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# *"A Study on Skin Barrier Damage and Temporary Microvascular Activation by SLS-induced Skin Irritation"*

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## 1. Introduction

The major functions of the skin include protecting the body from physical and chemical insults [1]. The stratum corneum, the outermost layer of the skin, serves as the principal barrier to external environmental factors by preventing the ingress of harmful substances such as antigens and infectious microorganisms, while also minimizing moisture loss from within [2,3]. A variety of factors can disrupt the integrity of this barrier, leading to clinical symptoms such as dryness, itching, redness, flaking, cracking, and a rough texture [4,5,6,7].

As the importance of maintaining healthy skin barrier function grows, the cosmetic industry has increasingly focused on developing products and ingredients that support barrier repair and maintenance [8,9,10]. Optimal evaluation of skin barrier function should ideally assess not only surface changes but also structural alterations within the skin. However, many clinical evaluations to date have relied on subjective parameters such as participant-reported itchiness or surface-level visual assessments [11,12,13].

Recent advancements in non-invasive skin measurement technologies have enabled objective and quantitative analysis of both structural and functional changes in irritated or sensitive skin, thereby overcoming the limitations of surface-only evaluations [14]. Skin tone, texture, and pigmentation—including erythema—can be assessed via image analysis using specific light sources and filters [15]. TEWL (transepidermal water loss) quantifies the amount of moisture evaporating from the skin surface, serving as an indicator of barrier disruption [16]. Laser Doppler techniques can evaluate microvascular blood flow as a proxy for inflammatory responses [17].

For assessing changes beneath the surface, high-frequency ultrasound imaging provides insights into the thickness and density of both the epidermis and dermis [18]. In addition, Optical Coherence Tomography (OCT) offers high-resolution scans that allow evaluation of epidermal thickness, Vessel density, and overall skin structure [19].

In this study, we investigated the physiological and structural changes that occur following skin barrier damage induced by Sodium Lauryl Sulfate (SLS). Additionally, we aimed to directly confirm the involvement of vascular activation in the erythema response observed on the skin surface following surfactant-induced irritation. Furthermore, we quantitavely evaluated the changes within the skin after applying a barrier-repairing cosmetic to irritated skin, using a suite of non-invasive measurement techniques to quantify outcomes.

## 2. Materials and Methods

### *2.1 Clinical study*

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the Institutional Review Board (P2504-8519). All participants were informed of the purpose of the study and gave written consent before participation.

A total of 15 healthy participants were recruited, with a mean age of 41.27 ± 11.74 years. Those with skin diseases such as acne, sensitivity, or keloids, or who were pregnant or lactating were excluded from the study. Before measurements, participants thoroughly washed their forearms and were allowed to acclimatize for 30 minutes in an evaluation room maintained under constant temperature and humidity conditions (temperature: 22 ± 2°C, relative humidity: 50 ± 10%). Skin barrier damage was induced by applying a 2% sodium lauryl sulfate (SLS) solution to a 1 × 1 $cm^2$ area of the forearm for 24 hours. The participants were instructed to apply a designated skin barrier cream to the designated damaged area twice a day for 14 days. The area to which each participant applied the skin barrier cream and the area to which they did not apply the product were randomly assigned.

### *2.2 Evaluation of Skin Barrier Function*

Skin barrier function was quantitatively assessed by measuring transepidermal water loss (TEWL) and skin hydration before and after SLS-induced irritation. TEWL was measured using a Vapometer (Delfin Technologies Ltd., Finland), while skin hydration was evaluated using a Corneometer® CM825 (Courage+Khazaka electronic GmbH, Germany). These measurements were used to assess the functional changes in the skin barrier following chemical irritation.

### *2.3 Evaluation of Skin Structure (Thickness and Density)*

Changes in the structure of the skin—including epidermal and dermal thickness as well as overall density—were assessed using two imaging modalities. The VivoSight Optical Coherence Tomography (OCT) device (Michelson Diagnostics, Maidstone, UK) provided detailed visualization of skin structures, particularly allowing the assessment of Vessel density, epidermal thickness, and skin density (dermal brightness) in relation to barrier function, enabling direct evaluation of changes associated with barrier damage. Additionally, high-resolution ultrasound imaging was conducted using the Skin Scanner High Resolution Ultrasound (TPM

taberna pro medicum, Germany), which is commonly used for non-invasive assessment of skin thickness and density.

### *2.4 Evaluation of Redness and Microvascular Blood Flow*

Skin redness and microvascular responses following SLS-induced irritation were evaluated using OCT, Antera 3D® CS, and Laser Doppler imaging. Antera 3D® CS (Miravex Ltd., Ireland) reconstructs three-dimensional images of the skin surface using multidirectional LEDs and reflection angles. In this study, the device was used to quantify erythema via haemoglobin mode and analysis of the a* value. Laser Doppler Perfusion Imaging (PeriScan PIM3, Sweden) was utilized to monitor superficial tissue blood flow, visualizing changes in microcirculation as a response to irritation. OCT further contributed to the evaluation of vascular changes by visualizing and quantifying Vessel density beneath the skin surface.

### *2.5 Statistics*

The significant difference in the measurement data before and after inducing skin irritation was analyzed using SPSS Statistics. In the statistical analysis, the following notations were used: * indicates a *p*-value less than 0.05, as determined by the Paired t-test, and # represents a *p*-value less than 0.05, as determined by the Wilcoxon signed-rank test.

## 3. Results

### *3.1 Transepidermal Water Loss (TEWL) and Skin Hydration*

After SLS-induced skin irritation, a significant increase in TEWL was observed, indicating disruption of the skin barrier. In contrast, skin hydration levels, as measured by the Corneometer, showed a noticeable decrease, reflecting impaired moisture retention ability of the stratum corneum(Table 1).

**Table 1.** Changes in TEWL and skin hydration before and after SLS-induced Irritation

| (mean ± SD) | Before | After | *p*-value |
|---|---|---|---|
| TEWL | 7.203±2.738 | 21.857±5.244 | 0.001# |
| Skin Hydration | 41.511±10.289 | 40.947±11.765 | 0.820 |

### *3.2 Evaluation of skin structure (epidermal thickness and density)*

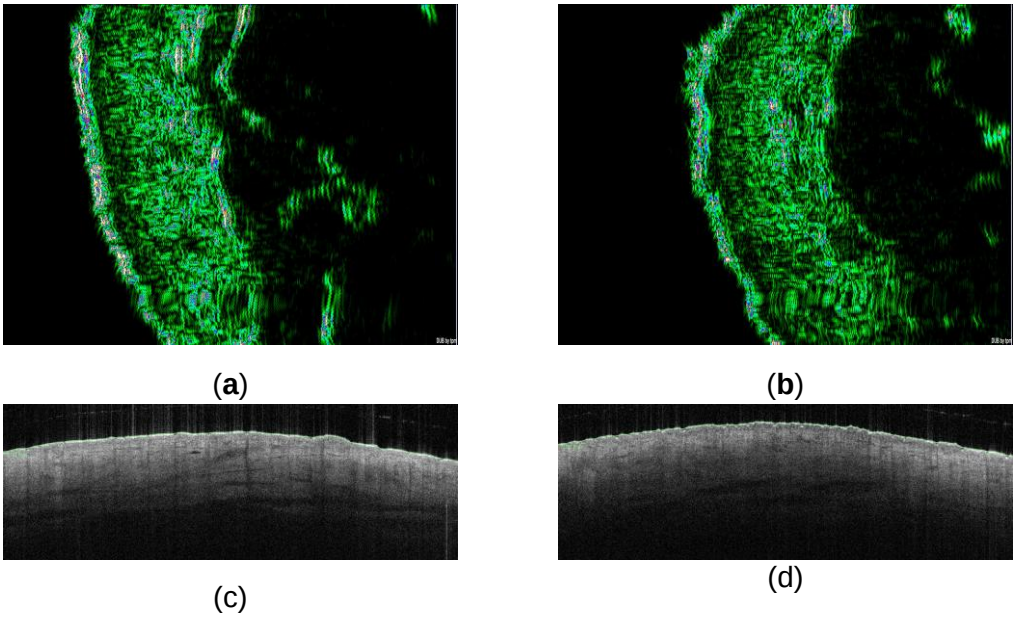
Following SLS-induced damage, analysis of ultrasound images revealed a decrease in epidermal thickness and density due to barrier damage. Regarding the dermis, although the thickness slightly increased, the density decreased after SLS irritation. OCT measurements showed similar results to the ultrasound findings, with a decrease in skin density in deeper layers. These findings suggest structural damage affecting both the superficial and deeper layers of the skin (Table 2).

**Table 2.** Changes in skin thickness and density before and after SLS-induced Irritation

| (mean ± SD) | Before | After | *p*-value |
|---|---|---|---|
| Epidermal thickness | 111.333±23.957 | 102.667±19.855 | 0.181 |

| (mean ± SD) | Before | After | *p*-value |
|---|---|---|---|
| Epidermal density | 43.735±6.303 | 37.308±8.593 | 0.026# |
| Dermal thickness | 1015.667±214.738 | 1042.400±329.406 | 0.510 |
| Dermal density | 17.881±4.318 | 15.445±6.235 | 0.082 |
| Skin density(OCT) | 1.067±0.068 | 0.904±0.065 | 0.000* |

The following are representative imaging results illustrating structural changes in the skin before and after SLS-induced irritation. Ultrasound images (a and b) demonstrate a reduction in epidermal thickness and density after damage, and the OCT images (c and d) show a concomitant decrease in skin density, indicating damage to both the epidermal and dermal layers (Figure 1).



(**a**) (**b**)

(c) (d)

Figure 1. (a)High-resolution ultrasound image before SLS application; (b)High-resolution ultrasound image after SLS application; (c)OCT image before SLS application; (d)OCT image after SLS application.

### *3.3 Evaluation of erythema and microvascular blood flow*

Antera 3D analysis showed elevated erythema levels, especially in the haemoglobin distribution image. Laser Doppler imaging demonstrated increased superficial blood perfusion, particularly in the damaged areas, reflecting microvascular activation. Additionally, OCT visualizations confirmed enhanced Vessel density(Table 3).

**Table 3.** Changes in erythema and microvascular blood flow before and after SLS-induced Irritation

| (mean ± SD) | Before | After | *p*-value |
|---|---|---|---|
| Erythema | 1.793±3.723 | 13.361±8.793 | 0.001# |
| Blood flow | 46.933±8.328 | 76.667±26.755 | 0.000* |
| Vessel density | 3.260±2.037 | 4.253±2.541 | 0.388 |

Visible erythema was observed on the surface of the irritated area, with a concomitant increase in blood flow and vessel density within the same region (Figure 2).

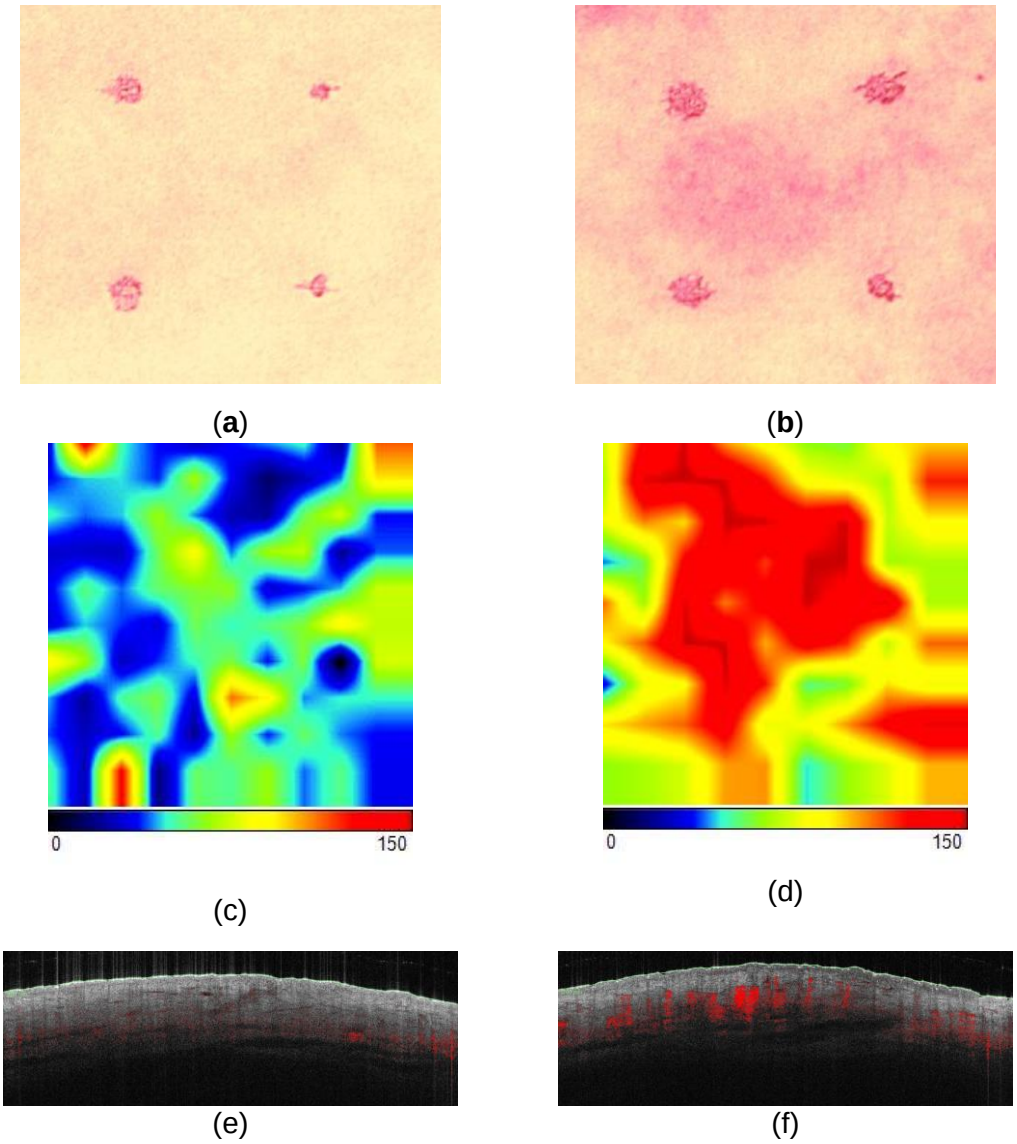



Figure 2. (a) Erythema image before SLS application; (b) Erythema image after SLS application; (c) Blood flow image before SLS application; (d) Blood flow image after SLS application; (e) Vessel density image before SLS application; (f) Vessel density image after SLS application.

## 4. Discussion

This study aimed to objectively evaluate the structural and functional changes occurring after skin irritation induced by Sodium Lauryl Sulfate (SLS) using various non-invasive measure-

ment devices. The significant increase in transepidermal water loss (TEWL) and the decrease in skin hydration clearly indicate impairment of the barrier function of the stratum corneum, which is consistent with previous studies on surfactant-induced irritation.

Structural analysis using high-resolution ultrasound and optical coherence tomography (OCT) revealed a decrease in epidermal thickness, a significant decrease in epidermal density, and a tendency for decreased dermal density. In particular, with regard to density, ultrasound measurements showed a significant decrease in epidermal density, and dermal density also showed a tendency to decrease. Additionally, OCT-measured skin density (dermal brightness) significantly decreased. These findings suggest that SLS affects not only the superficial layers of the skin but also penetrates into the deeper layers, causing microstructural damage. These results highlight the limitations of conventional methods that primarily rely on TEWL and surface erythema to evaluate skin barrier function and underscore the need for deeper, more precise assessments of skin damage.

Additionally, the observed increase in erythema and microvascular activation indicates that physiological responses accompany the structural damage. Antera 3D analysis confirmed enhanced erythema through an increase in hemoglobin distribution, while Laser Doppler and OCT measurements showed elevated blood flow and vessel density in the irritated regions. These findings can be interpreted as part of a natural physiological response to repair the skin following barrier disruption.

## 5. Conclusion

As in previous studies, the results of this study revealed that SLS-induced skin irritation results in both functional and structural damage, including increased TEWL, decreased hydration, thinning of the epidermis, and reduced skin density[20]. Moreover, the observed increase in erythema and microvascular activity suggests that physiological responses are triggered by barrier impairment.

These findings demonstrate that multidimensional changes following skin barrier damage, including both functional and structural alterations, can be effectively captured using various non-invasive measurement tools. In particular, direct imaging of deeper skin layers allowed for the confirmation of structural damage associated with barrier disruption, thereby overcoming the limitations of surface-level indirect assessments. The integrated skin analysis approach proposed in this study shows great potential for broader applications, not only in evaluating irritation and recovery processes or assessing the efficacy of products with barrier-repairing functions, but also in studying baseline differences in sensitive or redness-prone skin.

*Reference*

[1] Rajkumar J, Chandan N, Lio P, Shi V. The Skin Barrier and Moisturization: Function, Disruption, and Mechanisms of Repair. Skin Pharmacol Physiol. 2023;36(4):174–185. doi: 10.1159/000534136.

[2] Yosipovitch G, Misery L, Proksch E, Metz M, Ständer S, Schmelz M. Skin Barrier Damage and Itch: Review of Mechanisms, Topical Management and Future Directions. Acta Derm Venereol. 2019;99(13):1201–1209. doi: 10.2340/00015555-3296.

[3] Fluhr JW, Moore DJ, Lane ME, Lachmann N, Rawlings AV. Epidermal barrier function in dry, flaky and sensitive skin: A narrative review. J Eur Acad Dermatol Venereol. 2024;38:812–820. doi: 10.1111/jdv.19745.

[4] Baker P, Huang C, Radi R, Moll SB, Jules E, Arbiser JL. Skin Barrier Function: The Interplay of Physical, Chemical, and Immunologic Properties. Cells. 2023;12(23):2745. doi: 10.3390/cells12232745.

[5] Kim BE, Leung DYM. Significance of Skin Barrier Dysfunction in Atopic Dermatitis. Allergy Asthma Immunol Res. 2018;10(3):207–215. doi: 10.4168/aair.2018.10.3.207.

[6] Engebretsen KA, Johansen JD, Kezic S, Linneberg A, Thyssen JP. The effect of environmental humidity and temperature on skin barrier function and dermatitis. J Eur Acad Dermatol Venereol. 2016;30(2):223–249. doi: 10.1111/jdv.13301.

[7] Barresi R, Chen E, Liao IC, Liu X, Baalbaki N, Lynch S, et al. Alteration to the Skin Barrier Integrity Following Broad-Spectrum UV Exposure in an Ex Vivo Tissue Model. J Drugs Dermatol. 2021;20(4):23s–28s. doi: 10.36849/JDD.2021.589D.

[8] Schild J, Kalvodová A, Zbytovská J, Farwick M, Pyko C. The role of ceramides in skin barrier function and the importance of their correct formulation for skincare applications. Int J Cosmet Sci. 2024;46(4):526–543. doi: 10.1111/ics.12972.

[9] Skibska A, Perlikowska R. Signal Peptides - Promising Ingredients in Cosmetics. Curr Protein Pept Sci. 2021;22(10):716–728. doi: 10.2174/1389203722666210812121129.

[10] Wang R, Yan S, Ma X, Zhao J, Han Y, Pan Y, et al. The pivotal role of Bifida Ferment Lysate on reinforcing the skin barrier function and maintaining homeostasis of skin defenses in vitro. J Cosmet Dermatol. 2023;22(12):3427–3435. doi: 10.1111/jocd.15831.

[11] Koseki K, Kawasaki H, Atsugi T, Nakanishi M, Mizuno M, Naru E, et al. Assessment of skin barrier function using skin images with topological data analysis. NPJ Syst Biol Appl. 2020;6(1):40. doi: 10.1038/s41540-020-00160-8.

[12] Montero-Vilchez T, Cuenca-Barrales C, Rodriguez-Pozo JA, Diaz-Calvillo P, Tercedor-Sanchez J, Martinez-Lopez A, et al. Epidermal Barrier Function and Skin Homeostasis in Atopic Dermatitis: The Impact of Age. Life (Basel). 2022;12(1):132. doi: 10.3390/life12010132.

[13] Kim DW, Park JY, Na GY, Lee SJ, Lee WJ. Correlation of clinical features and skin barrier function in adolescent and adult patients with atopic dermatitis. Int J Dermatol. 2006;45(6):698–701. doi: 10.1111/j.1365-4632.2005.02644.x.

[14] Jayachandran M, Rodriguez S, Solis E, Lei J, Godavarty A. Critical Review of Noninvasive Optical Technologies for Wound Imaging. Adv Wound Care (New Rochelle). 2016;5(8):349–359. doi: 10.1089/wound.2015.0678.

[15] Matias AR, Ferreira M, Costa P, Neto P. Skin colour, skin redness and melanin biometric measurements: comparison study between Antera(®) 3D, Mexameter(®) and Colorimeter(®). Skin Res Technol. 2015;21(3):346–362. doi: 10.1111/srt.12199.

[16] Barel AO, Clarys P. Study of the stratum corneum barrier function by transepidermal water loss measurements: comparison between two commercial instruments: Evaporimeter and Tewameter. Skin Pharmacol. 1995;8(4):186–195. doi: 10.1159/000211345.

[17] Eun HC. Evaluation of skin blood flow by laser Doppler flowmetry. Clin Dermatol. 1995;13(4):337–347. doi: 10.1016/0738-081x(95)00080-y.

[18] Hoffmann K, Winkler K, el-Gammal S, Altmeyer P. A wound healing model with sonographic monitoring. Clin Exp Dermatol. 1993;18(3):217–225. doi: 10.1111/j.1365-2230.1993.tb02174.x.

[19] Trojahn C, Dobos G, Richter C, Blume-Peytavi U, Kottner J. Measuring skin aging using optical coherence tomography in vivo: a validation study. J Biomed Opt. 2015;20(4):045003. doi: 10.1117/1.JBO.20.4.045003.

[20] Agner T, Serup J. Sodium lauryl sulphate for irritant patch testing--a dose-response study using bioengineering methods for determination of skin irritation. J Invest Dermatol. 1990;95(5):543–547. doi: 10.1111/1523-1747.ep12504896.

[21] Lodén M. Barrier recovery and influence of irritant stimuli in skin treated with a moisturizing cream. Contact Dermatitis. 1997;36(5):256–260. doi: 10.1111/j.1600-0536.1997.tb00213.x.

[22] Wakeman MP. An open-label forearm-controlled pilot study to assess the effect of a proprietary emollient formulation on objective parameters of skin function of eczema-prone individuals over 14 days. Clin Cosmet Investig Dermatol. 2017 Jul 27;10:275-283. doi: 10.2147/CCID.S135841. PMID: 28794649; PMCID: PMC5538541.