Prosthetic Vision: Where we are now and where we are going

Abstract: Hundreds of thousands of people worldwide suffer from retinal degenerative diseases that have left them with little or no vision. Their best hope for regaining sight is through prosthetic devices. In February 2013, the FDA approved implantation of the Argus™ II retinal prosthesis system as a humanitarian device. On June 27 Second Sight Medical Products, Inc, the manufacturer of the Argus II, announced that 10 medical centers in the US will start implantations, most likely towards the end, making it imperative that optometrists understand this technology to better serve their patients. This symposium will provide the most up to date information about difficulties of working with a degenerating retina for prosthetic vision, the different prosthetic vision projects going on worldwide, rehabilitation of patients with prosthetic vision and the psychological considerations of people who have received or are contemplating implantation of prosthetic vision devices.

Introduction to the Symposium
Gislin Dagnelie, PhD, Johns Hopkins University, School of Medicine.

Anatomy & Physiology Of The Degenerating Visual System
Bryan Jones, PhD (Moran Eye Institute, Salt Lake City, UT).

I. Retinal degeneration and remodeling encompasses a group of pathologies at the molecular, cellular and tissue levels that are initiated by inherited retinal diseases like retinitis pigmentosa (RP), genetic and environmental diseases like age-related macular degeneration (AMD) and other insults to the eye/retina including trauma and retinal detachment

II. Understanding how retinal circuitry changes in disease and how it is altered from wild type conditions is critical to understanding pathogenic processes and deriving therapeutic interventions

III. Insults induce retinal changes and apparent plasticity resulting in neuronal rewiring and reprogramming events that include:
   a. alterations in gene expression
   b. *de novo* neuritogenesis
   c. formation of novel synapses, creating corruptive circuitry in bipolar cells through alterations in the dendritic tree and supernumerary axonal growth
   d. neuronal migration throughout the vertical axis of the retina along Müller cell columns exhibiting altered metabolic signals
   e. retinal pigment epithelium (RPE) invasion of the retina forming the pigmented bone spicules that have been classic clinical observations of RP diseases

IV. Historical perspective and current thinking
   a. Historically thought that retinal degenerative diseases such as RP affect the sensory retina, leaving the neural retina relatively unscathed
   b. Currently known that resulting loss of rod and cone input to the neural retina constitutes deafferentation and remodeling at the cellular and molecular level becomes unavoidable
   c. If photoreceptors are lost, particularly cones, a sequence of progressive events is initiated that induces negative plastic remodeling of the neural
retina
d. Essentially every disease process that results in photoreceptor loss, triggers retinal remodeling as the final common pathway culminating with cell death and topological restructuring of the retina

V. Phases of retinal remodeling
   a. Phase 1: photoreceptor stress initiates early remodeling & reprogramming events
   b. Phase 2: microglia, Müller glia and RPE cells become involved. ONL ablation occurs and cell stress pathways are engaged while Müller cells begin sealing the retina off from the choroid
   c. Phase 3: de novo neurite formation, rewiring and neuronal death start a process that continues to progress with neuronal translocation and massive topological restructuring of the retina
   d. All retinal degenerative diseases examined to date including natural, crafted and induced models demonstrate remodeling to some extent and the severity of the negative plasticity depends upon coherency of insult and whether or not cones survive
   e. In humans, early retinal remodeling is often clinically occult and occurs prior to any notable clinical fundoscopic imaging
   f. The progression of retinal remodeling is similar to that negative plasticity that occurs in CNS pathologies like trauma and epilepsy and constitutes substantial impediments to rescue strategies of all types

Overview Of Visual Prosthesis Systems Currently In Use And Under Development
Gislin Dagnelie, PhD, (Johns Hopkins University, Baltimore, MD)

I. What are the principles of operation underlying visual prostheses?
   a. Congenital vs. acquired deficits along the visual pathway
   b. Compensating for lost function, not creating vision “de novo”

II. What approaches are currently in use?
   a. Modular electronic systems (Argus II)
   b. Integrated electronic systems (Alpha IMS)

III. What approaches are under development?
   a. Trans-scleral and suprachoroidal stimulation
   b. Infrared electro-optics systems
   c. Cortical stimulation

IV. Performance with current implants
   a. Argus II
   b. AAlpha IMS

V. Expectations for clinical introduction

Rehabilitation for Prosthetic Vision
Duane Geruschat, PhD (Salus Univ/PCO, Philadelphia, PA)

I. How they use what they see
II. Why is rehabilitation necessary?
   a. This is not a reintroduction of native vision
   b. The new visual input needs to be learned/interpreted as new visual memory
   c. The importance of context of what is seen
   d. The technology does not replace good blindness skills; it enhances them

III. What are they taught?
   a. Basic skills, visual mobility, visual orientation, visual memory
   b. Basic skills ((on/off, filter manipulation, pointing the camera, eye alignment)
   c. Visual mobility
   d. Visual orientation
   e. Visual memory
   f. Integrating the prosthetic vision within the context of the pts lifestyle and goals
   g. Practice with the system in real-world environments
   h. An aid for orientation more than mobility: spatial information gathered while standing still
   i. Users are blind, but with a little sight input
   j. Mobility: continued use of long cane or dog guide
   k. ADL: continued use of blindness skills with some sight input to enhance independence
   l. Another tool (adds information) not a replacement for good blindness skills

IV. Who are the best candidates?
   a. Importance of goals
   b. Quality of life
   c. Improved independence

Psychological Considerations for Prosthetic Vision
Frank Lane, PhD (Illinois Institute of Technology, Chicago, IL)
I. Research about individuals who are blind and who are interested in a vision prosthesis
   a. Motivations
   b. Perceived benefits
   c. Perceived risks
   d. Decision-making process

II. Review of completed research on people who were previously implanted with a vision prosthesis
   a. Cortical prosthesis
   b. Optic nerve prosthesis
   c. Functional benefits
   d. Psychological benefits

III. Ethical implications for future vision prosthesis research
   a. Potential for emotional and psychological harm
   b. Information necessary for an informed consent process
   c. Appropriate screening for individuals who express interest in participating in clinical trial research
Testimonial from a Prosthetic Vision User
Kathy Blake

Panel Discussion