needed to confirm transferability and to explore potential benefits for other perioperative professionals, such as surgeons and anesthesia staff. Further investigation into optimal dosing frequency, formulation characteristics, and integration with existing hand hygiene protocols may help refine occupational skin care recommendations for health care workers.

CONCLUSION

This RCT demonstrated that a lamellar-structured, ceramide-containing emulsion substantially improved hand skin barrier function in surgical nurses over a seven-day period. Compared with usual care, use of the emulsion resulted in significant reductions in TEWL, increased stratum corneum hydration, and improved clinical dry skin scores, while no statistically significant changes were observed in the control group. These findings suggested that lamellar ceramide–based moisturizers could provide rapid and clinically relevant barrier support for nurses exposed to frequent perioperative hand hygiene. Integration of evidence-based moisturizing regimens into routine perioperative practice may help prevent work-related skin disorders, promote nurse well-being, and support sustained adherence to hand hygiene. Further studies are warranted to clarify long-term outcomes and broader applicability in diverse clinical settings.

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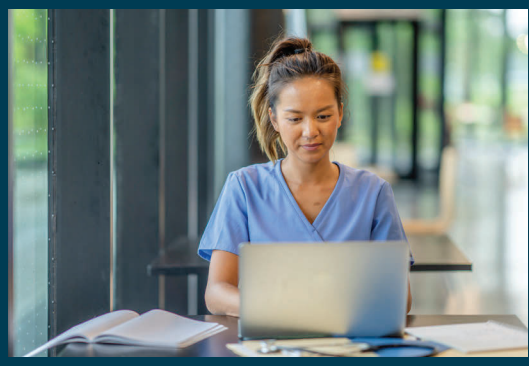
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