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Mini Review

Blind can "See" through Optogenetics Technology

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Abstract

Some are born blind and some become due to old age diseases, such as cataract, glaucoma and macular degeneration. As it is mentioned that we see with our brain not with eyes, because whatever light is gathered by the lens retina receives these through photoreceptors, convert in to electric signals and sends through optic nerve to the brain where this information is computed and forms the image which we see. Until recently, Macular degeneration and Retinitis pigmentosa which are the major causes of blindness were incurable. Recently developed techniques such as artificial retina, gene replacement therapy were partially successful to cure blindness in human, however most recently developed 'Optogenetic technique' proved to be most promising. Opsingene is directly introduced in the eye where it starts making opsin which is regulated by special wavelength of light. Patient has to wear "GenSight" glasses which emit a particular wavelength of light.

Keywords: pigmentosa; blindness; retinitis; optogenetics technology; opsins; vision; retina; photoreceptors; ncbi

Introduction

The Eye

Light enters the eye through the transparent cornea, passes through the aqueous humor, the lens, and the vitreous humor, where it finally forms an image on the retina. The human eye lens is a nearly transparent biconvex structure suspended behind the iris of the eye. It collects light from every point of the object. The light need not fall on the eye but the object should be nicely illuminated. The lens collects the light which is reflected from the object around us and converts it into nerve impulses. The optic nerve transmits these signals to the brain, which forms an image thereby providing sight. When light hits the retina special cells called photoreceptors turn the light into electrical signals. These electrical signals travel from the retina through the optic nerve to the brain where the image is computed the images we see. In other words, we see with our brains, not with our eyes [1].

In addition to being capable of receiving visual images, the human eye is capable of several photo response functions that are independent of vision [2].

Causes blindness?

There are many causes of blindness some are curable whereas others are not

Glaucoma, in this disorder, the optic nerve is damaged and it can't be reversed.
Macular degeneration, there's no cure, but progression can be slowed down.

Cataracts, Can be cured successfully

Retinitis pigmentosa refers to damage of the retina. It leads to blindness only in rare cases. Recently a cure was experimented. The majority of inherited retinal degenerations are due to photoreceptor cell death. In many cases ganglion cells are spared making it possible to stimulate them to restore visual function in blind patients.

Tumors that affect the retina or optic nerve can also cause blindness and cannot be cured

Birth defects such as optic atrophy and eye malformations cannot be corrected [3, 4].

What is Optogenetics?

Optogenetics is a technique whereby excitable cells, such as neurons, can be controlled at will by light. To do this, cells are genetically engineered to produce ion channels called opsins that sit in the cells' membranes and open in response to a certain wavelength of light [5]. Optogenetics is still in its early stages in human disease models. However, recent clinical trials are working on the use of optogenetics to relieve vision loss, deafness, pain, and other conditions in humans. The first application of optogenetics in a human disease model was in 2016 [6].

Optogenetics is a newly evolved technique for controlling a neuron's activity using light and genetic engineering to achieve gain or loss of function within neuronal circuits. "Optogenetics" a kind of gene therapy that delivers light-sensing molecules into the eye [7]. The molecules, called opsins, generate an electrical signal when they are exposed to a particular wavelength of light. In optogenetic studies, scientists take the

genetic code of the neurons they want to study and add a new piece of code to it. The new code allows these neurons to make special proteins, called opsins Proteins, that respond to a specific type of light (for example, ChR2 only responds to blue light).

In neuroscience, these proteins are used to control neuron activity. To do this, the researchers injected a gene for an opsin directly into the eye. The opsin they chose was a modified version of one found in algae, designed to respond to light in the red-orange part of the spectrum. There are two types of opsins for modulating membrane potential of neurons: (i) microbial opsins from unicellular organisms that respond to a light stimulus by mediating a flow of ions across the membrane (ii) animal opsins that are naturally present in mammalian retinas that initiate G protein coupled signaling in response to light. The former category has been extensively employed for vision restoration in the past decade with two ongoing clinical trials employing microbial opsins to restore light sensation in retinitis pigmentosa patients. The latter subtype of animal opsins is emerging more recently as strong candidates to restore vision with the promise of greater light sensitivity and tolerability [8].

In healthy eyes, cells called photoreceptors react to light by sending electrical signals to another type of cell, called ganglion cells. Photoreceptors in normal retinas respond to a broad spectrum of light wavelengths spanning the rainbow of visible colors [9]. The opsin that GenSight used only responds to light in the dark orange/red part of the spectrum. The special goggles take in the visual field and translate that into amber points light that could trigger the opsin in the patient's ganglion cells, and send a signal to the brain [10]. Optogenetic therapy could be used for diseases involving photoreceptor degeneration, such as retinitis pigmentosa or age-related macular degeneration. Clinical trials results obtained so far lay the groundwork for the ongoing clinical trial with the AAV2.7m8 - ChR-tdT vector for vision restoration in patients with retinitis pigmentosa [11]. The field of optogenetics has been rapidly expanding in efforts to restore visual function [12].

Although optogenetics has drawn closer to clinical utility, advances in opsin engineering, therapeutic targeting and ultimately in molecular inhibition of remodeling will play critical roles in the continued clinical advancement of optogenetic therapy [13].

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