GUEST EDITORIAL

Can Accommodation be Surgically Restored in Human Presbyopia?

The treatment of presbyopia, the age-related loss of accommodation, although classically and effectively accomplished with near addition spectacle lenses, has received considerable attention recently and now represents an explosive and rapidly developing new market. Progressive addition spectacle lenses; monovision, bifocal, or multifocal contact lenses; monovision, bifocal, or multifocal corneal refractive surgery; multifocal and diffractive intraocular lenses (IOLs); accommodative intraocular lenses; and scleral expansion surgery are but a few of the exciting and potential options for presbyopia correction.

Although many old and new nonsurgical options for optical compensation of presbyopia are available, recently developed unproven surgical options in use on humans are receiving considerable attention. The use of more mainstream surgical interventions such as corneal refractive surgery and IOLs (including multifocal, monovision, and even flexible or hinged haptic accommodative lenses) should be cautioned because reversibility in cases of patient dissatisfaction is often impossible. The development of controversial surgical options such as scleral expansion surgery aimed at accommodation restoration are more disconcerting. Trials of two scleral expansion surgical procedures are underway within and outside the United States. These include radial sclerotomy, in which radial incisions (similar to radial keratotomy) are made in the sclera past the limbus, and the use of scleral expansion bands. Scleral expansion bands have undergone several iterations since their first appearance. The first was a continuous polymethylmethacrylate (PMMA) band that was sutured beneath the conjunctiva to the sclera approximately 2 mm past the limbus. The second was a discontinuous band that was inserted beneath four scleral belt loop incisions and then ultrasonically fused. The third and current iteration is comprised of four separate PMMA bands that are inserted into partial thickness scleral tunnel incisions at the 2, 4, 8, and 10 o'clock positions around the globe. Each of these techniques is intended to stretch and expand the sclera overlying the ciliary muscle to reintroduce natural accommodation in presbyopes.

The use of scleral expansion surgery to restore accommodation is based on novel theories for the accommodative mechanism and the causes of presbyopia espoused by ophthalmologist Ronald A. Schachar, M.D. He believes that accommodation occurs not as described by Helmholtz, but through a paradoxical increase in zonular tension at the lens equator. Based on this theory of accommodation, presbyopia is theorized to occur because of continued growth of the crystalline lens equatorial diameter throughout life and a speculated resultant loss of equatorial zonular tension. Under these theories, surgical expansion of the sclera and restoration of the resting zonular tension would again allow accommodation to occur.

These theories of accommodation and presbyopia fly in the face of considerable old and new experimental evidence. The inability of the aging human lens to undergo accommodative optical changes *in vitro*[1] and an exponential increase in the hardness of the lens[2] between age 10 and 96 reaffirm that lenticular sclerosis must be considered as a, if not the, major factor in the loss of accommodation. The classical Helmholtz accommodative mechanism has yet again been verified through comprehensive experiments that were initiated by Dr. Schachar himself on rhesus monkeys in the belief that his accommodative mechanism would prevail.[3] Furthermore, no accommodation could be measured after scleral expansion surgery in three patients examined postoperatively with an objective optometer.[4] In addition, the claimed increased equatorial growth of the lens throughout life is erroneously based on conclusions[5] from measurements of isolated human cadaver lenses[6] in which it was originally recognized that the measurements do not reflect the diameter of the lens in the living eye. Recent magnetic resonance imaging (MRI) measurements in unaccommodated human subjects confirm that lens diameter does not increase with age.[7]

All of the above evidence undermines the very foundation of scleral expansion surgery. Because the lens diameter does not increase with aging, the accommodative mechanism is as Helmholtz described it, substantial lenticular hardening occurs and accommodation has not been observed after scleral expansion surgery; it seems that there is little support for the procedure. It is possible that near vision may be improved through nonaccommodative mechanisms. However, the reported improved near vision in the unoperated contralateral eye may be more indicative of possible drawbacks of repeated subjective evaluations than of mechanistic possibilities. Subjective testing after cycloplegia, which has not been done, would help to identify if active accommodation is truly present. Good objective tests for optical dioptric changes in the eye with accommodation are available; subjective evaluation of near vision is no substitute, as it does not distinguish between true accommodation and pseudoaccommodation, as obtained with multifocal lenses, and should be avoided. The continued hardening of the lens throughout life, even beyond the age at which accommodation is lost, together with the inevitability of cataract would seriously limit the use and longevity of any possible serendipitous consequences of scleral expansion surgery.

If new surgical approaches, accommodative IOLs, or other yet to be identified presbyopia cures are to become available—and any

reasonable prediction recognizes that many more will—they should be in accordance with accepted mechanisms of accommodation and presbyopia and viewed with caution until they are verified to be safe and effective through thorough animal testing and independent and objective evaluations. It is equally important that future prostheses, such as injectable polymer accommodative IOLs, perhaps the most likely to succeed at reintroducing accommodation, are based on sound empirical evidence. Substantial difficulties need to be overcome, including polymer biocompatibility, leakage of polymers from the capsular bag, secondary subcapsular opacification, and surgical techniques, if this approach is to resolve successfully the age-old problem of presbyopia which plagues mankind increasingly as the human lifespan lengthens and quality of life issues become more important.

REFERENCES

1. Glasser A, Campbell MC. Presbyopia and the optical changes in the human crystalline lens with age. Vision Res 1998;38:209–29.
2. Glasser A, Campbell MC. Biometric, optical and physical changes in the isolated human crystalline lens with age in relation to presbyopia. Vision Res 1999;39:1991–2015.
3. Glasser A, Kaufman PL. The mechanism of accommodation in primates. Ophthalmology (Rochester) 1999;106:863–72.
4. Mathews S. Scleral expansion surgery does not restore accommodation in human presbyopia. Ophthalmology (Rochester) 1999;106: 873–7.
5. Rafferty NS. Lens morphology. In: Maisel H, ed. The Ocular Lens: Structure, Function, and Pathology. New York: Dekker, 1985:1–60.
6. Smith P. VI. Diseases of the crystalline lens and capsule. On the growth of the crystalline lens. Trans Ophthalmol Soc UK 1883;3: 79–99.
7. Strenk SA, Semmlow JL, Strenk LM, Munoz P, Gronlund-Jacob J, DeMarco JK. Age-related changes in human ciliary muscle and lens: a magnetic resonance imaging study. Invest Ophthalmol Vis Sci 1999;40:1162–9.

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