METHOD OF EVALUATING METABOLISM OF THE EYE

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

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TECHNICAL FIELD

The disclosed device generally relates to measuring characteristics within the retina. In particular, the device embodies a non-invasive, single image method and apparatus for measuring metabolic activity within the retina and optic nerve.

BACKGROUND

FIG. **1** illustrates an exemplary eye **10** including a cornea **20** and a lens **22** to focus and direct light onto a retina **30**, which is the light detection and neural processing component of the eye **10**. The retina **30** extends from the optic nerve **24**, which is composed of retinal nerve fibers, near the posterior pole **26** of the eye **10** to the or a serrata **28** extremitfy near the anterior segment **32** of the eye **10**. The retina **30** contains two types of photoreceptor cells, rods and cones, which generate electrical signals in response to light.

Failure of any retinal component may result in blindness. For example, total or partial blindness may be caused by a reduction in blood supply to the retina, which in turn, may be the result of diabetic retinopathy or ischemic events such as retinal vein occlusion. Research has shown that other causes of blindness such as cytomegalovirus retinitis, glaucoma, Leber's optic neuropathy, retina detachment, age-related macular degeneration, retinitis pigmentosa, or light induced blindness are commonly associated with the apoptotic, or programmed death of retina cells.

Apoptosis generally involves the activation of one or more apoptotic signaling pathways by intrinsic or extrinsic stimuli causing the selective degeneration of neurons. The onset of apoptosis has been linked to mitochondrial dysfunction (which is indicative of a change in cellular metabolic activity) characterized by the loss of mitochondrial integrity leading to the release of apoptotic mediators and the activation of enzymes and other pathways leading to cell death. These changes in mitochondrial integrity result in a gain or a loss of pro- and anti-apoptotic signals and have been linked to the retina disorders that result in 95% of the instances of irreversible blindness. Early detection of mitochondrial dysfunction can allow for diagnosis, treatment, and monitoring of these disorders.

Current diagnostic techniques used in routine eye examinations typically employ ophthalmoscopes to visually inspect the retina and tonometers to evaluate intraocular pressures. While ophthalmoscopes can be used to diagnose retinal degeneration, they are only effective after substantial damage has already occurred and do not provide any indication of mitochondrial activity. Tonometers indent the eye in order to determine changes in intraocular pressure that may result in glaucoma, retinal ganglion cell death, or ischemia. However, the correlation between intraocular pressure and disease is not robust, as evidenced by patients developing glaucomatous degeneration with low pressures and patients with high pressure remaining disease free. Furthermore, these older methods cannot be correctly interpreted in the presence of biomechanical artifacts such as abnormal corneal thickness due to, for example, natural variations, disease, myopia, or refractive corneal surgery.

U.S. Pat. No. 4,569,354 entitled "Method and Apparatus for Measuring the Natural Retinal Fluorescence" discloses a method and apparatus for determining oxygenation of the retina by measuring the fluorescence of flavoprotein in the retina. According to this patent, a spot of excitation light of a wavelength of about 450 nanometers (nm) is scanned across the retina, in response to which retina auto-fluorescence at a wavelength of about 520 nm is detected. In particular, retinal emission light is detected at two wavelengths of about 520 nm and 540 nm to allow for compensation with respect to absorption and transmission variables in the eye. To compensate for fluorescence of the lens of the eye, the center of the pupil is imaged onto scanning mirrors so that the scanning beam of excitation light pivots at the center of the eye lens. Because this method and apparatus scans a small area of the retina (i.e. a very limited number of pixels) at a time, the strength of the measured signal is extremely low, resulting in a measured signal having a low signal-to-noise (S/N) ratio and little, if any, accuracy. Further, the small scan area necessitates an extended procedure time to completely scan the retina, which further increases potential for error caused by eye movement due to natural instability of extraocular muscle tone, blood pulsation and light contamination. Because of the inherent inaccuracies of this method and device, it is unable to operate as an accurate diagnosis and monitoring system.

Accordingly, a device and method for measuring the metabolism of the eye is needed to address the shortcomings of the known diagnostic tools and methods discussed above. Specifically, a device and method for non-invasively measuring the metabolic activity of cells that increases the diagnostic accuracy and speed in detecting retinal disorders is needed.

SUMMARY

The method and apparatus disclosed herein provides a rapid and non-invasive clinical and experimental tool to measure directly the vitality of a retinal cell based on the auto-fluorescence of excited flavoprotein (FP) within the retinal mitochondria. The disclosed method and apparatus for measuring the retinal auto-fluorescence of a subject retina includes an excitation light source for providing an excitation light at a wavelength of approximately 450 nm and an image capture device for recording an ocular auto-fluorescence signal generated in response to the excitation light. The image capture device includes a filter for filtering out undesired wavelengths from the ocular auto-fluorescence signal and includes an image intensifier for increasing the ocular auto-fluorescence signal strength. The method and apparatus may further include a processor that analyzes the ocular auto-fluorescence signal to determine a contrast change or pattern and can compare serial readings taken at different times or dates. Salient objectives addressed by the device and method disclosed below include: fast procedure time, high accuracy, a direct correlation between retinal metabolic activity and the existence of a retinal disorder, and increased signal-to-noise ratio (S/N).

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the disclosed device, reference should be made to the following detailed description and accompanying drawings wherein: