VISUAL PROSTHESIS FOR MACULAR DEGENERATION AND RETINISTIS PIGMENTOSA

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Abstract: This paper incorporates majorly visual prosthesis that results in electronic solution such as bionic eye for the disease macular degeneration and retinitis pigmentosa. Both diseases damage the eyes’ photoreceptors, the cells at the back of the retina that perceive light patterns and pass them on to the brain in the form of nerve impulses, where the impulse patterns are then interpreted as images. The Argus II system takes the place of these photoreceptors. In the past 20 years, biotechnology has become the fastest-growing area of scientific research, with new devices going into clinical trials at a breakneck pace like Monash Vision System.

Keywords: Age Related Macular Degeneration, Retinitis Degeneration, bionic eye, Argus II System, Monash Vision System

I. INTRODUCTION

Age-related macular degeneration (AMD) is a deterioration or breakdown of the eye’s macula. The macula is a small area in the retina — the light-sensitive tissue lining the back of the eye. The macula is the part of the retina that is responsible for your central vision, allowing you to see fine details clearly. The ability to give sight to a blind person via a bionic eye depends on the circumstances surrounding the loss of sight. For retinal prostheses, which are the most prevalent visual prosthetic under development (due to ease of access to the retina among other considerations), patients with vision loss due to degeneration of photoreceptors (retinitis pigmentosa, choroideremia, geographic atrophy macular degeneration) are the best candidate for treatment [1].

The macula makes up only a small part of the retina, yet it is much more sensitive to detail than the rest of the retina (called the peripheral retina).

The macula is what allows you to thread a needle, read small print, and read street signs.

Fig. 2. Internal Eye structure representing macula.

Candidates for visual prosthetic implants find the procedure most successful if the optic nerve was developed prior to the onset of blindness. Persons born with blindness may lack a fully developed optical nerve, which typically develops prior to birth.

Fig. 1. Two views of Age Related Macular Degeneration

The peripheral retina gives you side (or peripheral) vision. If someone is standing off to one side of your vision, your peripheral retina helps you know that person is there by allowing you to see their general shape.

One symptom of macular degeneration is dark areas in your central vision. With macular degeneration, you may have symptoms such as blurriness, dark areas or distortion in your central vision [2], and perhaps permanent loss of your central vision. It usually does not affect your side, or peripheral vision. For example, with advanced macular degeneration, you could see the outline of a clock, yet may not be able to see the hands of the clock to tell what time it is.

Causes of macular degeneration include the formation of deposits called drusen under the retina, and in some cases, the growth of abnormal blood vessels under the retina. With or without treatment, macular degeneration alone almost never causes total
blindness. People with more advanced cases of macular degeneration continue to have useful vision using their side, or peripheral vision. In many cases, macular degeneration’s impact on your vision can be minimal.

When macular degeneration does lead to loss of vision, it usually begins in just one eye, though it may affect the other eye later. Many people are not aware that they have macular degeneration until they have a noticeable vision problem or until it is detected during an eye examination.

Types of macular degeneration: dry macular degeneration and wet macular degeneration. There are two types of macular degeneration:

Dry, or atrophic, macular degeneration (also called non-neovascular macular degeneration) with drusen. Most people who have macular degeneration have the dry form. This condition is caused by aging and thinning of the tissues of the macula. Macular degeneration usually begins when tiny yellow or white pieces of fatty protein called drusen form under the retina. Eventually, the macula may become thinner and stop working properly.

With dry macular degeneration, vision loss is usually gradual. People who develop dry macular degeneration must carefully and constantly monitor their central vision. If you notice any changes in your vision, you should tell your ophthalmologist (Eye M.D.) right away, as the dry form can change into the more damaging form of macular degeneration called wet (exudative) macular degeneration. While there is no medication or treatment for dry macular degeneration, some people may benefit from a vitamin therapy regimen for dry macular degeneration.

grid every day to monitor your vision, as dry macular degeneration can change into the more damaging wet form.

1. To use the Amsler grid, wear your reading glasses and hold the grid 12 to 15 inches away from your face in good light.
2. Look directly at the center dot and hold your eye focused on it.
3. Cover one eye.
4. While looking directly at the center dot, note whether all lines of the grid are straight or if any areas are distorted, blurry or dark.
5. Repeat this procedure with the other eye.
6. If any area of the grid looks wavy, blurred or dark, contact your ophthalmologist.
7. If you detect any changes when looking at the grid, you should notify your ophthalmologist immediately.

Wet, or emulative, macular degeneration (also called neovascular macular degeneration)

About 10 percent of people who have macular degeneration have the wet form, but it can cause more damage to your central or detail vision than the dry form.

Wet macular degeneration occurs when abnormal blood vessels begin to grow underneath the retina. This blood vessel growth is called choroidal neovascularization (CNV) because these vessels grow from the layer under the retina called the choroid. These new blood vessels may leak fluid or blood, blurring or distorting central vision. Vision loss from this form of macular degeneration may be faster and more noticeable than that from dry macular degeneration.[3]

The longer these abnormal vessels leak or grow, the more risk you have of losing more of your detailed vision. Also, if abnormal blood vessel growth happens in one eye, there is a risk that it will occur in the other eye. The earlier that wet macular degeneration is diagnosed and treated, the better chance you have of preserving some or much of your central vision. That is why it is so important that you and your ophthalmologist monitor your vision in each eye carefully. The Argus II Retinal Prosthesis System can provide sight -- the detection of light -- to people who have gone blind from degenerative eye diseases like macular degeneration and retinitis pigmentosa. Ten percent of people over the age of 55 suffer from various stages of macular degeneration. Retinitis pigmentosa is an inherited disease that affects about 1.5 million people around the globe. Both diseases damage the eyes’ photoreceptors, the cells at the back of the retina that perceive light patterns and pass them on to the brain in the form of nerve impulses, where the impulse patterns are then interpreted as images. The Argus II system takes the place of these photoreceptors.

Fig. 3. Using an Amsler grid to test for macular degeneration

If you have been diagnosed with dry macular degeneration, you should use a chart called an Amsler grid every day to monitor your vision, as dry macular degeneration can change into the more damaging wet form.

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The second incarnation of Second Sight's retinal prosthesis consists of five main parts:

1. A digital camera that's built into a pair of glasses. It captures images in real time and sends images to a microchip.
2. A video-processing microchip that's built into a handheld unit. It processes images into electrical pulses representing patterns of light and dark and sends the pulses to a radio transmitter in the glasses.
3. A radio transmitter that wirelessly transmits pulses to a receiver implanted above the ear or under the eye.
4. A radio receiver that sends pulses to the retinal implant by a hair-thin implanted wire.
5. A retinal implant with an array of 60 electrodes on a chip measuring 1 mm by 1 mm.

The processor sends these pulses to a radio transmitter on the glasses, which then transmits the pulses in radio form to a receiver implanted underneath the subject's skin. The receiver is directly connected via a wire to the electrode array implanted at the back of the eye, and it sends the pulses down the wire [4].

It can be put the other way round:

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4. A retinal implant with an array of 60 electrodes on a chip measuring 1 mm by 1 mm [5].

The entire system runs on a battery pack that's housed with the video processing unit. When the camera captures an image -- of, say, a tree -- the image is in the form of light and dark pixels. It sends this image to the video processor, which converts the tree-shaped pattern of pixels into a series of electrical pulses that represent "light" and "dark." The processor sends these pulses to a radio transmitter on the glasses, which then transmits the pulses in radio form to a receiver implanted underneath the subject's skin. The receiver is directly connected via a wire to the electrode array implanted at the back of the eye, and it sends the pulses down the wire.

When the pulses reach the retinal implant, they excite the electrode array.

6. The array acts as the artificial equivalent of the retina's photoreceptors. The electrodes are stimulated in accordance with the encoded pattern of light and dark that represents the tree, as the retina's photoreceptors would be if they were working (except that the pattern wouldn't be digitally encoded). The electrical signals generated by the stimulated electrodes then travel as neural signals to the visual center of the brain by way of the normal pathways used by healthy eyes -- the optic nerves.

7. In macular degeneration and retinitis pigmentosa, the optical neural pathways aren't damaged. The brain, in turn, interprets these signals as a tree and tells the subject, "You're seeing a tree."
8. It takes some training for subjects to actually see a tree. At first, they see mostly light and dark spots. But after a while, they learn to interpret what the brain is showing them, and they eventually perceive that pattern of light and dark as a tree.
9. It takes some training for subjects to actually see a tree. At first, they see mostly light and dark spots. But after a while, they learn to interpret what the brain is showing them, and they eventually perceive that pattern of light and dark as a tree. The first version of the system had 16 electrodes on the
implant and is still in clinical trials. Doctors implanted the retinal chip in six subjects, all of whom regained some degree of sight.

10. They are now able to perceive shapes (such as the shaded outline of a tree) and detect movement to varying degrees. The newest version of the system should offer greater image resolution because it has far more electrodes. If the upcoming clinical trials, in which doctors will implant the second-generation device into 75 subjects, are successful, the retinal prosthesis could be commercially available. The estimated cost is $30,000 [6].

II. MONASH VISION SYSTEM FOR BIONIC EYE

The Monash Vision system will combine state of the art digital and biomedical technology with consumer-friendly glasses.

1. Outside glasses – digital camera
2. Inside glasses – eye movement sensor will direct the camera
3. Side of glasses – digital processor and wireless transmitter
4. Brain implant – small implant under the skull will receive wireless signals and directly stimulate the brain’s visual cortex

A digital camera embedded in the glasses will capture images. As your head turns, the glasses, of course, turn with you. Cutting edge digital processors will modify the images captured by the camera; a wireless transmitter will then present the image that you are "looking at" to a chip that has been implanted at the back of the brain. The chip will then directly stimulate the visual cortex of the brain with electrical signals using an array of micro-sized electrodes -the brain will learn to interpret these signals as sight.

A. Will it destroy the areas of natural sight
With many conditions, patients gradually lose sight in some areas of their visual field but not others. As the MVG approach does not require eye surgery, we believe that existing sight will be retained and supplemented. With the direct to brain bionic eye, the exact effectiveness of the restored sight will be determined through research and clinical programs. This is likely to vary strongly between patients depending on their medical history and individual conditions.

B. Will the brain implant be inserted
Using standard neurosurgery techniques, a small area of the skull will be temporarily removed. A sterile, Biologically inert chip will be placed directly on the surface of the visual cortex of the brain. The small area of the skull will then be replaced and eventually heal, providing a natural barrier to protect against infection.

C. Will the bionic eye work for me
The direct to brain bionic eye is being developed for people with vision impairment caused by a number of conditions, including glaucoma and macular degeneration. It may also help people who have damage to their optic nerves or eyes resulting from trauma or disease.

D. MVG Technical Advancements and Tools
- Cutting edge biomedical materials that are safe for implanting in the brain.
- Advanced digital processing technology.
- The latest in wireless transmission to reduce the risk of infection
- Advanced microchips and digital arrays to stimulate the brain
- State of the art commercial design and production expertise [7].

E. DIGITAL PROCESSING
Algorithms will transform the camera image data to a pattern that transmits to micro-sized electrodes on the brain implant with an appropriate voltage, current and timing to stimulate the visual cortex of the brain. Third version is already being planned that has a thousand electrodes on the retinal implant, which they believe could allow for facial-recognition capabilities.
CONCLUSION

Thus, we have studied remedy for retinal prosthesis and age related macular degeneration using Monash Vision System For Bionic Eye and Second Sight Retinal Prosthesis.

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