523 Lens physiology and homeostasis
Thursday, May 05, 2016 11:00 AM–12:45 PM
609 Paper Session
Program #/Board # Range: 6092–6098
Organizing Section: Lens

Program Number: 6092
Presentation Time: 11:00 AM–11:15 AM
Solute delivery to the core of the bovine lens is driven by the lens circulation system
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Purpose: To utilize T1-weight magnetic resonance imaging (MRI) of contrast agent penetration into the lens to test the hypothesis that the lens microcirculation system delivers solutes to the lens core faster than would occur by passive diffusion alone.
Methods: A lens of a pair of bovine lenses was organ cultured in Artificial Aqueous Humor (AAH), while the other lens was cultured in either AAH-High-K^+, or AAH + 0.1mM Ouabain for 4 hours, in the presence of MRI contrast agents of varying molecular size (GadoSpinD, 17,000g/mol; GadospinF, 1,300g/mol; FeraSpinFS, 10nm). The time course of contrast agent penetration into the lens in the different culture conditions was visualised by T1-weighted imaging utilising a 4.7T high-field small animal magnet[1]. Penetration rates of reagents were extracted and compared to rates of passive diffusion calculated by a 1D model of diffusion.
Results: Penetration of all contrast agents in the outer cortex of the lens was observed in lenses incubated in AAH, but only the lower molecular weight tracers (GadoSpinF and FeraSpinXS) were detected in the core of the lens. The pattern of GadoSpinF and FeraSpinXS penetration revealed two regions of contrast enhancement in the outer cortex and core, which were separated by a zone in the inner cortex from which the delivery of the contrast agents was restricted. The rate of delivery of GadospinF and FeraSpinXS to the core of the lens was calculated to be significantly faster by a factor of 8 than what could be achieved by passive diffusion alone. Furthermore the delivery of GadospinF and FeraSpinXS was abolished by the incubation of lenses in the presence of AAH-High-K^+ or AAH + 0.1mM Ouabain, two conditions that are known to inhibit the lens circulation system by depolarising the lens potential and blocking the Na^+ pump, respectively.
Conclusions: Our results show that the lens circulation system delivers small solutes to the lens core at a rate that is faster than would be predicted by passive diffusion alone. The extracellular pathway used to delivery solutes to the core appears to be associated with the sutures and exhibits a size selectivity that restricts the delivery of large molecules to the core. Our results support earlier work that shows an extracellular diffusion barrier exists in the inner cortex that divides the lens into two compartments.
(1) Vaghefi et al. Am J Physiol Regul Integr Comp Physiol, 302: R1250–1259, 2012.
Commercial Relationships: Paul J. Donaldson, None; **Ehsan Vaghefi**, None
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Monitoring the optical changes of the lens in real time under physiological perturbations
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Purpose: Develop a laser ray tracing (LRT) system to monitor in real time how changes to the cellular physiology of organ cultured bovine lenses alters the gradient of refractive index (GRIN) and lens geometry, and how changes to these key parameters impact the overall optical properties of the lens and bovine eye.
Methods: Bovine lenses were organ cultured in three separate chambers that contained Artificial Aqueous Humor (AAH), AAH+high K^+, and AAH+Ouabain (1.0 mM). LRT was performed on all three lenses using a fully custom built and coded system. Images of the passage of the laser light through the lens was recorded using two cameras orthogonal to each other, and the resultant data was analysed using an established tomography based method that used deflection angles and exterior ray paths to calculate the GRIN[1]. Changes in lens shape in the meridional plane were also extracted using an original image processing routine. These key optical parameters were implemented in a ZEMAX model of the bovine eye to quantify what effect each physiological perturbation had on lens power, spherical aberration, focal length and overall vision quality.
Results: Preliminary results showed that ray deflection angles and radius of curvature both increased when the lenses were incubated in AAH+Ouabain and AAH+High-K^+. Both conditions decreased the refractive index in the outer cortex (1.38 to 1.36), while at the core AAH+Ouabain increased (1.44 to 1.46) and AAH+High K^+ decreased (1.44 to 1.43) the refractive index, respectively. These changes to the optical parameters of the lens produced an increase in overall refractive power of the lens, with changes in geometry contributing primarily to the shift in the optical power, while changes in the GRIN were primarily responsible for a shift towards positive spherical aberration.
Conclusions: An automated LRT system has been developed that allows up to three lenses to be sequentially monitored in real time, enabling the effects of perturbations to their cellular physiology to be linked to changes in their optical properties. LRT is a powerful alternative to previous approaches that measure the optical properties of the lens due to lower cost, improved ex vivo control and better temporal and spatial resolution.
1. Vazquez. D et al, the Optical Society of America, 2551-2565, 2006
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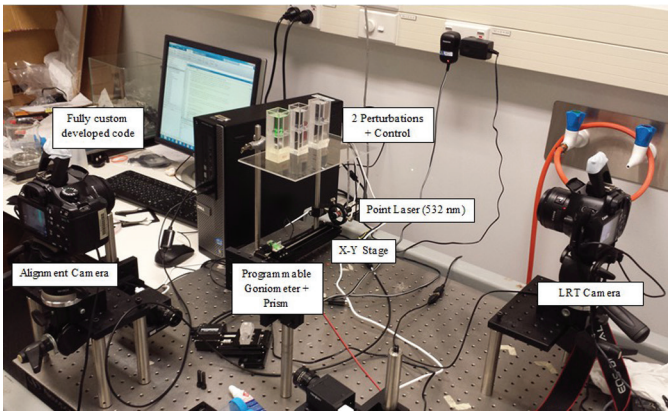

Real time ray-tracing system rig
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