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Morie Topography를 이용한 피부 탄력 평가와 Cutometer 결과와의 상관성 연구

안 성 연† · 배 지 현 · 김 승 훈 · 이 해 광 · 문 성 준 · 장 이 섭 · 이 옥 섭

태평양기술연구원 피부과학연구소
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Correlation between Cutometer and Quantitative Evaluation Using Moire Topography in Age-related Skin Elasticity

Sung Yeon Ahn†, Ji Hyun Bae, Seung Hun Kim, Hae Kwang Lee, Seong Joon Moon, Ih Seop Chang, and Ok Sub Lee

Skin Research Institute, Amorepacific Corporation R&D Center,
314-1, Bora-ri, Giheung-eup, Yongin-si, Gyeonggi-do 449-729, Korea
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요 약: 나이가 들어감에 따라 피부에 주름이 생기고 건조해지며 탄력이 감소하게 된다. 피부 탄력은 주름과 같은 다른 변화항목처럼 노화에 따른 변화를 극명하게 눈으로 확인하기 힘들어 평가 방법에 타당성을 부여하는 과정이 더욱 중요하다. 본 연구에서는 연령과 기기측정 결과인 Cutometer parameters 값 간의 상관관계를 확인하였으며, 각각의 parameters가 노화에 의한 피부 탄력 감소를 반영해준다는 사실을 확인하였다(Ur/Uf, Ua/Uf, Ur/Ue, Ua, $r = 0.687 \sim 0.725$). 또한 눈으로 보여지는 변화와 직접 피부를 만져보았을 때 느껴지는 변화를 정량평가하기 위한 평가법을 개발하였다. 60명의 건강한 여성을 대상으로 얼굴 부위에서 Moire 사진을 획득하였으며 이중 피부 탄력을 설명해줄 수 있는 다섯 단계의 Moire topographic photo scale을 선정하였다. 그 다음 동일한 조건으로 20~61세의 여성을 대상으로 Moire 사진을 촬영하고, 제시된 scale을 기준으로 피부 탄력정도를 평가하였다. 본 연구 결과, Cutometer를 이용한 기기평가($r = -0.687 \sim -0.725$)와 Moire topography score ($r = -938$)에 의한 결과는 연령과 매우 높은 음의 상관관계를 가짐을 확인할 수 있었다. 또한 Cutometer 값과 Moire topography 점수간의 상관성도 비교, 두 평가법 간의 상관관계가 높음을 알 수 있었다($r = 0.711$). 따라서 안면부 Moire topography를 이용한 평가는 기기측정으로 확인할 수 있었던 피부 탄력 변화를 시각적으로 나타내어 줄 수 있었다.

Abstract: As aging occurs, our skin gets more wrinkles, becomes drier and loses its elasticity. Validating the evaluation of skin elasticity is especially important, because it is not as visible as other signs of aging such as wrinkles. Here, we identified the correlation between age and the parameters given by Cutometer, and (we present) the parameters of that reflect the decreases in skin elasticity along with ages (Ur/Uf, Ua/Uf, Ur/Ue, Ua, $r = 0.687 \sim 0.725$). Also we developed an evaluation method to quantify the difference of skin by viewing or touching. A five-grade standard of Moire topographic photo scale on face was prepared using sensory evaluation of 20 to 61 year-old women. Based on this photo standard, scoring was performed using (a) 5-grade system by three specialists to obtain the consensus score. Significant negative correlations between age and results of Cutometer ($r = -0.687 \sim -0.725$), Moire topography scores ($r = -938$) were found. Finally, we have shown the significance of the correlation between the result of Cutometer and the score of Moire topography ($r = 0.711$). Our studies using Moire topography on face have confirmed that instrumental measurements reflect the decrease in skin elasticity, which is perceived visually.

Keywords: *skin elasticity, Moire topography, cutometer, sensory, correlation*

† 주 저자 (e-mail: syahn@amorepacific.com)

1. Introduction

As aging occurs, human skin shows many changes. It gets more winkles and pigmentation, less moisture and lipids and becomes the sagged because of the skin looses elasticity [1,2]. Especially, wrinkles are a change that is visible. Therefore, if wrinkles were quantitatively measured, they would provide a relatively accurate standard of aging the customers perceive. However, measuring skin elasticity using instrument often makes it difficult to comprehend the thoughts of customers, because such instruments work by a different mechanism to evaluate skin elasticity from touching and seeing directly.

In this paper, we present a Moire topography system for the visual evaluation of skin elasticity. Moire is the interference pattern which is generated when more than two periodical patterns are overlapped. When a latticed frame is placed in front of the face and a light is illuminated from one side, a shadow of the lattice is generated on the face. This shadow is curved according to shape of the face and waved contour lines are generated on the face (Figure 1). This phenomenon is the Moire effect. Here, we developed a method to measure the extent of skin sagging based on the fact that Moire image represents information on height. Using our method based on the Moire system, we observed facial shapes such as indentation, flattening and sagging and used this as a tool for visually measuring skin elasticity.

In this study, first we observed changes in skin elasticity by age using various tools (especially, we searched for Cutometer parameters that changed as aging processed) and then checked correlations among the different measurement results. In addition, we investigated the validity of sensory evaluation that involves similar mechanisms and criterions the customers use to estimate their skin status.

2. Material and Methods

2.1. Subjects

A group of 44 healthy female volunteers, aged 20 to 61, participated in this study after giving informed consent. All subjects participated throughout the whole process of this study.

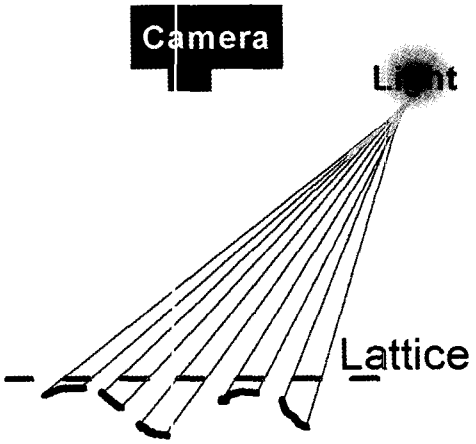

Figure 1. Principle of generating Moire topography.

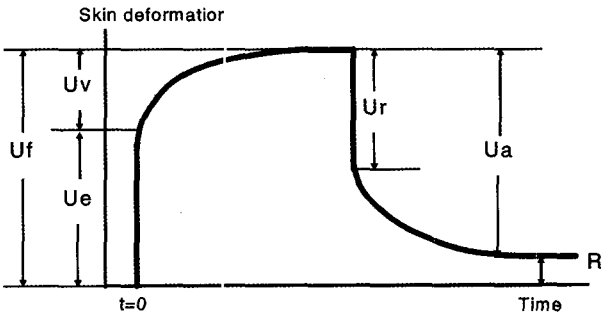

Figure 2. Skin deformation curve obtain with a Cutometer.

2.2. Study Protocol

The subjects washed their face then were adapted for 15 min in a controlled room with constant temperature and humidity (23℃, RH 40%). First, a Moire topography image was taken from the subjects using Moire system, and their skin elasticity was measured with a Cutometer. Then, skilled evaluators pinched the subjects' cheeks with their fingers to assess the sensibility of flexibility and volume, and responded to a brief questionnaire.

2.3. Instruments

Skin elasticity was determined on the cheek using a non-invasive, *in vivo* suction skin elasticity meter, Cutometer SEM 575 (Courage and Khazaka, Kln, Germany) equipped with 2-mm measuring probe. The time / strain mode (mode1) was used with a 2 s application of a constant negative pressure of 500 mbar, followed by a 2 s relaxation period. Each measurement consisted

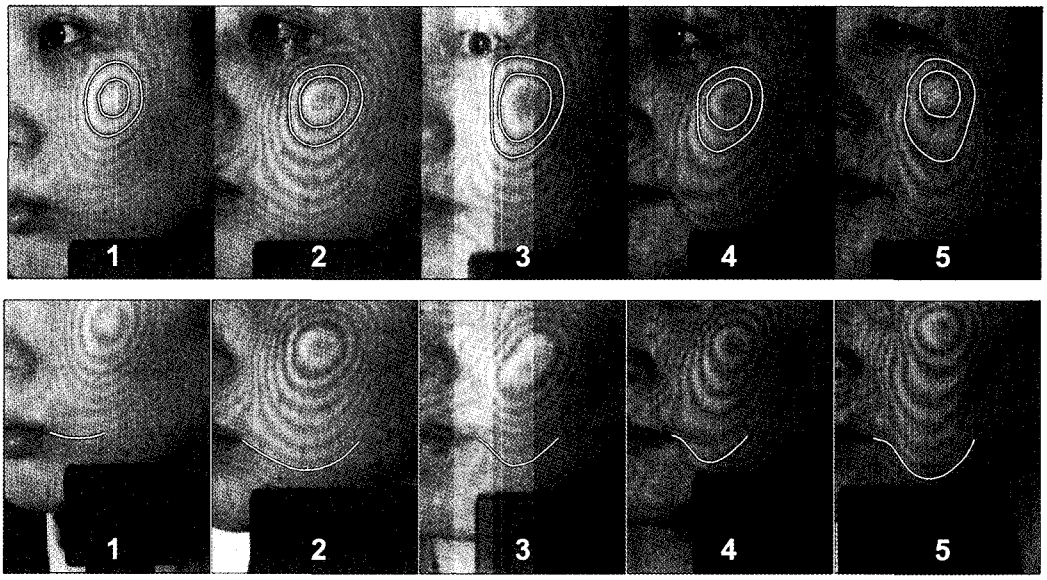

Figure 3. Criteria for evaluating Moire topography.

Table 1. Criteria for Evaluation of Moire Topography

Region	Criteria for evaluation of Moire topography
Cheek	- Space of contour lines (sagging of lower line in circle) - Breaking of circle form
Perioral region	- Direction of contour lines from side of the mouth - Degree of sagging contour lines

Table 2. Correlation Coefficients between the Results of Various Evaluations

	R2	R5	R7	R8	Moire	Flexibility	Volume
Age	-0.687 0.000	-0.664 0.000	-0.725 0.000	-0.667 0.000	-0.938 0.000	-0.765 0.000	-0.599 0.000
Volume	0.320 0.034	0.305 0.044	0.394 0.008	0.432 0.003	0.581 0.000	0.743 0.000	-
Flexibility	0.549 0.000	0.562 0.000	0.628 0.000	0.560 0.000	0.718 0.000	-	-
Moire	0.679 0.000	0.663 0.000	0.711 0.000	0.594 0.000	-	-	-
R8	0.715 0.000	0.563 0.000	0.628 0.000	-	-	-	-
R7	0.830 0.000	0.986 0.000	-	-	-	-	-
R5	0.821 0.000	-	-	-	-	-	-

cell contents: Pearson correlation
P-value

of three consecutive cycles. A typical skin deformation curve is illustrated in Figure 2. The following parameters were analyzed: R0(*Uf*), final distension (skin distensibility); R2(*Ua/Uf*), gross-elasticity of the skin, including viscous deformation; R5(*Ur/Ue*), neto-elasticity of the skin without viscous deformation; R6(*Uv/Ue*), the ratio of viscoelastic to elastic distension; R7(*Ur/ Uf*), biological elasticity, i.e., the ratio of immediate retraction to total distension; and *R8(Ua)*, viscopart, i.e., the area under the suction part of the deformation curve.

2.4. Moire Topographic System

We generated a contour line on the face using the Moire system we developed, and then took a picture with a digital camera DCS 760 (Kodak, USA). Three evaluators read the contour lines near the cheek and the perioral region in the printed digital image and selected 5 images orderly in based on the criterion of evaluation (Table 1). The evaluators graded other images base on the 5 reference images (Figure 3) previously selected. The average values from three evaluators were used in subsequent calculations.

2.5. Sensory Evaluation

In sensory evaluation, the flexibility and volume were evaluated. Three evaluators assessed flexibility and volume based on the 5 grades by holding and pulling the subjects' cheeks. Standardized regions on the cheeks

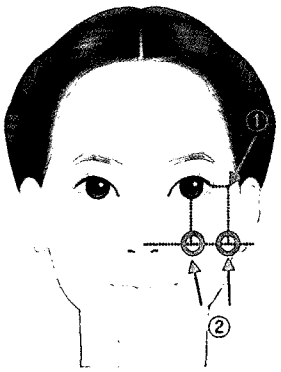

Figure 4. Standardized regions for sensory evaluation: ① = a point 1 cm apart from eyelid; ② = two points to hold with fingers for evaluation.

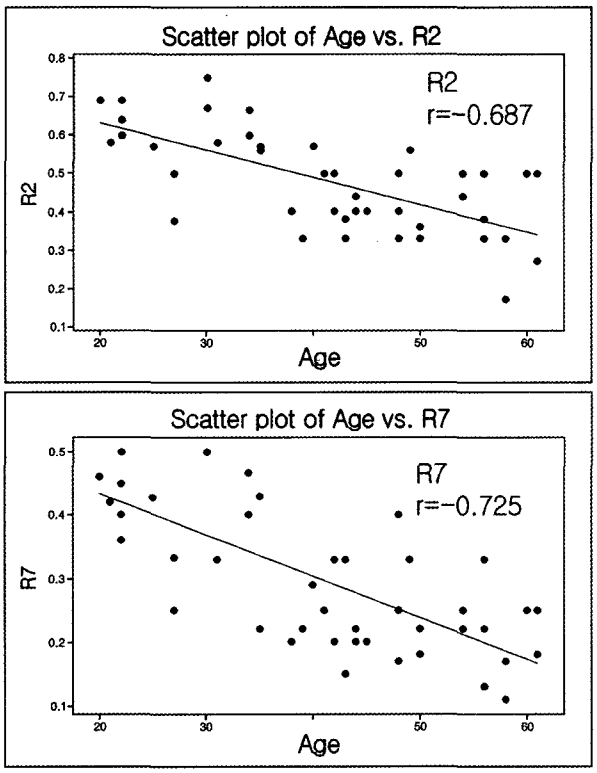

Figure 5. Scatter plots of Cutometer parameters R2 or R7 versus age generated in Minitab.

were measured by the three evaluators who had been trained with the 5-grade references to carry out the assessment by holding and pulling cheek subjects (Figure 4). Again, average values from the three evaluators were used in subsequent calculations.

2.6. Statistical Analysis

Correlations among the results from each method were analyzed using the statistical software Minitab 14 (Minitab Inc., USA).

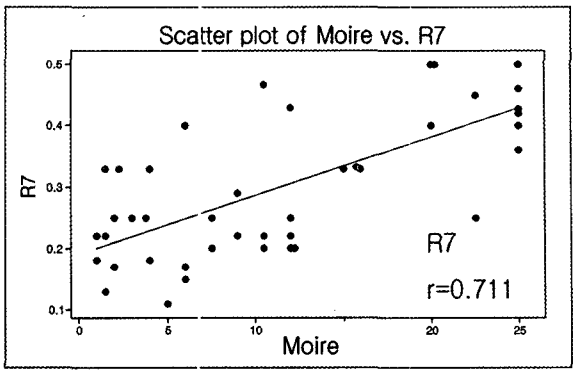

Figure 6. Scatter plot of a Cutometer parameter R7 versus Moire topography mark generated in Minitab.

3. Results

3.1. Correlation Among the Results of Each Evaluation Methods and Age (Cutometer Parameters, Sensory Evaluation, Moire Topographic System) (Table 2)

Cutometer parameters R2, R5, R7 and R8 and the decreases in skin elasticity in terms of ages were highly correlated (r = -0.687 ~ -0.725). Especially R7 showed the strongest correlation with age.

The results from Moire system had very high correlation with age (r = -0.932). According to the sensory evaluation results, correlation between flexibility and age was also significant (r = -0.765). However, volume and age were not correlated.

3.2. Correlation Between the Results of Each Tools of Evaluation (Table 2).

Our evaluation using Moire system has shown high correlation with not only age but also Cutometer parameters R2, R5, R7 and R8 (r = 0.594 ~ 0.711; Figure 5). In sensory evaluation, flexibility also showed significant correlation with Cutometer parameters (r = 0.549 ~ 0.628; Figure 6), but volume had a low correlation coefficient.

4. Discussion and Conclusion

Parameters obtained from Cutometer explain various skin mechanical properties, such as skin total defor-

mation, viscoelasticity, recovery etc. According to a study on the parameters of skin elasticity related to skin moisture, the R6 value changed as skin moisturized [3-5]. And, Pierard *et al.* also have shown that elasticity ratio is lower, while viscoelastic parameters (Uv) is higher [6-8]. However, as aging process, elasticity ratio changes more remarkably than viscoelasticity. We have also confirmed these in our study. In this study, R7 and R2 parameters, expressed as an elasticity ratio, have higher correlation coefficient than others. Therefore, we can say that the ability to recover skin deformation decreases as aging occurs. However, because skin elasticity is not visible unlike wrinkles, the instrumental measurement results could not have reflected the customers' awareness on the changes in their skin. The most common signals of lower skin elasticity remarked by the customers were lower skin elasticity, 'sagging' and 'not resilient' (questionnaire results not shown). Therefore, it was necessary for the evaluation of skin elasticity to be carried out not by instrumental measurement alone, but also with methods based on sensation. Here, we present Moire topography evaluation and sensory evaluation as methods to assess skin elasticity. In addition, we have confirmed the validity of the two methods, and also have shown the significant correlation with Cutometer results.

In conclusion, we have confirmed that the ability to recover from skin deformation decreases as aging occurs. So we consider that Cutometer parameters R7 and R2 are used as main parameters to assess skin elasticity and aging. As the results of Moire topography and sensory evaluation are highly correlated with system and with the result of instrumental measurement as well as age, we expect to be able to carry out a reliable assessment of changes in skin elasticity, which are perceived by the customers.

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