

Psychological impact of visual impairment and the miracle of the bionic eye

Abstract

Visually impaired people suffer from grave psychological consequences that have an adverse effect on their health and wellbeing and day to day functioning. It is indicated that they are at a greater risk for mortality, anxiety, depression, suicide ideation, substance abuse. They have low self- concept, confidence and self- esteem and also at times suffer from complete personality disorganization. Taking this into consideration, the aim of the present article is to provide its readers with a snap shot of the role and contribution of the bionic eye as a ray of hope for dealing with such impairments to help the visually impaired lead a better tomorrow.

Keywords: visually impaired, bionic eye, psychological, consequences

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Abbreviations: ICD, international classification of diseases; VFL, visual field loss; VCL, visual acuity loss; ASR, artificial silicon retina; PCB, printed circuit board

Introduction

The first global estimate of the extent of visual impairment in 1975 indicated that there were 28million blind people in the world. In the 1990 there were 38million blind people and almost 110million with low vision. In 1996 the number of blind people rose to 45million and 135million people with low vision and these estimates indicated that the global extent of visual impairment would double in the period 1990–2020. Out of this global magnitude of visual impairment, in 2002, more than 161million people globally were visually impaired due to eye diseases (refractive error as a cause of visual impairment was not included in this statistic), 124million of whom had low vision and 37million were blind and in 2006 an additional 153million people developed impairment due to uncorrected refractive errors of which 13million children (aged 5–15) and 45million working-age adults (aged 16–49) were affected globally.¹

Definition of legal blindness (U.S.A) & visual impairment

Any person having a visual acuity of 20/200 or worse in the better eye (with best eyeglass or contact lens correction) - or having a Visual field restricted to 20 degrees or less in diameter in the better eye is known to suffer from legal blindness.² Visual impairment is defined as the lack of functioning of the eye which can be measured tests used based on one's visual acuity, visual field, color vision and contrast sensitivity. According to International Classification of Diseases (ICD-9) the classification of the various levels of visual impairment are as follows.²

- Moderate low vision -20/80
- Severe low vision -20/200
- Profound low vision -20/500
- Near blindness -20/1250
- Total blindness -no light perception

The basic causes for the development of visual impairment however, can be attributed to a wide range of diseases such as diabetes,

glaucoma, trauma, optic nerve disease, more than one eye disease in the same person, cataract, retinitis pigmentosa, age related muscular degeneration, macular holes and dystrophy, visual acuity loss (VCL), visual field loss (VFL) and a combination of both VCL and VFL. However, it is seen that the impact of any such visual impairment is dependent on a number of factors such as: age of the person, the degree and severity of loss of vision, presence of comorbidities, and type of strategies used to deal with it and the availability preventive, medical and social support services. Research indicates that coping with visual impairment is complex and dynamic; as it involves adjustments in all the three spheres of life i.e. psychological, physical and social.³

Visual impairment psychological consequences

Research conducted across the globe indicates that visually impaired people may suffer from grave psychological consequences ranging from loss of physical integrity to lack of self -confidence, self-esteem, posttraumatic stress disorder, lack of sense of self, lack of contact with the real environment, obscurity, lack of both written and oral communication, lack of career and vocational opportunities and financial security, being less active socially and interpersonally, and at times a complete disorganization of personality and self.² They were also found to be more anxious, prone to depression and indulging in substance abuse. Furthermore, visually impaired people also suffer from a wide range of emotions such as fear, anger, frustration and denial in trying to deal with the daily challenges of life.³ Recent studies have also suggested that sensory impairments such as visual and auditory impairments lead to an increase in the risk for mortality especially among the elderly.⁴ Furthermore, it has been reported that children with blindness experience problems, in the areas of social interaction and communicative competence; emotional expressiveness and emotional recognition; symbolic and functional (i.e., pretend) play; behavioral mannerisms, rituals and stereotypes; repetitive and unusual patterns of language use (i.e., echolalia and pronoun reversal) and autistic-like developmental regression.⁵ Research has also indicated that facial expressions of children and adults with visual impairment are less florid than their sighted counterparts.⁶ It has also been indicated that blind individuals are prone to suffer from sleep-wake schedule disorders and are deprived of the major light-dark zeitgeber, and therefore they are more prone to develop schedule disorders.⁷ Taking the above backdrop into consideration, the bionic eye is not only a life line for the visually impaired but is truly a miracle unfolded.

Bionic eye invention concept

The invention of the bionic eye derives its roots from the amalgamation of medical science with engineering with the contribution of Mark Humayun which is indeed a vision of hope not only for people suffering from genetic retinal degenerative diseases that leads to blindness in old age but also for people suffering from any retina and eye related problems across the globe. For creating the bionic eye the retinal implant is used as a prosthetic device that maps visual images to control signals, based on which it stimulates the surviving retinal circuitry. It works on the principle of image compression, where the bionic eye compresses and reshapes and resizes the images preserving the object detection rate of the image. The sized image obtained is compared with the comparable object detection rate of the original image which in turn reduces the processing of visual information from the retina.⁸ These retinal implants can partially restore the vision of people with particular blindness caused by diseases such as macular degeneration or retinitis pigmentosa.⁹

Functioning of the bionic eye

Figure 1 the functioning of the bionic eye implant is based on a small computerized chip enclosed in a titanium casing that is implanted

surgically behind the retina, placed right at the back of the eyeball. An ultra-thin wire is inserted that strengthens the damaged optic nerve that assists in transmitting light and images to the visual system of the brain, where it is normally processed. Other than the implanted chip and wire, most of the device lies towards the outside of the eye where the users need to wear specially designed eye glasses that contain a tiny battery-powered camera and a transmitter that would assist in relaying images to the chip implanted behind the retina. Researchers estimate that the bionic eye is quite durable and is expected to last up to a decade as it is both water-proof and corrosion-proof.⁸

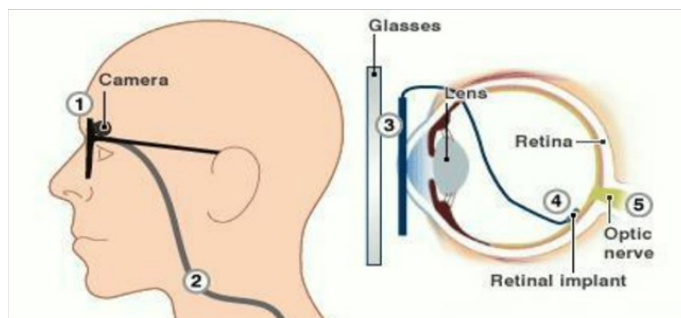


Figure 1 Bionic eye—the retinal implant.

Types of bionic eye implants

The bionic eye consists of the following parts:

Types of bionic eye implants	Functioning
Artificial Silicon Retina (ASR)	ASR is a solid biocompatible silicon chip that contains photoreceptors implanted to replace the defective photoreceptors. Diameter- 2mm & 1/1000 inch thickness. Contains 3,500 micro photodiodes having own electrodes that help to convert the light energy from images into thousands of tiny electrical impulses to stimulate the remaining functional cells of the defective retina. The multiple unit artificial retina chip consists of an external camera that sends images to secondary receiving coil in the form of electrical impulses mounted close to the cornea.
The MARC System	It consists of: power transceiver, processing chip, stimulator-current device, and proposed electrode pathway through silicon rubber or polyimide ribbons connecting the devices. Here the external camera acquires images of the viewer that are encoded in the data stream creating higher frequency carrier signals which are stimulated on the retina of the patient. these act as stimulating electrodes in terms of magnitude and frequency to provide sight to the patient. However, for this the optic nerve of the person needs to be at least partly functional.
Nano Generator Power Supplies	Nanogenerators consist of interconnected nanowires made up of Zinc oxide which are then bent in order to produce electric charges and power supply for small scale devices. The nanogenerator when used on the blood vessels can produce sufficient potential to run a camera for the bionic eye.
Prosthetic Eye	The prosthetic eye consists of a printed circuit board(PCB) placed in between the lenses set in the front of the eye replacing the iris and the lens in the human eye. The function of PCB is to capture the images of the viewer and process these images into digital signals transmitting them to the retina.

Source: Adapted from: Narayanan & Senthil.¹⁰ Bionic Eye Powered by Nanogenerator.

Procedure for conducting the bionic eye surgery

The bionic eye surgery involves the implantation of a miniature Galilean telescope containing wide-angle micro-optical lenses into the eye of the patient. This mini telescope is implanted into one eyeball, first replacing the lens which is removed post-surgery. The procedure is then moved along to the cornea where once functional the telescope assists in enlarging the images to about 2.2 to 2.7 times their average size. This magnification then allows the images to project themselves onto the healthy parts of the retina by bypassing the damaged blind spot which helps in restoring at least some of the patient's normal vision.⁸

Advantages of the bionic eye

With research going on further based on the proposed models, the bionic eyes have the following advantages:

- The bionic eye can be implanted easily and the patient need not carry external batteries and external wiring.
- Helps treat patients with total loss of vision.
- Bionic eye implants and services are quite easily available and accessible.
- It has amazing optical properties as the ceramic detectors used are biocompatible, compact and efficient.
- It has a structure that is naturally porous which allows nutrients to flow from the back to the front of the eye easily.
- Since it is FDA approved quality and durability are not in question anymore.

Disadvantages of the bionic eye

- It is an expensive treatment and not everyone can afford it.
- Since research is still going on results are yet not 100% successful.
- The facility is yet not that accessible in many countries.
- Creating a replacement that is artificial may be risk laden.

Conclusion

Even though the bionic eye on the one hand is a dream come true for the visually impaired, yet on the other hand it remains a distant dream for maximum population across the world. The WHO statistics clearly indicate that the incidence and prevalence rate of blindness dominates the scene in the developing countries, where unfortunately

the awareness and impact of this miraculous technology has not even touched the tip of the iceberg. In times to come however, with research on bionic eye implants expanding at a rampant pace there is likelihood that more people across the globe will be able to benefit from it that too at affordable prices.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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