Glaucoma Research Society

FINITE ELEMENT MODELING OF THE OPTIC NERVE HEAD (ONH) CONNECTIVE TISSUES – BUILDING A SCIENCE FOR ONH SUSCEPTIBILITY

Burgoyne C[1,2], J Downs JC[1,2] Bellezza A[1], Hirons B, Reynaud J, and Hart R[2]
[1] LSU Eye Center; New Orleans, LA
[2] Dept. of Biomedical Engineering, Tulane University; New Orleans, LA

We are building the first digital 3D reconstructions of the load-bearing connective tissues of the normal and early glaucomatous monkey ONH from serial 3 micron histologic sections as the first step in constructing Finite Element (FE) models of these structures. Visualization of these geometries is currently a hypothesis forming step which will lead, in the near future, to the first quantitative 3D characterization of early glaucomatous connective tissue damage.

Finite element (FE) modeling can be used to estimate the stress and strain within complex biological structures. To construct a FE model, a digital geometry of the structure to be modeled is constructed and then divided into small, regularly shaped, finite elements, to which material properties (stiffness) are assigned. Stress and strain (deformation) is calculated for each element and then superposed to determine the structure's overall behavior. As the complexity of the structure increases, the number of finite elements required to model that structure increases. Incorporating anisotropic (non-homogenous) and visco-elastic (time-dependant) material properties further refines and complicates the modeling.

While clinical FE modeling will not soon be possible, our goal is to eventually build a science that will determine, for an individual ONH, those aspects of the 3D geometry and material properties of the peripapillary sclera, scleral canal wall, and lamina cribrosa which principally determine their susceptibility to a given level of IOP. Characterizing stress and strain within the ONH connective tissues will lay the foundation for studying their effects on the contained capillary blood flow and adjacent astrocyte/axon interactions.

Updated: March 11, 2008 12:55 PM AST