DOI: 10.21088/ijsn.2277.467X.15126.4

Indian Journal of Surgical Nursing
Volume 15, Number 1 January–April 2026

REVIEW ARTICLE

Bionic Eye: A Review

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HOW TO CITE THIS ARTICLE:

Elsy Jeya Priyam ER, Jaivin Jaisingh J.. Bionic Eye: A Review. J Surg. Nurs. 2026; 15(1): 21-24.

ABSTRACT

Bionic eyes, or visual prostheses, represent a transformative advancement in restorative medicine for the millions worldwide suffering from blindness. Unlike cosmetic prosthetic eyes, these functional implants use micro-electrodes to stimulate surviving neurons in the retina, optic nerve, or visual cortex, bypassing damaged tissue. Currently, recipients perceive a "flashing mosaic" of light spots known as phosphenes, which requires specialized training to interpret. While existing models such as the Argus II and Bionic Vision Australia devices provide enough functional vision for basic navigation and object localization, they remain limited by low electrode density and a lack of color perception. Future developments focusing on higher-resolution electrode arrays and cortical stimulation (like the Orion system) aim to broaden eligibility to patients with glaucoma or optic nerve trauma, ultimately striving to more closely replicate natural sight.

KEYWORDS

• Bionic Eye (or Visual Prosthesis) • Phosphenes (light perception) • Retinitis Pigmentosa • Micro-electrodes • Retinal Degeneration • Artificial Vision • Cortical Implant • Optic Nerve Stimulation • Functional Vision • Neuroprosthetics

INTRODUCTION

With nearly 40 million people suffering from blindness worldwide and another 124 million affected by low vision, it's no surprise that researchers are intent on developing novel ways to restore sight. One such effort is the development of a so-called bionic eye or bionic eye implants.

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➤ **Received:** 06-10-2025 ➤ **Accepted:** 12-11-2025

Definition

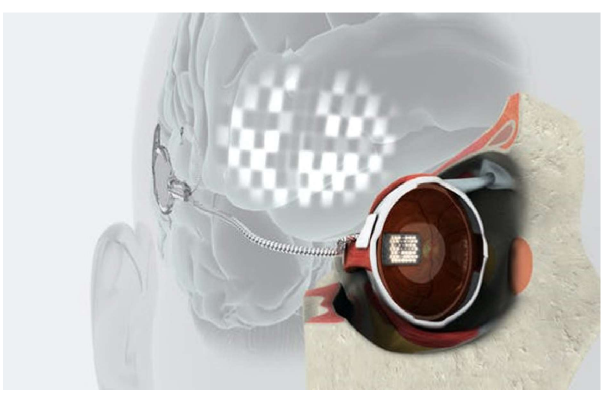
Visual prostheses or "bionic eyes", promise to provide artificial vision to visually impaired people who could previously see. The devices consist of micro-electrodes surgically placed in or near one eye, along the optic nerve (which transmits impulses from the eye to the brain), or in the brain (bionic ear or cochlear implant).

Bionic eye, electrical prosthesis surgically implanted into a human eye in order to allow for the transduction of light (the change of light from the environment into impulses the brain can process) in people who have sustained severe damage to the retina.

Working of Bionic Eye:

A bionic eye converts images from a video camera to a high-contrast representation, of which a portion is selected for further processing.

An external video processor then converts this high-contrast image to electrical stimulation parameters, which are sent to electrodes implanted in the eye. The bionic eye recipient perceives a blurred image comprised of flashes of light.



What Recipients Actually See?

Electrical stimulation of the surviving neurons leads the person to perceive small spots of light called phosphenes.

A phosphene is a phenomenon of experiencing seeing light without light actually entering the eye. So the vision provided by a bionic eye is not like natural sight. It is a series of flashing spots and shapes the person uses to interpret their environment through training - somewhat like a flashing mosaic.

Recipients need to use these irregular flashes to interpret the camera image. The field of view (the extent of the observable world) is small about 30 degrees wide or one hand span at arm's length so recipients need to have a good memory to put the whole image together.

Indications of Bionic Eye:

- People with vision loss.

Retinal bionic eye implants are placed into the eyeball itself, and are only suitable for people who have lost their vision from specific diseases such as inherited types of retinal degeneration known as retinitis pigmentosa and age-related macular degeneration.

Implants placed on either the optic nerve or directly into the brain may be able to provide benefit to people with a broader range of conditions, such as trauma or glaucoma.

Limitations of Bionic Eyes:

- It does not restore sight to the extent
- Present bionic eye has only 60 electrodes but for a natural vision million electrodes should be placed
- It doesnot perceive colors
- It is expensive

Drawbacks:

Another complicating factor is that there are many neuron types in the retina but the electrodes are too large to selectively target individual types. For this reason, bionic eyes cannot replicate the sense of colour. In fact, artificial vision is very different from normal vision and takes a lot of getting used to.

Improvement of Quality:

At present, there are several approaches to improve image quality. One is to increase the number of implanted micro-electrodes and make them smaller, allowing them to target selective neurons for more independent "pixels" and greater resolution.

First Bionic Eye:

The first implantation of a rudimentary version of the bionic eye was reported in 2012. The patient, who suffered from profound vision loss as a result of retinitis pigmentosa, reported being able to see light but not being able to make distinctions within the environment.

The first model was created by the Australian company Bionic Vision Australia. More-advanced technologies developed since then have been used in newer models implanted into patients whose vision was affected by retinitis pigmentosa.

Related Studies:

The Argus II in the USA, the Alpha-AMS in Germany, and the IRIS V2 in France, ran clinical trial with three people, between 2012 and 2014, using a new device developed in Melbourne, Australia. This device may have a safer surgical profile than existing bionic eyes as it is implanted at the back of the eye rather than inside the eye.

Prior to surgery, the Melbourne patients would not have been able to see a hand waving in front of their face. With the bionic eye implant, they were able to locate objects on a table, and navigate around objects in their path while walking.

Further Studies:

Further research could raise the level of acuity that the bionic eye provides, and different materials, such as diamond, are being tested for their effectiveness in the implant. Long-term effects of the implantation of a bionic eye remain unknown.

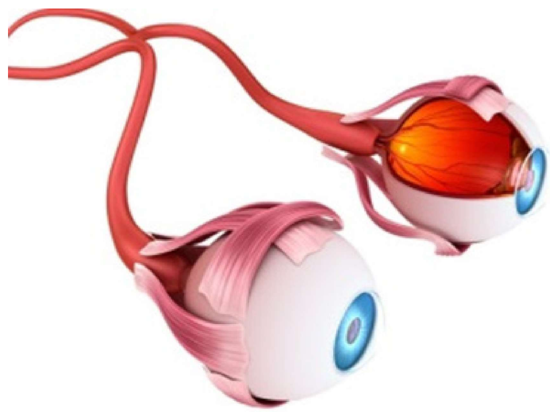
Bionic Eyes are More than Prosthetic Eyes:

A bionic eye is not the same thing as a prosthetic eye. Prosthetic eyes (also called “glass eyes” or “artificial eyes”) replace the physical structure and appearance of an eye that must be removed due to trauma, pain, disfigurement or disease. Bionic eye implants, on the other hand, work inside the existing eye structures or in the brain. They are designed to achieve functional vision goals as opposed to physical, cosmetic ones.

The Future of Bionic Eyes:

The Orion Visual Cortical Prosthesis System company describes “an implanted cortical stimulation device intended to provide useful artificial vision to individuals who are blind due to a wide range of causes, including glaucoma, diabetic retinopathy, optic nerve injury or disease, and eye injury.”

The Orion device is being designed to convert images captured by a miniature video camera mounted on glasses into a series of small electrical pulses. The device will bypass the diseased or injured eye and transmit these electrical pulses wirelessly to an array of electrodes implanted on the surface of the brain’s visual cortex to provide the perception of patterns of light.



CONCLUSION

Bionic eye technology offers a functional, rather than cosmetic, restoration of sight by enabling users with retinal degeneration to perceive light, shapes, and improve navigation through electrical stimulation. While current devices are limited by low resolution and narrow fields of view, advancements in micro-electrodes and cortical implants like the Orion system promise increased visual acuity and broader applications for varied causes of blindness.

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