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VISION SCIENCE AND EYE

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Hitting the bull's-eye: Computer models for treating vision disorders

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Statement of the Problem: Over 300 million people worldwide are affected by vision impairment. Thus, extensive research efforts are being directed towards developing new and improved treatments. The sclera (white of the eye) is vital for healthy vision because it maintains the eye's structural stability and shape, properties which are compromised in prevalent conditions such as myopia and glaucoma. To better comprehend the disease mechanisms, we aim to create biomechanical computer models of the eye that incorporate physiological data on both the scleral cell cytoskeletal and extracellular matrix (ECM) components. Specifically, we targeted the scleral region bordering the optic nerve, a key region in glaucoma and myopia development.

Methodology & Theoretical Orientation: We required specimens from closely-matched young adult age because body physiology slows down with time. This is particularly problematic when dealing with human tissues. Therefore, we compared several mammal species to find a suitable human analogue. Wide-angle X-ray scattering (WAXS) was used to map the scleral collagen orientation and distribution, while multi-photon microscopy provided clarity on the depth profile. The geometry of the eyeball was acquired from video motion capture imaging of specimens that were inflated under simulated eye pressure. Planned experiments include studies of fibroblast cytoskeletal reorganization under simulated eye pressure (mimicking glaucoma).

Findings: After comparing 11 mammal species, our results revealed that the peripapillary sclera of the bovine has a tissue structure closely resembling that of humans, including the important annular structure around the optic nerve, which is vital for its mechanical support. Furthermore, we have optimized protocols for bovine fibroblasts, which will be used to study their pressure-controlled mechanotransduction pathways.

Conclusion & Significance: ECM and cytoskeletal structural information will be used along with geometric data to create integrated models of the eye for driving future scleral-targeted treatments for glaucoma and myopia.

Biography

Petar Markov is currently pursuing his PhD at Cardiff University as part of a joined project between the Schools of Optometry and Vision Sciences, Biosciences and Engineering. He completed his Master's thesis at Institute of Genetics and Molecular and Cellular Biology (IGBMC) in Strasbourg, France. Having background in Molecular biology and Biophysics, respectively, his Bachelor and Master degrees at Sofia University benefits his investigation of the role of ocular fibroblasts in determining tissue biomechanics in healthy and diseased eyes. He is also a member of the Cardiff Institute of Tissue Engineering and Repair (CITER).

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