Polymeric STAR Systems for an Artificial Cornea to Treat Global Blindness

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Statement of Purpose: Corneal blindness, affecting 12 million people, is the second leading cause of treatable blindness worldwide [1]. While corneal transplantation using high-quality human donor corneas has been successful in selected developed countries, majority of the people with corneal blindness today remain untreated because of the lack of donor cornea. Currently available artificial corneas for human use includes the Boston-keratoprosthesis (K-pro) [2] and AlphaCor [3]. Both corneal substitutes have limited use clinically because of the poor integration with host tissue, leading to high risks for catastrophic infections and extrusions [4]. We have developed polymeric materials and porous structures that can well-integrate with the host as complete replacement for human cornea. Our artificial cornea is made as a one piece consist a transparent polymer optic-core inter-connected with a flexible, porous polymer periphery. The composite hydrogel fabrication is made using an injection molding technique. Our device is designed and engineered to enhance the essential functions of the human cornea (refractive function and strong barrier) and eliminate its weaknesses (astigmatism, vulnerable to infections). The design has the potential to be adapted in the developing nations where resources are limited. Our artificial cornea can play a key role in fighting treatable corneal blindness worldwide.

Methods: Our approach combines the advantages of current Boston K-Pro designs while improving on their deficiencies. The design consists of a wide, rigid polymeric optic core, fully integrated with a flexible, porous polymer periphery. The optic center is ensuring superb optic properties enable to restore vision and can be customized to refractive requirements of individual patients. The hybrid composite structure is made of collagen covalently attached to synthetic hydrogels. This structure is rigid, contains high water percentage and achieves improved biocompatibility. The well-defined porous periphery of the scaffold design based on the unique tissue integration properties of the **spherically templated angiogenic regenerative (STAR)** porous biomaterials. The STAR porous biomaterials are maximizing the rapid tissue attachment and integration to the host. In addition, the surface properties of the device are readily customized for post-implantation healing when further facilitated by embedding bio-molecules to the porous peripheral scaffold.

Results and Discussion: Healing and biointegration of implanted scaffold was encouraged by optimizing the porous structure with optimum pore size of 30-38μ and biomolecules embedded in the hydrogel. The polymeric system properties were examined both *in-vitro* using different analytical tools including rheological and morphological analysis, microscopy and bioassays in addition to *in-vivo* in rabbit models, which were further analyzed by using immuno-histochemistry and electron microscopy (EM). Surface modification was accomplished using a hetero-bifunctional crosslinker to conjugate biological factors that encourage epithelial and endothelial cell adhesion and proliferation.

Conclusions: Our preliminary findings suggest that the materials tested are well-tolerated *in-vivo* as shown in the rabbits model. Those findings were supported by additional analyses including the immuno-histochemistry and morphological examinations. Those materials have the potential to be adapted as an artificial cornea on a worldwide scale, especially in developing-nations with limited resources.

References:

1 Whitcher JP, Srinivasan M, Upadhyay MP. *Bull World Health Organ.* 2001;79(3):214-21..

2 Duan, D, Klenkler BJ, Sheardown H, *Expert Review of Medical Devices*, 2006. 3(1): p. 59-72.

3 Chirila TV, Hicks CR, Dalton PD, Vijayasekaran S, Lou X, Hong Y, Clayton AB, Ziegelaar BW, Fitton JH, Platten S, Crawford GJ, Constable IJ, *Progress in Polymer Science* 1998; 23,3, 447-473.

4 Dudenhoefer EJ, Nouri M, Gipson IK, Baratz KH, Tisdale AS, Dryja TP, Abad JC, Dohlman CH. *Cornea*. 2003; 22(5):424-8.