Quantitative Analysis of Facial Features

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Canfield 2D and 3D imaging systems are valuable tools for evaluating and substantiating claims of treatment efficacy with volumetric measurements of physical changes to skin microstructure using PRIMOS close-up 3D imaging, and substantiating those with global objective assessment of individual topographical and aesthetic skin features using VISIA-CR's full-face, multi-modal 2D images analyzed in VAESTRO.

Background

Canfield Scientific, Inc. has developed a variety of 2D and 3D imaging systems, analysis methods, and algorithms for studying facial features.

VISIA-CR (Figure 1) is a 2D clinical imaging system, designed to take highly reproducible full-face images in a controlled environment. Images can then be analyzed using **VAESTRO**® Image Analysis Toolkit, developed for objective, quantitative assessment of 2D facial images based on area, shape, color, and contrast.

PRIMOS Lite (Figure 2) is a 3D fringe-projection system, which captures smaller-field 3D images of facial target areas. PRIMOS software is used to measure skin geometric microstructure using a 3D topographical height map image.

FIGURE 1: ***Canfield's VISIA-CR is designed to take high quality, reproducible 2D facial images in a variety of lighting modes.***

Purpose

The purpose of the following experiment is to demonstrate a general correlation in data between two analysis methods and capture systems, and to highlight and differentiate the types of measurements and data that can be generated with each system.

FIGURE 2: ***PRIMOS Lite 45x30 generates concrete 3D measurements of skin microstructure within a small capture field.***

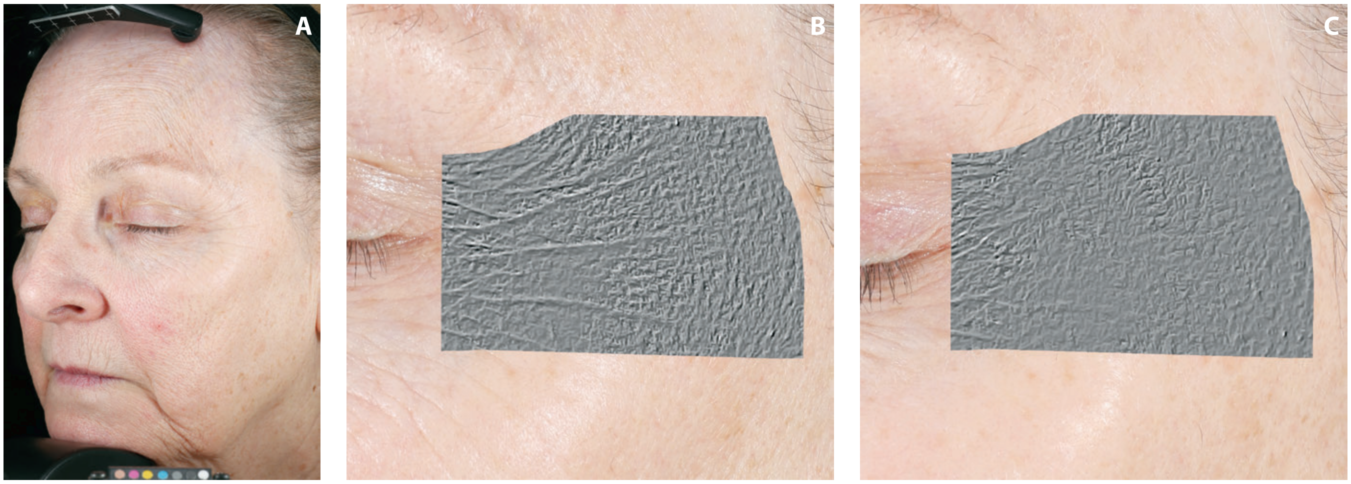

FIGURE 3: ***Images captured with VISIA-CR. (A) Shows the full face image. The region of interest (ROI) is defined for Texture analysis in VAESTRO on baseline (B) and follow-up (C).***

Objectives

- To establish both VAESTRO Image Analysis Toolkit and PRIMOS 3D Image Analysis software as reliable and complementary methods of skin feature detection in a defined region of interest (ROI) over multiple time points.
- To present examples of 2D and 3D analysis methods and measurements using a sampling of subjects with clear cosmetic benefit.

Methodology

2D IMAGE CAPTURE A Canfield VISIA®-CR v2.2 with Mirror® software was used to capture and manage a series of 2D images of the subject's face. Image analysis was performed with VAESTRO Image Analysis Toolkit software.

3D IMAGE CAPTURE Canfield's PRIMOS Lite fringe-projection 3D camera system with 45mm x 30mm field of view was used to capture small-field 3D images of the lateral canthi target area. PRIMOS software was used for both management and analysis of 3D images.

Five subjects with varying severity of wrinkles and skin texture in the lateral canthi region (crow's feet), were photographed. Clinical, Cross-Polarized, and Parallel Polarized 2D images were captured of the subjects' left oblique view using the VISIA-CR. Of the two imaging timepoints, the initial captured image is considered the baseline and the subsequent captured images are considered follow-ups. For 3D imaging, the target area was reproduced using the overlay pattern projection feature in PRIMOS to ensure consistent capture of the same target area.

After baseline, subjects were treated with a commercially available anti-wrinkle silica base serum, and imaged again after 10 minutes. Between each capture, the subject relaxed and was repositioned into the VISIA-CR system using the MatchPose® image overlay function of Mirror.

Image Analysis

VAESTRO Image Analysis Toolkit (version 2.1.3) was used to quantify facial features from 2D images captured with the VISIA-CR. Though VAESTRO has tunable threshold and sensitivity parameters for each feature, default detection settings were used in this experiment.

TEXTURE/ROUGHNESS The subjects' left view images were analyzed for texture in the lateral canthi region (Figure 3).

The texture analysis algorithm in VAESTRO provides quantitative data and scoring for skin texture under standard daylight conditions. Granularity parameters enable the technician to specify the level of detail of texture detection to generate a roughness measurement, which represents an average magnitude of textural content of the image.

PRIMOS software was used to quantify the corresponding facial region from 3D fringe-projection images captured with the PRIMOS Lite 45x30mm system (Figure 4). From the resulting topographical height map image, PRIMOS surface area roughness measurements were made referring to the arithmetic mean of the surface roughness in 3D. This measurement used a vertical parameter to describe the roughness in a vertical direction, and data from both systems were compared (Figure 5).

In addition to Surface area roughness, PRIMOS generates a variety of line-based roughness measurements to represent the data. These can be shown as an average of the absolute values of profile heights of the line(s) within an area (Ra), the root mean square average of profile heights in a star roughness picture (Rq), or the largest height difference in a single measurement section (Rmax), measured vertically from the highest profile peak to the lowest profile valley.

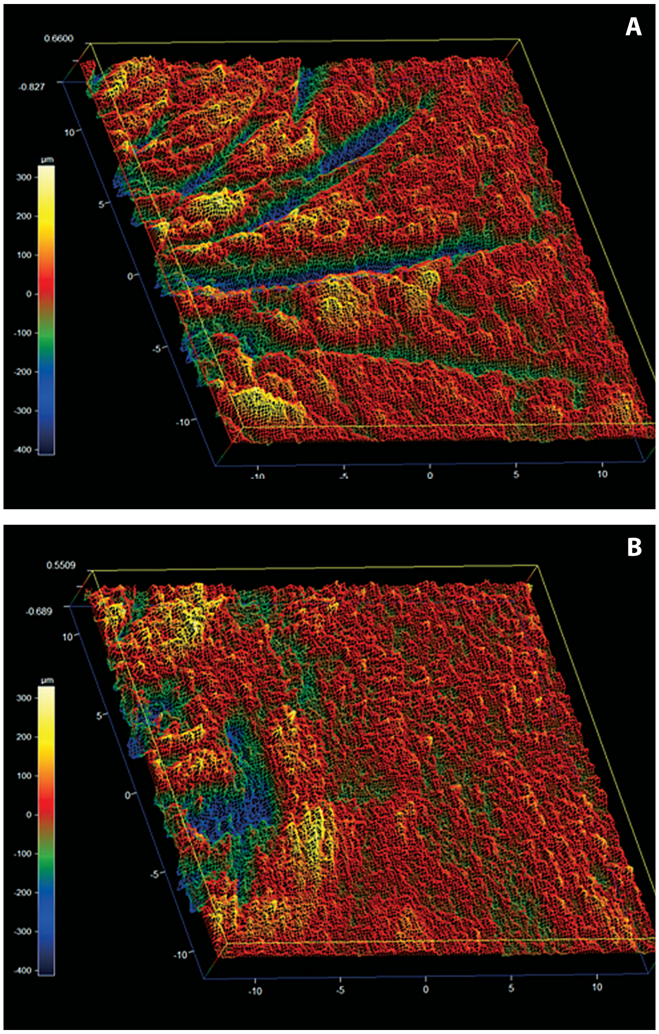

FIGURE 4: *Corresponding ROI was imaged with PRIMOS Lite at baseline (A) and follow-up (B). Topographical height map shows a 3D representation of the skin surface to be analyzed for line, star, and overall roughness.*

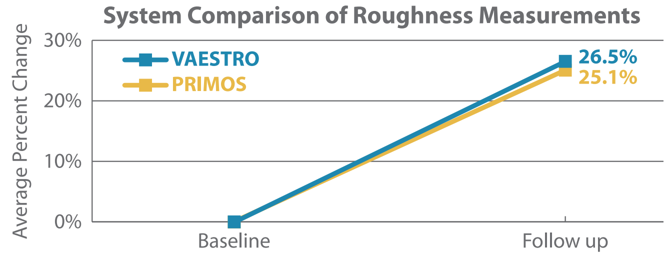

FIGURE 5: *Comparison of Texture assessment between 2D (VAESTRO) and 3D (PRIMOS) systems showing the average percent change in Texture scores for five subjects.*

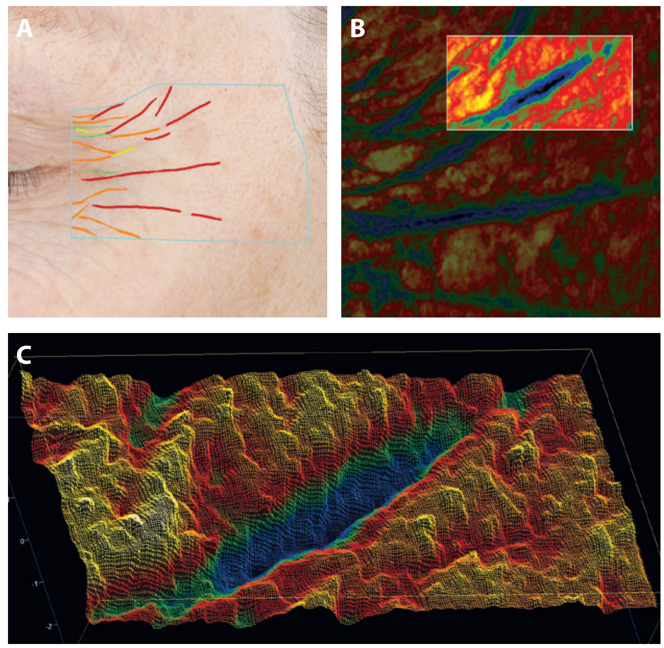

FIGURE 6: *Images captured with VISIA-CR (A) and PRIMOS 3D (B) showing Wrinkle detection in the same ROI at the same timepoint. VAESTRO analyzes all detected features within a given ROI, while PRIMOS enables calculations on a single feature for depth/volume measurements (C).*

WRINKLES Left view images were also analyzed with VAESTRO and PRIMOS for wrinkles (Figure 6). VAESTRO's wrinkle analysis algorithm provides quantitative data and scoring for assessing the severity of facial wrinkles and fine lines, and operates on a high-resolution VISIA-CR image captured in Standard 2 imaging modality (uniform white light). The data that is generated represents a cumulative measurement value of the detected features within the masked ROI. Subset targeted wrinkle analysis was conducted on select features yielding accurate and precise measures of wrinkle volume, depth and profile changes. The resulting data from both VAESTRO and PRIMOS image analysis show a correlated trend across subjects in the reduction of fine lines and surface texture from Baseline to Follow-up. The measurements vary slightly depending on whether analysis was performed on a 2D or 3D image (Table 1). Significant reduction of detected features was observed from Baseline to Follow-up.

TABLE 1: *Different types of wrinkle data generated with 2D and 3D photography from comparative region of interest, single subject, single timepoint.*

VAESTRO analysis of images captured with VISIA-CR 2D system	
Total Wrinkle Length	236.16 mm
Wrinkle Count	36
Total Area	90.52 mm^2

PRIMOS 3D system	
Total Wrinkle Length	224 mm
Average Depth	108.6 µm
Max Depth Largest Wrinkle	373.5 µm
Total Wrinkle Volume	18.05 mm^3

Conclusions

All subjects show a corresponding trend in the overall reduction of detectable surface features both qualitatively and quantitatively. When clinical images are captured by a trained technician, quantitative analysis of facial features can be used as end-point data for product/treatment efficacy in both 2D and 3D.

PRIMOS 3D small-field skin imaging and analysis can generate reliable 3D measurements including depth, volume, and profile of individual surface features as well as more general roughness and texture data within the region. PRIMOS generates a concrete three dimensional measure of skin microstructure within a small capture field.

VAESTRO Image Analysis Toolkit and VISIA-CR full-face 2D images produce data on count, contrast-based intensity, area, and severity measurements of features that relate well to 3D geometry. Beyond texture and geometry alone, the capture field encompassing multiple target ROI in a single capture may be used in the assessment of color/pigment/vascularity and be combined with multimodal imaging. The full-face images from VISIA-CR are also invaluable in qualitative assessment and use with Global Aesthetic Improvement Scales.

The high precision of image analysis presented demonstrates that VAESTRO and PRIMOS are powerful complementary tools in facial feature assessment.

Control Experiment: Analysis of Skin Replica Standard

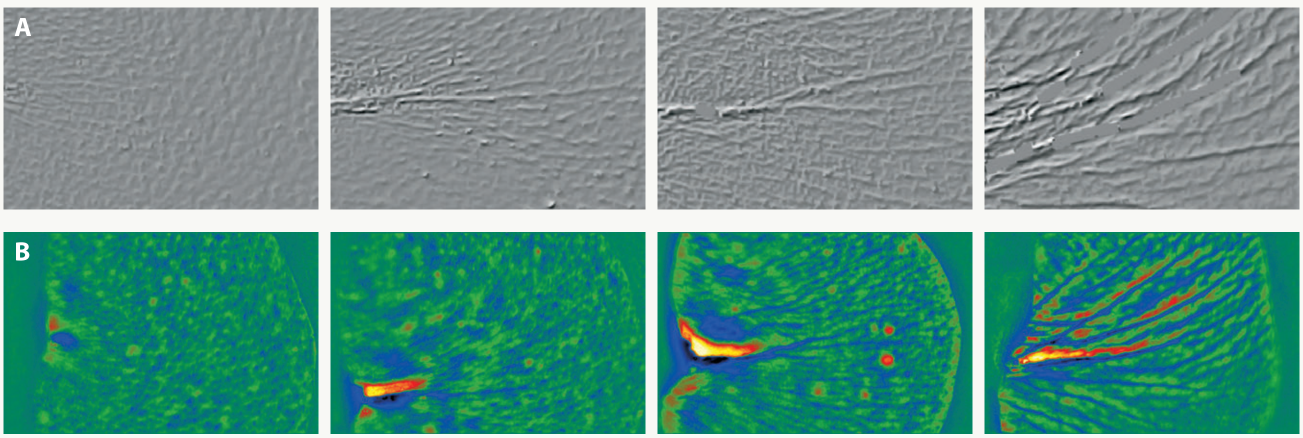

FIGURE 7: ***Comparison of Texture assessment between 2D (VAESTRO) and 3D (PRIMOS) systems for Polyurethane Elastomer skin reference patches. (A) Shows images captured with VISIA-CR and analyzed using VAESTRO Texture module. (B) Shows the same targets captured with PRIMOS 3D and analyzed using Sa (Surface area) measurement.***

To establish the accuracy and consistency of VAESTRO and PRIMOS methods of analysis, a control group consisting of skin replica patches was captured in 2D and 3D (Figure 7).

Skin replica standard patches offered an opportunity for analysis with both systems on a static surface, eliminating variables like movement and noise in the image due to hairs, specularity, etc.

Four polyurethane elastomer skin replica patches were imaged, each representing varying severity of wrinkles, fine lines, pores, and surface texture. Images of the individual replica patches were analyzed with VAESTRO and PRIMOS. Roughness measurements from VAESTRO were compared to Surface roughness measurements from Primos, and the resulting data shows a matching trend between the two systems when analyzing a static reference standard (Figure 8).

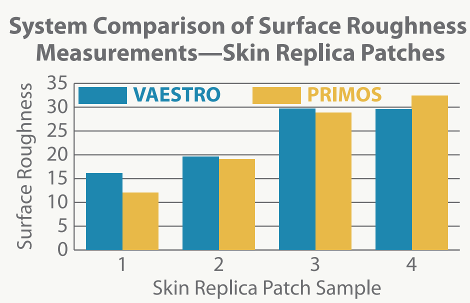

FIGURE 8: ***Surface Texture/Roughness analysis scores for each patch as generated by VAESTRO (blue) and PRIMOS (gold). The calculated coefficient of correlation is 0.9793. Quantitative assessment correlates with visual assessment for surface roughness.***