Potential Benefits of Mathematical Models to Predict Endothelial Cell Density Following Penetrating Keratoplasty

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Endothelial cell loss following penetrating keratoplasty is progressive, with greater loss in the perioperative time period. However, we do not know why, for example, a density of 500 cells/mm² stabilizes in some eyes maintaining corneal clarity, whereas a similar density in other eyes leads to late onset graft failure. Can one predict the decay of cells to explain this example? Why do we have graft failure in some eyes and not others in the absence of inflammation, glaucoma, trauma, or immune rejection? A single exponential model is unable to answer such questions. Riddlesworth et al.¹ explain why the biexponential model does not explain such losses. Surgeons have assumed that donor and surgical factors are the major source(s) of acute cell loss. Because of the physical limitations imposed on specular microscopic cell counting of limited areas of focus that are unable to return to the same exact areas, we have been guessing as to the mechanism(s) of chronic cell loss and re-establishment of corneal clarity in Fuchs’ endothelial dystrophy cases whose central endothelium was removed. Recent morphologic studies as well as this current analysis that use repeated measurements from the same subjects over time better define the time course and mechanism(s) of the endothelial movement. By developing a mathematical model that allows the exponential rate of decline to vary continuously while incorporating significant nonlinear rates of decline, the authors have fit the clinical data for the first time to account for a slower secondary rate of cell loss in some cases and stabilization of the loss in others. Such cell loss is affected by the quality and quantity of the donor endothelium, and is most likely modified by the condition/quality of the recipient stroma and Descemet’s membrane, the quality of the wounds, as well as the health of the host endothelium that in some cases is able to either prevent progressive centripetal cell migration or actually perform centrifugal cell movement. The authors clearly define the limitations of their study, but provide us with a confirmation of endothelial cell biology that may be applicable to newer posterior lamellar grafts, such as Descemet’s stripping automatic endothelial keratoplasty (DSEAKe) and Descemet’s membrane endothelial keratoplasty (DMEK).

Reference