J. Soc. Cosmet. Scientists Korea
Vol. 34, No. 4, December 2008, 333-338

3D 측정 기기를 이용한 얼굴의 부피 정량법 연구

박 신 영† · 남 개 원 · 김 승 훈 · 이 해 광 · 안 성 연 · 문 성 준 · 김 한 곤

아모레퍼시픽 기술연구원

(2008년 11월 24일 접수, 2008년 12월 23일 채택)

A Quantitative Method for Human Face Volume Using 3D Optical Measurement

Shinyoung Park†, Gaewon Nam, Seunghun Kim, Heakang Lee, Sungyeon Ahn, Seongjoon Moon, and Hankon Kim

Skin Research Institute, Amorepacific Corporation/R&D Center, Bora-dong, Giheung-gu, Yongin-si, Gyeonggi-do 446-729, Korea

(Received November 24, 2008; Accepted December 23, 2008)

요 약: PRIMOS body® 기기를 이용한 얼굴부피 평가법 개발에 관한 연구를 진행하였다. 평가법의 신뢰성을 확인하고자 세 명의 시험자가 마네킹과 사람을 대상으로 얼굴 부피를 측정하였다. 마네킹의 얼굴에 여러 가지 부피의 찰흙을 붙이고, 기기로 얼굴을 측정하였는데, 실제 찰흙의 부피와 측정값 사이에 높은 상관성(R^2 = 0.99)이 있는 것으로 나타났다. % RSD와 Gage R&R 분석으로 기기의 정확성, 반복성, 재현성을 확인한 결과 신뢰성이 있는 결과를 얻었다. 이와 같은 평가법을 얼굴 붓기 감소에 영향을 주는 화장품의 효능을 평가하는데 적용하였다. 10명의 건강한 여성을 대상으로 화장품 사용 전후 얼굴의 부피를 측정한 결과, 얼굴의 부피가 감소하는 것으로 나타났다. 이와 같은 결과를 통해 PRIMOS body®를 이용한 얼굴 부피 평가법은 인체평가에 유용하게 사용될 수 있을 것으로 보인다.

Abstract: The evaluation for the visage volume was performed with human and dummy face using PRIMOS body®. Three researchers measured the dummy face attached different volume of clay (6.6 mL, 13.2 mL, and 19.8 mL). It is identified that the high correlation between measured values and real volume (R^2 = 0.99). The percent (%) of relative standard deviation (RSD) of the data was shown below 10 %. In Gage R&R analysis, the percent of contribution, the percent of study variation and distinct categories values were 0.78 %, 8.85 %, and 15 % respectively. Therefore this method was regarded as the good standard condition in aspect of reproducibility and repetitiveness of data. The face volume variation was measured by PRIMOS body® on the face in participated 10 healthy Korean women volunteers. Subjects used the product once a day for two weeks as night sleeping pack. After application of the test products, the 3D image data of face were taken 1 and 2 weeks later. We found the face volume was significantly decreased after using products. In conclusion, this novel non-invasive technique was useful in measuring and visualizing alterations in face volume as a consequence of certain treatments. This system will provide a rapid and precise analysis of 3D topographical information for face.

Keywords: *PRIMOS body®, 3D image, face volume, validation, % RSD, Gage R&R*

1. Introduction

Various non-invasive methodologies have been used to evaluate the skin surface topography. Many groups also have developed numerous techniques for the reconstruction and evaluation of the three-dimensional (3D) topographical information. Most of previous studies have been reported that tried to evaluate skin

† 주 저자 (e-mail: petite824@amorepacific.com)

roughness and wrinkle depth with various devices. However there was a rare report for measuring human face variation quantitatively.

The purpose of this study was to develop the novel evaluation method of human face variation with 3D optical measurement. We applied a commercially available instrument, PRIMOS body® optical three dimensional *in vivo* skin measurement (PRIMOS body®, GFMesstechnik, Germany) for acquiring 3D face image data.

2. Materials and Methods

2.1. Subjects

2.1.1. Validation Study

We used a dummy to set up the constant face condition. One female volunteer participated in this study.

2.1.2. Clinical Test

A group of 10 healthy female volunteers, in 20 ~ 40 ages, participated in this study after giving informed consent. The volunteers thought that they had a swollen face. All subjects participated throughout the whole process of this study.

2.2. Instruments

The measurement of the skin surface topography was performed using the PRIMOS optical 3D *in vivo* skin measurement device (GFMesstechnik, Germany). This system is based on the digital stripe projection technique, which is used as an optical measurement process. A parallel stripe pattern is projected onto the skin surface and depicted on the CCD chip of a shooting camera through a shooting optic. The measurement system consists of a freely movable optical measurement head (with an integrated micro-mirror projector, a projection optic, a shooting optic, and a CCD recording camera) together with an evaluation computer. The 3D effect is achieved by the minute elevation differences on the skin surface, which deflect the parallel projection stripes. These deflections provide data for a qualitative and quantitative measurement of the skin profile. They are digitalized and evaluated quantitatively using the software, PrimosBody 6.3E®.

2.3. Study Protocol

2.3.1. Validation Study

To confirm repeatability, a dummy was measured three times with PRIMOS body® (GFMesstechnik, Germany). Clay was used to change the volume of the dummy's face. Three different volume of clay (6.6 mL, 13.2 mL, and 19.8 mL) was attached on the cheeks of dummy. Then the dummy was measured three times in each condition. To confirm reproducibility, three researchers measured a dummy and a volunteer three times at an interval of one hour. The image obtained at each time point was compared with prior images. Then, the difference volume between several image data was evaluated.

2.3.2. Cosmetic Product Test

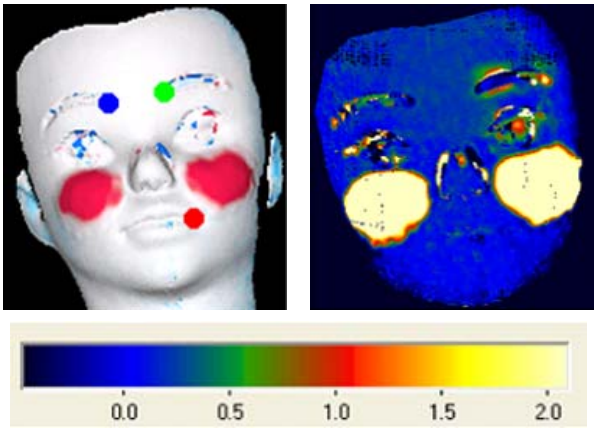
The subjects washed their face and were then acclimated for 15 min in a controlled room with constant temperature and humidity (23 ℃, RH 40 %). First, each volunteer's face was detected with the PRIMOS body® before using the product. All volunteers applied the cosmetic product (Sulwhasu Yeo-yoon night sleeping pack, Amorepacific, The republic of Korea) on the face every night for 2 weeks. The volunteers were followed at an interval of one week.

2.4. Statistical Analysis

First of all, it was checked that the machine operated properly using the Gage R&R, one of the evaluating tools in the statistical software Minitab 14® (Minitab Inc., State College, PA, USA). The Gage R&R analyzes the variation of measurements of a gage (repeatability) and variation of measurement by operators (reproducibility). It plays a significant role in contemporary quality control process for the reason that the goal of process control is to reduce variation in the process and the products. We used two samples *t*-test in Gage R&R to compare actual value with a

Table 1. % RSD Analysis of Measurement (The Face of Dummy)

Researcher	1	2	3
Mean (mL)	6.3	6.1	6.4
S.D.	0.5	0.1	0.5
% RSD	7.7	2.2	7.3

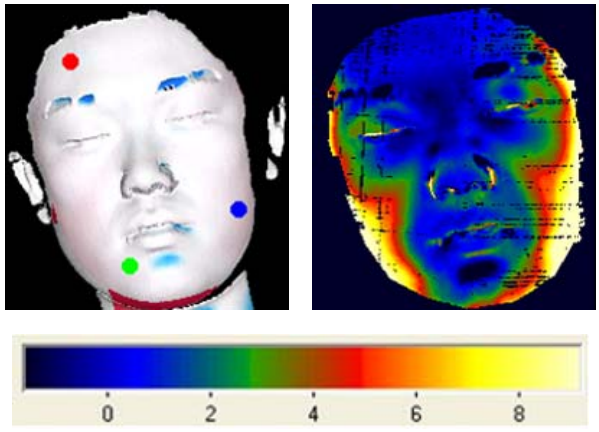


(The scale bar for right image)

Figure 1. 3D images of the dummy attached with 6.6 mL clay. Red area in the left image represents increased volume. The right image is the result of evaluation.

Table 2. % RSD Analysis of Measurement (The Face of a Female)

Researcher	1	2	3
Mean (mL)	18.5	16.8	18.9
S.D.	0.8	2.5	1.6
% RSD	4.3	14.6	8.3



(The scale bar for right image)

Figure 2. 3D image of a female compared with an image taken approximately 10 months ago. Red area of cheeks in the left image represents increased volume. The right image is the result of evaluation.

measure of difference volume. It confirms there are significant differences between the two values. It has three estimating standards, the percent (%) of contribution, the percent (%) of study variation, and the distinct categories values. If the machine is in good standard condition, the percent (%) of contribution, the percent (%) of study variation and the distinct categories values are below 1 %, below 10 % and over 10 %. On the other hand, if the % of contribution, the % study variation and distinct categories values are over 10 %, over 30 % and below 4 %, it demonstrate that the machine is in unusable condition. Second, we checked the percent (%) of relative standard deviation (RSD) of measuring data. The % RSD identified repeatability and reproducibility of the machine.

3. Results and Discussion

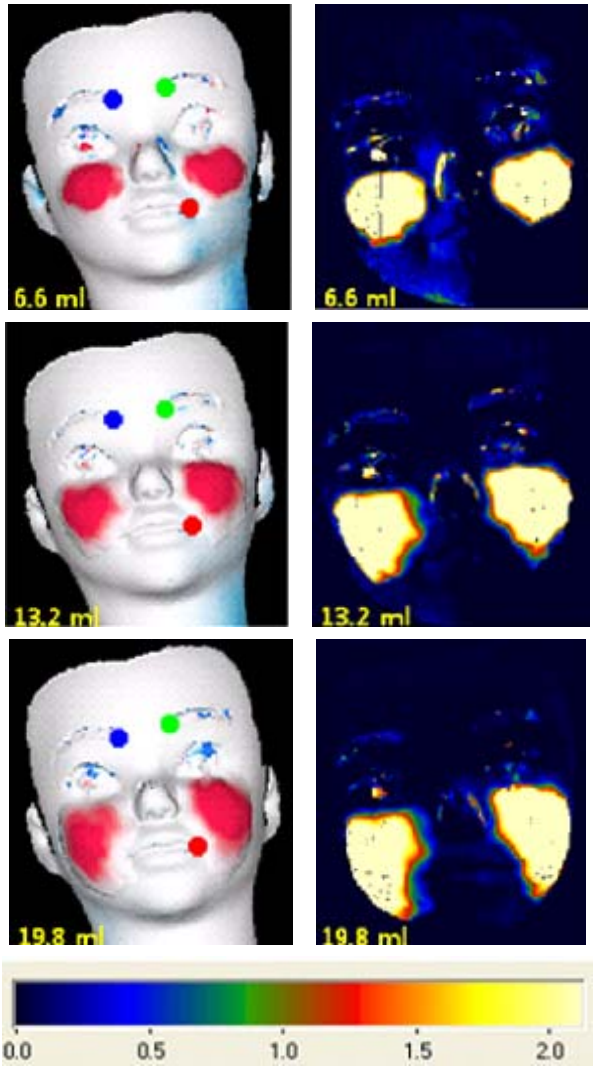
3.1. Repeatability and Reproducibility with the % RSD

Three researchers measured the face of dummy before putting clay on. After that, they measured the face attached with 6.6 mL clay three times to compare these images with prior image. Experimental averages of volume difference volume between before and after clay application were 6.3 mL, 6.1 mL, and 6.4 mL (Table 1 and Figure 1). All % RSD (% relative standard deviation = mean / S.D. × 100) of three researchers were below 10 %. In addition, each researcher measured the face of female volunteer three times (Table 2, Figure 2). To estimate a realistic possibility of the comparative *in vivo* study with the instrument, the researchers tested the volunteer gained weight significantly for 10 months. These images were compared with the images taken approximately 10 months ago. There was no statistically significant difference between the values statistically, although the values were slightly different each other depending on researcher. The % RSD measured by two researchers were below 10 %. The results indicated that

Table 3. The Results of Two Sample *t*-test

Actual volume of clay (mL)	Experimental values (mean, mL)		
	R* 1	R* 2	R* 3
6.6	6.7	7.1	6.8
13.2	13.5	13.1	13.5
19.8	19.4	20.3	19.8
p-value	0.937	0.089	0.597

R*: Researcher



(The scale bar for right image)

Figure 3. 3D images of the dummies attached with various volumes of clay (6.6 mL, 13.2 mL, and 19.8 mL)

the PRIMOS body® measuring system had repeatability and reproducibility.

Table 4. The Results of Gage R&R Analysis

Contents	% Contribution	% Study variation
Repeatability	0.78	8.85
Reproducibility	0.00	0.00
Researcher	0.00	0.00
Total Gage R&R	0.78	8.85
Distinct categories value	15	

3.2. Accuracy

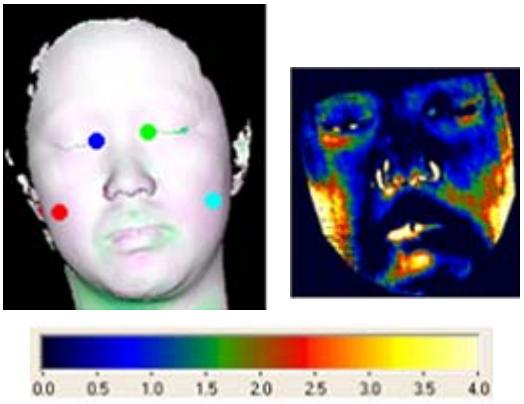
Three different volume of clay (6.6 mL, 13.2 mL, and 19.8 mL) was attached on the cheeks of dummy. Three researchers measured the dummy three times in each condition. The actual values and experimental values are presented in Table 3 and Figure 3. All *p*-values calculated with two samples *t*-test were over 0.05. The correlation coefficients (R^2) between the actual values and the mean of the experimental values were 0.997 (researcher 1), 0.996 (researcher 2), and 0.999 (researcher 3). The results demonstrated no significant differences between actual values and measuring values. In addition, this measuring system had accuracy.

3.3. Gage R&R Analysis

The results of Gage R&R analysis are presented in Table 4. The % of contribution and the % of study were 0.78 % and 8.85 %. All items of the % of contribution were below 1 % and those of the % of study variation were below 10 %. The distinct categories value was 15 %. The results coincided with the satisfaction level of machine. The measuring system was also certified stable.

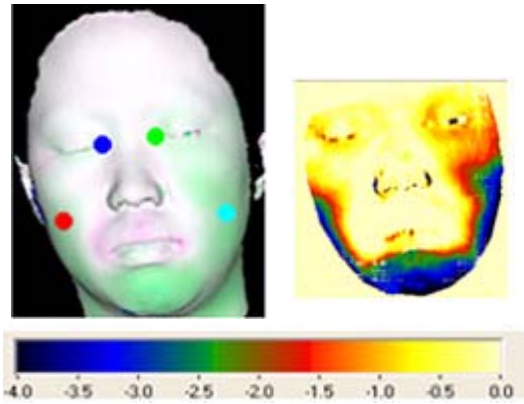
3.4. Confirmation Using The Commercial Products

The face volume variation was measured by PRIMOS body® on the face in participated 10 healthy Korean women volunteers. We selected volunteers whose faces usually become swollen in the morning. We measured the volume of the swollen face after sleeping. The images taken in the morning were compared with the images taken in the evening one day before (Figure 4). The average volume change was



(The scale bar for right image)

Figure 4. The 3D image of a swollen face before application of the cosmetic products.



(The scale bar for right image)

Figure 5. The 3D image of the face compared before with after treatment with cosmetic product.

Table 5. The Results of Before and After Treatments

The loss of the volume	0 week	1 week	2 weeks
Mean (mL)	0.0	-3.1	-3.2
S.D.		1.5	1.4
p-value*		0.003	0.002

p-value*: 1 week and 2 weeks were compared with before treatment with cosmetic product.

approximately 3.6 mL. The volunteers used the cosmetic product once a day for two weeks. The 3D image data of face were taken after application of the test product for 2 weeks later (The first week data not shown). The weights of volunteers did not changed for 2 weeks. The maximum difference of volume compared before with after treatment of the cosmetic product was 5.0 mL. The average difference of volume in 10 volunteers was 3.2 mL (Table 5 and Figure 5). It is found that the significant decrease in face shape was obtained after treatment. All *p*-values calculated with paired *t*-test were below 0.05 %. The results demonstrated significant differences of the face volume between before and after treatment and verified measuring system worked fine. It could be used to evaluate the out come of medical or cosmetic treatments of the skin surface.

4. Conclusion

It is made a precise determination of the accuracy of the system and of the coefficients of variation of both repeatability and reproducibility. The accuracy was validated by the correlation coefficients (R^2). R^2 between the actual values and the mean of the experimental values was over 0.995. Repeatability and reproducibility were ascertained by the % RSD and the Gage R&R. The novel non-invasive technique in this study was useful to measuring and visualizing alterations in face variation as a consequence of certain treatments. This system will be provided a rapid and accurate analysis of 3D topographical information for face in clinical test.

References

1. P. M. Friedman, G. R. Skover, G. Payonk, A. N. Kauvar, and R. G. Geronemus, 3D *in vivo* optical skin imaging for topographical quantitative assessment of non-ablative laser technology, *Dermatol. Surg.*, **28**, 199 (2002).
2. T. W. Fisher, W. Wigger-Alberti, and P. Elsner, Direct and non-direct measurement techniques for analysis of skin surface topography, *Skin Pharmacol. Appl. Skin Physiol.*, **12**, 1 (1999).
3. U. Jacobi, M. Chen, G. Frankowski, R. Sinkgraven, M. Hund, B. Rzany, W. Sterry, and J. Lademann, *In vivo* determination of skin surface topography using an optical 3D device, *Skin Research and Technology*, **10**, 207 (2004).

4. J. M. Lagarde, C. Rouvrais, D. Black, S. Diridollou, and Y. Gall, Skin topography measurement by interference fringe projection: a technical validation, *Skin Research and Technology*, **7**, 112 (2001).
5. J. M. Lagarde, C. Rouvrais, and D. Black, Topography and anisotropy of the skin surface with ageing, *Skin Research and Technology*, **11**, 110 (2005).