



BIONIC EYE: A REVIEW

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ABSTRACT

Retinitis pigmentosa (RP) is a group of genetic eye conditions that leads to incurable blindness. It further results in tunnel vision, people with *Retinitis pigmentosa* are not legally blind until their 40s or 50s, while in some cases patients may become blind due to RP as early as in their childhood. However, patients who have gone blind because of retinitis pigmentosa are a step closer to perhaps one day regaining some of their sight with the news that the United States FDA has approved a study to evaluate an artificial retina. Researchers at the USC Doheny Eye Institute have developed the technology that hopefully will help patients with *Retinitis pigmentosa* and macular degeneration regain some vision using an implanted artificial retina. The Food and Drug Administration approved an Investigational Device Exemption to conduct a clinical study of the new device – dubbed the Argus II Bionic Retinal System. Apart from these there have been breakthroughs in development of bionic eye in number of institutions throughout the world. This review paper deals the technology and the working of the device which would help in eradicating blindness in the near future.

Keywords: Bionic eye, *Retinitis pigmentosa*, Argus II, Doheny eye institute.

INTRODUCTION

The Argus II is the second generation of an electronic retinal implant designed for the treatment of blindness due to *Retinitis pigmentosa*. The first phase of the implant study began in 2002 which was followed by successful implantation in six patients in the trial, it was found that the devices are indeed electrically conducting and possess potential to be used in patients to detect light or even distinguish between objects such as cup or plate. The device is basically meant to take place of photoreceptors. While the first generation of implant contained 16 electrodes laid out in array, the Argus II is meant to contain 60 electrodes, which would further help in providing higher resolution images. The new device is approximately one quarter the size of original device, reducing surgery and recovery times.^{1,2}

The device consists of

- The array is attached to the retina and used in conjunction with an external camera.
- Video processing system to provide a rudimentary form of sight to implanted subjects.

Following observations were made after the device was implanted in few individuals

The clinical trial of the first generation of implants continues at the Doheny Eye Institute at USC. All six previously blind patients in the first trial have been able to detect light, identify objects in their environment and even perceive motion after implantation with the device.

STATE AND DEVELOPMENT OF BIONIC EYE

Apart from Argus II there are number of devices which are in development and would be made available in near future. One such device is the Prototype device created by the Bionic Vision Australia

Researchers at Bionic Vision Australia (BVA) have produced a prototype version of a bionic eye implant that could be ready to start restoring rudimentary vision to blind people as soon as 2013. The system consists of a pair of glasses with a camera built in, a processor that fits in your pocket, and an ocular implant that sits against the retina at the back of the eye and electronically stimulates the retinal neurons that send visual information to the brain. The resulting visual picture is blocky and low-res at this point, but the technology is bound to improve, and even in its current form it's going to be a major life-changer for those with no vision at all. And the future potential - even for sighted people - is fascinating.

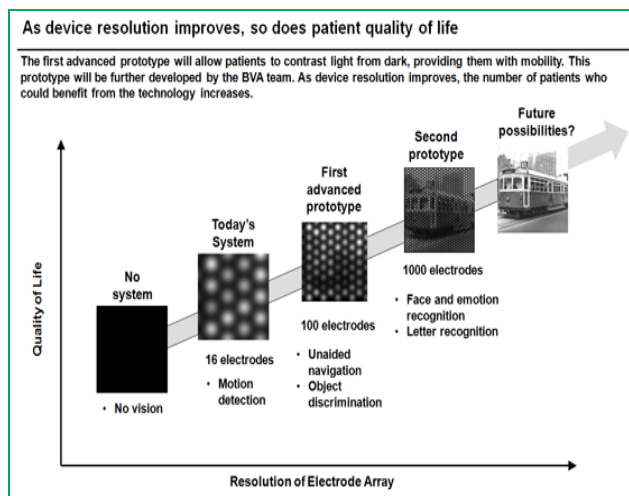


Figure 1: Comparisons between different prototype of Argus II

Thanks to an Australian government injection of almost \$40 million in 2009, Bionic Vision Australia has been able to revise the timeline of its innovative bionic eye program from "around 2020" to as close as three years away. Researchers have demonstrated a prototype of the device they hope will begin restoring sight to blind people as early as 2013.^{3, 4}

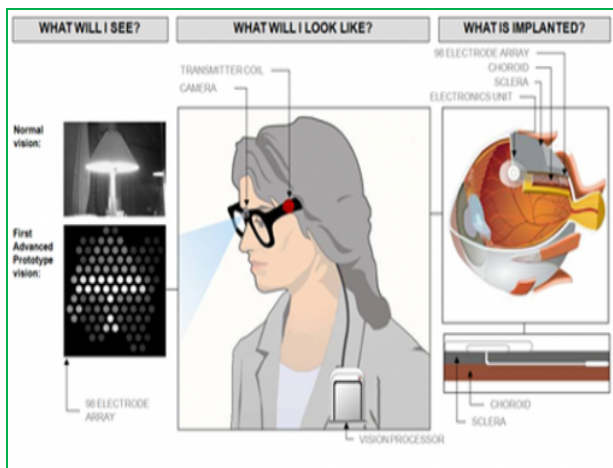


Figure 2: Construction of Argus II.

WORKING OF DEVICE

The retina can be very simplistically described as a matrix of nerve cells that fire when they're struck by certain types and levels of light. Those neurons send an electrical signal back to the brain's visual cortex, where information about colour, light intensity, edges and lots of other interesting stuff is reassembled and the brain can begin processing it to try to work out what's going on - working out what objects you're looking at, what's moving, what's important. It's an incredibly complex and fascinating system, but it all starts with the retina, where light that comes into the eye is converted to nerve impulses. You could view the bionic eye implant as an aftermarket replacement for a retina that's no longer capable of performing this function.

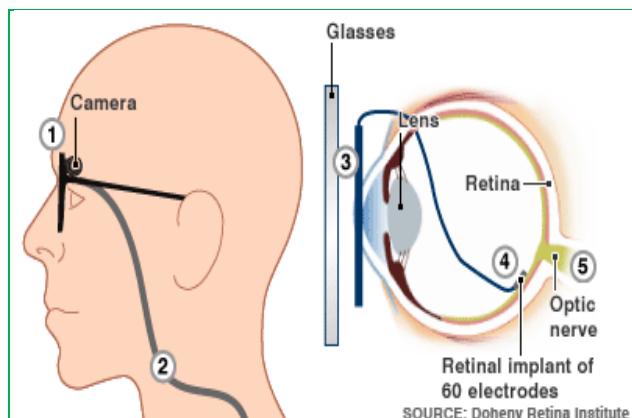


Figure 3: Working of the BVA implant

BVA's bionic eye works in a similar way to the US-based Argus II system. A small camera is mounted on top of a pair of glasses, and the resulting images are sent to a small processor unit that can be kept in a patient's

pocket. This processor sends a crunched image to a tiny 2x4mm chip that's implanted directly onto the retina - and the chip directly stimulates the visual neurons, sending a rough visual signal to the brain for processing.⁴

THE RESOLUTION CHALLENGE

The challenge in bionic eye design is not to get a signal through to the brain, but to improve the resolution and detail of that signal. The first version of the Argus system had only 16 electrodes, so it effectively sent a 16-"pixel" image to the brain. The next-gen Argus II carries 60 electrodes. The prototype unveiled this week by BVA is a little more advanced, but still quite rudimentary in the scheme of things. It offers 100 electrodes - so the eventual picture will still be blocky and difficult for somebody with normal vision to interpret. But researchers say it will be enough to give enough vision to a patient to let them walk around without assistance: "Patients would be able to contrast light from dark and move more independently, with the ability to distinguish large objects and to avoid walking into them. They will be able to see outlines such as buildings, cars and park benches. This prototype should be ready for the first human implant in 2011." The second prototype model they're working on for its first trial run in 2013 is more exciting - with 1000-electrode resolution, the picture will become a lot clearer for patients who receive the implant. Talking of 20/80 vision, or more than enough to recognize faces, read large print and generally integrate much better into a visually-focused world.

BIOLOGICAL CONSIDERATIONS

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), vision loss due to degeneration of photoreceptors (retinitis pigmentosa, choroideremia, geographic atrophy macular degeneration) is the best candidate for treatment. 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.

LOOKING INTO THE FUTURE

Beyond these two prototype stages, it should theoretically be possible to improve the device up to and even beyond the capability of a working human eye. At that stage, all sorts of things become possible, from bionic super-vision, to the ability to see infra-red, night vision or X-ray content, to the ability to relay augmented reality "terminator vision" directly to the visual cortex. You could magnify images without binoculars, run software algorithms to block out bright sunlight and glare so you'd never need sunglasses, or watch a video in one eye while the other's free to let you walk around. And just imagine



the potential for virtual reality and immersive movies that are played out directly into your own eyes...Communicating directly through an implant to the brain's visual cortex is a very exciting area of technology that's currently in its infancy but has massive future potential. And while there are immediate benefits in sight for the blind, it's fascinating to speculate where this might lead for the rest of us.

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Mr. Mayuresh.U.Chittal, presently pursuing Bachelors in Pharmacy from M.G.V's Pharmacy College, Nashik, Maharashtra, INDIA. He dedicated this Review to his Professor and Mentor Mr.S.V.Amrutkar. He is looking forward to a career in Drug Design and Research.

