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Preliminary study in the evaluation of anti-aging cosmetic treatment using two complementary methods for assessing skin surface

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Background/purpose: One of the constantly developing fields in the area of cosmetology is the analysis of the efficacy of cosmetics products. Various instrumental techniques are available nowadays to evaluate changes in skin surface and measure anti-wrinkle activity. The aim of our study was to present and confront two methods of the analysis of skin surface, Primos and Visioscan, regarding their applicability in evaluating anti-wrinkle properties of cosmetic formulations and treatments.

Methods: The study was performed on women, taking part in anti-wrinkle cosmetic treatments. Various skin aging parameters were analyzed, including skin surface changes. The results obtained with Visioscan and Primos were compared regarding their usefulness in anti-wrinkling properties assessment.

Results: The assessment of skin condition suggested anti-wrinkle properties of the applied cosmetic treatment. Both Visioscan and Primos analyses were consistent with each other and had similar faults as well.

Conclusion: The results of this study show that both complementary technologies (Visioscan and Primos) are appropriate for characterizing the skin surface and could be useful in testing the efficacy of anti-aging properties. There are some measurements which are unique to just one method, none, however, seems to be significantly more useful for efficacy testing than the other.

Key words: skin surface – primos – visioscan – anti-aging cosmetic treatment

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SKIN AGING is a complex biological process, affected by a variety of internal (like genetic predisposition, hormonal disorders, vitamin deficiencies) and external factors (such as UV radiation, environmental pollution, improper care). The result of aging is a decrease in biological activity of skin cells, regenerative processes, and adaptation. Visible effects of aging are dry skin, thinning of the epidermis, and dermal laxity (1).

The analysis of skin surface has been a subject of research for more than 25 years. Since 1973, surface profile was measured with a mechanical stylus (2), in the 1980s topography was quantified (3,4) and since the end of the decade the mechanical stylus was replaced by optical laser profilometers (5). However, for quite a long time these methods were treated with reserve by the non-cosmetic industry as not entirely objective ones. Since the middle 1980s only some of the measurement methods were used in research department of a cosmetic industry (6,7). In the 1970s an 1980s all measurements were executed on silicone replicas of human skin. This was a time-consuming procedure which remained not without influence on the analyzed skin surface.

With the advent of the 90s a new chapter of *in vivo* studies of skin surface topography began, the one without replicas. Kim et al. (8) were the first who used confocal microscopy to study a human skin *in vivo*, Potorac et al. (9) created an optical laser with triangulation system for *in vivo* 2D skin profilometry, Altmeyer et al. (10) published a report about a system based on triangulation principle using gray-code and phase-shift technique and Rohr and Schrader (11) described fast optical *in vivo* topometry of human skin system.

The aim of our study was to present and confront two methods of the analysis of skin surface, Primos and Visioscan, in evaluation of an anti-wrinkle cosmetic treatment. Visioscan is a system offered by Courage-Khazaka, one of the leaders in skin diagnostic equipment. It is a high resolution UV-A handheld camera. It allows a direct analysis of skin topography by assessing the gray level distribution of the image. These data are used to evaluate four clinical parameters to quantitatively and qualitatively describe the skin surface as an index: skin smoothness, roughness, scaliness, wrinkles (12). Primos, on the other hand, is an optical system that produces three-dimensional measurements of skin surfaces. It is based on active image triangulation using temporal phase-shift techniques and enables fast and more importantly a contact-free analysis (13). It is interesting to compare the two methods regarding their applicability in evaluating anti-wrinkle properties of cosmetic formulations and treatments.

Materials and Methods

The study was performed on four healthy women, aged over 35. Each subject gave her informed consent in writing. They were obliged to use the same daily-care cosmetics throughout the study.

Each subject took part in four cosmetic anti-aging treatments, twice a week.

The following skin aging parameters were examined before treatments, after the 1st treatment and after the 4th treatment:

- smoothness (Visioscan V98, Courage-Khazaka, Cologne, Germany) and roughness (Visioscan V98, Courage-Khazaka, Cologne, Germany and Primos, **GFMesstechnik GmbH**, Germany)
- depth and volume of wrinkles (Primos, **GFMesstechnik GmbH**, Germany).

Visioscan measurements were performed on the skin on the cheekbone by a trained researcher. Only the Primos test was conducted at the corner of the eye, for technical reasons. The detailed skin surface analyses shown below were carried out on one exemplary volunteer.

The results of skin surface topography evaluation (microprofiles) acquired with Visioscan and Primos, as well as skin roughness parameters, were compared. The SELS (Surface Evaluation of the Living Skin) and texture parameters (unique to Visioscan), as well as obtained wrinkle depth and volume values (unique to Primos) were calculated. Moreover, their usefulness in anti-wrinkling properties was estimated.

Results

Surface analysis

Both techniques are primarily designed to analyze and compare surface profiles. During the experiment both methods were used to evaluate how the topography of skin surface changed after cosmetic treatments.

Visioscan evaluation. Visioscan-acquired images (Fig. 1a,b,c) were subsequently analyzed with Visioscan-associated software. The resulting microprofiles (Fig. 1d,e,f) show the differences in skin topography before and after cosmetic treatments.

The first microprofile – obtained before treatment (Fig. 1d) was very irregular with numerous micro-bumps, suggesting rough skin surface and visible wrinkling. After the 1st treatment the profile was similar (Fig. 1e), while after the 4th treatment it was visibly milder (Fig. 1f). We observed a reduction in number and size of micro-irregularities of the skin. This suggests smoothing and anti-wrinkle properties of the cosmetic's application but also shows that results may be visible only after a series of treatments.

Based on the same photographs the surface parameter was analyzed, which is the ratio of wavy to stretched plane. The higher values of this factor indicate uneven or irregular surface, while decreasing of surface value shows that the analyzed area is becoming smoother. During the study period, this factor has been gradually changing (–24% after the first treatment), and after the 4^{th} treatment a decrease by 48% was noticed (Table 1), which suggests good smoothing properties of treatments.

Primos evaluation. The photographs obtained with Primos (Fig. 2a,b,c) were also utilized to prepare microprofiles of skin surface (Fig. 2d,e, f).

As shown in Fig. 2e and f, the microprofiles were significantly smoother after treatments than before (Fig. 2d). Microprofiles from Primos (Fig. 2) showed the similar effect as the Visioscan ones (Fig. 1), however, Primos shows the

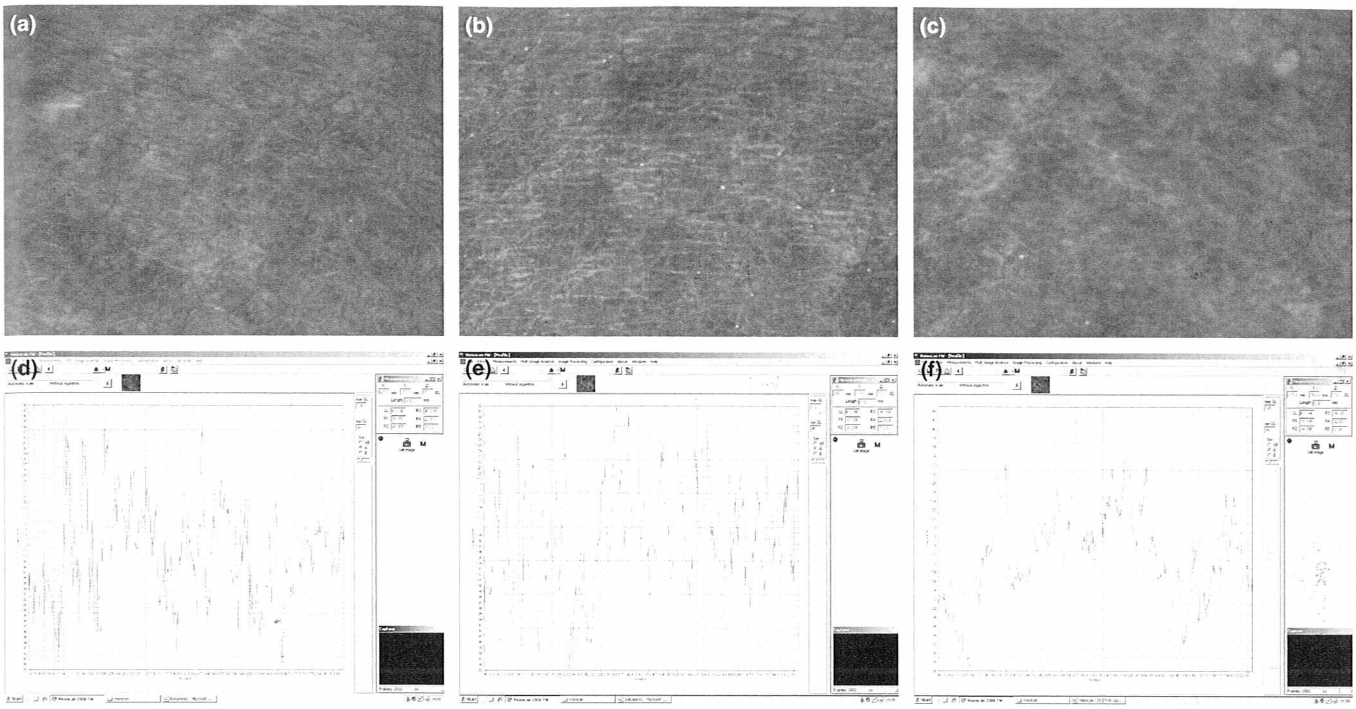

Fig. 1. Skin surface effect (a,b,c) and micro profile (d,e,f) made by Visioscan (a,d – before treatment, b,e – after the 1st treatment, c,f – after the 4th treatment).

TABLE 1. Surface analysis by Visioscan during the study

	Before	After the 1st treatment	After the 4th treatment
Surface (wavy/ stretched)	5	3.8	2.58

smoothing of the analyzed surface even after just one treatment, sooner than Visioscan. This suggests a higher sensitivity of the former.

Roughness

During the experiments the roughness parameters were also analyzed. The parameters in this

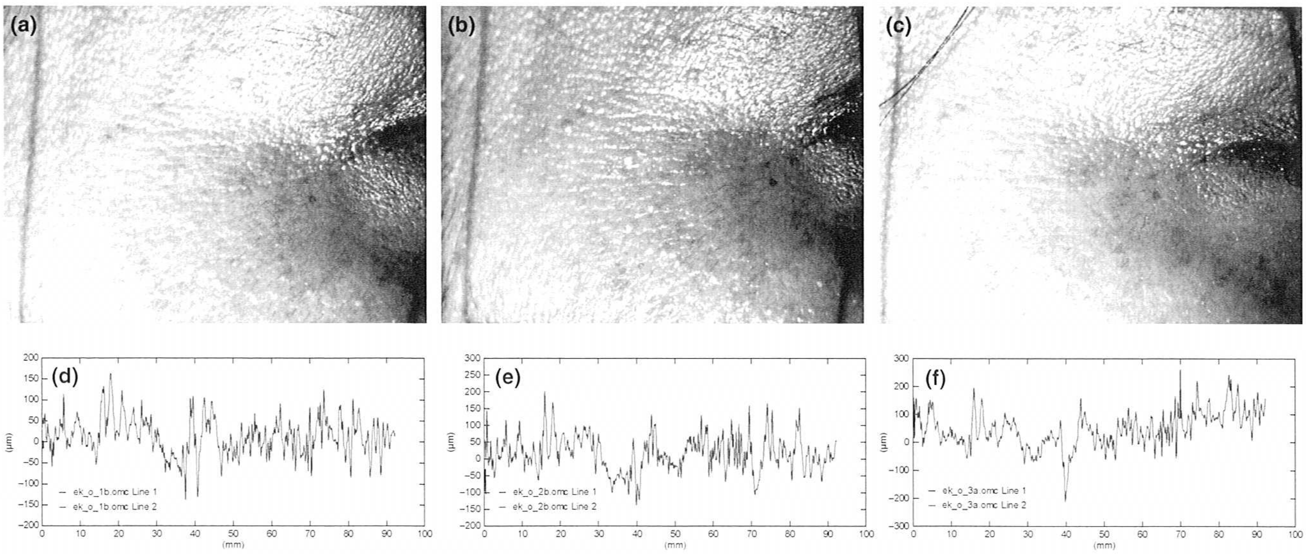

Fig. 2. Skin surface effect (a,b,c) and micro profile (d,e,f) made by Primos (a,d – before treatment, b,e – after the 1st treatment, c,f – after the 4th treatment).

calculation system are used to describe an irregular and uneven surface texture.

Roughness from Visioscan and Primos was calculated along intersecting lines arranged in a star shape (circle/star roughness). Each parameter was then calculated from surface profiles on the lines (reference profiles).

Visioscan analysis. As shown in Table 2, there were some changes in roughness (i.e. an increase after the 1st treatment and a slight decrease by the end of the test) but mostly insignificant. This was surprising when compared with surface analysis results, since if the skin was gaining in smoothness then the roughness parameters should have gone down. However, during the treatment the skin had been often touched and irritated mechanically, which could have temporarily increased the superficial roughness of the skin immediately after the cosmetic intervention, which was exactly when the measurements were performed. This suggests a weakness of this method in this aspect and confirms that it may not be a calculation system of choice for living skin analysis.

Primos analysis. The exact roughness values calculated with Primos software differed from those obtained with Visioscan. The reason for this is in differences in image processing for the two methods. With Visioscan the depth values used in calculations are displayed in gray values and not in real depth. This should not influence the results of the cosmetic treatment evaluation themselves, since it is not the exact value that is of interest but rather the level of change in it. As with Visioscan, the results for roughness parameters calculated with Primos software were inconclusive (Table 2). A decrease in all or most parameters was expected, especially taking into account skin surface analysis results, yet was not observed.

This shows that both methods are liable to temporary, superficial surface changes, immediately after cosmetic interventions.

SELS parameters: SEr, SEsc, SEsm, SEw (unique to Visioscan)

Visioscan clinical parameters SELS (Surface Evaluation of the Living Skin) were also evaluated during the test. These parameters are unique to the Visioscan equipment and are obtained from detailed analyses of differences in gray values in the evaluated image.

The values of SELS parameters (Table 3) in our experiment showed a significant decrease in the asperity of the skin – SEr (−47%) and skin scaliness – SEsc (−41%) after the series of treatments, which was expected. The temporary increase in these parameters after the 1st treatment was surprising but it might be due to a slight skin irritation when the treatments began.

Skin smoothness (SEsm) increased after the first (+32%) but returned to its basal value after all treatments. The SEw parameter has not

TABLE 2. Roughness parameters before treatments, after the first treatment and after a series of four treatments, measured with Visioscan and PRIMOS. If a cosmetic anti-aging treatment is effective in decreasing roughness all the parameters are expected to decrease

Roughness	Parameter description	Visioscan (pixels)			PRIMOS (μm)		
		Before	After the 1st treatment	After the 4th treatment	Before	After the 1st treatment	After the 4th treatment
R1	Maximum height of the profile along a given line (roughness)	49	59	45			
R2/R3z	Average roughness estimated form several measurements	41	51	39	52 ± 8	64 ± 9	61 ± 3
R3/Rmax	Maximum roughness depth (highest peak-depression difference)	31	38	29	141 ± 28	143 ± 22	153 ± 18
R4	Area above reference profile (smoothness depth)	26	35	25			
R5/Ra	Arithmetic average departure of roughness profile from the mean	6	8	7	18 ± 1	20 ± 2	20 ± 1
Rt	Arithmetic average value of amplitudes of highest profile peaks and deepest depressions in single measuring lengths				142 ± 27	151 ± 23	177 ± 33
Rz	Average maximum height of the profile				98 ± 3	109 ± 5	112 ± 3
Rq	Root mean square of profile roughness peaks				23 ± 1	25 ± 2	26 ± 1
Rp	Maximum profile peak height				78 ± 25	79 ± 22	92 ± 18
RKU	A comparison of the reference profile with the Gaussian curve	3.18	3.18	3.19	2.91 ± 0.29	2.8 ± 0.51	3.24 ± 0.62

TABLE 3. Visioscan SELS and texture parameters measured before the treatment, after the first treatment and after a series of four treatments

	Parameter description	Expected change if anti-aging treatment effective	Before	After the 1st treatment	After the 4th treatment
Sesc	Scaling calculated as a portion of light pixels (gray level higher than established threshold)	↓	0.46	0.8	0.29
SEr	Roughness calculated as a portion of dark pixels (gray level is below established threshold)	↓	1.12	1.74	0.59
SEw	Proportion of horizontal and vertical lines (wrinkles)	↓	33.71	39.04	50
SEsm	Smoothness in proportion to wrinkle number (Sew)	↑	29.93	39.62	30
NRJ	Surface uniformity	↑	0.061	0.061	0.086
ENT	Entropy	↑	1.564	1.577	1.635
HOM	Surface homogeneity	↑	1.515	1.562	1.702
CONT	Contrast	↓	0.921	0.651	0.337
VAR	Variance	↓	3.396	3.452	2.128

dropped as expected. These results were not entirely consistent with surface microprofiles (Fig. 1d,e,f). These values (Table 3) were obtained as a result of image processing and it is still open for discussion to what extent they show the real changes in skin topography.

Texture parameters (unique to Visioscan)

These parameters analyze the differences in the color of neighboring pixel and are also a result of an analysis unique to the Visioscan system. Their values correspond to skin smoothness.

To sum up, energy – NRJ, entropy – ENT, and homogeneity – HOM are higher, but contrast – CONT and variance – VAR are lower in young, smooth skin when compared with older, wrinkled one.

In our test almost all of these parameters improved after the last cosmetic treatment (NRJ: +41%, ENT: +5%, HOM: +12%,CONT: −63%, Var: −37%) (Table 3), which is consistent with skin microprofiles (Fig. 1d,e,f) and indicates and improvement in skin condition and a probable anti-wrinkle activity of the cosmetic treatment.

Depth and volume of a wrinkle (unique to Primos)

Primos allows a precise evaluation of depth and volume of a wrinkle. The resulting wrinkle profile enables quick and efficient visualization of changes in the analyzed wrinkle.

We observed a gradual refilling of an eye wrinkle during the treatments (Fig. 3). As shown, the analyzed wrinkle depth decreased by 16.8 μm after one treatment and then decreased further by 17.3 μm after the 4th treatment. Volume of the wrinkle did not change after the 1st treatment (the observed slight increase by 9% is most probably an oscillation in the measurement) but decreased (by 45%) after the 4th treatment (Table 4). This shows a specific change, which can be associated with the tested treatment.

Conclusion

Nowadays Visioscan V98 and SELS software, is one of the most frequently used equipment to analyze skin surface. Visioscan method is based on graphic depiction of living skin under special illumination, electronic processing and the evaluation of the obtained image in gray level distribution with regard to four clinical parameters. Tronnier et al. (14) described the skin parameters such as smoothness (SEsm), roughness (Ser), scaliness (SEsc -), wrinkles (Sew) corresponding quantitatively and qualitatively to the physiological condition of the living skin surface and perfectly suitable to characterize this surface. Our results showed that these parameters indeed have changed in accordance with overall skin condition improvement and skin surface smoothing, however, the changes were small and sometimes difficult to analyze.

To avoid the self-movement of the body and hence interference with the measured surface, it is reasonable to apply a contact-free method with short time data acquisition (15). One of the most advanced methods of evaluating the topography of human skin surface is to utilize a measuring device called PRIMOS. This optical method is the digital stripe projection technique, based on digital micro mirror projectors

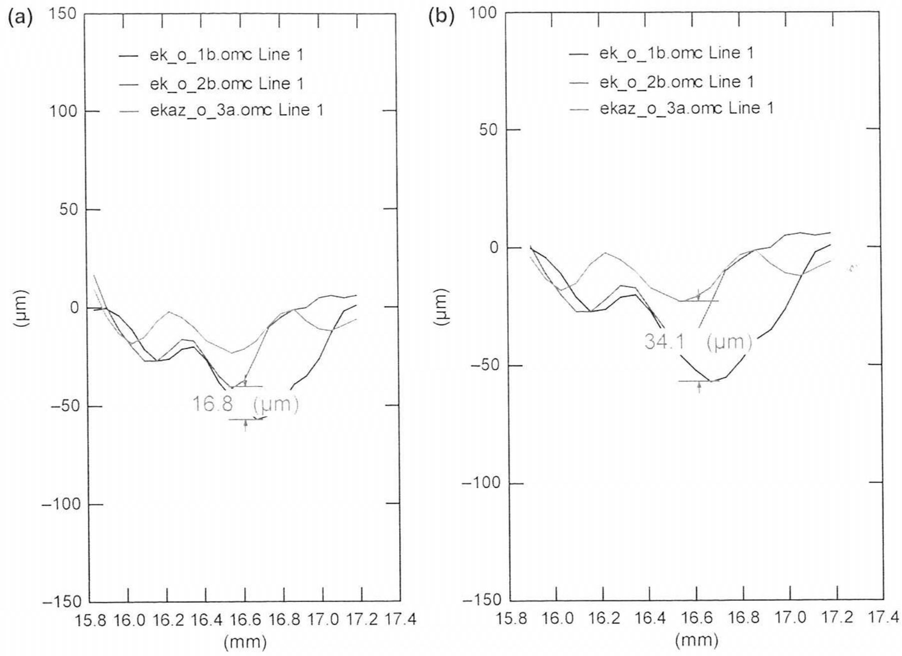

Fig. 3. Difference in depth of an eye wrinkle (a) difference in depth shown for the wrinkle before treatments and after the 1st treatment; (b) difference in depth shown for the wrinkle before treatments and after the 4th treatment.

TABLE 4. Differences in volume of an eye wrinkle during the study

	Volume (mm^3)
Before	0.63509
After the 1st treatment	0.692569
After the 4th treatment	0.348815

(DMD ^{TM} Digital Micro mirror Device) (13). Stripes with sinusoidal intensity of brightness (depending on the height profile of the measured object) are projected onto the measured surface and the projections are recorded at a defined triangulation angle by a CCD camera. The introduction of active image triangulation in conjunction with phase-shift techniques in skin topometry enables a fast and non-invasive measurement of the skin surface *in vivo*. The principle of these instruments is described in details by Jaspers et al. (16).

This way it is possible to objectively assess the changes in the topography of skin surface before and after a cosmetic treatment and to visualize the efficacy of such a treatment without interfering with the skin itself. This introduces new possibilities in validating the efficacy of anti-wrinkle cosmetics and treatments as well as a more objective comparison between them.

Visioscan and Primos methods are suitable for demonstrating the smoothness properties on human skin, but give different results. Visioscan software displays the data as a gray level distribution, while Primos output data are present as metric units describing the picture taken. Both of them utilize roughness parameters such R2/R3z, R3/Rmax, R5/Ra or RKU,while Primos generates additional parameters like -S (mean spacing of local peaks of the profile), Wt (waviness height) and PC (peak count/density) allowing varied presentation of the acquired data. On the other hand, Visioscan allows the calculation of the surface parameters (SELS) allowing a more comprehensive analysis, since these parameters change in response to skin hydration and color changes as well. However, by using Primos software it was possible to calculate the depth or volume of a specific wrinkle.

The results of this study show that both complementary technologies (Visioscan and Primos) are appropriate for characterizing the skin surface and could be useful in testing the efficacy of anti-aging cosmetics or treatments. Our experiment presented quite similar results from both equipments: microprofile smoothed up, roughness parameters grew (as a result of superficial skin roughness, which was a temporary effect) and SELS and texture parameters were generally consistent with a refill of the depth and volume shown with Primos. Acquired data are just preliminary and further research on broader group of volunteers is still required to confront these two methods. There are some measurements which are unique to just one method, both of them, however, seem to be applicable for anti-wrinkle properties evaluation.

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