Scleral CXL mimics age-related ocular rigidity
Model used to validate potential new ocular rejuvenation treatment for presbyopia

By Lynda Charters;
Reviewed by AnnMarie Hipsley, DPT, PhD, and George O. Waring IV, MD

A NEW BIOMEDICAL engineering model may provide more information about the effect of ocular rigidity on loss of accommodation. Ultimately, it may become a model to demonstrate the mechanism of action of how reduced ocular rigidity could facilitate more control over ocular accommodation in humans.

The Laser Anterior Ciliary Excision (LaserACE) procedure (Ace Vision Group) uses a laser to create matrices of micropores in the sclera over the ciliary muscle complex. The group performed a pilot study that showed the impact of this novel procedure on ocular rigidity.

“Have suspected for some time that crosslinking impacts the cornea, the sclera, and crystalline lens,” said George O. Waring IV, MD, assistant professor of ophthalmology, Medical University of South Carolina, Charleston, and adjunct assistant professor of bioengineering, Clemson University, Clemson, SC.

“This study induced these changes in a laboratory setting to model aging changes,” Dr. Waring added. “Furthermore, it allows us to undo the aging changes with biomechanical manipulation of the aging eye.”

In a research setting at the National Taiwan University Biomedical Engineering Department, scleral crosslinking was used to alter the ocular rigidity in porcine eyes to a predetermined ocular rigidity.
OCULAR RIGIDITY

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coefficient that correlates with a specific age (Pallikaris, et al.). This allowed an in vitro assessment of the effects of the LaserACE procedure to enhance ocular resilience—a key factor thought to improve the eye’s ability to accommodate.

“Lens stiffness has been correlated with loss of accommodation in aging adults,” said Ann Marie Hipsley, DPT, PhD, founder and chief executive of ACE Vision Group, Silver Lake, OH. “However, ocular rigidity also has been correlated with accommodative loss.”

She cited a 2012 Greek study that evaluated the biomechanics of ocular rigidity.

Based on the premise of that and other recent studies, Ace Vision Group researchers hypothesized that decreased ciliary muscle force and increased scleral rigidity resulted in decreased accommodative ability in aging eyes.

The study showed that eyes with induced rigidity mimicking that of an elderly 60-year-old eye had the rigidity of a 30-year-old eye after LaserACE treatment, which was equivalent to controls.

The LaserACE technology is designed to restore dynamic accommodation and does so by increasing scleral resilience, increasing the net forces of the ciliary body, and thereby facilitating accommodation, Dr. Hipsley said.

LABORATORY STUDY

Dr. Hipsley and her colleagues conducted a laboratory study that aimed to:

- Develop a method of scleral crosslinking to mimic age-related ocular rigidity.
- Assess the potential effects of the procedure to decrease ocular rigidity.
- Establish a biomechanical model to test the benefit of intraocular accommodative resultant force efficiency as it relates to decreased ocular rigidity in vitro.

In the study, 50 freshly harvested porcine eyes were separated into four groups:

- **GROUP A:** Unablated controls that simulated normal or young eyes.
- **GROUP B:** Crosslinked eyes with different degrees of crosslinking to simulate aging eyes.
- **GROUP C:** Ablation with LaserACE without crosslinking to simulate young control eyes.
- **GROUP D:** Eyes that underwent crosslinking then ablation to simulate aging eyes treated with LaserACE.

In groups C and D, a nine-spot matrix LaserACE pattern was applied in the four oblique quadrants of the sclera to the porcine eyes using a VisioLite 2.94 Er:YAG laser.

The laser effects were measured using a pressure transducer, dosage injector controller, data computerized reader, and tissue holding frame. The eyes were fixed in the frame and distilled water was injected into the vitreous chamber at a rate of 8.42 ul/sec.

Scleral crosslinking was performed with 0.8 ml of 2% glutaraldehyde. Eyes were wrapped with cotton gauze and soaked for 5, 10, or 30 minutes.

Pressure was plotted against the injected volume curve to estimate the changes in the...
ocular rigidity from the slope of the linear regression line.

**AGE, RIGIDITY CORRELATIONS**

The age-versus-rigidity correlations were established from a referenced model for the cross-linked groups, according to Dr. Hipsley. The collagen crosslinking represented various distinct markers of ocular rigidity over time, she said.

Groups treated with the LaserACE pattern had a significant decrease in ocular rigidity. “The ocular rigidity was positively correlated with the crosslinking time,” Dr. Hipsley said. “The ocular rigidity in the group that underwent scleral crosslinking for 10 minutes corresponded to the rigidity coefficient of 60-year-old eyes at, and the control unablated group corresponded to the rigidity of the 30-year-old eyes of the referenced model.”

“The selected comparison groups—young and old eyes—showed that the rigidity coefficient of the LaserACE-treated old eyes achieved a resultant ‘coefficient of rigidity’ that was almost identical to the untreated young eye,” she said.

Improved ocular resilience may be beneficial to decrease the mechanical resistance of the ocular wall to improve the resultant centripetal forces of mechanical accommodation. Collagen crosslinking may be a novel tool to evaluate the effect of ocular rigidity on the globe and it may be a method to determine the mechanism of action of the LaserACE procedure and its impact on accommodative resultant force efficiency, she said.

The investigators concluded that the scleral crosslinking method might be a useful model to correlate age with ocular rigidity. When performed on porcine eyes in a laboratory setting, the LaserACE procedure reduced ocular rigidity and improved ocular resilience. This study could be a first indicator of the mechanism of action and an early indicator of the potential value of ocular rejuvenation solutions for restoring accommodation without manipulating the visual axis or using implants.

Further studies will investigate additional modeling, characteristics and further applications. ■

**References**