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INSIDE THIS ISSUE

3-D Video-Oculography Sheds New Light on Pediatric Strabismus

The role of luminance in generating common forms of pediatric strabismus and nystagmus is the current focus of study in the ocular motor physiology laboratory in the Department of Ophthalmology at Mayo Clinic in Rochester, Minn. The study uses video-oculography to noninvasively record eye movements in children with strabismus and nystagmus. Researchers will use the data to investigate the role of fixation versus luminance input to the two eyes in causing strabismus and nystagmus.

"Video-oculography can detect positional and velocity changes of the two eyes that cannot be detected on clinical examination. Quantitative analysis of these responses should provide new information about the neurophysiology of these disorders," says Michael C. Brodsky, M.D., who leads the research team. "It will also provide a means to evaluate and compare treatments."

Three-dimensional eye movement recordings are difficult to obtain in children because these recordings usually necessitate placement of thick contact lenses on the eyes during the test. This 3-D video-oculography system, however, measures horizontal, vertical and torsional eye movements using infrared light in a manner that is noninvasive and more applicable to children.

Noninvasive examinations

During the 10- to 15-minute examination, the patient is seated comfortably and merely looks straight ahead. The patient wears a lightweight (about 20 ounces) rubber mask, much like a scuba mask. The inside of the mask contains an infrared light source and two video cameras off to the side. The cameras measure the positions of the two eyes as the patient looks in different directions. The only risks to the patient include temporary feeling on the face and red marks from wearing the mask.

The 3-D video-oculography device records eye position at 250 hertz and is considered minimal risk for use in children and adults. Because the system works in the

Points to remember

- Infrared video-oculography is unique in its ability to measure binocular eye position in total darkness.
- Because it is noninvasive, video-oculography can be used in children.
- This study uses video-oculography to noninvasively determine horizontal, vertical and torsional eye position and provide detailed quantitative information regarding changes in eye position under different stimulus conditions.
- Infrared video-oculography is also useful in documenting other neurological forms of nystagmus and determining the efficacy of different forms of treatment.
- For more information or to refer a patient to the ocular motor physiology laboratory for eye movement recording, contact Dr. Brodsky at brodsky.michael@mayo.edu or 507-284-2233.

Michael C. Brodsky, M.D.

infrared wavelengths, it is capable of recording in either light or dark. The video camera records horizontal and vertical eye movements and also the torsional position (the degree of twisting) of the eyes in each position of gaze.

"This torsional measurement is critical to establishing which neural pathways are commanding the eyes to behave normally or abnormally during eye movement," says Dr. Brodsky. "It allows us to determine which muscles and nerve centers are affected within the brain, and could help direct surgical treatment with unprecedented precision. It will also provide measurement of the position and eye velocity of the eyes to determine whether a given surgery is effective for nystagmus.

"Some forms of pediatric strabismus, such as intermittent exotropia and dissociated vertical divergence, are modulated by luminance input," says Dr. Brodsky. "Similarly, infantile nystagmus and latent nystagmus are influenced by fixational effort. The power of infrared video-oculography is that it can noninvasively record eye position in total darkness, in darkness with a tiny fixation target present and in light through a semiopaque filter that blocks all fixational input but allows binocular luminance to be modulated." By comparing the 3-D eye position under these different conditions, the research team aims to quantitatively determine the roles of fixation versus luminance disparity in producing strabismic deviations that arise in children.

IRB approval and plans

Dr. Brodsky received a Mayo Clinic Scholarly Opportunity Award along with approval from the Institutional Review Board (IRB) to use this equipment for clinical diagnosis in children 8 years of age or older, and to use the data collected for future prospective studies. "This equipment will provide new insights into the mechanism of pediatric strabismus and nystagmus," says Dr. Brodsky. Its use may also be applied to the evaluation of surgical and nonsurgical treatments.

Macular Hole Repair Does Not Require Face-Down Positioning

Raymond Iezzi Jr., M.D.

A retrospective study of 68 eyes (65 patients) indicates that macular hole surgery with broad internal limiting membrane (ILM) peeling, 20 percent sulfur hexafluoride (SF6) gas and no face-down positioning is highly effective in the surgical treatment of idiopathic macular holes. The method also eliminates the morbidity associated with postoperative face-down positioning.

Currently, most surgeons employ face-down positioning for variable periods following macular hole repair surgery. "This may place a significant burden on patients and even eliminates the surgical opportunity for some," says Raymond Iezzi Jr., M.D., with the Department of Ophthalmology at Mayo Clinic in Rochester, Minn. "Macular hole closure using limited face-down posturing has been reported previously with varying rates of success."

Dr. Iezzi's team reviewed all idiopathic macular hole surgeries he performed at Mayo Clinic between March 2009 and December 2012. Broad ILM peeling, 20 percent SF6 gas and no face-down positioning were employed in all of the surgeries.

Of the 68 eyes studied, 48 were in women and 20 were in men. Their average age was 69 years. Characteristics include:

- 3 patients had bilateral macular holes, and 9 were referred to Mayo for treatment of their recurrent macular holes.
- 21 eyes had stage 2, 27 had stage 3, and 20 had stage 4 macular holes.
- At the time of surgery, 24 eyes were pseudophakic and 44 eyes were phakic.
- A posterior vitreous detachment was present in 20 eyes before surgery.

Patient outcomes

"We considered the single-procedure macular hole closure rate, the mean postoperative best corrected visual acuity, the incidence of cataract and intraocular pressure to compare this surgical treatment with methods that use longer acting gas endotamponade, face-down positioning or both," says Dr. Iezzi. In this study, all eyes completed one-month follow-up and 61 of 68 eyes completed the three-month follow-up. Findings, published online in the journal *Ophthalmology* in July 2013, include:

- The single-procedure macular hole closure rate was 100 percent (95 percent confidence interval was 95 to 100 percent) as observed by optical coherence tomography. No complications were observed.
- Overall, 56 of 68 eyes achieved best corrected visual acuity (BVCA) of 20/50 or better at last follow-up. Of the 61 eyes that completed at least three months' follow-up, 53 eyes

achieved 20/50 BCVA or better.

- There were no cases of gas bubble-induced cataract that required prompt cataract surgery. The mean interval from macular hole repair to cataract surgery was 207 days. Over a mean follow-up of 216 days, 79 percent of phakic eyes eventually proceeded to cataract surgery. The incidence of postoperative retinal detachment or macular hole reopening was 0 percent.
- Mean postoperative intraocular pressure (IOP) was 15 mm Hg and 16 mm Hg on postoperative days one, seven and 30, respectively, and did not differ significantly from the mean preoperative IOP of 16 mm Hg. "Face-down positioning reduces the anterior displacement of the lens-iris diaphragm that often elevates IOP in the presence of gas endotamponade," says Dr. Iezzi. "We needed to demonstrate that our no-face-down approach did not increase IOP."

Older patients benefit

Idiopathic macular holes occur almost exclusively in older patients, who are least able to maintain face-down positioning requirements because of increased incidence of cervical and lower back ailments.

"Closure methods that eliminate the need for face-down positioning and do not compromise closure rates would reduce patient morbidity significantly, improve patient satisfaction and represent a significant advancement in surgery for macular holes," says Dr. Iezzi. "Although this retrospective study has limitations, our data suggest that by using broad ILM peeling, 20 percent SF6 gas and no face-down positioning, macular hole closure rates are comparable with or better than those of other closure methods."

For more information

Iezzi R, et al. No face-down positioning and broad internal limiting membrane peeling in the surgical repair of idiopathic macular holes. *Ophthalmology*. In press.

Contact Raymond Iezzi Jr., M.D., at iezzi.raymond@mayo.edu or 507-284-4152.

Study Shows No Significant Correlation Between EVP and Elevated IOP in Patients With Open-Angle Glaucoma

A recent study indicates that episcleral venous pressure (EVP) is not the primary cause of high intraocular pressure (IOP) in patients with open-angle glaucoma (OAG). Results did show that EVP in patients with OAG was elevated slightly more than in normal subjects and so could contribute in small part to high IOP.

"Previous studies have produced contradictory results," says Arthur J. Sit, M.D., with the Department of Ophthalmology at Mayo Clinic in Rochester, Minn., who led the research team. "EVP's contribution to the elevation of intraocular pressure in patients with open-angle glaucoma is not yet fully understood. We want a clearer understanding of that relationship."

Venomanometer allows advanced measurement

The research team measured EVP using a computer-controlled venomanometer (pressure-chamber method) in one eye each of 101 subjects with untreated OAG and 191 eyes of 100 healthy volunteers. In the OAG group, ages ranged from 24 to 83 years and averaged 64 years, while in the control group ages ranged from 19 to 81 years and averaged 48 years.

"Measurement of EVP in humans is necessarily noninvasive," says Dr. Sit. "Currently, the only way to measure EVP noninvasively is the pressure-chamber method, which involves placing a clear inflatable balloon against the surface of the eye and increasing the pressure until the episcleral vein of interest is noted to collapse. The difficulty is in identifying the beginning of collapse, which is best correlated with true EVP, but cannot be visually identified at the time of measurement. Our computer-controlled system allows us to record video of the episcleral vein collapse and the synchronized pressure readings. Using video image analysis techniques, the pressure at the very beginning of collapse can be identified, corresponding to the EVP."

The study also evaluated relationships between EVP and other ocular and systemic variables in patients with OAG. The team measured intraocular pressure, axial length, central corneal thickness (CCT), systolic blood pressure, diastolic blood pressure, height and

Arthur J. Sit, M.D.

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weight, and calculated body mass index (BMI). As with IOP, there were no significant correlations between EVP and any of the physiological variables assessed in patients with OAG. (See Table 1.)

"We found that EVP in patients with open-angle glaucoma was elevated by a small amount compared with normal subjects," says Dr. Sit. "Although the increase could contribute in a small part to the elevation of intraocular pressure, it was not a primary cause of high IOP in these patients. We also found that EVP is not related to age, central corneal thickness, axial length, body mass index or blood pressure."

Although the EVP elevation in glaucoma was not large, it does represent a potential target for treatment. "Even a small decrease in EVP could represent an important therapeutic effect in glaucoma treatment," says Dr. Sit. "It is currently not known if existing therapies affect EVP, since previous techniques were sufficiently precise to detect small changes. We plan to evaluate the effects of existing and novel therapies on EVP."

Table 1: Correlation of Ocular and Systemic Variables with EVP in OAG Patients (n = 101)

	Mean ± SD	r^2
EVP (mm Hg)	7.7 ± 2.0	-
CCT (µm)	532 ± 34	0.04
IOP (mm Hg)	27 ± 8	0.08
Axial Length (mm)	23.0 ± 0.9	0.13
Age (years)	64 ± 12	-0.1
BMI	29.0 ± 5.3	0.14
Systemic Blood Pressure (mm Hg)		
Systolic	136 ± 21	0.03
Diastolic	83 ± 9	0.1
Pulse	52 ± 15	-0.02

IN THE NEWS

New Faculty in Minnesota

The Department of Ophthalmology at Mayo Clinic in Rochester, Minn., is pleased to announce the addition of two faculty members:

Alan D. Marmorstein, Ph.D., joins the Mayo Clinic faculty as a senior associate consultant and professor of ophthalmology following joint appointments in the Department of Ophthalmology and Vision Science and the College of Optical Sciences at The University of Arizona. Dr. Marmorstein earned his Ph.D. in cell biology from the State University of New York Downstate Medical Center. At Mayo, his research will focus on inherited and age-related macular degeneration — specifically Best vitelliform macular dystrophy — and glaucoma.

Alan D. Marmorstein, Ph.D.

Lihua Y. Marmorstein, Ph.D., joins the Mayo Clinic faculty as a senior associate consultant and associate professor of ophthalmology following joint appointments in the Department of Ophthalmology and Vision Science and the Department of Physiology at The University of Arizona. Dr. Marmorstein received her Ph.D. in neuroscience from the State University of New York Downstate Medical Center. At Mayo, her research will focus on understanding the mechanism and finding new treatment for both inherited and age-related forms of macular degeneration.

Lihua Y. Marmorstein, Ph.D.

Current Concepts in Primary Eye Care, Nov. 6, 2013, in Rochester, Minn. This continuous professional development course provides a balanced assessment of clinically relevant advances in eye care, taught by Mayo Clinic eye care specialists. For more information, visit *www.mayo.edu/cme/ophthalmology.*

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