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2D 및 3D 디지털 이미지 분석과 함께 Moiré Tophography 분석을 이용한 화장품의 가슴 탄력개선 효과 평가

서 영 경† · 유 미 애 · 류 자 현 · 김 소 정 · 조 성 아* · 남 개 원* · 조 준 철* · 부 용 출** · 고 재 숙

(주)더마프로 피부과학연구소, *(주)아모레퍼시픽 기술연구원 피부과학연구소,
**경북대학교 의학전문대학원 분자의학교실 세포기질연구소
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Assessment of the Breast-Firmming Effects of a Cosmetic Preparation with Moiré Tophography in Combination with 2D and 3D Digital Image Analyses

Young Kyoung Seo†, Mi Ae Yoo, Ja Hyun Ryu, So Jeong Kim, Seong A Cho*,
Gae Won Nam*, Jun-Cheol Cho*, Yong Chool Boo**, and Jae-Sook Koh

Dermapro Skin Research Center, Dermapro Co., LTD., 4F Jiho B/D, 919-1, Bangbae-Dong, Seoul 137-843, Korea
*Skin Research Institute, Amorepacific Corporation
**Department of molecular Medicine and Cell and Matrix Research Institute, Kyungpook National University School of Medicine
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요 약: 외과적으로 가슴의 볼륨 측정은 석고법, 가슴 X선 사진을 이용한 가슴의 볼륨을 산출하는 방법과 MRI, 3차원 측정 시스템 등을 이용한 측정 방법들이 주로 이용되었다. 그러나 최근 화장품 영역에서 가슴 볼륨 증가 및 탄력개선 제품의 증가로 효능평가가 필요하나 외과적 방법들의 적용은 어려운 실정이다. 그리하여 본 연구는 화장품 영역에서 최초로 등고선 사진을 이용하여 가슴 탄력개선을 평가하였다. 또한 가슴둘레 측정, 디지털 이미지 분석, 3차원 가슴이미지 분석 값과의 상관성을 비교하였고 등고선 사진평가를 가슴의 탄력을 평가하는 새로운 방법으로 제안하고자 하였다. 본 연구는 병력조사 및 피부 상태 진단을 통해 건강한 여성 피험자 30명이 시험에 참여하였다. 피험자로 하여금 제품사용 전과 2주, 4주, 8주 후 시점에서 가슴둘레 측정, 유두점의 각도와 거리 분석, Moire's Topography를 이용한 scoring, 3D가슴측정을 실시하여 가슴확대 및 탄력개선 정도를 평가하였다. 평가 결과 디지털 이미지를 분석결과 유두점의 각도(Angle)는 시점별로 증가하는 경향을 보였으나 유의성은 없었다. 유두점으로부터 밑가슴까지의 길이(Length)는 시점별로 유의하게 증가하였다($p < 0.05$). 또한, 유두점으로부터 밑가슴까지의 높이는 4주 후, 8주 후 시점에서 통계적으로 유의하게 증가하였다($p < 0.05$). Moire's Topography Score 평가 결과 각 시점별로 유의하게 개선하였다($p < 0.05$). 3차원 가슴 부피 분석 값은 각 시점별로 증가하는 경향을 보였으나 통계적 유의성은 없었다. 상관성 분석결과 Moiré tophography score는 디지털 이미지 분석 값 중 길이, 높이와 유의한 상관성이 있었고 3차원 부피 분석 값과 유의한 상관성이 관찰되었다. 따라서 Moire's Topography Score 평가는 이미지 분석과 3차원 부피분석 평가법과 더불어 화장품에 의한 탄력 및 처짐 개선을 평가하는 데 중요한 평가방법으로 사용될 것으로 사료된다.

Abstract: Cosmetic products which might augment the breast have attracted an attention and objective methods for the evaluation of such products are in high demand. This study was conducted to establish a method for assessing the breast-firmming effects of cosmetics. This study included a total of 30 healthy Korean females aged 20-50 years. A cosmetic product was applied by massaging it onto the breast twice a day for 8 weeks. Measurement of breast girth with a tape ruler, 2D and 3D digital image analyses, and Moiré topographic analysis were performed before and following the treatment. The application of a cosmetic onto the breast significantly increased breast girth at 2, 4 and 8 weeks without a significant change in underbreast girth, implicating the breast might be augmented. The 2D image analysis indicated that the arc length of the breast which represents the surface distance from the nipple to

† 주 저자 (e-mail: dermapro@dermapro.co.kr)

the periphery of the under-breast was significantly increased at 2, 4 and 8 weeks. The height of the breast which represents the perpendicular distance from the nipple to the periphery of the under-breast was also increased significantly at 4 and 8 weeks. The 3D image analysis of body surface also demonstrated a significant increase of breast volume at 2, 4 and 8 weeks. Moiré topographic analysis indicated that breast sagging was significantly reduced at 2, 4 and 8 weeks. The results of this study suggest that Moiré topography in combination with 2D and 3D digital image analyses may be useful for evaluating the breast-augmenting effects of cosmetics.

Keywords: *breast volume, breast firmming, 3D imaging, moiré tophography*

1. Introduction

Women's attentions are being focused not only on the beauty of the facial skin but also on slim body lines and beautiful silhouettes of the breast. As aging occurs, our skin shows many changes. It gets more winkles and pigmentation, less moisture and lipids and loses elasticity [1]. Changes of dermis and subcutaneous tissues are expected to affect the occurrence of facial sagging[2]. Skin sagging can also occur in the breast and other parts of body. Thus, numerous studies have been carried out to improve the volume and firmness of the breast in cosmetic field. Indeed, cosmetics have recently been produced by using phytoestrogen-rich plants in order to improve the volume and firmness of the breast [3,4].

Breast volume has been assessed by using thermoplastic castings, mammographic calculation by means of the breast radius and the nipple-to-nipple distance [5] and nuclear magnetic resonance imaging[6]. Qiao *et al*. Proposed an equation for the calculation of breast volume by using severa lparameters of the breast and chest[7]. Three-dimensional body surface scanning has recently been designed and has provided relatively accurate measurements of breast volume[8,9] Kovacs *et al*. compared breast volume calculations with 3D body surface scans and 3 conventional methods such as nuclear MRI, thermoplastic castings and the anthropomorphic method, focusing on the relative advantages, disadvantages and reproducibility of each method[10].

Differently from the field of surgery, breast volume assessment has not been frequently performed in the field of cosmetics. Cosmetics could produce, if any, smaller changes in the volume and firmness of the breast as compared to surgery and thus more precise quantitative methods are required. Moiré topography is one of the promising techniques for this purpose, because it can sensitively detect the morphological changes in terms of tophographic contour. Indeed, this technique has been widely used to evaluate firmness and sagging of the facial skin[11]. Thus Moiré tophography maybe potentially useful for the assessment of breast sagging as well, but no established methods are currently available.

The purpose of the present study was to establish a protocol for assessing changes in the various parameters of the breast following the use of a cosmetic preparation as a model case. Measurement of breast girth with a tape ruler, 2D and 3D digital image analyses, and Moiré topographic analysis were performed before and following the treatment of a cosmetic product on the breast of human subjects.

2. Materials and Methods

2.1. Human Subjects and Clinical Study Design

This study included a total of 30 healthy Korean females aged 20 ~ 50 years. Exclusion criteria were as follows: (1) subjects who had breast-related diseases, (2) those who had artificial breast implants, (3) those who were pregnant or nursing mothers, (4) those who had estrogen-sensitive tumors (benign or malignant) and cysts involving the breasts, ovaries and uterus, (5) those who had any form of hormonal medication (including hormonal contraception), (6) those who were postmenopausal and (7) those who participated in any other similar bust enhancement study within 3 months prior to this study. All eligible subjects gave written consent to participate in this study after they had been informed of the purpose and expectation of

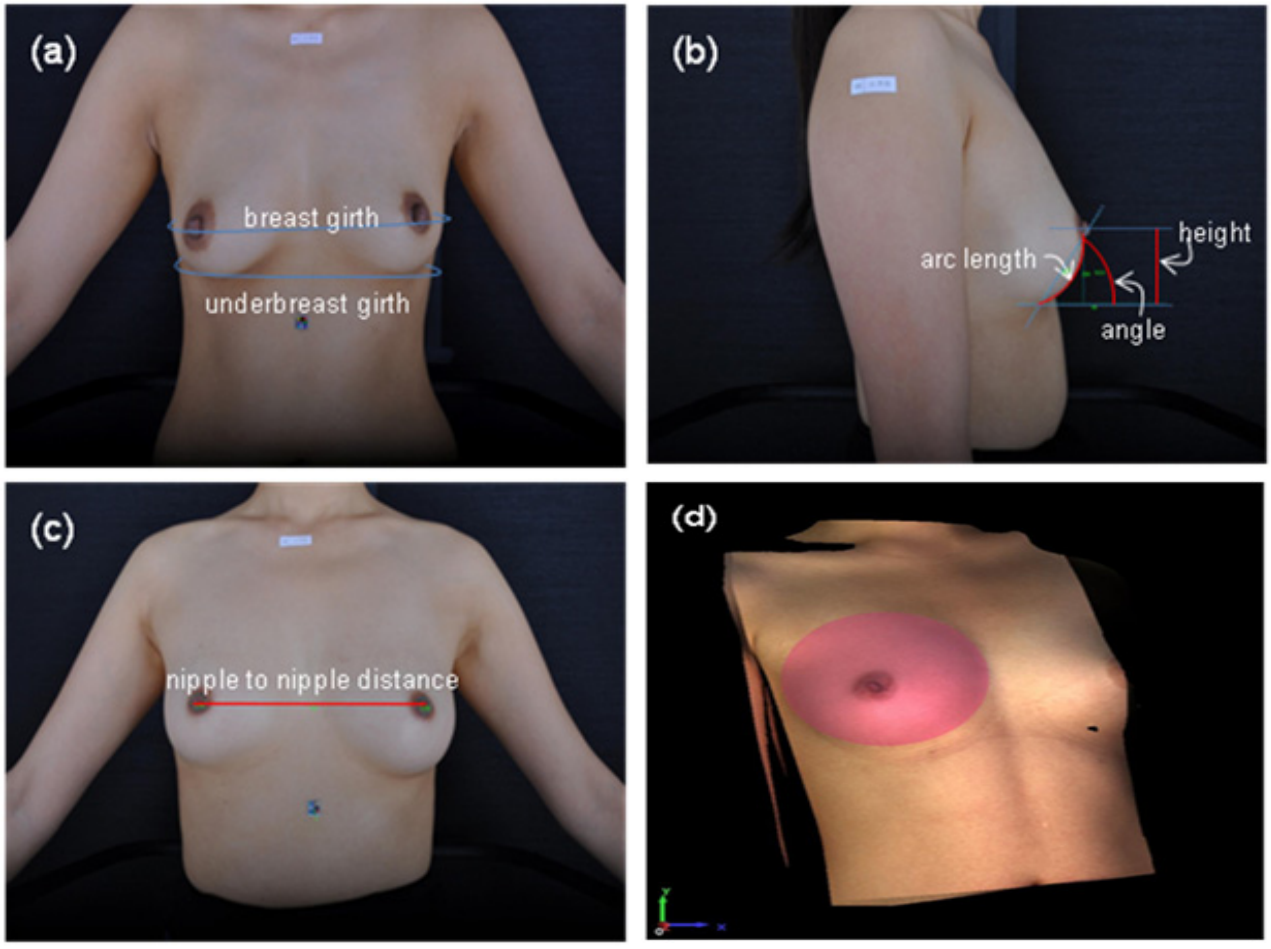

Figure 1. Determination of the breast parameters. (a) Tape measurement of breast girth and underbreast girth. (b) 2D image analysis for the angle, arc length and height of the breast. (c) 2D image analysis of the distance between nipples. (d) 3D Image analysis for breast volume.

the study, which was approved by the regional ethical committee (Institutional Review Board). This study was conducted in compliance with the Good Clinical Practice Guidelines.

The product was applied on the breast twice a day in the morning and in the evening with massage, in order to reducing the hormone cycles affect the test was performed for 8 weeks.

2.2. Tape-measurement of Breast Girth

Maximum breast girth of the unclothed subject across the fullest part of the breast over the nipples (Figure 1a) was measured with a tape ruler. Under-breast girth of the body (Figure 1a) was measured just below the breasts.

2.3. Measurement of the Arc Length and Height of the Breast by 2D Digital Image Analysis

The lateral and front chest photographs of the unclothed subject standing erect were taken with a digital camera (Nikon D90, Nikon Corporation, Tokyo, Japan). The digital images were subjected to image analysis for the determination of various parameters of the breast with an Image-pro®plus image program (Bethesda, USA). The parameters of the breast determined were as follows: (1) the angle of elevation for the nipple from the periphery of the under-breast (Figure 1b), (2) the arc length of the breast from the

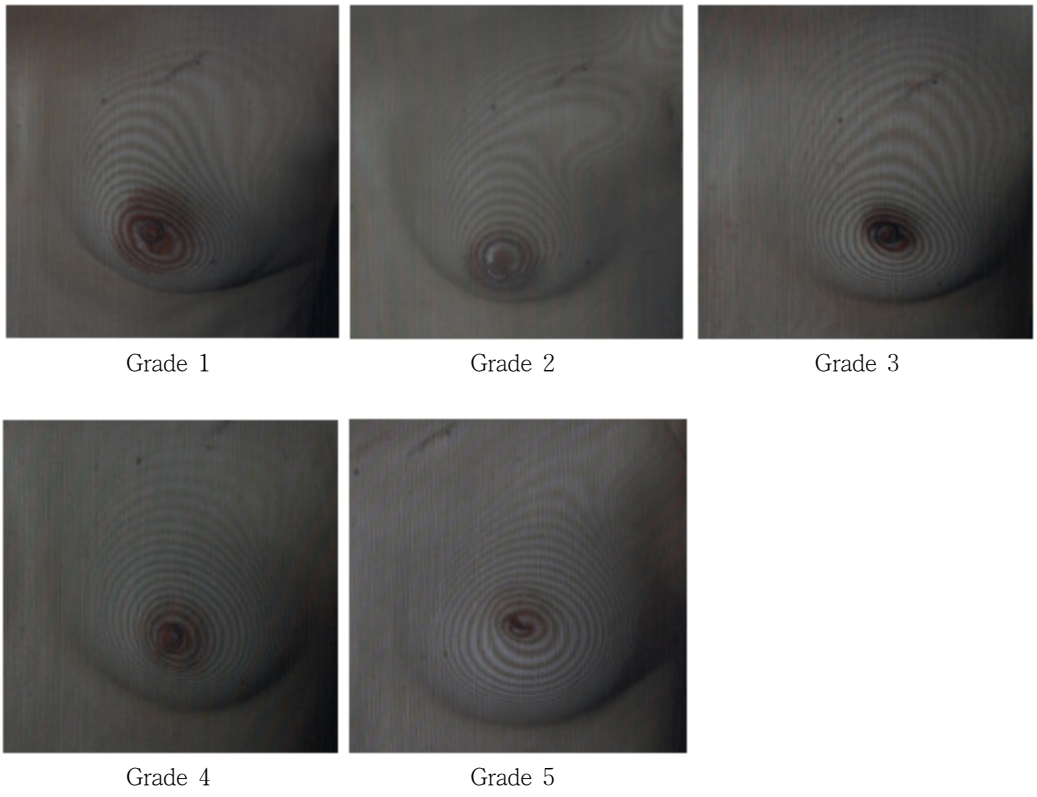

Figure 2. Moire's topographic scale for quantification of breast sagging. Breast sagging was classified as follows: Grade 1, very severe sagging; Grade 2, severe sagging; Grade 3, moderate sagging; Grade 4, mild sagging; Grade 5, no sagging.

nipple to the periphery of the under-breast (Figure 1b), (3) the height of the breast as the perpendicular distance from the nipple to the periphery of the under-breast (Figure 1b), and the nipple-to-nipple distance (Figure 1c).

2.4. Measurements of Breast Volume using a 3D Body Surface Imaging System

Breast volume was analyzed by 3D Image Analysis GFM PRIMOS body (GFMesstechnik GmbH, Berlin, Germany) (Figure 1d). The principle of this optical method is the digital stripe projection technique based on digital micromirror projectors. Stripes with a sinusoidal intensity of brightness are projected onto the surface of the object being measured and its projection (the stripes changed by the height profile of the object) is recorded at a defined strangulation angle by a CCD camera.

2.5. Establishment of Photograph-based Grading Criteria for Sagging Severity

Breast sagging was evaluated by Moiré topography. The subjects were unclothed and seated on a chair of contour device back and photographs of the left and right breast were taken with a digital camera (Nikon D40, Nikon Corporation, Tokyo, Japan) under the fixed lighting conditions. Breast sagging was classified as follows: 1, very severe sagging; 2, severe sagging; 3, moderate sagging; 4, mild sagging; 5, no sagging (Figure 2). Moiré topographic images were scored by 2 trained researchers independently.

2.6. Statistical Analysis

All statistical analyses were performed using the

Table 1. Effects of the Cosmetic Product on Various Parameters of Breast

Parameters	Before treatment	2 week	4 week	8 week
Breast girth (cm)	87.37 ± 7.01	88.05 ± 6.72*	88.20 ± 6.92*	88.33 ± 6.85*
Underbreast girth (cm)	77.04 ± 6.45	76.92 ± 6.20	76.98 ± 6.34	77.33 ± 7.18
Nipple Angle (°)	42.90 ± 11.60	42.91 ± 11.32	43.47 ± 11.74	43.73 ± 11.35
The surface distance from the nipple to the periphery of the under-breast (pixels)	264.43 ± 39.94	267.67 ± 40.92*	272.67 ± 41.30*	275.88 ± 38.70*
The height of the nipple from the periphery of the under-breast (pixels)	169.60 ± 52.15	171.15 ± 51.98	175.08 ± 54.71*	178.67 ± 51.88*
The nipple-to-nipple distance (pixels)	19.17 ± 1.79	19.30 ± 1.79	19.23 ± 1.76	19.44 ± 1.92
The Moiré topographic score	2.64 ± 1.14	3.03 ± 1.05*	3.26 ± 0.96*	3.41 ± 0.81*
Breast volume change (mL) (compare to before treatment)	-	14.68 ± 9.85	17.08 ± 10.68	17.19 ± 8.48

* $p < 0.05$ vs compared with before treatment

paired t-test on SPSS Package Program 11.5. Comparisons of mean values between the measurement techniques were made using Pearson correlation.

A p value of < 0.05 was considered statistically significant.

3. Results

The changes in the various parameters of the breast were summarized in Table 1.

3.1. Breast Girth

Maximum breast girth across the breasts was significantly increased by the treatment of the product. The values increased from 87.37 ± 7.01 cm (base line values before treatment) to 88.05 ± 6.72 at 2 weeks, 88.20 ± 6.92 at 4 weeks and 88.33 ± 6.85 cm at 8 weeks of the treatment. Underbreast girth was not significantly altered by 8 weeks of the treatment. These results indicated that the size of the breast might be increased by the treatment of the product.

3.2. Digital Image Analysis

The angle of the nipple from the lowest point of the periphery of the breast above the horizontal line tended to increase by the cosmetic treatment but the changes were not statistically significant. The arc length of the breast from the nipple to the periphery of the under-breast was significantly increased the values were increased from 264.43 ± 39.94 pixels (base line values) to 267.67 ± 40.92 pixels at 2 weeks, 272.67 ± 41.30 pixels at 4 weeks and 275.88 ± 38.70 pixels at 8 weeks. The height of the breast that represents the perpendicular distance between the nipple and the periphery of the under-breast was also increased by 4 weeks or longer treatment of the product. The values were 169.60 ± 52.15 before treatment, 175.08 ± 54.71 at 4 weeks and 178.67 ± 51.88 at 8 weeks. The nipple-to-nipple distance tended to increase without statistical significance. Breast volume determined by 3D image analysis tended to increase during the product application but there was no statistical significance.

3.3. Moiré Topographic Analysis

The Moiré topographic score of the breast was significant increased by the product treatment from 2.64 ± 1.14 before product application to 3.03 ± 1.05 at week 2, 3.26 ± 0.96 at 4 weeks and 3.41 ± 0.81 at 8

Table 2. Pearson Correlation Coefficients (r) between Breast Parameters

Parameters	Nipple angle (°)	The surface distance from the nipple to the periphery of the under-breast (pixels)	The height of the nipple from the periphery of the under-breast (pixels)	The nipple-to-nipple distance (pixel)	The Moiré topographic score
Breast girth (cm)	-0.488*	0.003	-0.344*	0.756*	0.028
Nipple angle (°)	1	0.411*	0.882*	-0.320*	0.107
The surface distance from the nipple to the periphery of the under-breast (pixels)	-	1	0.777*	-0.082	0.516*
The height of the nipple from the periphery of the under-breast (pixels)	-	-	1	-0.285*	0.322*
The nipple-to-nipple distance (pixels)		-	-	1	0.167
The Moiré topographic score	-	-	-	-	1

* Correlation is significant at the 0.01 level (2-tailed)

weeks after the treatment.

3.4. Correlation between the Parameters of the Breast

The correlations between the parameters of the breast determined in this study were analyzed, and the results were shown in Table 2.

4. Disccussion and Conclusion

So far, breast volume has been mainly assessed in the field of plastic surgery. A number of methods have been described to assess breast volume measurement. Anthropomorphic methods are surgically well defined and breast volumes are computed based only on individually measured values[9,14]. Recently, interest has increased in the cosmetics field regarding breast lift and breast firmness improvement. Slight changes by cosmetic application require more precise assessment techniques. The present study assessed the improvement in volume and firmness of the breast after the application of a cosmetic product by digital image analysis, Moiré topographic analysis and 3D body surface imaging analysis.

This study demonstrated that digital image analysis and Moiré topography can be used in the monitoring of morphological changes of the breast due to cosmetic treatments. In 2D image analysis using lateral breast photographs, the arc length of the breast from the nipple to the periphery of the under-breast, and the height of the breast from the periphery of the under-breast to the nipple were sensitively changed during the treatment of a cosmetic cream (Table 1). The angle of elevation for the nipple from the periphery of the under-breast or the distance between nipples was not significantly altered by a cosmetic product (Table 1). These results suggest that the whole size of the breasts rather than the lateral shape of the breasts were affected by a cosmetic cream. It is also suggested that the 'arc length' and 'height' of the breast would provide reliable indices for the assessment of breast augmenting effects of cosmetic products.

The breast consists of gland tissue, fibrous tissue

connecting its triangular-shaped lobules and fatty tissue in the intervals between the lobules. Fatty tissue which accounts for two-thirds of the entire breast, determines the volume and firmness of the breast. As body weight increases, the amount of fatty tissue increases, and the contour, location and elasticity of the breast vary. The morphology of the breast varies as the skin loses its thickness and firmness due to degeneration or decreases of collagen in the dermis and as the amount of fatty tissue decreases due to changes in body weight. After pregnancy, the mammary glands enlarge and the skin expands. Breast sagging occurs when this expanded skin does not return to its original state after lactation ceases. Of course there are many other factors which can cause severe breast sagging.

To examine the potential effects of a cosmetic cream on the breast sagging, Moiré topographic analysis was undertaken. For this purpose, new criteria of breast sagging was established using the real breast images of Korean women (Figure 2). Although Moiré topography has been widely used to evaluate facial skin sagging [11] and photographic grading criteria for facial skin sagging has been previously established by evaluating cheeks[12], no criteria for breast sagging has been reported previously. Thus this is the first study that has employed Moiré topography to evaluate breast sagging. The results showed that the breast sagging was reduced by the treatment with a cosmetic cream (Table 1). Thus Moiré topography was considered to be useful for the monitoring of frontal shape of the breast. As shown in Table 2, the Moiré topographic score was significantly correlated with the 'angle', 'arc length' and 'height' of the breast obtained from digital image analysis.

The breast firmming effects of a cosmetic cream in this study could also be verified by conventional tape-measurement of breast girth and 3D body surface imaging analysis for the breast volume (Table 1). Although the action mechanism of the active ingredient in this cosmetic cream is beyond the scope of the current study, it is expected to increase the extracellular matrix density of the skin and therefore help refine the breast features. Further studies are needed to address this important issue. It will be also carried out controlled trials to reduce the impact by massage.

The results of this study suggest that Moiré topography as well as digital image analysis and 3D body surface imaging may be useful for evaluating the volume and firmness of the breast after the application of cosmetic products.

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