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Effectiveness of noninvasive continuous glucose monitoring using OCT angiography-purified blood scattering signals

Submission date
15/08/2023

Recruitment status
No longer recruiting

Registration date
16/08/2023

Overall study status
Completed

Last Edited
16/08/2023

Condition category
Nutritional, Metabolic, Endocrine

[_] Prospectively registered
[X] Protocol
[_] Statistical analysis plan
[_] Results
[_] Individual participant data
[_] Record updated in last year

Plain English summary of protocol

Background and study aims
Diabetes is a chronic metabolic disease associated with severe complications such as heart disease, kidney problems, and strokes. Monitoring blood glucose levels is crucial for patients' overall well-being. Glucose levels are typically assessed in two compartments: blood and interstitial fluid (ISF). Blood glucose concentration (BGC) is commonly measured using enzymatic-based electrochemical devices which may lead to discomfort, infection risks, and poor compliance. ISF glucose concentration (IGC) can be continuously monitored using subcutaneous needle sensors, which is less accurate than blood glucose monitoring due to delayed ISF glucose level response. The development of a noninvasive and precise continuous glucose monitoring (CGM) technique holds significant potential.
Optical techniques utilizing near-infrared light scattering are promising for noninvasive glucose monitoring. The accuracy of CGM based on near-infrared scattering is challenged by mixed scattering signals from different compartments, where glucose can have opposite effects on the scattering. OCT angiography (OCTA), an extension of OCT, enables 3D mapping of blood perfusion down to the capillary level. OCTA vascular mapping has facilitated highly sensitive measurement of glucose-induced scattering changes in specific blood or ISF compartments, demonstrating a strong correlation between the blood optical scattering coefficient (BOC) and BGC in mouse retinas. Further investigation is needed to validate this correlation in humans and assess its practical utility for blood glucose monitoring.
The aim of this study is to explore the potential of using OCTA-purified blood scattering signals to achieve high accuracy in CGM.

Who can participate?
Healthy volunteers above 18 years old

What does the study involve?
Participants were enlisted to take part in both experimental and control study trials. In the experimental trial, each test comprised a 10-minute baseline period, succeeded by a 5-minute intake of a glucose solution and an 85-minute recovery phase to revert to baseline levels. Throughout the trial, OCTA imaging occurred every 5 minutes in the same region of interest on

the finger. Concurrently, the blood glucose concentrations were measured by a portable blood glucose meter every 10 minutes. The control trial followed a comparable protocol, with water replacing the glucose solution.

What are the possible benefits and risks of participating?
The risks to the participants are minimal. The only possible "risk" is slight bruising on the site where the finger is pricked to take blood for glucose testing. There are no direct benefits to the participants.

Where is the study run from?
Zhejiang University (China)

When is the study starting and how long is it expected to run for?
January 2022 to April 2023

Who is funding the study?
The National Natural Science Foundation of China

Who is the main contact?
Mr Peng Li, peng_li@zju.edu.cn

Contact information

Type(s)
Scientific

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Additional identifiers

Protocol serial number
No. 2022-044

Study information

Scientific Title
A pilot study on noninvasive continuous glucose monitoring in healthy subjects using OCT angiography-purified blood scattering signals

Acronym
OCTACGM

Study objectives
Test the feasible of a new technology (OCT angiography) for continuous noninvasive glucose monitoring:
1. Verify the correlation between the OCTA-purified blood scattering signals and the blood glucose levels in human skin in vivo
2. Develop a calibration method to calculate BGC based on the OCTA-purified blood scattering signals
3. Test the accuracy and reproducibility of the OCTA-based continuous glucose monitoring (CGM)

Ethics approval required
Ethics approval required

Ethics approval(s)
Approved 29/09/2022, Ethics Committee of the College of Biomedical Engineering & Instrument Science, Zhejiang University (38 Zheda Road, Hangzhou, 310027, China; +86 (0)571 87951249; zjuethic@zju.edu.cn), ref: No. 2022-044

Primary study design
Observational

Study design
Single-centre pilot observational trial

Study type(s)
Diagnostic

Health condition(s) or problem(s) studied
Continuous glucose monitoring

Interventions
Experimental group:
Each test involved a 10-minute baseline period, followed by the ingestion of a glucose solution for 5 minutes and an 85-minute recovery period to return to baseline levels. OCTA imaging was performed at the same region of interest on the finger every 5 minutes during the trial. A fingertip blood sample was taken every 10 minutes, using a portable blood glucose meter to measure the BGC.

Control group:
Similar experiments were conducted with the glucose solution replaced by water to serve as the control group.

Intervention Type
Other

Primary outcome(s)
1. 3D OCT structure images and 3D OCT angiography (OCTA) images of skin. The 3D OCT structure images of human skin were acquired by the swept source OCT system, and 3D OCTA

images were generated by applying the inverse signal-to-noise ratio and decorrelation OCTA (ID-OCTA) algorithm on the 3D OCT structure at -10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 and 90 min
2. Reference blood glucose concentrations (BGC) were measured every 10 minutes using a portable blood glucose meter on a sample taken from the finger at -10, 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 min

Key secondary outcome(s)
1. Blood optical scattering coefficient (BOC) extracted from the depth attenuation of backscattered light in OCT and then spatially purified under the guidance of a 3D OCTA vascular map in human skin at -10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 and 90 min
2. Correlation between BOC and reference blood glucose concentrations (BGC), linearly fitted based on the least squares criterion at -10, 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 min
3. Optical BGC, calculated from the BOC through a linear calibration at -10, 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 min
4. Accuracy of glucose measurements based on OCT angiography (OCTA), evaluated using Parke's error grid, ISO 15197 standards, and mean absolute relative difference at -10, 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 min
5. Tissue optical scattering coefficient (TOC), extracted from the depth attenuation of backscattered light in OCT and then spatially purified under the guidance of a 3D OCTA vascular map in the dermis layer of the skin at -10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 and 90 min
6. Correlation between TOC and reference blood glucose concentrations (BGC), linearly fitted based on the least squares criterion at -10, 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 min
7. Optical interstitial fluid glucose concentration (IGC), calculated from the TOC through a linear calibration at -10, 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 min
8. Lag time between IGC and BGC, assessed as the temporal delay between optical IGC and the reference BGC at -10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 and 90 min

Completion date
30/04/2023

Eligibility

Key inclusion criteria
1. Adults (18 years old or above)
2. In good health
3. Not taking any medication
4. Able to consent to participate

Participant type(s)
Healthy volunteer

Healthy volunteers allowed
No

Age group
Adult

Lower age limit

18 Years

Sex
All

Total final enrolment
10

Key exclusion criteria
1. Children and young adults (younger than 18 years old)
2. Having chronic disease
3. Unable to consent to participate

Date of first enrolment
01/12/2022

Date of final enrolment
30/04/2023

Locations

Countries of recruitment
China

Study participating centre
Zhejiang University
State Key Lab of Modern Optical Instrumentation
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Sponsor information

Organisation
Zhejiang University

Funder(s)

Funder type
Government

Funder Name
National Natural Science Foundation of China

Alternative Name(s)
Chinese National Science Foundation, Natural Science Foundation of China, National Science Foundation of China, NNSF of China, NSF of China, National Nature Science Foundation of China, Guójiā Zìrán Kēxué Jījīn Wěiyuánhuì, , NSFC, NNSF, NNSFC

Funding Body Type
Government organisation

Funding Body Subtype
National government

Location
China

Results and Publications

Individual participant data (IPD) sharing plan
The current data sharing plans for this study are unknown and will be available at a later date

IPD sharing plan summary
Data sharing statement to be made available at a later date

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Protocol file			16/08/2023	No	No