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Effects of Food Containing Pine Bark Extract on Scalp Condition: A Randomized, Double-Blind, Placebo-Controlled, Parallel-Group Study

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Abstract

Background: Supporting a healthy scalp environment by properly moisturizing the scalp is important for maintaining quality of life. Pine bark extract has been reported to improve blood flow, and it is expected that improved skin blood flow contributes to maintaining scalp moisture. However, clinical studies evaluating the effects of pine bark extract on human scalp conditions are limited. Therefore, the aim of this study was to evaluate the effects of a food containing pine bark extract on human scalp conditions. **Methods:** A randomized, double-blind, placebo-controlled, parallel-group trial was conducted to evaluate the effects of pine bark extract on scalp conditions in healthy participants. Eighty healthy men and women were enrolled and randomly divided into two groups. The active food group consumed a supplement containing pine bark extract (2.4 mg/day of procyanidins B1 and B3) for 12 weeks, while the placebo food group consumed a supplement without the extract for the same period. The primary endpoint measure was scalp transepidermal water loss. Secondary endpoint measures included scalp firmness and subjective questionnaire results. **Results:** At the end of the supplementation period, the active food group showed a statistically significant lower transepidermal water loss value compared to the placebo food group ($P < 0.05$). No adverse events related to the supplement were observed during the study period. **Conclusions:** These results suggest that taking food containing pine bark extract may have a positive effect on scalp moisture.

Keywords

Pine Bark Extract, Procyanidin B1, Procyanidin B3, Scalp

1. Introduction

Human skin is divided into the epidermis, dermis, and subcutaneous tissue. The stratum corneum, the outermost layer of the epidermis, is composed of corneocytes and intercellular lipids such as ceramides [1] [2]. It functions as a barrier between the internal and external environments, protecting the body from external factors and preventing water loss [3]. Beneath the epidermis is the thicker dermis, which is composed of collagen and elastin and provides structural support for the epidermis. Blood vessels in the dermis supply nutrients and oxygen to the skin [4].

Compromised skin barrier function is associated with skin diseases such as atopic dermatitis and psoriasis [5], and it has been reported that in dry skin, transepidermal water loss (TEWL), an indicator of impaired barrier function, increases [6]. It has been reported that TEWL is higher on the scalp compared to other areas, indicating a state of impaired barrier function [7]. Furthermore, skin barrier function is generally associated with skin dryness and itchiness [8]. Reports have correlated TEWL, an indicator of skin barrier function, with skin firmness [9] and, on the scalp, with dandruff [10]. The scalp is also known to be particularly susceptible to ultraviolet radiation. It has also been suggested that the scalp becomes stiffer with age, a change that is associated with alopecia [11]. Since scalp itchiness, dandruff, and hair loss reduce quality of life (QOL) [12], maintaining the scalp's barrier function and softness—that is, maintaining scalp health—contributes to maintaining QOL.

Pine bark extract (PBE) is an extract from the bark of the pine tree that is rich in polyphenols, represented by oligomeric proanthocyanidins [13]. It is known that the major components of the procyanidin dimer contained in pine bark are procyanidin B1 and procyanidin B3 [14]. PBE has been reported to have various physiological impacts, including antioxidant effects [15], cholesterol reduction [16], improvement of vascular endothelial function [17], promotion of blood flow [18], and improvement of platelet aggregation [19]. In Japan, it is sold as an ingredient in functional foods that claim benefits such as lowering LDL cholesterol.

The function and mechanical properties of skin are influenced by the qualitative and quantitative state of its constituent components, and the nutrients required to maintain these are delivered to the skin through the bloodstream [20]. Indeed, studies involving PBE intake have reported improvements in skin elasticity on the back of the hand, with the mechanism thought to be related to PBE's blood flow-enhancing effects [21]. Therefore, PBE is expected to improve skin characteristics such as moisture retention, elasticity, and firmness through its blood flow-enhancing action.

A previous report [22] on postmenopausal healthy women in China who consumed pine bark extract for six months indicated that although improvements were observed in scalp TEWL, no significant difference was found in scalp moisture content. Therefore, the primary objective of this study was to examine whether the intake of PBE in an amount typical for functional foods in Japan had an effect on scalp barrier function (TEWL) in healthy Japanese adult men and

women. Additionally, since PBE is known to support normal blood flow and platelet aggregation [23] purported to improve skin firmness [24], we decided to investigate whether it also has an effect on improving skin firmness. A randomized, double-blind, placebo-controlled, parallel-group comparative trial was conducted in healthy adult men and women concerned about scalp dryness and firmness. Percutaneous water loss, scalp firmness, and related subjective sensations were evaluated.

2. Materials and Methods

2.1. Study Design

A randomized, double-blind, placebo-controlled, parallel-group study (allocation ratio of 1:1) was conducted over 12 weeks. No changes were made to the protocol after the study started.

2.2. Study Participants and Setting

The participants were recruited as paid volunteers. The investigator enrolled healthy adults who met the inclusion criteria and did not violate the exclusion criteria. The study was fully explained to the participants prior to its initiation, and their written consent was obtained.

The inclusion criteria were as follows: 1) Healthy males and females aged 40 to 64 years old; 2) Subjects who are aware of their scalp skin dryness or firmness; 3) Subjects who can self-evaluate and voluntarily provide written informed consent.

The exclusion criteria were as follows: 1) Subjects who regularly use medications affecting the skin; 2) Subjects with skin disease, such as atopic dermatitis, or strange skin conditions at measurement points; 3) Subjects with severe hay fever symptoms and allergy symptoms; 4) Subjects with any food allergies; 5) Subjects who contract or are under treatment for serious diseases (e.g., liver disease, kidney disease, digestive disease, heart disease, respiratory disease, endocrine disease, vascular disorder, and/or metabolic disease); 6) Subjects who had received or planned to receive a cosmetic operation or beauty treatment on the test spot or had received hormone replacement therapy in the past 6 months; 7) subjects who cannot avoid direct sun exposure, such as through outdoor activities; 8) subjects with alopecia areata or other hair loss disorders (eczema of the head, seborrheic eczema, psoriasis, tinea capitis, or other scalp infections); 9) Subjects who regularly use wigs or have had or are planning to receive hair transplants or hair extensions; 10) Subjects who cannot discontinue the use of supplements and/or functional foods (including foods for specified health uses or foods with functional claims) affecting the skin; 11) Subjects who have a history and/or a surgical history of digestive disease affecting digestion and absorption; 12) Subjects who are pregnant, breastfeeding, or planning to become pregnant; 13) Subjects with an excessive alcohol intake of more than approximately 60 g/day of pure alcohol equivalent, a habit of drinking no less than 5 days a week, or cannot abstain from drinking on the days prior to each measurement; 14) Subjects who are under treatment

for or have a history of drug addiction and/or alcoholism; 15) Subjects who smoke 20 or more cigarettes a day or cannot abstain from smoking during the time from waking to inspection completion; 16) Subjects who work shifts and/or midnight shifts; 17) Subjects who participated or willing to participate in other clinical studies within one month prior to the current study; 18) Subjects who were determined to be unsuitable for the current study by the investigator for other reasons.

This study was reviewed and approved by the "The Ethics Committee of Miura Clinic, Medical Corporation Kanonkai" (Chair: Masaaki Nishi; approval date: 26 December 2024). It was conducted in accordance with the "Declaration of Helsinki (amended October 2013)" and "Ethical Guidelines for Medical and Biological Research Involving Human Subjects" (partially amended on 27 March 2023) and under the supervision of physicians at the Miura Clinic, Medical Corporation Kanonkai. The study design was registered in the clinical trial registration system of the University Hospital Medical Information Network Center, with the registration ID UMIN000056595 (name of the trial registration: A Study on the Effect of Food Containing Plant Extract on Skin Conditions-A Randomized, Double-blind, Placebo controlled, Parallel-group Study).

2.3. Intervention

During the trial period, the participants consumed the test food continuously for 12 weeks. A tablet containing PBE (TOYO SHINYAKU Co., Ltd.), maltitol, microcrystalline cellulose, sucrose esters of fatty acids, and silicon dioxide was used as the active food. The placebo food was prepared by replacing the PBE in the active food with caramel coloring so that it was indistinguishable from the active food in appearance. Both the active food and placebo food were designed for a daily intake of 250 mg × 2 tablets. During the intake period, the participants each consumed 1 packet (2 tablets) of the test food once daily with water or lukewarm water. The active food group received the active food, and the placebo food group received the placebo food. Table 1 shows the results of a nutrient composition analysis.

Table 1. Analysis of nutrient composition values of test food.

	Placebo food (2 tablets)	Active food (2 tablets)
Energy (kcal)[a]	2	2
Protein (g)[b]	0	0
Fat (g)	0.02	0.02
Ash (g)	0.5	0.5
Sodium (g)	0.004	0.0002
Pine Bark-Derived Procyanidin B1 and B3 (mg)	0.000	2.4

[a]Calorie conversion factors: protein, 4; fat, 9; carbohydrates, 4; [b]Nitrogen protein conversion factor: 6.25.

The amount of PBE-derived procyanidin, which is the sum of procyanidins B1 and B3 contained in PBE, was calculated to be 2.4 mg per daily dose.

2.4. Test Items

The primary endpoint was scalp TEWL, with secondary endpoints being scalp firmness and subjective sensations which were reported via a questionnaire. Evaluations were conducted three times: before intake, after 8 weeks of intake, and after 12 weeks of intake. No changes were made to the endpoints after the study began. Transepidermal water loss was measured using the Tewameter® TM nano (Courage + Khazaka electronic GmbH), and scalp firmness was measured using the Indentometer Scalp (Courage + Khazaka electronic GmbH). Measurements using the Indentometer show that the penetration depth decreases as skin firmness increases [25]; thus, lower values indicate firmer skin. To minimize variations due to factors other than the test substance, participants washed their hair and scalp before measurement and underwent 20 minutes of acclimatization in a constant temperature and humidity chamber (temperature: 21˚C ± 1˚C, humidity: 50% ± 5%) in a resting state prior to measurement. Measurements were taken in the temporal region, using the same site throughout the study period. For both TEWL and scalp firmness, seven measurements were taken at each assessment. The mean of the five middle measurements (excluding the highest and lowest values) was used for evaluation. For the subjective questionnaire, the participants assessed their scalp moisture and softness using the VAS (Visual Analog Scale) method. They were instructed to mark their response on a 100 mm straight line, and the distance from the left end to the mark was measured. The left end corresponded to "No moisture felt at all/Feels very hard", while the right end corresponded to "Feels very moist/Feels very soft".

All the participants were provided with a diary and instructed to record certain items daily throughout the intake period.

The following items were recorded: 1) Test food intake status; 2) Physical condition; 3) Intake of health supplements or medications; 4) Alcohol consumption, exercise, and smoking status.

2.5. Number of Cases

The target number of cases in this study was calculated based on a previous report on skin elasticity improvement following continuous PBE intake (2.4 mg/day as pine bark-derived procyanidins B1 and B3). Specifically, the change in skin elasticity from baseline was evaluated: [placebo food group −0.073 ± 0.015, active food group −0.003 ± 0.011] [21]. The sample size was calculated at a significance level of 0.05 and a power of 0.95. The sample size was set to 40 participants per group (80 participants in total), considering dropouts and discontinuations.

2.6. Research Methods

This study recruited paid volunteers, and the investigator enrolled the study par-

ticipants according to selection and exclusion criteria. The allocation manager used computer-generated random numbers to assign participants to groups using block randomization (block size 4), with age, gender, TEWL from the scalp, and scalp firmness as adjustment factors. The participants were assigned to an active food group or a placebo food group by the test's food allocation manager, who was not directly involved in the study. The test food allocation manager also prepared a table (key code) containing the allocation results and kept it in a sealed container; the key code was disclosed after the participants were determined, thereby ensuring blinding of persons other than the test food allocation manager. In addition, the tablets were placed in plain aluminum bags containing two tablets each and distributed to the research participants to ensure blinding of the research participants and intervention providers.

The participants were asked to take the following precautions throughout the study: to not make any major changes to their lifestyle, such as eating, drinking, exercise, sleeping, and smoking habits, from before participating in the study; to not change the type or frequency of use of cosmetics or skin care products (e.g., shampoo, conditioner, treatment, shampoo brush) from before the study; to avoid excessive exercise beyond the scope of daily life, as well as dieting and overeating; to generally prohibit the intake of medicines (including over-the-counter and prescription medicines), designated quasi-drugs, and health foods (including foods for specified health uses and foods with functional claims); to generally avoid the use of topical medicinal agents; to consult the testing institution in advance if required to take any medicine due to poor health or other reasons; to not change their habits if they used equipment that is expected to have an effect on the skin; to avoid visits to beauty salons for scalp care during the study period; to refrain from drinking alcohol or exercising excessively from the day before the test until the end of the test; to avoid consuming foods that may induce sweating or foods high in fat from the day before and the day of the test; to refrain from smoking from waking until the end of the test; to avoid bathing in hot springs (including saunas) for three days before the test; and to come to the clinic on the day of the test without consuming the test food.

The participants were asked to use drugs with permission from a principal investigator or sub-investigator, except in cases of emergency. Additionally, the monitoring officer was responsible for monitoring compliance with the required precautions (e.g., log entries) prescribed in the protocol.

2.7. Statistical Analysis

The population analyzed was defined as the per-protocol set (PPS). For each measurement, we performed an unpaired t-test between groups for each test and evaluated the results at the end of the intake period. All tests were two-tailed, with a significance level of 5%. Statistical analyses were performed using IBM SPSS Statistics 28. The study participants' backgrounds are presented as means ± standard deviations, and other data are presented as means ± standard errors. No additional

analysis was performed.

3. Results

3.1. Participants

In total, 80 participants (35 males and 45 females) were included in this study. The study was initiated with these 80 participants, with no dropouts after randomization, and the assigned intervention was implemented for 40 participants in each group. During the study period, one female participant in the active food group withdrew for reasons unrelated to the test food, resulting in a total of 79 participants completing the study. After the completion of the study, 70 participants (31 males and 39 females) were included in the analysis, with 9 participants rejected because they did not take the required precautions during the study period (3 participants in the placebo food group and 6 participants in the active food group). The analysis was performed according to the original allocation for each group. The intake rate of the active food in each group was 97.6%, and the intake rate of the placebo food was 97.3%. No difference was observed in the intake rate of the test food.

The period from recruitment to the end of follow-up was January 2025 to May 2025, and the study was terminated when all participants had received follow-up. The background of the study participants for the analysis is shown in Table 2, and a flowchart showing the process from inclusion to analysis is shown in Figure 1.

3.2. Analysis Results

Table 3 shows the results of the analysis of scalp TEWL. A comparison between the groups showed that TEWL after 12 weeks of intake was significantly lower in the active food group compared to the placebo food group (P = 0.045).

A comparison between the groups for scalp firmness and the VAS questionnaire results showed no significant differences in either. The results of the scalp firmness analysis are shown in Table 4.

Table 2. Participant characteristics.

Parameter	Placebo food group (n = 34)	Active food group (n = 36)
Male/Female	17/17	14/22
Age (years old)	50.4 ± 6.3	51.0 ± 5.7
Height (cm)	165.3 ± 9.4	164.2 ± 8.2
Body weight (kg)	61.1 ± 11.3	60.1 ± 10.6
Body mass index (kg/m^2)	22.2 ± 2.3	22.2 ± 2.8
TEWL of the scalp (g/m^2/h)	45.5 ± 13.0	42.2 ± 12.5

Values are expressed as means ± SDs. No significant difference was observed.

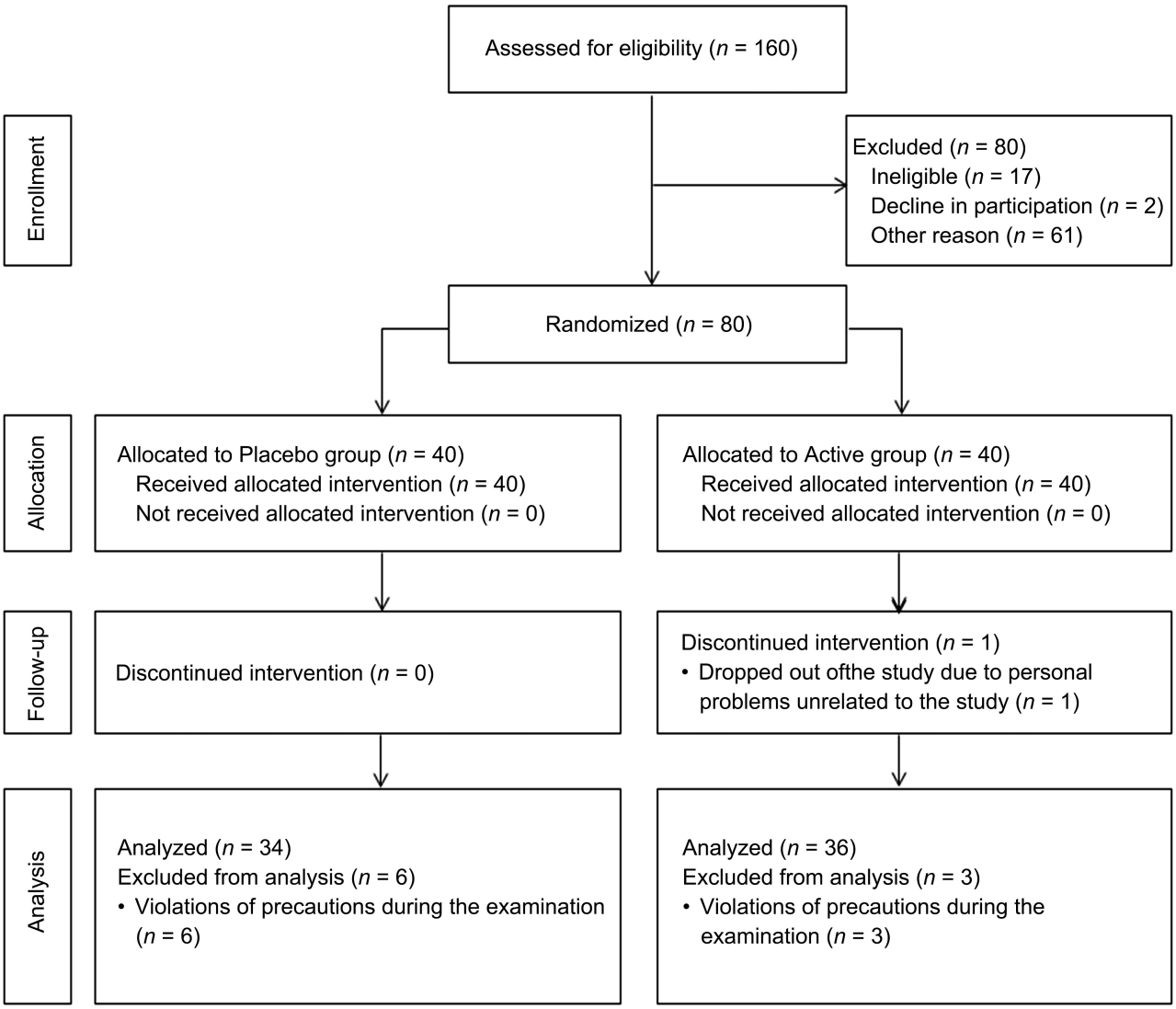

Figure 1. Flow diagram of progress through phases of randomized, double-blind, placebo-controlled, parallel-group study.

Table 3. Scalp TEWL measurement results.

	Group	Baseline	8 Weeks	12 Weeks
TEWL of the scalp ($g/m^2/h$)	Placebo food ($n = 34$)	45.5 ± 2.2	46.3 ± 2.7	51.3 ± 3.3
	Active food ($n = 36$)	42.2 ± 2.1	44.2 ± 2.8	43.9 ± 1.6*

Values are expressed as means ± Ses; *significantly different from the placebo food group ($P < 0.05$).

Table 4. Scalp firmness measurement results.

	Group	Baseline	8 Weeks	12 Weeks
Scalp firmness (mm)	Placebo food ($n = 34$)	0.81 ± 0.01	0.77 ± 0.01	0.77 ± 0.01
	Active food ($n = 36$)	0.83 ± 0.02	0.79 ± 0.01	0.78 ± 0.02

Values are expressed as means ± SEs.

3.3. Adverse Events

During the study, adverse events such as sore throat and hay fever were observed in both the placebo and active food groups, but the principal investigator ruled out a causal relationship between the events and the test food. No serious adverse events were observed.

4. Discussion

This study investigated the effects of food containing PBE on scalp condition in healthy adult men and women who were concerned about scalp dryness and firmness. The participants consumed either PBE-containing foods (active food) or PBE-free foods (placebo food) once daily for 12 weeks in a randomized, double-blind, placebo-controlled, parallel-group comparative trial. As a result, at the end of the intake period, TEWL was significantly lower in the active food group compared to the placebo food group.

TEWL is a noninvasive measurement of water evaporation from epidermal tissue and an important parameter for measuring skin barrier function [26]. It has been reported that skin with low barrier function exhibits increased water evaporation and that TEWL increases in dry skin [6]. Therefore, the improvement in TEWL observed in this study is considered to indicate an improvement in skin barrier function, which prevents moisture loss from the skin.

The mechanism by which PBE inhibits scalp water loss can be inferred from existing knowledge. Microcirculation is essential to the supply of nutrients and oxygen to the skin, and the state of microcirculation is known to affect skin condition [27]. Furthermore, skin circulation declines with age, which is thought to lead to insufficient oxygen and nutrient supply to skin tissue [28]. In fact, there are reports that continuous intake of food ingredients that improve skin blood flow can increase TEWL [27] [29]. In human studies, the PBE have been shown to improve platelet aggregation [19], enhancing vascular endothelial function [17] [30] [31], and promote capillary blood flow [18]. Furthermore, in a trial where postmenopausal women consumed PBE, improvements in scalp condition—such as TEWL and hair density—were observed after two months of intake. This mechanism is thought to be attributable to improvements in scalp microcirculation, including enhanced vascular endothelial function and blood flow [22]. Therefore, PBE is thought to improve blood fluidity and flow, promoting the delivery of necessary oxygen and nutrients to skin cells. This maintenance of normal cellular function is thought to contribute to the scalp moisture retention.

No significant difference was observed in scalp firmness or softness, as measured by the VAS questionnaire. Scalp firmness is influenced not only by the epidermis but also by the dermis and deeper subcutaneous tissue [32] and varies according to complex factors. Furthermore, it is known that dermal turnover is slower than turnover in other skin layers [33]. Therefore, while improving skin blood flow is thought to maintain skin cell function and mechanical properties by transporting nutrients and oxygen, compared to functional improvements in the

epidermis, such as TEWL and barrier function, improvements in indicators influenced by deeper subcutaneous tissue mechanical properties—such as scalp firmness—may take time.

Additionally, regarding the VAS questionnaire results for scalp moisture, although the active food group showed an improvement compared to the placebo food group after 12 weeks of intake, no significant difference was observed. Generally, subjective indicators are influenced by factors such as the respondent's mood or health status at the time of the response. The VAS questionnaire assesses the current state and does not negate the significant improvement observed in TEWL, an objective indicator for evaluating scalp moisture.

This study also confirmed the safety of PBE. No adverse events attributable to the intake of food containing PBE were observed, suggesting that long-term intake of food products containing PBE is safe.

Nevertheless, this study has several limitations. It was conducted on healthy men and women aged 40 to 64 years, and the effects of PBE on the scalp in younger participants are unknown. Future research should examine the effects of PBE on scalp condition by testing a wider range of participant populations to confirm its effects.

5. Conclusion

This study showed that food containing pine bark extract can reduce TEWL from the scalps of healthy adult men and women, meaning that they can help maintain scalp moisture.

Authors' Contributions

Conceptualization, T.K. and K.T.; Methodology, A.Y.; Validation, K.O.; Formal analysis, A.Y. and K.O.; Investigation, A.Y.; Writing-Original Draft Preparation, A.Y.; Supervision, K.T. and N.M.; Writing-Review & Editing, T.M. and S.T.; Visualization, A.Y. and K.O.; Project Administration, S.T. and T.K. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

This study was conducted in accordance with the Declaration of Helsinki and approved by The Ethics Committee of Miura Clinic, Medical Corporation Kanonkai (approval date: 26 December 2024; approval number: R2410).

Informed Consent Statement

Informed consent was obtained from all participants involved in the study.

Data Availability Statement

The data used in this manuscript are not publicly available because of commercial

restriction, but are available on reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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