PRESBYOPIA OUTLOOK

An exploration of where we are and where we are going.

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Second in a series of four CE activities for 2023

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The goal of this article is to review current and future trends in presbyopia correction, as well as critical examination components to consider for managing these patients. Optical, pharmaceutical, and surgical treatment methods will be highlighted.

TARGET AUDIENCE

This educational activity is intended for optometrists, contact lens specialists, and other eyecare professionals.

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IN A WORLD OF DIGITAL DEVICES, the demands on near vision have never been greater. Smartphones are ubiquitous among American adults,[1] while the use of other devices has become nearly essential to the daily routines of most households.

The modern workplace is evolving—in part in response to the global pandemic—and is becoming more technology-dependent with a larger percentage of the workforce working remotely. Although digital eyestrain is a growing concern, especially among the younger population, many patients will not manifest symptoms of reduced near function until they approach presbyopia.

Presbyopia can be described as an irreversible decrease in accommodative ability, leading to the loss of focus on near objects. The etymological roots imply that this is a process of age, although the physiological mechanism is quite nuanced. Regardless, its onset is inevitable, and the visual frustration it creates will drive patients to your chairs in search of relief. This article will review the treatment options available, and the clinical decision-making involved with the presbyopic patient.

THE PRESBYOPIC BURDEN

The accommodative triad consists of three physiological responses: pupillary constriction, convergence, and a physical change in the crystalline lens. Classical theory describes the crystalline lens as becoming thicker and more steeply curved, due to the contraction (anterior shift) of the ciliary muscle and relaxation of the zonules.[2,3] Although specific mechanisms are still debated, protein structure of the crystalline lens as well as zonular elasticity change over time. In general terms, this leads to a hardened, stiffer lens and a loss of accommodative ability.

When left under- or uncorrected, presbyopia can create a major hindrance in performing basic daily tasks, including reading, writing, and using electronic devices. Meanwhile, daily screen time continues to increase, and the impact of long-term near demand from device use is unknown and unprecedented.[4]

As recently as 2015, it was estimated that 1.8 billion people worldwide were presbyopic.[5] In the U.S. this number will grow, as Generation X is now in its fifth decade of life and millennials, who currently make up the largest generation of American adults, will soon be reaching their presbyopic years.[6] Globally, it is estimated that up to 45% of presbyopes have inadequate vision correction, which can negatively impact quality of life, reduce independence, and reduce productivity on both individual and macro levels.[7]

CLASSIFYING PRESBYOPIA

Most patients understand presbyopia to be an unfortunate product of aging. Typical onset is around 40 years of age; however, factors such as refractive error, systemic conditions, and medications can lead to varying onset of symptoms.[8]

Patients may describe a myriad of symptoms, including holding objects farther away, difficulty cycling between working distances, difficulty focusing in dim lighting, eyestrain, and headaches, and eventually blurred vision up close. While symptoms can be elicited from the patients rather easily, they may not always align with quantitative data. Near acuity can be wide-ranging for patients of presbyopic age and may not reflect their subjective vision or need for add power. Near object size, working distance, and luminance play a significant role in this variability.

Accordingly, recent work by an expert panel sought to simplify the classification of the severity of presbyopia based on add power.[9] They proposed that mild presbyopia would include add powers equal to or less than +1.25D, moderate presbyopia would range from +1.50D to +2.00D, and advanced presbyopia would be classified as needing greater than +2.00D of add power.

CORRECTING PRESBYOPIA

Spectacles Accommodative amplitude diminishes over time; however, patients may not seek help until they become symptomatic. Historically, spectacles have been the primary form of presbyopic correction due to accessibility and relative ease of use. Many patients will self-select over-the-counter (OTC) reading glasses due to their widespread availability and low cost. Single-vision spectacles with a near-vision correction can also be prescribed for patients who desire higher-quality materials or have refractive needs that cannot be addressed by OTC readers. In both scenarios, distance vision must be addressed separately, and working distance is important, given the single focal point.

Bifocal, trifocal, and progressive-addition lenses (PALs) are also available if variable lens powers are desired in a single pair of spectacles. PALs have a smooth transition of power with varying corridor shapes that can be tailored to the patient's needs. However, their utility can be offset by peripheral distortion and ergonomic limitations.

Contact lenses Aside from wearing OTC readers over contact lenses, there are two other methods of providing near-vision correction while wearing contact lenses: monovision or multifocal contact lenses. Monovision places a single-vision contact lens set for distance vision on the dominant eye, while reducing minus power or adding plus power in the contact lens on the nondominant eye.

Monovision is easier to establish for early presbyopes, as the near add increases at the same time as the power difference between eyes, affecting depth perception, contrast sensitivity, and even visual acuity.[10] Placing a multifocal contact lens on either the distance or near eye can create a modified-monovision setup, potentially enhancing the range of vision and slightly improving binocularity. Studies consistently reveal that, when given a choice, patients prefer multifocal over monovision contact lenses.[11,12]

Multifocal optics are available in corneal GP, soft, hybrid, and scleral lenses. Most multifocal contact lenses are considered simultaneous vision designs, meaning both distance and near optics are presented in front of the pupil simultaneously. The one exception is segmented, also known as translating GP lenses, which can provide crisp, uninterrupted vision both at distance and near.

If intermediate vision is desired, a smaller trifocal segment can be included as well. Previous attempts to provide translating designs with soft lens materials have been unsuccessful; however, a novel soft translating design is being investigated that utilizes the upper eyelid to suspend the contact lens in position without requiring the lower eyelid to push the lens upwards.[13]

The majority of non-segmented multifocals are aspheric multifocals, which use a change in curvature on either surface of the lens to produce gradual refractive power changes. Soft multifocals are primarily center-near aspheric designs, where the most plus power is in the center of the lens and the periphery becomes more minus in power. This allows adequate plus power to be centered over a miotic pupil in a lens that has minimal movement on the eye.

If a center-distance soft multifocal lens is desired, such a lens can be designed by several custom lens manufacturers. Custom soft multifocals can also incorporate astigmatic power, variable zone sizes, and decentered optics.

GP multifocals are typically center-distance designs with more minus in the center of the lens and increasing plus power toward the periphery. Although they do not have distinct segments or require translation, movement of the lens on the blink does help the peripheral near optics to reach the pupil. Asphericity is typically incorporated on the front surface of the GP lens to allow for a back-surface curvature that is similar to the corneal curvatures. There are also back-surface designs available that are often fit considerably steeper than "K."

When back-surface asphericity alone does not provide sufficient near vision, additional asphericity or a concentric annular zone can be added to the front surface of the lens to increase the add power. However, patients who have a nearly spherical cornea may achieve a better fit with a front-surface-only aspheric design, reducing the likelihood of corneal molding, which can occur with higher eccentricity back-surface aspheric lenses.[14] Aspheric designs are often fit empirically, providing the patient has good vision upon initial application.[15]

Within the hybrid lens portfolio, there are different multifocal optics designs. First-generation hybrid multifocals are still available with a center-near aspheric design with a single progressive add and two optic zone sizes. Second-generation hybrid multifocals are available as a center-near aspheric design with a 3.0mm fixed zone and three different add powers. Hybrid lenses later added a center-distance design with flexible zone sizes (1.80mm to 4.0mm) and variable add powers up to +5.00D. Their latest addition is an extended depth of focus (EDOF) design based on the Brien Holden Vision Institute design that utilizes higher-order aberrations (HOAs) to elongate the focal point and provide a full range of vision.[16]

Most contemporary scleral lens designs now have the ability to add multifocal optics. Using primarily center-near optics, they also have the ability to change zone sizes and decenter the optics to align over the visual axis. Multifocal optics can be implemented for patients who have both normal and irregular corneas; however, centration and a clear visual axis are essential for success.

Although orthokeratology has become quite popular for its myopia control application, those lenses can still be utilized for adult patients desiring freedom from spectacle wear and daily contact lens wear. Multifocal optics cannot be achieved with orthokeratology, but either slight under-correction or monovision are viable options.

Pharmaceutical With one drug currently commercially available and others on the horizon, pharmaceutical options for presbyopia present a noninvasive and convenient option for patients seeking improved near vision ability. The pharmaceutical approach involves either pupil miosis or crystalline lens softening.[17] Constriction of the pupil effectively creates a pinhole effect for the patient, reducing spherical aberrations and enhancing depth of focus.

Presbyopia drops aimed at miosis target the parasympathetic nervous system topically by activating the muscarinic receptors in both the iris and ciliary muscles. The most common parasympathomimetic utilized for these purposes is pilocarpine 1%.[17] Some researchers argue that these cholinergic agonists perform best and most safely when combined with nonsteroidal anti-inflammatory medications (NSAIDs), as this provides the best environment for a longer duration of action.[18]

Other pro-parasympathetic ophthalmic solutions considered for presbyopia treatment include carbachol and brimonidine, in varying concentrations.[17] In 2021, the first commercially available miosis drop option was launched with the U.S. Food and Drug Administration (FDA) approval of a 1.25% pilocarpine HCl drop. Two other pilocarpine-based drops are currently in phase 3 of FDA approvals, while several other miotic drops are still in phase 2.[17,18]

Presbyopia drops aimed at crystalline lens softening utilize the antioxidant lipoic acid and rely on the hypothesis of lens stiffening and hardening as the primary cause of the vision changes.[17] The theory behind these drops suggests that, as lipoic acid has the ability to break disulfide bonds, the crystalline lens may be loosened pharmaceutically, restoring its physical accommodative ability.[17] UNR844, formerly known as EVO6 (1.5% lipoic acid choline ester, Novartis) is currently still in clinical trials.[17]

Surgical When optical correction and pharmaceutical management reach their limits in improving near vision, patients may still find success in surgical presbyopia correction. There are also cases in which these conservative methods may not be feasible or convenient for the patient's lifestyle, and surgical methods ensure that patients are not out of options.

Already a common method of refractive error correction, laser-assisted in situ keratomileusis (LASIK) may be utilized to improve both ametropia and presbyopia. The simplest approach would be to create a monovision setup, with the nondominant eye being left slightly myopic.

Alternatively, in a method known as multifocal LASIK or presbyLASIK, the excimer laser may be administered to create HOAs to induce mid-peripheral asphericity and a multifocal-like effect. This may be conducted with either center-distance or center-near vision correction. These presbyopic LASIK techniques are ever improving, with novel technology and software being introduced in recent years.[19]

Sometimes performed in conjunction with LASIK, synthetic corneal inlays are intrastromal implants that either manipulate refractive index in a center-distance bifocal design, alter central corneal shape, or create a pinhole effect to increase the depth of focus in presbyopic patients.[18] These implants may be inserted underneath a LASIK flap or into a local opening created by a femtosecond laser. Pseudophakia is not a contraindication.

Relying on the pinhole effect, the first FDA-approved corneal inlay was introduced in 2015. A corneal shape-altering option and a small bifocal implant design were developed soon after. However, due to significant complications, including stromal haze and reduced distance visual acuities, these inlays are no longer available in the U.S.

A potential alternative to their synthetic counterparts is the use of human allograft corneal inlays.

> **"Determining the best path forward for the presbyopic patient involves several components."**

The aims of this design are to reduce potential foreign body reaction and enhance the safety profile. Currently, two designs are being investigated; both designs source their inlays from the small incision lenticule extraction (SMILE) procedure.

Early testing reveals a positive outlook and low likelihood of complications, but the risk of rejection must be considered when human tissue transplantation is involved.[19,20] Further research is indicated to fully assess the efficacy and long-term outcomes from this surgical technique.

Perhaps the most widely recognized and available surgical option for presbyopia at present, crystalline lens extraction, offers precise vision correction at all ranges. Intraocular lens (IOL) implants may be designed for monovision or multifocal correction. Multifocal IOLs are either accommodating or pseudo-accommodating, and they can be performed in cases of cataracts or clear natural lenses. Accommodating IOLs rely on robust function of the ciliary muscle to spur a change in IOL shape or position, moving the IOL enough to induce an optical shift. Current research is seeking to achieve this effect through a single optic and haptic hinge, dual-optic designs with positive anterior and negative posterior optic surfaces, fluid exchange through channels in the IOL, and other innovative approaches.[19]

Conversely, many pseudo-accommodating IOLs share similar design characteristics with multifocal contact lenses, such as zones of refractive or diffractive change to provide an effective power differential from center to periphery. One limitation of these pseudo-accommodating IOLs is a reduction of intermediate vision. Researchers are attempting to improve this limitation with trifocal pseudo-accommodating IOL designs.[19]

Targeting a specific theory of accommodation based on zonular traction that enlarges the crystalline lens at the equator, scleral procedures may also be viable options for presbyopic patients. These surgical techniques aim to reverse the proximity of the ciliary body to the crystalline lens and allow for more potential zonular tension by essentially loosening the sclera. These changes are achieved through laser ablations to the sclera or implantation of expansion bands into the sclera.[21] Due to a lack of reliable data and long-term studies, these operations are not as widely used.

MANAGING THE PRESBYOPIC PATIENT

Determining the best path forward for the presbyopic patient involves several components. Determining the refractive error, near add power, and best potential acuity is essential. High refractive error may indicate contact lens parameter or surgical limitations. For astigmatic patients, determine whether the astigmatism is entirely corneal or whether there is a lenticular component.

If corneal, the type of astigmatism (with-the-rule, against-the-rule, or oblique) and its distribution across the cornea (central versus limbus-to-limbus) both have implications for which contact lens and surgical options are considered. For instance, a patient who has an irregular cornea will typically require a rigid GP lens and may not be the ideal candidate for multifocal contact lenses.

Ancillary testing such as corneal topography and tomography are integral tools to obtain key measurements that aid in decision-making, which include keratometry, pachymetry, posterior corneal measurements, corneal diameter, pupil size, and angle kappa.

Pupillary constriction is part of the accommodative triad, where a smaller aperture increases depth of focus. In general, senile miosis leads to smaller pupils and decreased dilation with age.[22] Therefore, younger presbyopes may experience a greater effect from miotic pharmaceuticals compared to older presbyopes. Fitting a multifocal lens in front of a larger pupil may offer a greater power spread, but also a greater likelihood of glare and ghosting. In contrast, smaller pupils may have difficulty accessing the entire optical power spread on a multifocal lens.

Alignment of the optics over the visual axis is essential in the success of any multifocal device, be it a contact lens or IOL. The fovea is located slightly temporal, creating a discrepancy between the visual axis, a line directly connecting the object in focus to the fovea, and the pupillary axis, an orthogonal line passing through the physical pupil center.[23] The angle separating these axes is known as angle kappa, and it presents a problem: optimal vision correction may not be achieved if multifocal optics are designed simply to center over the anatomical pupil.

To counter this potential discrepancy, the optics of the lens can be decentered to align with the true visual axis. With scleral lenses specifically, the optic zone may be decentered superiorly and nasally to account for both predicted overall lens decentration and angle kappa.[24] Regarding pinhole-design corneal inlays, intentional decentration is also essential in optimizing each patient's true visual axis for the best results.[25]

Careful evaluation of ocular anatomy and health may help to avoid inappropriate or complicated treatment options. Starting anteriorly, a good candidate for contact lenses would have no significant ocular surface disease and would have a cornea healthy enough to tolerate and withstand regular contact lens wear. If the patient suffers from dry eye or ocular allergies, contact lens wear is not contraindicated, but management of these issues should be addressed.

If multifocal optics are desired, a clear visual axis is crucial. Corneal irregularity or scarring would likely reduce the odds of success, even with a contact lens designed for such irregularity. If a custom lens is required, eyelid position and conjunctival anatomy may increase the complexity of the lens fit and centration, particularly for scleral lenses.

For patients who have maturing cataracts, it may be more prudent to recommend IOL exchange, although out-of-pocket cost may be a factor. Finally, any vitreomacular disorders or diseases that reduce best-corrected acuity must be considered and discussed with the patient.

Besides examination findings, patient history and motivations should be considered. Learning the patient's occupational demands, hobbies, and lifestyle will provide a better understanding of vision demands. Some patients may only seek an occasional reprieve from spectacle wear, while others will go to great lengths and expense to gain full freedom from glasses.

Emmetropic patients or those who have low ametropia may struggle more, both visually and psychologically, with their changing vision, and they often require more education on their options. It is helpful to determine what aspects of the treatment options each patient values most, whether they be optimal vision, comfort, convenience, cost, etc.

As the presbyopic journey unfolds, setting expectations is immensely important and should be completed with care. It is understood by the practitioner that patients may struggle with adaptation to different forms of presbyopic correction. Studies reveal that a significant number of patients who have multifocal IOLs ultimately feel disappointed in their vision and may even request an IOL exchange.[19]

Similarly, patients interested in soft multifocal contact lenses may feel dissatisfied with their vision at certain distances or times of day. Ideally, a positive, yet realistic idea of potential outcomes should be delivered to the patient. Recommendations can be made to the patient, but hopefully they will be empowered to make their own decision that makes sense clinically and affords them the best likelihood of visual success.

CONCLUSION

Presbyopia today is not what it used to be. In this digital age, patients have more near demands than ever, and the frustration caused by their vision limitations will bring them to the examination chair.

Patients are seeking guidance for their ailment, and practitioners have the ability to manage their concerns with more presbyopic treatments than ever before. Assessing the patient, then using that information to understand and effectively communicate the multitude of optical, pharmaceutical, and surgical options currently available, will both drive a successful practice and build patient trust. CLS

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