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Assessment of biophysical properties of the scalp: Comparison according to the androgenetic alopecia with seasonal variations

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Introduction:

The scalp is physically bordered by the face and the neck, covering cranial vault. The scalp has a high density of hair follicles and a relatively large amount of sebum secretion, which is distinct feature from skin of other areas.[1] The scalp repeats exfoliation and regeneration through periodic desquamation of keratinocytes, which form "Brick and mortar" structure with ceramides. The keratinocytes-ceramides structure acts as a barrier to respond to environmental factors and to prevent water loss. [2,3]
Hair repeats growth and falling out according to the hair growth cycle, and excessive hair loss due to vatious reasons is called alopecia. Androgenetic alopecia, the most common type of alopecia is caused by hypersensitivity to androgen, male sex hormone.[4,5] Androgenetic alopecia does not directly cause scalp damage or lesions, but hair follicle miniaturization can be occured inducing arrector pili muscle damage, excessive sebum secretion, microinflammation and impairment of scalp barrier function.[6,7]
Therefore, we assumed that there will be differences in the scalp characteristics between Alopecia group and Non-Alopecia group, and that the change patterns in response to the environment will also be different. Seasons were selected as an environmental factor to evaluate the change pattern. The measurements were conducted in august, 2020, hot and humid summer and january, 2021, cold and dry winter. 60 subjects were divided into Alopecia group and Non-Alopecia group through dermatological screening in summer and winter respectively, making 120 subjects in total. Scalp hydration, sebum content, trans-epidermal water loss and stratum corneum content were measured. In addition, ceramide contents of scalp stratum corneum were analyzed as a preliminary study.

Materials & Methods:

Subjects aged 18 to 54 years were recruited and screened by a dermatologist according to the Basic and Specific classification in Figure 1.[8] Subjects with Basic type of M1, C1, and U1 or higher or Specific type of V1 and F1 or higher were selected as Alopecia group, and others as Non-Alopecia group. All subjects visited the institution for instrument measurements to collect scalp biophysical characteristics as follows.

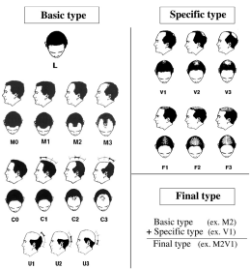

Figure 1. Basic and Specific (BASP) classification

The evaluation items were scalp hydration, sebum content, trans-epidermal water loss, and stratum corneum content. Items were measured using DermaLab ® USB Hydration (Cortex Technology, Denmark), Skin-O-Mat ® Sebumeter (COSMOMED, Germany), Vapometer (Delfin Technologies, Finland), respectively, and stratum corneum content was measured with SquameScan 850A Instrument (Heiland electronic GmbH, Germany) after tape stripped using D-Squame® D100 Standard Sampling Discs (Clinical and Derm, LLC, USA). The ceramide content of scalp stratum corneum samples obtained by tape stripping methods were analyzed by LaSS Corporation. All measurements were performed after acclimatization for at least 30 minutes under constant temperature and humidity (22±2 ℃, 50±10% relative humidity) conditions without air movement and direct sunlight.
Comparisons between seasons and groups were performed using IBM SPSS Statistics 28.0 (IBM Statistics, USA). All results were preceded by normality test, and independent t-test or Mann-Whitney U test methods were adopted depending on the satisfaction of normality. The results of statistical analyses were determined to be significant at the 95% confidence interval.
The test was approved by the Institutional Review Board (Approval number: 2020021201-202008-HR-001-01) and conducted in compliance with the ethical regulations and bioethics based on the Declaration of Helsinki with the voluntary consent of the subjects.

Results & Discussion:

All measurement results were compared based on season or group. There were statistically significant differences in all four biophysical parameters in Alopecia group. In Non-Alopecia group, there were differences in TEWL and stratum corneum content only. Both groups showed similar tendency in sebum content, TEWL, and stratum corneum content, but scalp hydration was statistically significantly greater in summer in Alopecia group. (Figure 2A) Compared between groups, there were statistically significant differences in scalp hydration and TEWL, but no significance in winter, however, scalp hydration of Alopecia group was noticeably decreased, showing significant difference with that of Non-Alopecia group. TEWL and stratum corneum content tended to increase greater in winter than in summer in both groups. (Figure 2B)

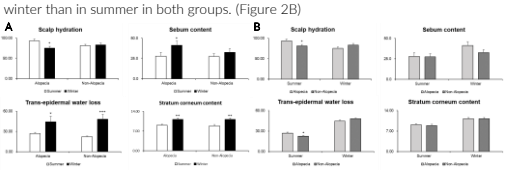

Figure 2. Comparison of scalp biophysical characteristics (A) By seasons (B) By groups

As a result of lipid analysis, ceramide content of tape stripped stratum corneum content in winter tended to be higher in Non-Alopecia group, but there was no statistical significance. (Figure 3) This study was performed to investigate the patterns of scalp of Alopecia group and Non-Alopecia group adapting to environmental factors. Based on the results, it was clear that there were differences between Alopecia group and Non-Alopecia group in biophysical parameters. With seasonal variations, both groups showed big differences in the TEWL and stratum corneum contents, however, scalp hydration and scalp sebum content increased significantly only in Alopecia group, showing more sensitive responses to environmental factors. We considered the disrupted barrier function to be the cause and analyzed the ceramides involved in the barrier function. Contrary to what was predicted, lipid analysis showed no statistical significance between Alopecia group and Non-Alopecia group in total amount of ceramides. Therefore, it is thought that further research is needed.

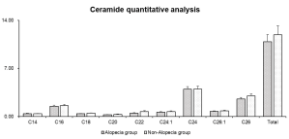

Figure 3. Results of ceramide analysis

Conclusions:

In this study, we hypothesized that the patterns of changes in the biophysical properties of scalp in Alopecia group and Non-Alopecia group would be different depending on the external environmental factors, temperature, and humidity. Comparing the scalp biophysical parameters according to the androgenetic alopecia with seasonal variations, there were significant differences in scalp characteristics and in change patterns between the Alopecia group and Non-Alopecia group, as we assumed. We thought that it would be related to the barrier function of the scalp, but there were limitations in result interpretation. In the next step, focusing on the scalp susceptibility to the temperature and humidity, we expect development of research to the correlation with the scalp barrier function and the mechanisms, hoping that it will be helpful as a fundamental data for the development of cosmetics, from seasonal scalp care products to products for scalp with hair loss.

Acknowledgements:

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