

Critical-depth Raman spectroscopy enables home-use non-invasive glucose monitoring

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Background: Self-monitoring of blood glucose in patients with diabetes is typically performed using invasive techniques, which might lead to discomfort for the user.

Methods: We report on the development of a table-top confocal Raman spectrometer that was used in the home of patients with diabetes and operated for 60 days unsupervised and without recalibration. The system is based on measurement of glucose levels at a ‘critical depth’ (CD) in the skin, specifically in the interstitial fluid located below the stratum corneum. The region chosen for routine glucose measurements was the base of the thumb (the thenar).

Results: The calibration of the CD-Raman system was stable for > 10 days, while measurement performance of glucose levels present at, or below, a depth of ~250µm below the skin surface was comparable to that reported for currently available invasive continuous glucose monitors.

Instrumentation

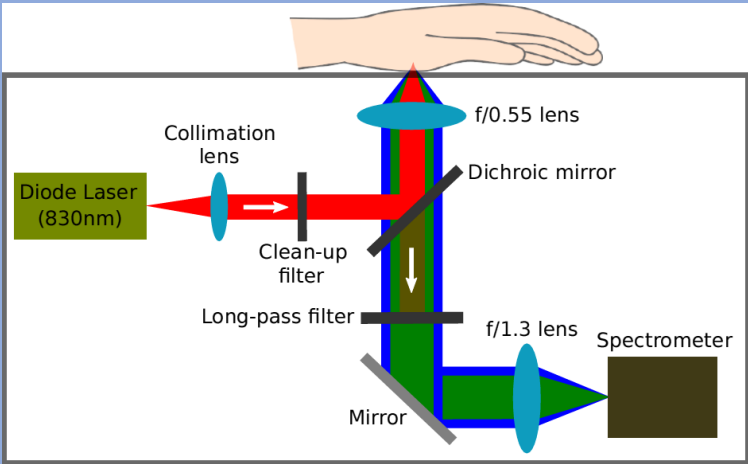


Fig. 1. Schematic presentation of table-top Raman spectrometer. The output from the CW laser is 300mW.

Raman signal from the skin

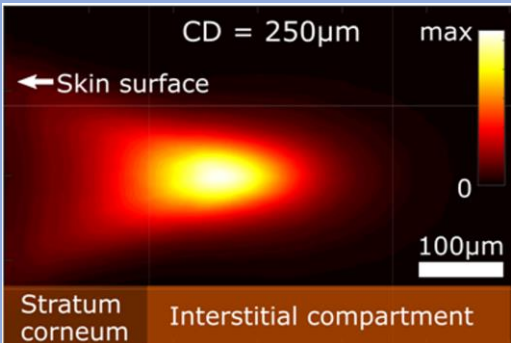


Fig. 2. Simulation of signal acquisition density distribution for CD of 250µm. The skin is modeled as a turbid medium.

Independent validation of last 5 days of analysis

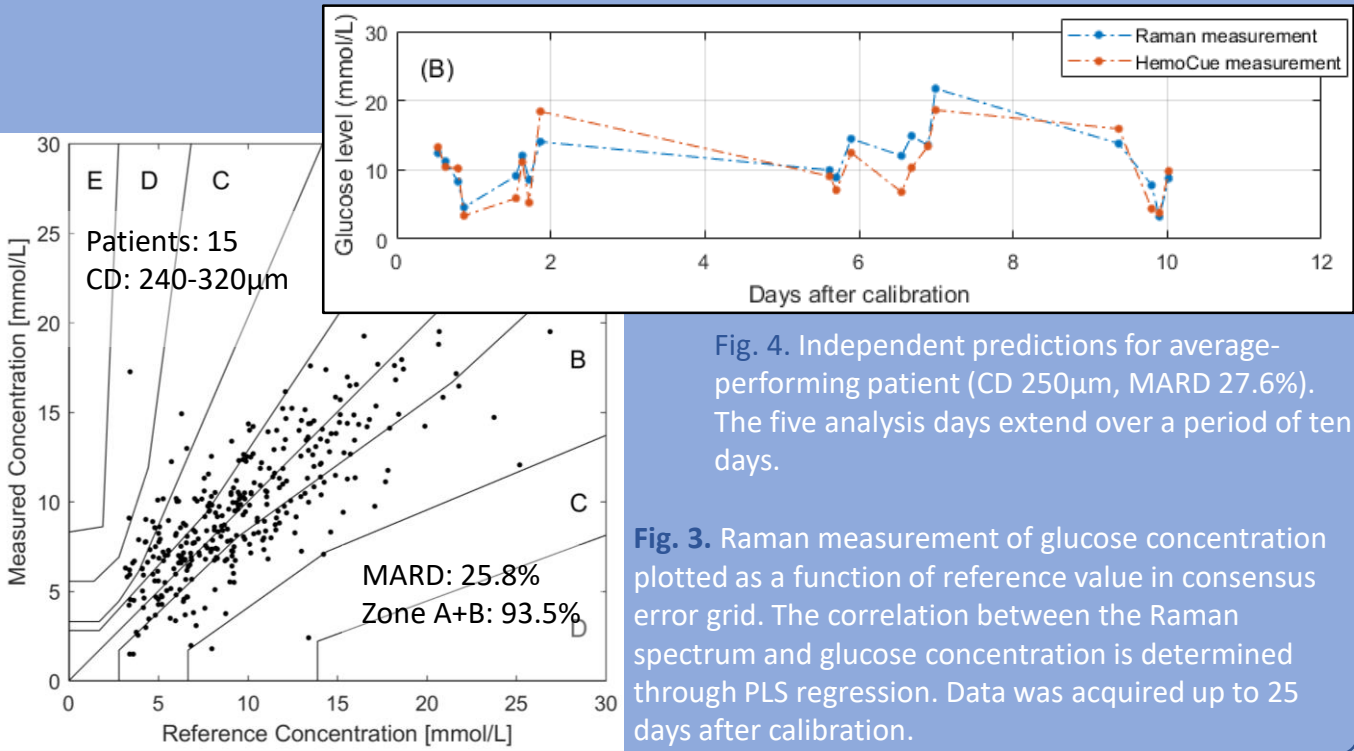


Fig. 4. Independent predictions for average-performing patient (CD 250µm, MARD 27.6%). The five analysis days extend over a period of ten days.

Fig. 3. Raman measurement of glucose concentration plotted as a function of reference value in consensus error grid. The correlation between the Raman spectrum and glucose concentration is determined through PLS regression. Data was acquired up to 25 days after calibration.

Conclusions: Using the CD-Raman technology, we have demonstrated the first successful use of a non-invasive glucose monitor in the home of diabetic patients.

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