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Characterization of comprehensive appearances of skin ageing: An 11-year longitudinal study on facial skin ageing in Japanese females at Akita

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SUMMARY

Background: Facial appearance is regarded as a typical index of ageing. However, people of the same age do not necessarily show the same degree of the facial appearance. The ageing of facial skin proceeds relatively slowly and therefore requires long-term follow-up to elucidate the mechanism of ageing changes.

Objectives: The purpose of this study was to identify facial skin parameters contributing the subjective impression of the overall ageing and characterize the degree of skin ageing by a 11 year longitudinal skin monitoring.

Methods: One-hundred-eight healthy Japanese females excluded outside workers aged 5–64 at 1999, and lived in Akita, Japan till 2010 were enrolled. Facial images were collected to quantify various skin optical parameters. Skin colour, hydration and barrier function were measured with Chromameter, Corneometer and TEWAmeter, respectively. The visual evaluation of the overall facial skin ageing impression was also carried out. The skin parameters contributing visible impression of skin ageing were identified by variable importance in projection analysis, and the degree of facial skin ageing over 11 years was statistically classified by a cluster analysis.

Results: Facial skin parameters that comprehensively influenced visible skin ageing, including hyperpigmented spots, wrinkles and texture were studied. The Skin Ageing Score calculated from these three skin factors was used to classify the subjects into a mild, age-appropriate, and severe skin ageing group. The mild skin ageing group maintained significant better both skin optical and physical conditions.

Conclusions: Variability and classification of the degree of facial skin ageing appearance were studied from this longitudinal research.

1. Introduction

When looking at a person who we do not know, we tend to estimate their age based on appearance including body type, hair style, and facial appearance. Especially, facial skin conditions, such as wrinkles, hyperpigmented spots, surface roughness (as called textures), visible follicles at skin surface (as called pores) and skin tone significantly influence the age estimation [1–5]. In various medical fields including dermatopathology, aesthetic dermatology, and epistemology it is essential to understand the changes that take place in ageing facial skin. In previous skin ageing studies, facial skin conditions were evaluated for various age generations, to comprehensively grasp their skin ageing phenomena [6–14]. However, the study procedures could not avoid the variability caused by individual living environment, lifestyle, and genetic background [15–18]. Variability must be minimised in order to precisely elucidate skin ageing. Hillebrand et al. conducted an 8-year study to quantify changes in wrinkles by age and race [19]. Their study classified the skin conditions susceptible to wrinkles, and clinically proved that long-term repetition of expression wrinkles (for example, laugh wrinkles) eventually settled into permanent wrinkles. The present study evaluated skin changes over a period of 11 years in the same subjects in various age groups. In March 1999, an epidemiologic study of skin photoageing was conducted with 602 Japanese females who lived in Akita and Kagoshima, Japan, as the first phase [20]. Eleven years later, in March 2010, a study on skin ageing was performed in the same subjects from Akita, under the same measurement conditions. It

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was considered that this study procedure using the same subjects might eliminate inter subject variability and thus allow more precise quantification of the changes and variations in facial skin. Furthermore, identification of facial skin parameters contributing the subjective impression of the overall ageing and characterize the degree of skin ageing by tracking individual skin condition over a 11 year period of time.

2. Materials and methods

The first skin evaluation was performed in 1999 on 300 healthy Japanese females who were either in-door workers or house-holding wives, excluding outside workers, and lived in Akita City, Japan. The examination room was maintained at a constant temperature and humidity (room temperature 20 ± 2 °C, relative humidity $50 \pm 5\%$). In 2010, 11 years later, 108 subjects who had participated in the first evaluation, and lived in Akita City until 2010, and agreed to participate in this study were evaluated again under the same measurement conditions. In order to avoid any influence from seasonal variations, both the 1999 and 2010 studies were performed in late March. The age of the subjects ranged from 5 to 64 years old (mean ± standard deviation (mean ± SD): 36.3 ± 17.0) in 1999, and from 16 to 75 years old (mean ± SD: 46.3 ± 17.0) in 2010. The number of subjects by age group in 2010 was 10 in their teens (17.5 ± 1.08), 12 in their 20 s (23.7 ± 3.23), 12 in their 30 s (37.8 ± 1.94), 23 in their 40 s (44.6 ± 2.29), 23 in their 50 s (55.6 ± 3.13), 15 in their 60 s (65.1 ± 3.18), and 13 in their 70 s (72.2 ± 1.28). None of the subjects underwent any type of aesthetic treatment such as laser cosmetic procedures during the study period. The study protocol was approved by an external ethics committee and written informed consent was obtained from all subjects.

2.1. Facial optical imaging and objective image analysis

The subjects washed their faces using the prescribed cleansing foam and then spent 20 min becoming accustomed to the environment of the measurement room at a constant temperature and humidity. Each subject's face was photographed using an image capture system (BIS®: Beauty Imaging System, P&G) (Fig. 1) consisting of a high-resolution digital camera with a close-up lens (Fujifilm DS330), fluorescent lighting (5500 K, EFS13UED, Panasonic Corporation), and an anchor to fix the jaw and forehead to take the photos in the same position. The camera was calibrated for each measurement, which made it possible to apply the same measurement conditions, including the position of the face, for both the 1999 study and 2010 study. The region of interest (ROI) of the images was from the outer edge of the eyes to the cheek, and the following characteristic objects were extracted by measuring the contrast in the shape and pixels using an image analysis algorithm. Wrinkles were defined as ≥5 mm in length; perimeter/length ratio ≤2.5; and circularity (perimeter^2/area) ≥34, and detected total wrinkle area fraction (total wrinkle area (pixels)/ROI (pixels)) was quantified. Hyperpigmented spots were defined as ≥5 mm^2 in area, colour contrast DeltaE ≥3 compared to its surrounding skin region, and circularity (perimeter^2/area) ≥20, and total hyperpigmented area fraction (total hyperpigmented area (pixels)/ROI (pixels)) was also quantified. As the index of skin surface roughness, total texture area fraction (total texture area (pixels)/ROI (pixels)) was quantified as ≤3 mm^2 in area, aspect ratio ranging from 0.5 to 2, and colour contrast Delta E ≥ 1.5, while pores were defined as ≤4 mm^2 in area, colour contrast DeltaE ≥ 2, and circularity (perimeter^2/area) ≥ 20, that are different from hyperpigmented spots by its size and circularity, for quantification as total pore area fraction (total pore area (pixels)/ROI (pixels))*3. In addition, the subjective impression of the subject's facial skin from the periorbital region including eye area to the cheek region were visually evaluated on the colour-calibrated monitor, by ten examiners and scored on a 7-point scale from 0 (looks much older than the actual age) to 6 (looks much younger than the actual age) compared to their chronological age (Fig. 2). The mean values of the resulting data by the 10 evaluators were analysed. The measurements from both the 1999 study and the 2010 study, and the difference between them were statistically analysed.

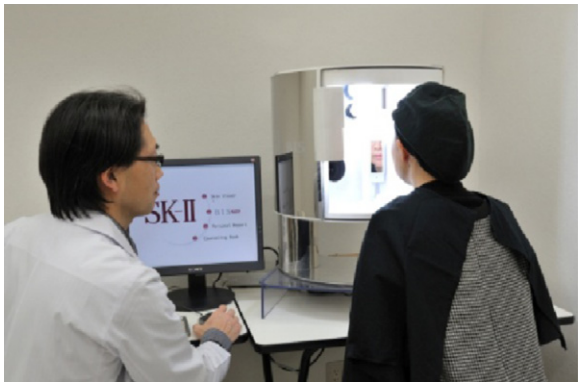

Fig. 1. BIS facial imaging system.

2.2. Biophysical measurements

Water content in the stratum corneum of the cheek was measured using the same Corneometer® (Courage + Khazaka Electronic GmbH) in 1999 and 2010. Total epidermal water loss and mechanical properties of skin (elasticity and firmness) were measured in 2010 study using a Tewameter™ (Courage + Khazaka) and Cutometer® (Courage + Khazaka), respectively. Sebum excretion at foreahead was measured with a Sebumeter® (Courage + Khazaka) at one hour after the cleansing the face. Skin colour (L*, a*, b*) measurement with a Chromameter CR-300 (Konica Minolta Holdings, Inc.) was repeated 10 times to completely cover the cheek region on the face and its average data was used for the following analysis.

2.3. Statistical analysis

Pearson's correlation coefficient (r) between all seven skin optical parameters (image analysis data on wrinkles, hyperpigmented spots, texture, and pores, and the skin colour (L*a*b*) with the chromameter) and age was examined at both the 1999 and 2010 studies. Quantitative comparison of those skin parameters from the 1999 and 2010 studies were also made by age group using two-way ANOVA (significance level $p < 0.05$). Variable importance in projection (VIP) is a score indicating the degree of contribution for each parameter to the dependant variable estimated by PLS (partial least squares) regression statistical analysis. VIP of each skin optical parameter was generated and compared for the selection of key skin parameters contributing on visual evaluation on the degree of subjective impression of younger-looking or older-looking skin on the face, by using the standardized coefficients of skin parameters compared to the visual evaluation data as a dependant variable. The visual evaluation data on the degree of the subjective impression of younger-looking or older-looking skin was compared between the two studies, and the smaller difference and the greater difference between them were respectively defined as "smaller visible skin ageing" and "greater visible skin ageing" over 11 year of period. To adjust the measurement scale for the selected skin parameters that highly contributed on the subjective impression of overall subjective impression on facial skin ageing by VIP score analysis, the relative