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Short- and Long-Term Effects of Adding Topical Cosmetics to a Dermatological Procedure (Thermage): A Randomized Controlled Comparative Study Exploring the Synergistic Effects

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ABSTRACT

Background: Dermatological procedures improve skin changes caused by aging. However, few studies have focused on the effect of improving various skin characteristics compared with the concurrent use of cosmetics. We aimed to confirm changes in skin characteristics owing to anti-aging dermatological procedures in the short- and long-term and to determine the efficacy of the procedure when products with anti-aging and repair effects are used together.

Materials and Methods: We included 42 women (mean age, 47.667 ± 3.183 years) divided into a test (n = 21) and control (n = 21) group, with no history of dermatological procedures within 3 months of the test participation date. The dermatological procedure involved a single application of Thermage treatments, and products containing repair and anti-aging ingredients were used for the test group. The skin changes were assessed using device-based measurements and image analysis up to 4 weeks post-procedure. **Results:** Post-procedure side effects were alleviated 1 day after the procedure, and transepidermal water loss (TEWL) improved when the products were used together. Skin hydration, elasticity, density, fine lines, texture, and pores improved at 4 weeks after the procedure. When the test product was also used, the improvement was significantly greater, and TEWL of the face improved in the test group only. Aging-related skin characteristics were improved by Thermage, and the combined use of test products and procedures with repair and anti-aging effects improved skin characteristics.

Conclusion: Dermatological procedures and cosmetic products have internal and external anti-aging effects on the skin, respectively, resulting in synergy.

1 | Introduction

Dermatological procedures are effective ways of improving skin changes caused by aging [1]. Interest in dermatological procedures is increasing, not only among the age groups where aging has already progressed, but also among millennials, an age group that has begun to notice changes due to aging [2, 3]. Additionally, during the coronavirus disease 2019 (COVID-19) period, people became more aware of their own appearance owing to increased video conferencing and the occurrence of skin problems, such as

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acne, caused by wearing masks [4]. Furthermore, due to concerns about infection by diseases such as COVID-19, the preference for noninvasive or minimally invasive procedures is expected to increase [4].

Interest in dermatological procedures is increasing among various populations; however, to date, studies on dermatological procedures have been conducted to prove that they are safe without irreversible side effects [5–7], or to confirm the efficacy of the procedure in direct connection with the principles thereof [8, 9]. Additionally, studies have been conducted on the effects of using cosmetics, another skin improvement method, after the procedure [10, 11], but there are few studies where the treatment alone is accurately compared to that of different groups simultaneously.

Few studies have focused on how dermatological procedures and cosmetics change skin characteristics in the short- and long-term, as well as their synergistic effects. Therefore, the aim of the current study was to evaluate the short- and longterm effects of dermatological and cosmetic procedures on the skin, with a focus on changes in skin characteristics caused by noninvasive anti-aging dermatological procedures. In addition, we compared and evaluated the short- and long-term differences between cases where only the procedure was performed and cases where cosmetics with anti-aging effects were used. Cosmetics containing anti-aging ingredients can have an anti-aging effect on the skin by themselves; however, we aimed to determine the effect they would have when combined with dermatological procedures with a stronger effect in this regard, and suggest a more effective skin care method. To this end, we confirmed skin changes due to anti-aging dermatological procedures from various aspects, derived insights into changes by period after the procedure, and evaluated the synergistic effect when cosmetics are also used.

2 | Materials and Methods

2.1 | Participants, Cosmetic Procedures, and Products

The study was approved by the Institutional Review Board (IRB) of Global Medical Research Center (GMRC), with IRB approval number GIRB-23120-NB. All participants provided voluntary written informed consent prior to the commencement of the study. The test was conducted on 42 healthy women in their 30s and 50s (mean age, 47.7 ± 3.2 years) who did not undergo dermatological procedures within 3 months of the test participation date and had not used topical agents. Additionally, participants who were healthy and without any physical conditions, including skin disorders, and who were available for follow-up during the study period were recruited. These women were divided into a test (n = 21) and control group (n = 21). Participants understood the purpose of the test, participated voluntarily, and signed an informed consent form. The dermatological procedure was Thermage (Thermage Inc., Hayward, CA, USA), a representative anti-aging treatment that improves the skin by applying highfrequency energy to break down collagen in the skin layer and induce new collagen production [12]. As the radiofrequency energy passes through the skin, heat is generated owing to the resistance within the skin tissue. This heat in the dermal layer causes collagen fibers to undergo thermal denaturation, leading to the contraction of existing collagen fibers and the promotion of new collagen production [13]. The procedure was performed with 300 shots on the face, excluding the nose and forehead, with an energy level of 2, and a Total Tip area of 4.0 cm²; the intensity and number of shots were the same in the test and control groups. The dermatological procedure was performed by a board-certified dermatologist who is an expert in performing such treatments. To confirm the effect of combined product use after the procedure, both groups stopped using cosmetics with anti-aging effects during the study period, and used cream products.

The products manufactured by AMOREPACIFIC used by the test group during the study period contained repair and anti-aging ingredients called Lactobacillus Ferment Lysate, manufactured by extracting nucleic acids from lactic acid bacteria, L. plantarum APsulloc331261, and Lactobacillus Ferment, an exosome raw material that captures the extracellular vesicles of L. plantarum APsulloc331261 [14, 15]. These ingredients demonstrated cell regeneration efficacy in vitro and showed barrier improvement functionality through epidermal improvement in artificial skin models. The control group used a non-functional moisturizing cream that lacked anti-wrinkle ingredients but provided basic moisturizing effects. Both groups used the product twice a day, in the morning and evening, during the 4 weeks of the test. To minimize variables that could affect the test results, participants were instructed to use only the test product or control product allocated to their respective groups for a period of 4 weeks. Additionally, they were prohibited from undergoing any additional cosmetic procedures and were encouraged to maintain a consistent daily routine without significant lifestyle changes. The amount of product used by each group was also monitored to ensure there was no significant difference between the two groups.

2.2 | Measurements

Transepidermal water loss (TEWL) measurements were performed on the cheeks using a Tewameter TM 300 instrument (C + K, Köln, Germany). Skin redness of the cheeks was analyzed using RBX red mode images from VISIA-CR (CANFIELD, Fairfield, CT, USA). Skin temperature was measured on the cheeks using a thermal imaging camera (FLIR-E6390, Wilsonville, OR, USA). Facial swelling and lifting were measured and analyzed using Morpheus 3D (Morpheus Co., Korea). Skin hydration was measured using a Corneometer MPA580 device (C+K, Köln, Germany). Cheek skin hydration was measured. All measurement times are listed in Table 1.

Skin elasticity was measured on the cheeks using Cutometer MPA580 devices (C+K, Köln, Germany). Skin density on the cheeks was measured and analyzed using a skin scanner (TPM, Germany). The density (%) and thickness (μ m) of the epidermis and dermis were evaluated. The number of skin pores on the cheeks was measured and analyzed using an Antera 3D (Miravex, Ireland).

Fine lines and skin texture were measured and analyzed using PRIMOS Lite (CANFIELD, Fairfield, CT, USA). A fine-line

TABLE 1	Measurement time for each skin characteristic.

	Base	Immediately after the procedure	At 1 day after the procedure	At 2 weeks after the procedure	At 4 weeks after the procedure
Transepidermal water loss	0	0	0	0	0
Skin redness	0	0	0	0	0
Skin temperature	0	0	0	—	—
Facial swelling	0	0	0	—	—
Skin elasticity	0	—	—	0	0
Skin density	0	—	—	0	0
Skin lifting	0	—	—	0	0
Fine lines	0	—	—	0	0
Skin pore number	0	—	—	0	0
Skin texture	0	—	—	0	0
Skin hydration	0	—	—	0	0
Skin glossiness	0	—	—	0	0
Skin color (L*, a*, b*)	0	—	—	0	0
Facial yellowness (L*)	0	—	—	0	0

analysis was performed on the nasolabial folds, and skin texture analysis was performed on the cheeks. The Ra value was evaluated, with the unit being μ m.

Skin glossiness, color, lightness (L*), redness (a*), and yellowness (b*) were analyzed on the cheeks using parallel-polarized and standard 2-mode images from VISIA-CR (CANFIELD, Fairfield, CT, USA). The yellowness of the entire face was analyzed using images obtained using Visia-CR.

2.3 | Statistical Analysis

All statistical analyses were performed using SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). Changes in skin characteristics between the test and control groups were compared using repeated-measures analysis of variance (RM-ANOVA). If normality was satisfied, paired-sample *t*-tests or RM-ANOVAs were performed. If normality was not satisfied, Wilcoxon signed-rank or Friedman tests were used. Statistical significance was set at p < 0.05.

3 | Results

3.1 | Skin Changes Due to Procedure

Skin redness, temperature, swelling, and TEWL significantly increased immediately after the procedure compared to before the procedure by 4.1 (a*), 1.2° C, 9.8 mL, and 4.4 g/m²h, respectively (Figure 1). These measurements were significantly reduced by 4.8 (a*), 1.8° C, 9.6 mL, and 1.6 g/m^2 h, respectively, 1 day after the procedure compared to immediately after the procedure. There were no significant differences in skin redness, temperature, and swelling 1 day after the procedure compared to before



FIGURE 1 | Short-term changes in skin characteristics due to the procedure (control group results). *p < 0.05, **p < 0.01, ***p < 0.001 Base versus immediately after the procedure and at 1 day after the procedure.

the procedure, confirming that these changes returned to a significant level compared to that before the procedure (Figure 1).

Skin hydration, elasticity, density, lifting (cheeks), and glossiness significantly increased at 2 and 4 weeks after the procedure compared to before the procedure. Fine lines, skin texture, pores, and lifting (chins) were significantly reduced (Figure 2).

3.2 | Short-Term Effects of Combined Procedure and Cosmetic Product Use

Because most skin changes caused by the procedure tended to be alleviated at 1 day after the procedure, it was difficult to identify a clear difference depending on whether the test product was used. The skin characteristic showing a significant difference between the test and control groups was TEWL, which decreased significantly more in the test group at 1 day after the procedure



FIGURE 2 | Long-term changes in skin characteristics due to the procedure (control group results). *p < 0.05, **p < 0.01, ***p < 0.001 Base versus 2 weeks after the procedure and 4 weeks after the procedure.

than immediately after the procedure (Figure 3) (decreased by $3.2 \text{ g/m}^2\text{h}$ in the test group and $1.6 \text{ g/m}^2\text{h}$ in the control group). The test group increased significantly less (by $1.2 \text{ g/m}^2\text{h}$) than the control group at 1 day after the procedure compared to before the procedure, whereas that of the control group increased by $2.8 \text{ g/m}^2\text{h}$. Although the changes in these values may be too small to be considered clinically significant, the statistical significance suggests that there was a slight improvement in the test group.

3.3 | Long-Term Effects of Combined Procedure and Cosmetic Product Use

In the group that underwent the procedure and used test products, skin redness, TEWL, hydration, elasticity, density, fine lines, texture, pores, lifting, glossiness, and color improved significantly after 2 weeks of the procedure and product use compared with before the procedure. Additionally, after 4 weeks of procedure and product use, facial yellowness significantly improved. The skin characteristics that showed significant differences between the groups were TEWL, skin hydration, skin density, fine lines, skin texture, and pores (Table 2). Results showing an improvement rate of less than 10% were excluded, even if they exhibited statistical significance.

The TEWL of the test group decreased by 14.2% after 2 weeks of treatment and product use and by 16.4% after 4 weeks. The control group did not show a significant difference, while the test group showed a significant difference from the control group (Figures 4 and 5).

4 | Discussion

Thermage is a procedure that induces collagen regeneration by applying high-frequency energy to the inside of the skin. It does not cause direct damage to the skin surface [12]; however, if the heat energy is high, it may affect the skin from the inside to the outside [16]. Increases in skin redness, temperature, TEWL, and swelling are thought to be due to the direct or indirect effects of this heat. Most skin changes caused by this procedure tended to be alleviated at 1 day after the procedure. Skin redness, temperature, and swelling decreased significantly compared with those



FIGURE 3 | Comparison of the group that used the test product after the procedure (test group) and the group that only underwent the procedure (control group) (short-term). *p < 0.05, **p < 0.01, ***p < 0.001 Base versus immediately after the procedure and at 1 day after the procedure. †p < 0.05, ††p < 0.01, †††p < 0.001 test group (A) versus control group (B).

immediately after the procedure, and there were no significant differences compared with those before the procedure. TEWL significantly decreased compared to that immediately after and 1 day after the procedure, but significantly increased compared to that before the procedure. Considering that the test participants occasionally felt heat in the treatment area for several days after the procedure, TEWL, an indicator that responds more sensitively than the other three characteristics, could have increased owing to the heat of the skin that was still affected by the procedure.

There were direct and indirect skin changes at 2 and 4 weeks after the procedure compared with before. Skin characteristics that significantly changed after the procedure were skin elasticity, density, fine lines, number of pores, texture, and hydration; the rate of change was higher at 4 weeks after the procedure than at 2 weeks after the procedure. Thermage is based on the principle of inducing regeneration by damaging collagen with heat energy [12], and skin elasticity and density may have changed as a direct effect of collagen regeneration. Fine lines and the number of pores were also significantly reduced, calculated by evaluating and quantifying areas that exceeded a certain level on the skin surface. Therefore, as the collagen inside the skin regenerates, fine lines and shallow pores improve [17, 18], resulting in a decrease in the **TABLE 2** | Changes in the skin characteristics of the test and control groups at 2 weeks after the procedure or 4 weeks after the procedure compared to before the procedure and statistically significant differences between the groups.

Measurement time point	Skin characteristics	Test group	Control group	Statistically significance
After 2 weeks	TEWL	-14.23%	_	0
After 4 weeks		-16.39%	—	0
After 2 weeks	Skin hydration	18.70%	12.74%	0
After 4 weeks		26.88%	16.92%	0
After 4 weeks	Skin elasticity (R2)	15.48%	12.66%	Х
After 4 weeks	Skin density	16.55%	7.37%	0
After 4 weeks	Fine line	-11.94%	-6.96%	0
After 4 weeks	Skin texture	-12.02%	-6.75%	0
After 2 weeks	Pore number	-14.78%	-7.73%	0
After 4 weeks		-25.08%	-16.69%	0

Note: All results organized in the table have statistically significant differences.

number of fine lines and pores. The decrease in skin texture and the increase in hydration may have been indirectly affected by the improvement in the overall skin condition as collagen was regenerated.

When test products with repair and anti-aging effects were used after the Thermage procedure, the differences compared to the control group that used the basic moisturizing cream were as follows. The skin characteristic that showed a significant improvement difference between the test group and the control group 1 day after the procedure and 4 weeks was TEWL. As seen in the results of the control group, although Thermage acts on the principle of minimizing skin surface damage and helping collagen regeneration inside the skin [19], it appears to have influenced TEWL slightly, a skin barrier-related indicator. The use of the test product appears to have provided slight assistance in mitigating the increased TEWL compared to the control group. Furthermore, the test group showed a significant improvement in TEWL 4 weeks after the procedure, with a notable difference from the control group, whereas the control group did not exhibit any significant changes compared to the baseline measurements. The test product contains ingredients that have efficacy in improving the skin barrier, which may have helped strengthen the skin barrier upon usage. Because the epidermis and dermis interact with each other, a healthy epidermis can also benefit the condition of the dermis [20]. Therefore, the improvement of the skin barrier in the test group may have contributed to the improvement of other skin characteristics. Moreover, although cosmetics are applied to the epidermis, with consistent use, some ingredients can reach the dermis [21]. This could explain why the skin of both the test group and the control group improved following the procedure, with the test group showing greater improvement. The consistent use of the test product may have contributed to this enhanced outcome.

In the test group that used the test product during the procedure, significant long-term changes in skin elasticity, density, fine lines, pore, TEWL, texture, and hydration were observed. The skin characteristics that were significantly different from those of the control group included skin density, fine lines, TEWL, texture, and hydration. Skin elasticity and density are characteristics that are directly related to the treatment principle [16], and changed in a positive direction even in the control group that received only the treatment without using the test product. In the test group that used the test product, the rates of change in skin density were significantly higher than those in the control group. For skin density, the rate of change after 4 weeks was more than twice that of the control group. The anti-aging ingredients contained in the test product may have aided in the collagen regeneration process after the procedure [22]. In the case of skin elasticity, the rate of change in the test group was slightly higher; however, there was no significant difference between the groups. Because skin elasticity changed significantly with only the procedure, it is thought that it would have been difficult to observe significant differences due to skincare product use.

Fine lines and the number of pores significantly decreased more following the procedure and test product use compared to the control group, which may be attributed to the antiaging ingredients included in the test product [22]. Skin texture and hydration also decreased and increased significantly more, respectively, than those in the control group, and additional skin moisturization through product application may have been helpful.

Usually, studies on skin changes due to procedures are conducted to confirm the safety of the procedure [5-7], or conducted on skin characteristics that are directly related to the procedural principles and prove the efficacy of the procedure [8, 9]. This study is meaningful in that it focused on the overall skin changes by period after the procedure, measured various skin characteristics that were directly and indirectly affected, and identified the changes in the short- and long-term. Additionally, studies on the combined use of procedures [10] and products have been conducted using half-tests on the same participants when looking only at the results of the combined use of procedures and products or comparing them with the results of the procedure alone [11, 23]. In our study, two groups were tested: one group received the procedure and used the test product, while the other group received the procedure and used a basic moisturizing cream to better observe the effects of the procedure alone. Therefore, the seasonal influence of the clinical period, the influence of



FIGURE 4 Comparison of the group that used the test product after the procedure (test group) and the group that only underwent the procedure (control group) (long-term). (a) TEWL change and rate of change. (b) Skin hydration change and rate of change. (c) Skin density change and rate of change. (d) Change in the number of pores and rate of change. (e) Fine lines change and rate of change. *p < 0.05, **p < 0.01, ***p < 0.001 Base vs. 2 weeks after the procedure and 4 weeks after the procedure. *p < 0.05, **p < 0.01, ***p < 0.01, ***p < 0.01 Base vs. 2





age of the participants, and the influence of the operator were minimized. Furthermore, it was possible to accurately compare skin changes when products containing repair and anti-aging ingredients were used in parallel. A limitation of this study is that the control group, set up to observe effects of the procedure alone, also used basic moisturizing cream. The test period was a dry winter with low temperatures; therefore, if no skincare products had been used at all, the skin would be so dry that it would have been difficult for test participants to manage it. To minimize the impact of the product, we provided a control product containing only the minimum amount of moisturizing ingredients, excluding the other active ingredients such as antiaging. For a more accurate comparison of the effects of using the product or not, a comparison with a control group that did not use the product during the test period may be necessary. Furthermore, the duration of this study was set at 4 weeks, which may be insufficient to observe the full spectrum of skin changes induced by the treatment. Therefore, a subsequent study that observes the skin over a longer period is necessary to ascertain the persistent effects of the treatment and the extended skin changes following the use of skincare products.

In conclusion, aging-related skin characteristics are improved by Thermage. The combined use of procedures and products with repair and anti-aging effects improves the skin characteristics that are not improved by the procedure alone. Dermatological procedures and cosmetic products will provide anti-aging effects from the inside of the skin, while the cosmetic product will provide anti-aging effects from the outside the skin, resulting in a synergistic effect.

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Ethics Statement

All data collection and testing were conducted in accordance with the regulations and deliberations of the Institutional Review Board.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Research data are not shared.

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