Near-Infrared Microspectroscopic Analysis of Rat Skin Tissue Heterogeneity in Relation to Noninvasive Glucose Sensing

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Abstract

Background:

Noninvasive glucose measurements are possible by analysis of transmitted near-infrared light over the 4000- to 5000-cm^{-1} spectral range. Such measurements are highly sensitive to the exact position of the fiber-optic interface on the surface of the skin sample. A critical question is the degree of heterogeneity of the major chemical components of the skin matrix in relation to the size of the fiber-optic probed used to collect noninvasive spectra. Microscopic spectral mapping is used to map the chemical distribution for a set of excised sections of rat skin.

Method:

A Fourier transform near-infrared microspectrometer was used to collect transmission spectra from 16 tissue samples harvested from a set of four healthy Harlan–Sprague male rats. A reference point in the center of the tissue sample was probed regularly to track dehydration, changes in tissue composition, and changes in instrument performance. Amounts of the major skin constituents were determined by fitting microspectra to a set of six pure component absorbance spectra corresponding to water, type I collagen protein, keratin protein, fat, an offset term, and a slope term.

Results:

Microspectroscopy provides spectra with root mean square noise levels on 100% lines between 418 and 1475 microabsorbance units, which is sufficient for measuring the main chemical components of skin. The estimated spatial resolution of the microscope is 220 μm. The amounts of each tissue matrix component were determined for each 480 × 360-μm^2 location of a 4.8 × 3.6-mm^2 rectangular block of skin tissue. These spectra were used to generate two-dimensional distribution maps for each of the principal skin components.

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Abbreviations: (ANOVA) analysis of variance, (μAU) microabsorbance units, (RMS) root mean square

Keywords: near-infrared microspectroscopic mapping, noninvasive glucose sensing, skin heterogeneity

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Abstract cont.

Conclusions:

Distribution of the chemical components of rat skin is significant relative to the dimensions of noninvasive glucose sensing. Chemical distribution maps reveal that variations in the chemical composition of the skin samples are on the same length scale as the fiber-optic probe used to collect noninvasive near-infrared spectra. Analysis of variance between tissue slices collected for one animal and analysis of variations between animals indicate that animal-to-animal variation for all four chemical components is significantly higher than variations between samples for a given animal. These findings justify the collection and interpretation of near-infrared microspectroscopic maps of human skin to establish chemical heterogeneity and its impact on noninvasive glucose sensing for the management of diabetes.

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