Noninvasive Methods for the Determination of
Skin Hydration

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Introduction

In 1953, Blank [1] showed that water makes up 10%–20% of the stratum corneum. As soon as the amount of water decreases below 10%, the skin develops a rough and dry looking appearance. Kligman [17], in 1963, maintained that the lipids of the skin surface were of no essential significance for the appearance of the horny layer, rather that the appearance of the skin is mainly due to the water content of the horny layer. Based on the postulated affiliation between stratum corneum hydration and the macroscopic aspect of the skin, diverse methods for assessing horny layer hydration have been developed (for details see Gloor’s outline in chapter 3 of [7]).

The aim of our own investigations was to answer the following questions: (1) To what extent do the results achieved by some of the frequently used hydration assessment methods correlate with one another. (2) The water content of which layer of the stratum corneum is determined by the various methods? (3) Do changes in the water content of the horny layer which are within the physiological range impact the appearance of the skin, as may be supposed on the basis of Blank’s [1] work? Before addressing these questions, some of the more frequently used in vivo techniques will be outlined.

Methods

Capacitance Measurement with the Corneometer-technique

The fundamentals of this method were developed by Bingmer and Tronnier. The method is based on the dielectric constant of water ($\varepsilon_r \approx 81$), which is very high in comparison with that of other substances. The probe is designed as a scatter-field capacitor (Fig. 1). By a polymer foil of defined thickness, it is separated from the horny layer, which forms the major part of the dielectric measured. Due to the above mentioned high $\varepsilon_r$ of water, the dielectric characteristics of the stratum corneum depend on its water content, to a large extent, so that a range of determinations is possible. State of the art equipment which is available on the market includes the Corneometer CM 820 (Courage and Khazaka, Cologne, FRG). Possible sources of error or potential sources of variation in the method are, according to the location of the measurement site, sweat production, filling of the sweat gland ducts, the number of hair follicles, the electrolyte content of the stratum corneum, and artefacts from applied topical agents.

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Fig. 1. Principle of the corneometer probe. Metallic conductor tracks are separated from the skin by a polymer foil covering the probe. During the measurement, an electric scatterfield penetrates the skin. The dielectric measured is highly dependent on the water content of the stratum corneum, due to the high dielectric constant of water.

Resonance Frequency Measurement

This method was first described by Tronnier and Wagener [33]. The principle is based on the fact that changes in the water content of the stratum corneum also induce changes in the mechanical properties of the horny layer. A stylus conducts the oscillations produced by a frequency generator onto the skin. At a certain distance, these oscillations are registered by a receptor stylus. The oscillation generating and receiving functions may also be taken over by a single stylus. While measuring, the frequency of the magnetic system is gradually raised, and the intensity of the oscillation of the skin can be registered as a function of the frequencies used. Thus, determination of the resonance frequency of the skin is possible. The more the stratum corneum hydration increases, the lower the resonance frequency of the skin.

The thickness of the horny layer, the thickness and tension of the skin, and the nature of underlying tissues (e.g., bone, muscle) are to be considered as sources of error. By using the same sites for measuring before and after an experimental application of topical agents, some sources of error may be eliminated.

A further method using the mechanical properties of the skin for the determination of stratum corneum hydration was described by Potts et al. [24], a few years ago. These authors made use of an instrument which evaluates, at frequencies between 8 and 1016 Hz, the dynamic mechanical properties of the skin by measuring the propagation and impairment of shear waves.

Electric Conductance / Resistance Measurements

Diverse electric signals may be attained from human skin, for example, the galvanic skin response and the skin potential level (for detailed explanations see [34]). To gain insight into skin hydration in vivo, we are interested in changes of the skin resistance level. In normal skin, this is a tonic value which shows little change during the course of the day.

Variations in the method include the option of AC/DC current or voltage, and the electrode design (form, surface, contact pressure, material, humid/dry, polarizable/nonpolarizable, unipolar/bipolar, etc.). For AC measurement techniques, additional options include current intensities, voltages, and frequencies used. The distinct pro-