BIONIC EYE

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Abstract*—Acc. to WHO , about 285 million people are visually impaired worldwide. Bionic eye is electronic device that replaces functionality of a part or whole of the eye. A bionic eye works by stimulating nerves which are activated by electrical impulses .High-tech resources in microelectronics, Optoelectronics, computer science, biomedical engineering and also in vitro retinal surgery are working together to realize the device for the Electrical stimulation of the visual system. Bionic Eye, which works through retinal implants, optic nerve implant or cortical implant could restore sight to millions of people around the world who suffer from degenerative eye diseases. This has progressed to human trials and finally it is commercially available.

Index Terms—*Visual prosthesis, retinal implants.*

I. INTRODUCTION

An ocular prosthesis or Bionic eye or Bio-electronic eye is a craniofacial prosthesis that replaces an absent Natural eye which may be due to damaged retina, optic nerve or visual cortex. Although the prosthesis involves replacing any of the above, the most prominent one is retinal implant. Patient has a small device implanted in retina as either epi-retinal ,sub-retinal or supra-choroidal transretinal implant that can receive radio signals and transmit those signals to brain through nerves and can interpret the image. It is still at a very early stage in its development but if successful, it could restore vision to people who have lost sight during their lifetime. This technology can add life to their visionless eyes .

II. THE PROCESS OF VISION

Photoreceptors (rods and cones) absorbs light which is focused on retina and sends electrical signals to ganglion cells following retina which forms optic nerve. The retina performs spatial, temporal, and chromatic processing of light and converts it into a "digital" neural impulses and send to the visual cortex via optic nerve.

III. VISUAL PROSTHESIS AND ITS HISTORY

Nerves, once damaged are incapable of regeneration and so there is no effective treatment for patients who are visually handicapped by damage to Retina, Optic nerve or Visual cortex. Bionic eye or visual prosthesis is used for restoring vision. Basic concept is to provide focal electrical stimulation to intact visual structures evoking the sensation of discrete points of light called *PHOSPHENES* , hence providing vision. Firstly, Neurosurgeon Forester (1929) exposed and electrically stimulated occipital pole, inducing phosphenes followed by Tassicker patented light-sensitive selenium cell implant in 1956.And finally first commercial implant Argus II approved for use in 2011 and implanted in 30 clinical-trial patients since 2007 came into picture.

IV. VISUAL PROSTHESIS TYPES

Based on where electrodes are implanted, there are 3 types of visual prosthesis, Retinal, Optic nerve and cortical implant. Among them, Retinal ones are commercially used. Retinal implants involve stimulating the retina with the electrodes and it is further divided into 3 types based on from which direction retina is stimulated. They are epiretinal, subretinal and Suprachoroidal Transretinal. In optic nerve implant, optic nerve head is stimulated with wire electrodes. Cortical implant includes stimulation of the visual cortex in the brain with electrode arrays.

V. RETINAL IMPLANTS

To replicate process of vision artificially, we require-

1) *IMAGER* – Converting light signals to electrical signals.
2) *ELECTRONIC CIRCUITRY*- For signal conditioning and processing to generate electrical stimulus as biphasic waveforms /pulses.
3) *ELECTRODE ARRAY*- Stimulating intact retinal cells by biphasic current waveforms.

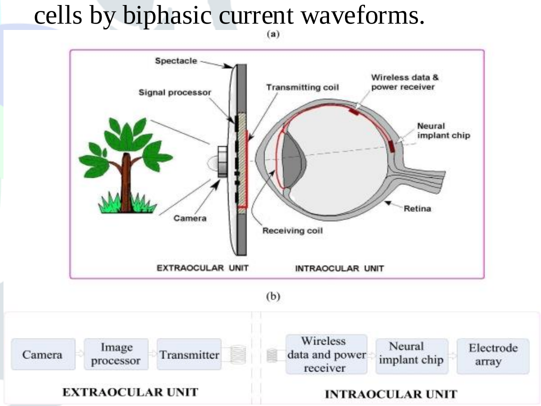

Fig-1: Retinal implant block diagram

VI. RETINAL IMPLANTS TYPES

1) *Epi-Retinal:* On top of the retinal surface, directly stimulating ganglion cells.

ADVANTAGES*:*Provide visual perception even if all other layers have been damaged.

DISADVANTAGES*:*

- Eye movements do not shift the image on the retina, creating a perception of the moving object as person changes direction of gaze.
- Requires very sophisticated image processing techniques.

2) *Sub-Retinal*: At outer retinal surface, stimulating bipolar cell layer.

ADVANTAGES*:*

- Simpler design and more accurate then epiretinal
- Enable subjects to use normal eye movements to shift their gaze.

DISADVANTAGES:

- Lack of sufficient incident light to generate adequate current.
- The compact nature causes size constraints .
- Possibility of thermal damage to the retina
- Not beneficial for retinal diseases extending beyond the photoreceptor layer.

3) *Suprachoroidal:* Microelectrode array is implanted between the firm fibrous sclera and the outer retina i.e choroid and is powered by percutaneous connector.

ADVANTAGES:

- More stable than others.
- No risk of retinal detachment and breaching of retina.
- No high technical surgery required and is more biocompatible.

DISADVANTAGES:

- Electrodes are 250 to 400 µm away from ganglion cells so might not produce accurate stimulation.

ONGOING PROJECTS

	Argus II Retinal Prosthesis System	Retina Implant Alpha IMS	EPI-RET3	Intelligent Retinal Implant System (IRIS V2)	Supra choroidal Retinal Prosthesis
Research Group	Second Sight Medical Products	Retina Implant AG	EPI-RET Project	Pixium Vision	Bionic Vision Australia
Location	Sylmar, CA, USA	Reutlingen, Germany	Aachen, Germany	Paris, France	Melbourne, Australia
Site of Implant	Epiretinal	Subretinal	Epiretinal	Epiretinal	Suprachoroidal
Image Recording/ Processing	External video camera and processing unit (VPU)	Internal light-sensitive photodiodes; no image	VPU	VPU	VPU
Number of Electrodes	60	1500	25	49	33

Table-1: Ongoing projects in retinal implants

VII. FUTURE PROSPECTS

More advanced technology to improve visual acuity and biocompatibility would be introduced.Light weight & more no. of electrodes will be installed for high resolution. Automatic gaze direction and motor control to be introduced. Color sensing to be added. Opsins ,virus vectors , neurotransmitters injected through microfluids to avoid electronics altogether.

VIII. CONCLUSION

There are a number of anatomical considerations in design of visual prosthesis.The resulting images are low-resolution lights that flicker in black and white, enabling users to see walls, lights and facial outlines. Though there is still much work to be done, yet restoring even the smallest amount of sight can make a world of difference.

IX. REFERENCES

[1] Brindley, G.S. and Lewin, W.S. (1968) “The sensations produced by electrical stimulation of the visual cortex.” J. Physiol., 196, 479-493.

[2] Veit Peter Gabel (Editor),various authors,” Artificial Vision: A clinical guide”, Springer international publishing, Switzerland, 2016

[3] Derick L. Cheng, David A. Borton, and Paul B. Greenberg, “Retinal Prostheses— Now and in the Future”, Review of Ophthalmology, 9th June 2017

[4] Kevin C. Firl, Peter Hao Tang, Sandrick Montezunna, “Retina Prosthesis”, American Acedemy of Ophthalmology, sep 11, 2016

[5]Journals.plos.org/plosone/article?id=10.1371/journal.pone/First-in-Human Trial of a Novel Suprachoroidal Retinal Prosthesis, 2014

[6] Valerie C. Coffey,Optics and Photonics News,” Vision Accomplished: The Bionic Eye”, April, 2017

[7] Mohd. Ismail Talukder, Gregory Aunar, Bentham Open,” High Resolution Implantable Microsystem and Probe Design for Retinal Prosthesis”, April 29, 2008