IFSCC 2025 full paper (IFSCC2025-1431)

“Proposal of a New Analysis Method of Skin Lifting through the Correlation Between VECTRA XT and Ballistometer”

Myungjin Seo, Yuri Park, Kyoungae Won and Miyeong Lee*

6F, Dongyang Bld., 214, Pungseong-ro, Gangdong-gu, Seoul, Republic of Korea
+82-2-2088-3304, mmv@mariedm.com

1. Introduction

Skin aging is characterized by a variety of physiological and structural changes, among which the loss of skin elasticity and the onset of sagging is one of the most prominent and visually perceivable symptoms. These changes are influenced by both intrinsic and extrinsic aging processes. Intrinsically, aging leads to a gradual decline in key dermal components such as collagen and elastin, which are responsible for maintaining skin elasticity, as well as hyaluronic acid, which plays a critical role in hydration [1]. These compositional changes alter the skin’s mechanical properties, ultimately contributing to wrinkle formation and skin sagging [2].

On the other hand, extrinsic factors—including ultraviolet (UV) exposure, smoking, environmental pollution, and unhealthy lifestyle habits—play a significant role in accelerating skin aging. These external stressors increase oxidative stress in the skin, promoting collagen degradation and exacerbating the aging process [3]. In particular, photoaging induces structural alterations in dermal collagen fibers and enhances the activity of matrix metalloproteinases (MMPs), thereby accelerating structural deterioration of the skin [4].

As skin elasticity declines due to both intrinsic and extrinsic factors, wrinkle formation and skin sagging become more prominent, especially when accompanied by age-related atrophy of facial muscles, fat, and bone [5]. These changes result in a noticeable alteration of facial contours, which is recognized as a key visual marker of aging and has a significant impact on an individual’s perception of their appearance and psychological well-being.

In response, the cosmetic industry has seen the emergence of various products aimed at improving skin elasticity and enhancing lifting effects. This has prompted active research into objective evaluation methods for skin lifting efficacy. Current standard assessment tools include instrumental measurements and image-based analyses. However, devices such as the ballistometer, which uses vibrational energy, and the Cutometer, which applies suction to assess skin elasticity, are limited to localized measurements and do not fully capture changes in the overall facial structure. Additionally, these methods yield numerical data only, offering limited visual interpretability.

Likewise, moiré topography, which relies on contour imaging principles, is highly sensitive to photographic conditions and often lacks reproducibility and objectivity, making it difficult to

obtain reliable quantitative data. Similar to elasticity measurements, this technique is also limited in its ability to reflect three-dimensional facial structural changes [7].
Given these limitations, there is a growing need for more reliable and visually demonstrable evaluation methods for assessing improvements in facial lifting. In this study, we propose a novel evaluation approach using the VECTRA XT 3D imaging system. By defining facial landmarks and analyzing linear distances, this method enables comprehensive assessment of facial skin lifting effects. We further examined the correlation between this new method and conventional elasticity measurement techniques to verify its validity as an objective and quantitative assessment tool. This study presents an innovative approach based on 3D imaging and landmark analysis, offering a more precise and objective method for evaluating improvements in facial lifting.

2. Materials and Methods

2.1. Participants

This study was conducted with 40 Korean females who satisfied with the criteria of selection and exclusion in testing volunteers. Selection criteria for this study included female volunteers aged 40 to 60 who exhibited visible signs of skin aging, including decreased elasticity, wrinkles, and facial sagging. Participants were required to have received sufficient explanation from the researchers regarding the purpose and contents of the study and voluntarily signed the informed consent form. They were also required to be able to visit our lab in the morning on the visit day and be available for follow-up observation. Additionally, participants were required to maintain their usual habits and conditions (such as diet, sleep, wake-up time, and lifestyle) throughout the study period, storty from the day before each visit. Volunteers who had taken medications that may affect the test - such as systemic acne medications, oral retinoids, steroids, and antibiotics within the last three months were excluded from the study. Individuals who received treatments, used functional cosmetics or cosmecetical products for wrinkle improvement, or underwent medical procedures or massages aimed at skin improvement within one week prior to the start of the study, as well as those who had plastic surgery or ablative laser resurfacing on the skin around the eyes within one year preceding the study, were excluded [6]. The study protocol was approved by Institutional Review Board of mariedm Co. Ltd. And approval no. are MDSRC-2300FR-160 and MDSRC-2400FR-171. The study was performed Oct. 10, 2023 ~ Dec. 27, 2024.

2.2. Evaluations

All evaluations are conducted in a temperature and humidity-controlled room at a temperature of 22 ± 2 °C and a relative humidity of 50 ± 5 %. Participants are allowed to relax in the controlled room for 30 minutes after washing their face with a cleanser. The selected participants (aged 40s to 60s) used a product, which is commercially available and designed to improve skin elasticity and lifting, for 4 weeks according to the specified usage instructions. They visited the research institute twice for a test period for image analysis. The participant’s face was photographed from the front using VECTRA XT (Canfield Scientific, Inc., Parsippany, NJ07054USA), and landmark areas on the participants' faces were measured using the Ballistometer® BLS780 (Dia-Stron Ltd., United Kingdom) to analyze each parameter at the baseline and at 4 weeks after application of the product.

2.3. Measurement using VECTRA XT

VECTRA XT accurately captures the surface shape, contour, and color of the human body or face through a 3D imaging system. This involves capturing stereo images of the participant, using photometric algorithms to create a high-resolution 3D computer model of the participant's anatomical shape. These 3D images are obtained by capturing synchronized 2D digital camera views of the participant. The image processing software of VECTRA XT then uses information from multiple planes to calculate a highly accurate map of the 3D shape and color coordinates of the observed surface. The VECTRA XT system utilizes photogrammetric stereo imaging to generate a high-resolution 3D model of the participant's face for quantitative facial contour analysis.

2.4. Measurement using Ballistometer® BLS780

Ballistometer operates on the principle of electromagnetic vibrations within the embedded probe. When placed on the skin's surface, rapid oscillations are transmitted through the probe, and the resulting oscillation pattern (decrease) is detected by a control mechanism. Non-invasively quantifying skin elasticity, viscoelasticity, and resilience. By analyzing the changes in the waveform when vibrational energy is applied, the device measures characteristics such as elasticity, resilience, firmness, softness, and edema. Additionally, it can be used on narrow or curved areas and serves as a representative device for measuring skin elasticity, capable of analyzing skin surface elasticity index, edema conditions, level of aging, and skin age indicators.

2.5. Analysis methods

In this study, quantitative analysis was conducted by setting landmarks when measuring with the VECTRA XT and Ballistometer® BLS780. The designated landmarks allow for effective evaluation of skin sagging, based on the widening of the lower facial area as the facial bone structure changes and unfolds with aging progresses and sagging occurs. These landmarks were selected as fixed reference points that remain unaffected by changes in the face (Figure 1).

1. In this study, to evaluate the lifting effect using the proposed analysis method, facial image matching was performed through surface registration between two time points to minimize errors. Following this, the lifting effect was assessed by calculating the total distance between the facial landmarks: the inner ends of both eyebrows, the side of both eyes, both cheeks (defined as the intersection point of a vertical line dropped from the side of eyes and a horizontal line drawn from the nose tip), and the center of the chin.

2. To compare the consistency between the VECTRA XT-based skin lifting evaluation method proposed in this study and the representative skin elasticity measurement devices, Ballistometer measurements were performed at the same landmarks defined by VECTRA XT analysis, with each point being measured three times. The average value of the Mean CoR (ratio) parameter, which represents the relative elasticity (bounce) height of the first curve, was calculated, along with the sum of the average values for each landmark. The results were then compared with the VECTRA XT analysis results to analyze the correlation.

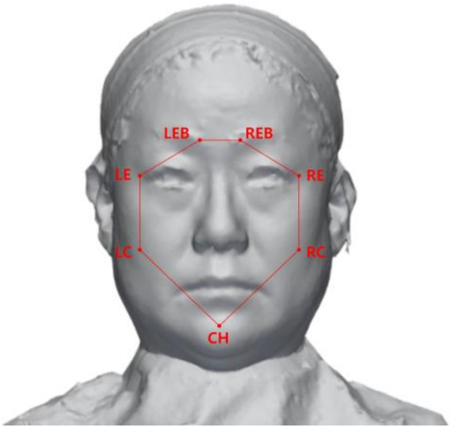


Figure 1. Image of the landmarks designated on the face: Center of the chin (CH), Left cheek (LC), Right cheek (RC), Left side of the eye (LE), Right side of the eye (RE), Inner end of the left eyebrow (LEB), and Inner end of the right eyebrow (REB).

2.6 Statistical analysis

All statistical analyses were performed using IBM SPSS® Statistics software (Version 20). To evaluate the effects of the test product, a paired t-test was conducted to compare facial landmark distances and skin elasticity values before and after application. Additionally, to assess the relationship between changes in facial lifting and skin elasticity, Pearson correlation analysis was performed between the distances measured by the VECTRA XT 3D system and the Mean CoR values obtained from the Ballistometer. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Participants

In this study, a total 40 volunteers participated, aged from 42 to 60 (average age: 50.9±4.9 yrs.). The demographic characteristics of the participants were investigated by the survey, and the results of the analysis are as follows: Table 1.

Table 1. The characteristics of the participants (n=40)

Items	Classification	Frequency (n)	Percentage (%)
Age	40's	12	30.00
	50's	26	65.00
	60's	2	5.00
Skin type	Dry	35	87.50
	Normal	3	7.50
	Oily	0	0.00
	Combination	2	5.00
	Troubled skin	0	0.00
Skin moisture	Moist	0	0.00
	Normal	9	22.50
	Dry	31	77.50
Skin sebum	Greasy	1	2.50
	Normal	27	67.50

	Deficient	12	30.00
Sleeping hours (daily)	Less than 5 hours	1	2.50
	5~8 hours	38	95.00
	More than 8hours	1	2.50
Exposure hours on UV (daily)	Less than 1 hr	15	37.50
	1~3 hrs	22	55.00
	More than 3 hrs	3	7.50
Smoking (daily)	No	40	100.00
	Less than 10 cigarettes	0	0.00
	More than 10 cigarettes	0	0.00
	More than a pack of cigarettes	0	0.00

3.2. Comparison of Measurements Before and After Application Using VECTRA XT and BALLISTOMETER

To first confirm whether both evaluation methods are capable of assessing improvements in skin elasticity, study participants were instructed to use a commercially available cream designed to enhance skin elasticity and lifting during 4 weeks. After 4 weeks application, changes in skin elasticity and lifting were assessed using the VECTRA XT and Ballistometer. A significant reduction in the sum length of the whole face and lower face areas was observed through VECTRA XT analysis (p<0.05, Figure 2), while the sum of elasticity values measured with the Ballistometer at the same landmarks significantly increased (p<0.05, Table 2). When analyzing changes in skin elasticity by each landmark, significant increases were found in the left cheek, right cheek, and chin. However, no significant changes were observed in the areas around the eyes and the inner ends of the eyebrows (Table 3).

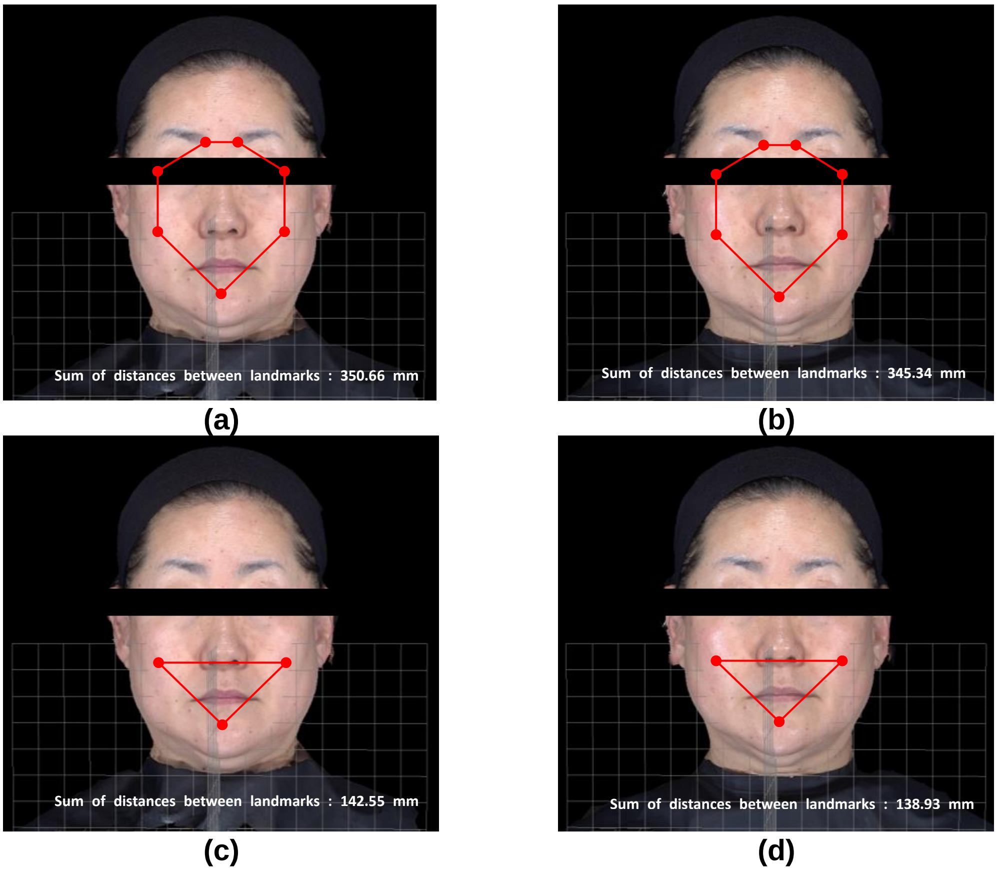


Figure 2. Changes in summed distances between facial landmarks in the whole and lower face regions. Images show facial changes before and after application of a commercially available cream formulated to improve skin lifting and elasticity. (a) VECTRA XT whole face distance before product use (350.66 mm); (b) VECTRA XT whole face distance after product use (345.34 mm), showing a reduction compared to (a); (c) VECTRA XT lower face distance before product use (142.55 mm); (d) VECTRA XT lower face distance after product use (138.93 mm), showing a reduction compared to (c).These reductions in landmark distances, as measured by the VECTRA XT system, indicate a lifting effect.

Table 2. Statistical Analysis of VECTRA XT and BALLISTOMETER Measurements Before and After application (n=40)

Area	VECTRA XT (mm)	Ballistometer® BLS780 (ratio)
Whole face	-9.061±7.091***	0.106±0.050***
Lower face	-5.011±4.696***	0.100±0.025***

Comparison before and after was calculated by Paired *t*-test

*Statistically significant paired *t*-test (*p<0.05, ** p<0.01, *** p<0.001)

Table 3. Statistical Analysis of BALLISTOMETER Measurements Before and After application (n=40)

Area	Ballistometer® BLS780 (ratio)
LC	0.040±0.008***
RC	0.034±0.014***
CH	0.026±0.017***
LE	0.002±0.019
RE	0.002±0.013
LEB	0.001±0.016
REB	0.001±0.016

Correlation coefficient was calculated by Pearson Correlation analysis.

*Statistically significant paired *t*-test (*p<0.05, ** p<0.01, *** p<0.001)

3.3. Comparison of Measurements Before and After Application Using VECTRA XT and BALLI STOMETER

To examine the relationship between facial lifting improvements assessed by the VECTRA XT 3D system and skin elasticity measured by the Ballistometer® BLS780, Pearson correlation analysis was conducted. As shown in Table 4 and Figure 3, a significant negative correlation was observed between the VECTRA XT-derived whole face values and the Ballistometer values for the lower face (r = –.578, p<0.001), left cheek (r = –.800, p<0.001), and right cheek (r = –.651, p<0.001). Likewise, the VECTRA XT-derived lower face values showed significant negative correlations with Ballistometer measurements for the lower face (r = –.285, p<0.05), left cheek (r = –.557, p< 0.001), and right cheek (r = –.476, p<0.001).

These results indicated that as the distance between facial landmarks decreased (indicating a lifting effect), the skin elasticity, as measured by the Ballistometer, significantly improved. No significant correlations were found between the VECTRA XT values and the measurements taken from the chin and the periorbital (eye area) sites.

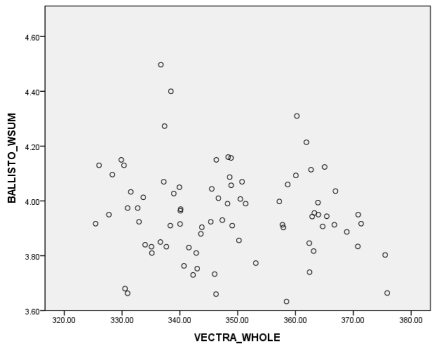
Table 4. Correlation of VECTRA XT and BALLISTOMETER

	Ballistometer® BLS780								
	Whole	Lower	LC	RC	CH	LE	RE	LEB	REB

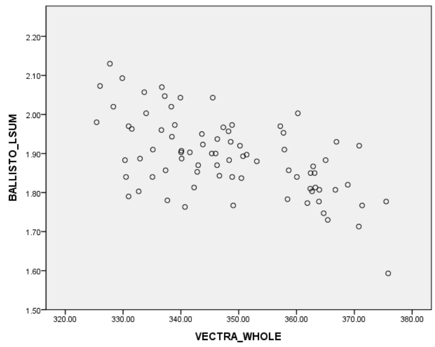
		face	face							
VEC-TRAXT	Whole face	-.111	**-.578****	**-.800****	**-.651****	-.053	.236*	.162	.214	.159
	Lower face	-.122	**-.285***	**-.557****	**-.476****	.166	.008	-.063	.069	.185

Correlation coefficient was calculated by Pearson Correlation analysis.

Statistically significant correlation (p<0.05, ** p<0.01, *** p<0.001)



(**a**)



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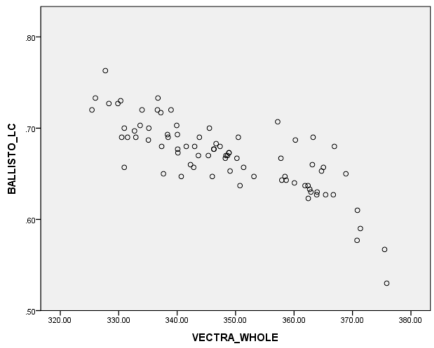

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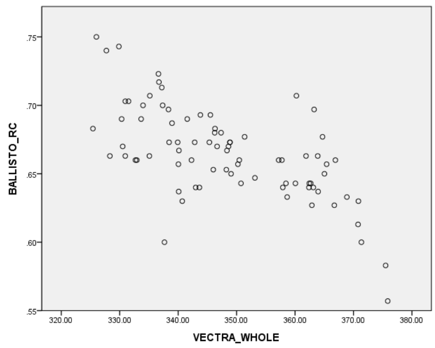

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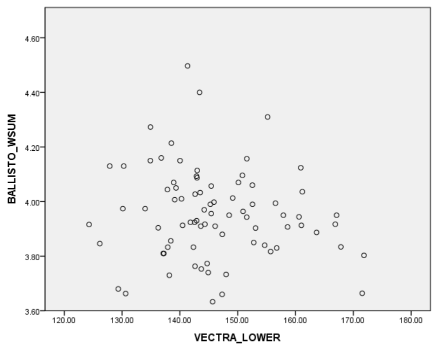

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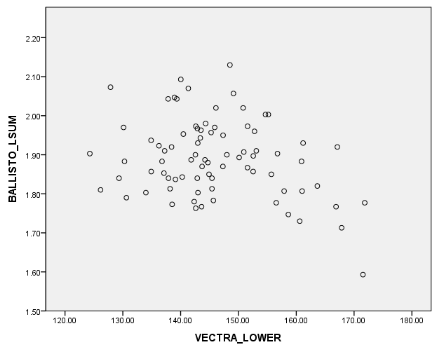

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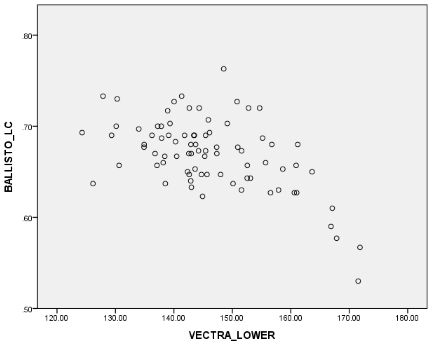

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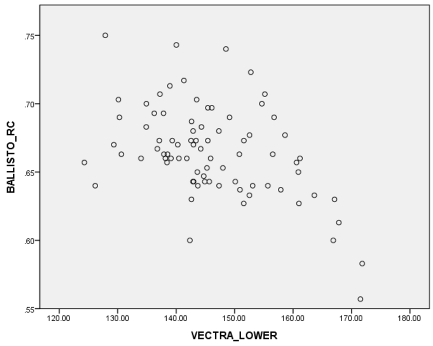

(**h**)

Figure 3. Graphic representation of correlation between facial lifting distances measured by VECTRA XT 3D system and skin elasticity values measured by Ballistometer® BLS780. Scatter plot illustrating the Pearson correlation between the VECTRA XT-based facial lifting measurements (x-axis) and the Mean CoR values obtained from Ballistometer® BLS780 (y-axis). Each plot shows the correlation between the designated VECTRA XT measurement and Ballistometer measurement: (a) VECTRA XT whole face distance vs. Ballistometer whole face sum; (b) VECTRA XT whole face distance vs. Ballistometer lower face sum; (c) VECTRA XT whole face distance vs. Ballistometer left cheek; (d) VECTRA XT whole face distance vs. Ballistometer right cheek ; (e) VECTRA XT lower face distance vs. Ballistometer whole face sum; (f) VECTRA XT lower face distance vs. Ballistometer lower face sum; (g) VECTRA XT lower face distance vs. Ballistometer left cheek; (h) VECTRA XT lower face distance vs. Ballistometer right cheek. Each dot represents a subject's measured values. A negative correlation was observed, indicating that a decrease in facial landmark distances, as measured by the VECTRA XT system, was associated with an increase in skin elasticity. A regression line is included to visualize the trend.

4. Discussion

In this study, we quantitatively analyzed the improvement in lifting effects using the VECTRA XT 3D system by measuring changes in distances between facial landmarks. This was validated through correlation with skin elasticity indicators measured using the Ballistometer. As a result, we observed a significant reduction in the total distance between landmarks on the whole face and the lower face in before and after comparisons using VECTRA XT analysis indicators. Additionally, Ballistometer analysis indicators showed a significant increase in elasticity values in the same area. In particular, skin elasticity values in the left cheek, right cheek, and chin increased significantly.

Based on results, a correlation analysis between the VECTRA XT and Ballistometer analysis indicators showed a significant negative correlation in the lower face and cheek, suggesting that the lifting effect is closely associated with improvements in skin elasticity. According to the literature, the Ballistometer evaluates skin elasticity by applying mechanical stimulation to the skin surface and measuring its vibrational response. It has primarily been used for localized elasticity assessments [6,7]. However, this approach has limitations in capturing structural changes across the entire face [7]. In contrast, the VECTRA XT system offers a 3D visual and structural analysis of the entire face, providing a more comprehensive evaluation. This study is among the first to empirically demonstrate the correlation between 3D image-based analysis and actual skin elasticity. This suggests that 3D imaging analysis, such as that provided by the VECTRA XT system, may be a valuable tool for objectively evaluating facial lifting effects in clinical settings.

In addition, this study identified area-specific differences. Notably, improvements in both lifting effects and skin elasticity were most prominent in the lower face, particularly in the cheek and chin areas. In contrast, the periorbital area exhibited relatively limited changes. These differences are likely attributable to anatomical structure of each area. The periorbital skin has a thin dermis, contains fewer collagen and elastin fibers, and has almost no subcutaneous fat [8], which may result in reduced responsiveness to external stimuli and lifting treatments. Moreover, the region's complex curvature and high degree of mobility may compromise the accuracy and reproducibility of contact-based measurement tools such as the Ballistometer. In contrast, the cheek and chin areas have a relatively thicker dermis and a higher density of fibrous connective tissue [9], which may contribute to their greater responsiveness to mechanical support and cosmetic products treatments. making them more responsive to mechanical support and cosmetic treatment. As a result, changes in elasticity and contour were more clearly observed in these areas. Understanding such anatomical and structural differences provides important insights into interpreting area-specific lifting responses and developing more targeted lifting strategies.

Despite these promising findings, several limitations should be noted. First, the participants were limited to Korean women in their 40's and 50's, which restricts the generalizability of the findings across different ethnicities, genders, and ages. Second, variables related to the type and conditions of the lifting products used were limited, and comparisons across various products or testing conditions were not performed. Third, certain areas, such as area the around the eyes, showed relatively low consistency in Ballistometer, indicating the need for further review in terms of measurement sensitivity and reproducibility.

Based on the findings, it can be concluded that improvements in skin elasticity and skin lifting effects were most noticeable in the lower face. Future studies should include a more diverse range of participants in terms of different ethnicities, genders, and ages to improve the generalizability and reliability of VECTRA XT-based lifting analysis. Additionally, comparing VECTRA XT with other elasticity measurements could help develop a more comprehensive assessment method. Moreover, further advancement in 3D imaging technologies—including automation and algorithm refinement—may enhance the precision and reproducibility of facial lifting effect evaluations in future research.

5. Conclusion

This study proposes a new method for evaluating improvements in facial skin lifting effects using the VECTRA XT 3D imaging system, landmark setting and length analysis method. By examining the correlation with existing skin elasticity analysis methods, the reliability of the proposed approach as a quantitative and objective evaluation method was also verified.

The study demonstrates that the new approach, based on 3D imaging and landmark analysis, can complement the limitations of existing evaluation methods. Unlike previous methods that relied on localized and subjective interpretations, the method proposed in this study enables a more precise and objective analysis of skin lifting effects, providing a quantitative analysis with high visual reproducibility.
In the future, to verify the clinical efficacy of this analysis technique using VECTRA XT, further research involving larger sample sizes and including various skin conditions and ages will be necessary.

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