Journal of Diabetes Science and Technology
Volume 1, Issue 6, November 2007

ORIGINAL ARTICLES

Polarization-Based Diffuse Reflectance Imaging for Noninvasive Measurement of Glucose

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Abstract

Background:

The ability to measure glucose concentration through noninvasive approaches would impact the treatment of diabetes significantly. Polarization-based optical approaches have received considerable interest because of their potential medical applications. Glucose, a chiral molecule, has the ability to rotate the plane of linearly polarized light, commonly referred to as optical activity, as well as changing the refractive index of the media, which therefore affects the overall scattering coefficient in a given media. The magnitude of each effect is related to the concentration of glucose. Although most previous studies have reported on the use of polarimetry in the aqueous humor of the eye because of its nonscattering nature, one would also expect that glucose concentration could be measured in more turbid media such as tissue through a similar approach. This study investigated how each of these effects is correlated to glucose concentration in a physiological range for highly scattering biological media.

Methods:

A custom-designed imaging polarimeter was used to image highly scattering Intralipid-based media containing different concentrations of glucose. Model formation and glucose prediction were performed through the use of partial least squares (PLS) regression. Further insight into the differences between polarization-based image measurements and encoding of glucose information was provided through the use of principal component analysis (PCA).

Results:

When coupled with PLS regression, *in vitro* polarization measurements yielded highly correlated glucose predictions in both calibration and independent validation, 0.999 and 0.998, respectively. Through the use of PCA, it appears that the majority of the image-based signal yielding the most significant glucose information is attributable to changes in the overall scattering coefficient due to glucose concentration and, to a lesser degree, effects of optical activity.

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Abbreviations: (CCD) charge-coupled device, (PC) principal components, (PCA) principal component analysis, (PLS) partial least squares, (SEC) standard error of calibration, (SEP) standard error of prediction

Keywords: diabetes, glucose, imaging, polarization

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Abstract cont.

Conclusions:

This study showed how polarimetric-based imaging coupled with PLS regression can be used to quantify glucose concentration in highly scattering media. Such methods may potentially be able to extend the use of noninvasive *in vivo* polarimetric measurements, normally acquired in the anterior chamber of the eye, to other preferred sensing sites such as the skin.

J Diabetes Sci Technol 2007;1(6):873-878