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Hyperspectral fundus camera with sensitivity beyond the visible range: a pilot study

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Purpose
To test a new hyperspectral fundus camera that allows recording spectral images of the retina both in the visible and in the infrared in order to improve diagnosis of diseases which manifest themselves in the retina.

Methods
A full custom-made experimental hyperspectral system with sensitivity beyond the visible range was developed and used to acquire retinal images through a considerable number of spectral bands. It consists of CMOS (Orca Flash 4.0, Hamamatsu, Japan, 2048x2048 pixels) and InGaAs (C12741-03, Hamamatsu, Japan, 640x512 pixels) imaging detectors with sensitivity from 400 nm to 1000 nm and from 950 nm to 1700 nm, respectively and an illumination system based on light emitting diodes (LEDs) with narrow emission for spectral sampling. Due to the considerable spectral band extension, a robust optical system was especially designed, tested and coupled to the former cameras and light sources to acquire images with good optical quality with an angular field of view of 30°. As a preliminary attempt, some healthy patients and others with retinal diseases such as macular degeneration were analyzed.

Results
Spectral images between 400 nm and 1300 nm were finally taken, as light reaching the retinal layers was strongly reduced beyond this wavelength due to water absorption. We observed that optimal viewing of different ocular structures was achieved depending on the wavelength. Short wavelengths such as blue and green are reflected and scattered back more superficially, so that structures as the optic disk and retinal blood vessels are well contrasted in this spectral region. On the contrary, images in the infrared range, especially those beyond 950 nm that have never been explored, allowed obtaining information from deeper layers of the retina and the choroid, due to reduced absorption of the chromophores.

Conclusions
In common clinics, fundus photography is restricted to color imaging with only three spectral bands. In addition, due to metamerism, many ocular structures remain hidden. Hyperspectral imaging comes in to view as a promising and powerful tool for the spectral analysis of retinal diseases, increasing the amount of information extractable from fundus photography to improve the diagnosis. Furthermore, images beyond the visible range allow obtaining information from deeper layers, which can have a relevant impact on the diagnosis of some retinal diseases.

Layman Abstract (optional): Provide a 50-200 word description of your work that non-scientists can understand. Describe the big picture and the implications of your findings, not the study itself and the associated details.