BIONIC ACCOMMODATION

Harnessing the ciliary muscle's action potential may be key to restoration of accommodation.

BY PHILIP C. ROHOLT, MD

Electronic sensing is being used in the human body with increasing frequency in a range of specialties. In ophthalmology, a glaucoma sensor is now in development to help monitor patients' IOPs. Electronic sensors may also hold promise for the restoration of accommodation in presbyopic eyes.

PATHWAY OF ACCOMMODATION

The visual pathway of accommodation is a parasympathetic system, in which the ciliary muscle is innervated to provide accommodation through a muscle action and an electrical signal. In the brain, peristriate area 19 (also known as Brodmann area 19) interprets accommodation and sends signals via the Edinger-Westphal nucleus to the third cranial nerve, terminating in the ciliary ganglion, then to the ciliary muscle, where an action potential and muscle movement occur.

An electroactive presbyopia-correcting device requires several components that are available thanks to modern technology: an application-specific integrated circuit, inductive charging, long-life battery power, and biocompatible materials. Wireless communication of the components is readily achievable, and a 6-mm–diameter, variable optic that could be larger than the camera in a cell phone is available. The missing link is the accommodative activation of these components. Other technology approaches for electronic IOLs are intuitively unsuitable for reliable activation.

The transdermal electromyogram (EMG) is a way of recording electrical activity in muscle. The EMG is generated upon muscle activity, and then that EMG can be read and utilized. For the purpose of driving an accommodating IOL, the ciliary muscle is targeted. The signal from the muscle can then be processed via a circuit to activate a variable-focus optic.

In the presbyopic eye, despite the loss of accommodation, an EMG signal is available. As the eye ages, the lens stops functioning due to stiffening, but the ciliary muscle is still innervated and activated. My colleagues and I at Vista Ocular wanted to find out whether or not the ciliary muscle has an action potential that could be recorded as an EMG.

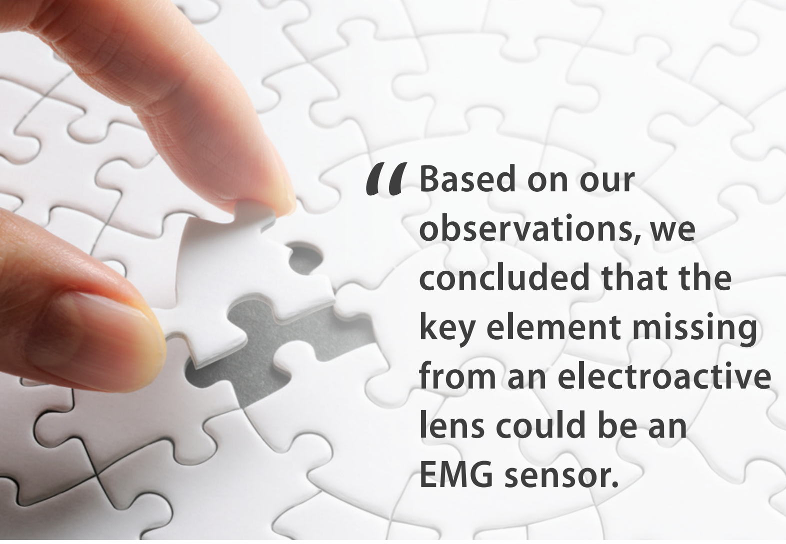
UNDER INVESTIGATION

We conducted a study in rhesus monkeys at a major university in the United States. We used implanted electrodes in the Edinger-Westphal nucleus to simulate natural accommodation. The outcomes were the EMG, or electrical activity, and the accommodation as read with a refractometer.

We found that when we used a low-amplitude stimulus, we got a low-amplitude EMG, which was recorded along with mild accommodation. At a higher level of stimulation, we observed higher amplitude along with more accommodation. The response was variable, but we wanted to know whether we could detect a mass electrical effect from these electrodes going to the muscles, even though we used electrode filters. When carbachol, which directly targets the ciliary muscle, was instilled, using the same electrode system we still obtained an electrical response.

AT A GLANCE

- The visual pathway of accommodation is a parasympathetic system, in which the ciliary muscle is innervated to provide accommodation through a muscle action and an electrical signal.
- As the eye ages, the lens stops functioning due to stiffening, but the ciliary muscle is still innervated and activated.
- The Vista sensing device bypasses both pupillary and ciliary muscle movement—the most common trigger for existing presbyopia-correcting IOLs—and instead harnesses the ciliary muscle's action potential to serve as the signal for accommodation.



THE MISSING PIECE

Based on our observations, we concluded that the key element missing from an electroactive lens could be an EMG sensor, which is where our technology comes in. The Vista sensing device bypasses both pupillary movement and ciliary muscle movement—the most common trigger for existing presbyopia-correcting IOLs—and instead harnesses the ciliary muscle's action potential to serve as the signal for accommodation.

The Vista sensing device could be used with various electronic presbyopia-correcting designs. There are several advantages of this device: the sensor is independent of pupil movement, range, and ambient lighting; it is much simpler and more elegant than other designs; it may provide improved target discrimination that is responsive to the ciliary muscle; and there is the potential for universal application.

This, we call *bionic accommodation*.

The Vista technology is being engineered for implantation through a 4-mm incision. The procedure would involve a foldable lens with expanding haptics, and the sensors would be proximate to the ciliary muscle. Accommodation would occur after signals from the muscle travel though the circuit to the variable-focus lens.

CONCLUSION

The Vista technology has the potential for broad application, as the sensors may be surgically implanted in various locations in the body. Human studies and investigation into further applications are under way. I believe that this approach is the most viable for successful restoration of active accommodation in presbyopic eyes. ■

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