Stem Cell Therapies: An Avenue for Restoring Vision Loss

By Sabina Khan

If you've ever gone to the optometrist for an eye exam, your optometrist has probably put you through numerous vision tests. The purpose of these tests is to evaluate your overall eye health and eyesight, as well as to determine whether you're at risk for any sort of eye diseases that could eventually lead to loss of sight or vision. Numerous people in the United States end up losing their vision as a result of issues with certain components of the eyeball or deterioration of the eye itself due to some type of eye disease. Eye diseases include retinitis pigmentosa (RP), retinal degeneration, macular degeneration, and glaucoma [1].

The eye consists of several major anatomical parts that collectively aid in receiving and processing visual stimuli. These parts include the lens, sclera, cornea, iris, ciliary body, pupil, macula, retina, and optic nerve. In particular, the retina and macula are located toward the back of the eye and play major roles in processing the visual world. The macula is responsible for processing central vision and providing sharpness in clarity—allowing us to see fine details. The retina serves a similar function, in that it receives and processes visual stimuli and light, but it also transmits information about such stimuli to the brain. Both the macula and retina contain special cells called photoreceptors of which there are two types—rods and cones [1,2]. These photoreceptor cells carry out a process called phototransduction which converts visual and light information into signals that can be sent to the brain to elicit biological responses related to vision [1]. Damage to either the macula or retina can often result in degenerative eye disorders, such as macular or retinal degeneration. Both macular and retinal degeneration are incurable, as both are characterized by the damage or loss of photoreceptor cells located within the macula and retina in the eye—this is what ultimately leads to the deterioration or loss of vision.

One innovative approach to treating macular or retinal degenerative disorders is through stem cells therapies. Unlike other cell types, stem cells possess self-renewal capabilities and are able to give rise to any specialized cell type within the body (e.g. skin cells, stomach cells, eye cells, etc.), making them an ideal option for vision restoration. In fact, scientists are already trying to regenerate retinal cell types—including photoreceptor cells—using stem cells. There are a number of different types

of stem cells that scientists are currently using for regenerative experiments related to vision restoration—including human pluripotent stem cells (hPSCs) and mesenchymal stem cells (MSCs). Retinal stem cells isolated from the cilliary bodies of different mammalian species are also beginning to seem like a viable option for such regenerative experiments [3]. Finally, retinal pigment epithelium stem cells are becoming more and more common for use in retinal transplantation purposes.

In a 2016 research study conducted by Alona O. Barnea-Cramer and team, photoreceptor cell-replacement therapies were explored [4]. This particular study revolved around whether photoreceptor cells derived from induced pluripotent stem cells (iPSCs) or embryonic stem cells (ESCs) held therapeutic value in repairing tissue damaged from retinal diseases. They found that when pluripotent stem cells were transplanted into mice with retinal degeneration, the stems cells were able to successfully differentiate into photoreceptor cells and, critically, vision was also partially restored to the mice. More recently, another research study conducted by Harshini Surendran and team investigated the therapeutic potential of hiPSCs for replacement of damaged or lost photoreceptor cells [6]. Their study involved transplantation of retinal pigment epithelial cells and photoreceptor cells—both derived from hiPSCs—and assessment of their functionality following transplantation into mice. Findings of the study showed that transplantation of stem cell-derived retinal pigment epithelial cells and photoreceptors improved visual function and light perception [6]. Both studies are great examples of why stem cell therapies are an incredibly promising avenue for treatments related to eye diseases and vision restoration!

Results from various clinical trials have demonstrated that transplantation of photoreceptor cells and retinal pigment epithelium cells—derived from different stem cell types—can effectively restore vision in people with retinal degenerative disease [5,7]. Thus far, the use of both stem cell-derived photoreceptors and stem cell-derived retinal pigment epithelial cells have improved visual acuity. The trials also demonstrated these treatments are safe—patients tolerated the transplantation of the cells quite well.

Research and clinical trials related to stem cells and their potential in vision regeneration and treating eye diseases continues. Currently, researchers are studying the photoreceptors derived from stem cells to delineate the molecular and cellular mechanisms underlying eye diseases [7]. The intention of this research is to better

understand how amenable these diseases will be to regenerative-medicine based therapies [7]. Additionally, researchers are also working to determine whether transplanting photoreceptors, retinal pigment epithelial cells, or both cell types together will most efficiently restore vision in patients suffering from eye diseases such as RP or age-related macular degeneration. Overall, while research using stem cells to treat damaged eye tissue and ocular diseases continues, this regenerative medicine-based approach presents a promising avenue toward the restoration of vision.

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