Gene Therapy for Red-Green Color Blindness

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Abstract—Red-green color blindness, “Daltonism,” is the most common single locus genetic disorder, affecting 6% of men worldwide. Gene therapy is a potential means of correcting the defective or missing locus through the injection/transplantation of a normal transgene. Through the evaluation of one case study, gene therapy has cured colorblindness in squirrel monkeys, and may provide promise for humans.

I. INTRODUCTION

Currently red-green color blindness, more accurately red-green “color vision deficiency” is the most common variation of the genetic disorder itself. Gene therapy has been around since the 1960’s/70’s, and although is more advanced than the developmental stages, it is still in its infancy. Through research and the analysis of one main case study, the implantation of a pigment transgene into the retina of a squirrel monkey existing with this kind of colorblindness, proved to cure the genetic disorder [1]. Within the past year, an alternative correction to red-green color vision deficiency was developed by EnChroma, a company whom, under an NIH SBIR grant, dedicated the past decade+ to developing a line of corrective and innovative eyewear products, which has proven to help approximately 80% of color blind cases in their study [2]. Gene therapy stands apart from EnChroma’s approach in that it’s invasive and a potential permanent cure. It requires an injection/implantation into the eye that has a series of potential risks. Although we know that the red-green color deficiency has been corrected in the monkeys, a major downfall in terms of the case study stands that there’s no way of telling to what degree the monkey’s internal perceptions of the colors are. In addition, ethical issues arise as a roadblock to conducting research on human beings. Understandably, in order for human testing to commence, this gene therapy and specific process must be passed, (reviewed and approved), by the NIH, ORDA/RAC, and the FDA. In addition there must be approval of an IND and the IRB. Overall, EnChroma has provided some humans with a correction for colorblindness through lens technology, but gene therapy is providing promise for a more permanent fix to the genetic disorder.

II. METHODS

Through molecular biology, focusing on the S (short), M (middle), and L (long) cones in the retina and the manipulation of the transgene, colorblindness was cured in squirrel monkeys. “This two stage model has become the accepted dogma for color vision” [3]. “The dichromatic monkey possessed only M & S cones (protanope), furthermore their M vs. M receptive fields leaving the retina carried only light-dark edge information, and could travel down one of two pathways, one with S-cone centers or one with M cone centers and S-cone inputs to the surround [1].” Through this invasive gene therapy experimentation, the addition of a new visual pigment transgene into the retina of the eye, (an addition of a third class of cone), led to new activity patterns exiting the retina, (the wavelengths of the activity patterns are altered) [3].

III. RESULTS

Through research and development and concentration on the field of color vision/color vision gene therapy we know the four main hue perceptions are blue, yellow, red and green, in addition to this these perceptions involve contributions from S, M, & L cone types wavelength-sensitive. Originally, when behaviorally tested, the dichromatic squirrel monkey, possessed the ability to distinguish between blue and yellow, while red and green were indistinguishable from gray [1], (hence red-green colorblindness). Through the addition of the missing photo pigment, the M cone, into the midget ganglion cell receptive fields the blue-yellow circuits split resulting in the correction of red-green color blindness confirmed through behavioral tests. This is proof that scientists have successfully “targeted therapeutic transgenes to cone photoreceptors in primates” and the squirrel monkeys can now distinguish between red and green.

IV. DISCUSSION

Overall, this gene therapy, and the evolution of the color vision circuitry specifically is the light providing hope for the future of red-green colorblind human beings [3]. Color blindness we know is a genetic disorder that specifically does not involve retinal degeneration. If the FDA approves human testing the scientific community would be able to understand the potential of gene therapy in restoring an individual to their full visual capacity [4]. Ethics is the main limitation existing in terms of working towards a cure for the estimated 300 million humans worldwide that possess a color vision deficiency. No one knows how gene therapy could affect humans in comparison to monkeys and finding willing and informed test subjects may be difficult. There are several risks associated with gene therapy: “the retinal injection may cause irritation or infection to the retina, result in vision loss and may even result in negative psychological effects associated with suddenly being able to see new colors” [1]. While EnChroma provides a temporary “external” fix to colorblindness through lens technology, gene therapy could provide a permanent cure.
REFERENCES


