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Skin smoothing effects of Dead Sea minerals: comparative profilometric evaluation of skin surface

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Synopsis

The skin smoothing effects of three different liquid gels compared on 20 mature women. Treatment applications were performed twice daily over a period of four weeks, and the skin roughness parameter (Rz) of all test participants was determined at the beginning and at the end of the study, using a computer-aided laser profilometry, in accordance with DIN 4768 ff. At the end of the application period, the liquid gel with 1% of a Dead Sea mineral solution had an average skin roughness parameter reduction of 40.7%. The liquid gel without mineral additives showed an average reduction in skin roughness of 27.8%. The control gel without anti-wrinkle agents or the additives showed an average reduction of only 10.4%.

Résumé

On a testé l'influence d'une formulation aux liposomes d'un mélange ceramide/phospholipide sur la fonction protectrice de la peau de personnes en test atopique, avce une peau saine, et après extraction lipidique. On a utilisé la perte d'eau transépidermique et l'hydratation de l'épiderme comme paramèters d'evaluation de l'influence du traitement sur la fonction protectrice. On a en outré effectué stabilisateurs de la fonction protectrice ave un ester d'acide nicotinique. On a constate de effets stabilisateurs de la fonction protectrice après application seulement sur peau atopique et après extraction lipidique mais pas sur peau saine, les résultants nous conduisent à espérer de effets positives uniquement en cas d'altération de la fonction protectrice.

Introduction

Surface roughness is one of the main criteria for assessing the health status of human skin. Changes in surface roughness occur, along with other changes, in congenital keratinization disturbances, environmental and job-related skin irritations, infectious skin diseases and age-related defects [1]. Many cosmetic producers wish to declare that their product has an 'anti-wrinkle effect' generally based on a reduction in skin surface roughness.

Such changes of skin surface cannot be objectively registered by palpation diagnosis or visual assessment by classical examination methods. The measurement procedures available hitherto have only allowed inexact or incomplete quantitative evaluation, or even caused distortion of skin profile through the process of direct palpation. With the goal of more accurately registering the roughness of the skin's surface in a contact-free process, Bochum and Lubeck University Clinics of Dermatology, in collaboration with the firm of UBM Messtechnik in Karlsruhe/ Ettlingen, have developed a system of a computer aided laser profilometry for quantitative analysis of the skin's surface structure. This method allows a much more exact measurement of skin parameters, as called for by DIN Standards 47618 ff [2,3].

Table 1. A comparison of major elements found in the Dead Sea, Mediterranean Sea and typical ocean water

Water source	Cl (mg/l)	Mg (mg/l)	Na (mg/l)	Ca (mg/l)	K (mg/l)	Br (mg/l)
Dead Sea	224,900	44,00	40,100	17,200	7,650	5,300
Mediterranean Sea	22,900	1,490	12,700	470	470	76
Ocean water	19,000	1,350	10,500	400	309	65

The Dead Sea is the richest natural mineral source in the world, with a concentration of 32% (w/v) dissolved minerals and a unique composition. The main elements are chlorine, magnesium, sodium, calcium, potassium and bromine. A comparison of major elements in the Dead Sea, the Mediterranean Sea and typical ocean water is shown in Table 1.

These elements, as has been acknowledged for years, are thought to be beneficial for human health, but the role of Dead Sea minerals in healthy skin metabolism is not yet fully understood [4].

Specific elements, which may be obtained from minerals, participate in regulatory activities of the metabolism of healthy skin. There are indications that magnesium (Mg^{2+}) is a co-factor for phosphate transferring enzymes, and participates in c-AMP c-GMP balancing regulation. Potassium (K^{+}) enhances CO_2 transport, and calcium (Ca^{2+}) is thought to induce lamellar secretion and regulate cell membrane permeability [5,6].

In some *in-vivo* and *in-vitro* tests, selected Dead Sea salts, magnesium bromide, magnesium chloride and potassium bromide, inhibited skin cell membrane proliferation after dermal application [7,8].

Minerals are capable of restoring moisture due to their hygroscopic characteristics. Therefore, minerals, if absorbed into skin cells, may enhance intracellular water capacity, and contribute to the skin's natural moisturizing factor (NMF) [9].

Assuming that electrolytes can be absorbed into skin cells, either by passive or active means, dermal application of mineral-rich cosmetics can be very useful. For example, in skin disorders that are related to a specific mineral shortage, dermal application of a mineral-rich preparation may help to alleviate the problematic skin.

Electrolytes may be absorbed into the skin from brine, from a bath with dissolved salts, or from application of a mineral-rich preparation. According to some models, penetration of electrolytes through the stratum corneum takes place between the horny cells. During the absorption process, partitioning of mineral from vehicle to skin may occur. Many factors and skin conditions can rapidly alter the skin's absorption parameters. The most relevant factors in the absorption kinetics of Dead Sea minerals to human skin are thought to be the concentration cascade and the characteristics of skin penetration of a specific ion. The nature of the vehicle, names the type and polarity of the preparation, is significant in determining the kinetics of mineral penetration of the skin.

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Another important factor is the pH value. Ions in varying ionic strengths, and cations in combination with various anions penetrate to differing extents. There are major differences in the extent of skin penetration in various areas of the body. Exposed surface area, frequency of dermal application, skin type, skin age, temperature and contact time should also be considered. The rate of dermal penetration can be partially manipulated by chemical methods of enhancement, such as co-solvent addition, ion pairing, or polarity techniques [10-12].

While skin absorption and skin penetration have frequently been investigated, there are only a few reports focused on the penetration through the skin barrier of mineral-rich preparation, and the dermal effects of the same. Many people, after bathing in the Dead Sea's salty water, have reported that they experience a special 'baby smooth skin' feeling. Using computer-aided laser profilometry of the skin surface, this work has tried to assess and validate through a comparative test the reported feeling.

Materials and methods

A computer-aided laser profilometric system

Computer-aided laser profilometry is a contact-free surface measuring method. To reduce errors caused by body movement, evaluation is performed on a silicone-based skin impression (white plastic silicone precision moulding compound, highly viscous poly-siloxane condensation linking, in accordance with DIN 12 913 A 2, ISO 4823, Type 1 Cat. B.). The compound for making the impression, supplied by Orbis Dental GmbH, is prepared immediately before use: 2.5 cm of universal paste hardener are added to 12 ml plastic silicone. After 45 s of mixing, the compound is applied evenly and with no pressure to the skin area, where it hardens within 3 min. This elastic impression is carefully removed from the skin and attached flat onto a glass plate. A field of measurement with dimensions between 2x2 mm and 5x5 mm was chosen. A UB 16 optical measuring system with a semiconductor laser (780 mm) is used to determine Rz parameters. The Rz parameter is the arithmetical mean of the roughness depths of five adjacent identical distances of the digitally filtered profile. The bundled beam is focused by an adjustable objective lens onto the skin surface impression and reflected from there. A half-silvered mirror guides the reflected beam through a prism onto two photodiodes, which activate the electronic adjustment of the objective lens until the beam is refocused on the surface. At the same time, the position of the lens is measured by a special computer program and stored as a digital value, which is generated as a true to life, three-dimensional monitored image of the skin [2.3].

Mineral active ingredient

A highly concentrated aqueous solution extracted from the Dead Sea through a natural evaporation process 'Osmoter^{TM}, Dead Sea Laboratories Ltd.) containing high levels of bivalent cations. This solution (INCI listed as 'Sea Salt and Water' (Maris Sal and Aqua)) has the majority of elements found in the Dead Sea as ions [4]. The composition solution is presented in Table II.

Table II. A typical chemical analysis of concentrated Dead Sea water

Ion or element	*Mg l^{-1}*
Chlorine	340,000
Magnesium	92,000
Calcium	38,000
Bromide	11,400
Sodium	2,000
Potassium	1,400
Strontium	800
Sulphate	60
Lithium	34

Treatment preparations

The following three cosmetic liquid gels were prepared and comparatively tested.

A basic gel with no active agent, serving as a control ('placebo').

A formulated gel containing commercial anti-wrinkle active agents inclding locust bean (*Ceratonia siliqua*) gum (Pentapharm Ltd.), glycoprotiens (Pentapharm Ltd.), and fruit extracts: water (*Aqua*) and bilberry (*Vaccinium myrtillus*) extract and sugar maple (*Acer Saccharinum*) and sugar cane (Saccharum officinarum) extract and orange (*Citrus aurantium dulcis*) extract and lemon (*Citrus medica limonum*) extract (Brooks Industries Inc.)

The same anti-wrinkle the gel with 1% of the concentrated Dead Sea water.

Treatment protocol

Each preparation was applied twice a day over a period of 4 weeks, to 20 mature women volunteers, aged 20 to 65, 10 with sensitive and 10 with normal skin, on both right and left forearms. The total number of repetitions for three different preparations that were double-blind chosen was 60. The impressions were taken from exactly the same are of skin on each arm. For 12 h before the silicon impression was taken, the participants were not allowed to apply cream or to use active washing substances. Each test participant was acclimatized to room temperature 30 minutes before the measurements were made. Rz values were checked in 45,000 skin points of each volunteer, using a computerized laser profilometric system, according to ISO 4287/1 'Surface roughness terminology, part 1: surface and parameters'. Skin surface changes were evaluated by comparing Rz values before and after the skin treatments [2.3].

Data evaluation

Rz values for each participant were gathered and observed from the computer-aided laser test system. Mean values, median, minimum, maximum and standard deviations were calculated for 20 repetitions of each preparation. Wilcoxon matched pairs signed rank tests were used to examine changes in Rz values, comparing before and after each treatment. The Kruskal-Wallis one-way non-parametric anova test was used to check if there were significant difference among the three preparations.

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Table III. Rz values of three skin treatments, lasting 4 weeks, as results of a computer-aided laser profilometric analysis.

	Variable	Mean	SD	Minimum	Maximum	N
Control (placebo)	Rz before	184.93	57,60	118.1	330.6	20
	Rz after	165.73	55.83	97.4	301.1	20
	ΔRz (b-a)	19.20	9.50	2.30	33.00	20
Formulated gel	Rz before	186.14	76.44	121.1	375.4	20
	Rz after	134.34	54.06	76.3	365.1	20
	ΔRz (b-a)	51.80	30.32	8.80	117.6	20
Formulated gel +1% Dead Sea salt concentrate	Rz before	189.61	61.90	122.5	330.2	20
	Rz after	112.54	35.53	73.3	196.1	20
	ΔRz (b-a)	77.08	29.09	34.10	140.5	20

Results

RZ is a roughness parameter of a surface profile. The measurement is contact-free, so it was used to evaluate the anti-wrinkle effectiveness of the tested skin treatments, as described in Material and methods.

The change in Rz values between the two measurements, before and after treatment, is significant in all three gel treatment groups (P=0.0001).

Significant differences were found among the three groups regarding ΔRz, the calculated differential Rz parameter (P=0.0001). (ΔRz = Rz before treatment – Rz after treatment). The results are shown in Table III.

Differential Rz values, ΔRz, after 4 weeks of applications, and Rz values before treatments were used to calculate the percentages of skin Rz reduction, which is correlated to improvement in skin roughness.

These results are shown in Figure 1.

% of ΔRz/Rz before treatment

%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
PLACEBO FORMULATED GEL FORMULATED GEL PLUS D DEAD SEA MINERALS

Figure 1. Skin smoothing effects of three gel preparations. Percentage of relative improvement after 4 weeks of skin treatment, as observed in a computer-aided laser profilometric analysis of skin surface: mean of 20 subjects.

From the results shown in Table II and Fig. 1, it can be seen that after treatment the placebo gel reduces Rz by an average of 10.4%, the anti-wrinkle gel reduces Rz by an average of 27.8%, and the gel with Dead Sea minerals reduces Rz by an average of 40.7%.

Discussion

Dead Sea anti-wrinkle effect

Since Rz parameter is the arithmetical mean of the roughness depths of the digitally filtered skin profile, a reduction in Rz correlates to an improvement in skin roughness, and hence, all three treatments have been proved to be significantly effective in smoothing the skin's surface. The product which contains the commercial anti-wrinkle active ingredients has a significant effect (more than 27%) on skin roughness reduction. The same product with 1% Dead Sea minerals is 46% more effective in average roughness reduction.

Additional research is required in order to establish the 'Dead Sea anti-wrinkle effect' and its possible mode of action.

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