Choosing the Mode of Presbyopia Correction

For true restoration of accommodation, the pupil dynamics and preoperative wavefront aberration profile must both be taken into account.

BY DAMIEN GATINEL, MD

The demand for presbyopia-correcting procedures increases every year in our practice. This is partially due to demographic factors, as the French population is aging, following the global trend in most developed countries. The median age in France is now close to 40 years, which means that almost half of our country's population is experiencing some level of presbyopia. Another reason for the growth in demand for presbyopia correction is that people of presbyopic age tend to gather and socialize with people of a similar age, who are of course also presbyopes. Word-of-mouth recommendation is, therefore, more likely in this population than in younger patients, for whom myopic or hyperopic refractive errors may not necessarily be a shared condition.

If asked my preference for presbyopia correction, I would say I have no preference other than to choose the mode of correction that I feel is best suited for a specific patient. In general, whenever the crystalline lens is clear and the desired refractive condition (along with the ocular and corneal status) is amenable to excimer laser and/or corneal inlay correction, I would opt for this type of technique and avoid clear lens extraction. This article presents some of my preferences for individual categories of patients, along with insights gleaned over a career of performing refractive surgery.

CORNEA-BASED PROCEDURES

Overview. Corneal procedures are less invasive than lens-based surgery, in my opinion. With corneal approaches, it is possible to fine-tune or enhance the correction shortly afterward or even years later, if needed; in my experience, well-executed LASIK procedures enable flap relifting as late as 15 years after the initial procedure.

Techniques such as LASIK, PRK, and small-aperture corneal inlays do not preclude performing cataract surgery when that becomes necessary. The argument that these procedures will make cataract surgery outcomes less accurate is flawed, because postrefractive-surgery IOL calculation has become more effective with newer-generation formulas and modern interferometry-based biometric techniques. Furthermore, if the refractive outcome after cataract extraction must be corrected, the presence of the LASIK flap interface facilitates the delivery of additional excimer laser ablation to fine-tune the refraction. Below I review several categories of cornea-based correction.

Hyperopic presbyopes. Hyperopic LASIK with slight overcorrection in the nondominant eye works well in hyperopic presbyopic patients. Even noncustomized or non-Q-value–optimized (ie, nonaspheric) hyperopic ablations generally induce some level of corneal multifocality because of the inherent characteristics of positive ablation profiles. These profiles tend to induce more negative spherical aberration than mathematically predicted and can be used to provide both eyes of the same patient with some level of multifocality (ie, slight in the dominant eye and accentuated in the nondominant eye). Ideally, the degree of multifocality and overcorrection should be different for each patient, depending on visual needs.

Presby-LASIK programs. It is interesting to me that some laser manufacturers try to differentiate and position their presby-LASIK–correction protocols with different names and claims of unique concepts, when, in fact, any such multifocal correction relates to the same principle: some increase in the magnitude of negative (or positive) spherical aberration, which provides the eye with multifocality. Although the specifics of these ablation profiles may be proprietary or based on Q-values or aspheric shapes, they are ultimately aimed at inducing some positive spherical aberration (ie, near correction in the midperiphery, distance vision in the center) or negative spherical aberration (ie, near correction in the center, distance in the midperiphery).

The link between multifocality and higher-order aberration (HOA) is usually unstated; this may be due to the fact that inducing specific HOAs is a paradigm that seems in blunt opposition with the goal of cus-

tomized monofocal ablations, which aim at reducing the HOA level to increase the quality of vision. Spherical aberration is not the only aberration that causes effective multifocality; rotationally asymmetric multifocal IOLs such as the Lentis Mplus (Oculentis GmbH) use a combination of coma and trefoil aberrations to induce some near addition power within the entrance pupil zone. These multifocal strategies must offer some level of global spectacle independence and minimize the risks of glare and halos.

Previous RK. Patients who underwent radial keratotomy decades ago have now reached presbyopic age. In my experience, they can benefit from customized or noncustomized hyperopic PRK to reduce—sometimes dramatically—their spectacle dependence, although the results are less predictable in this patient category. Some of the operated eyes retain or exhibit useful multifocality due to the persistence of irregularity at the corneal surface, and these eyes can eventually achieve good UCVA and BCVA.

Myopic presbyopes. Caution is required in myopic presbyopic patients, who are usually more demanding regarding the quality of distance and near vision than hyperopes. In these patients, especially the low myopes, monovision should always be the first alternative to consider, and this should be simulated preoperatively using contact lens trials as part of patient education efforts.

LENS-BASED PROCEDURES

The presence of significant lens opacification should logically orient patient choices toward lens-based surgery. My favorite multifocal IOL platform—since I codesigned its optical profile and characteristics—is the FineVision trifocal diffractive apodized IOL (PhysIOL). The recent trend toward use of computers and electronic tablets for reading makes intermediate vision a legitimate request and not a bonus reserved for patients with specific activities such as playing and reading music.

As with corneal laser corrections, in mild and high myopes, monofocal IOLs should be considered. Patients who were previously emmetropic or hyperopic, who lately can read again without aid due to the development of nuclear cataract and myopic shift (ie, lens refractive index change) are potential candidates for multifocal IOLs. In these patients, monofocal IOLs can be unsatisfactory; although the emmetropic correction brings clear distance vision, patients may feel that their near vision has become blurry again.

TAKE-HOME MESSAGE

- With corneal presbyopia-correcting approaches, it is possible to fine-tune or enhance the correction shortly afterward or even years later, if needed; additionally, they do not preclude performing cataract surgery when that becomes necessary.
- The presence of significant lens opacification should orient patient choices toward lens-based surgery.
- There are no good or bad techniques, but rather good and bad candidates for a specific surgical technique.

A RANGE OF TECHNIQUES

I have tried all the presbyopia-correcting techniques for which I felt confidence in terms of their reproducibility and conceptual mechanisms. I have tended to avoid techniques when I felt that there were too many uncontrolled variables that could interfere with the final result and lower the chances of successful outcomes.

As an example, femtosecond intrastromal relaxing incisions for presbyopia correction (Intracor; Bausch + Lomb Technolas) are not part of my armentarium for presbyopia correction. Even today, the location of the optimum center for these concentric incisions is debated. Furthermore, any intended centration strategy is (a) not easy to achieve and (b) impossible to adjust postoperatively, and any technique based on the biomechanical response of the cornea (eg, radial keratotomy, peripheral corneal collagen shrinking—both currently abandoned techniques) is subject to too many variables, such as intraocular pressure, the viscoelastic properties of the cornea, and the intensity of the wound-healing response.

In contrast, I was an early adopter of the small-aperture corneal inlays (Kamra corneal inlay; AcuFocus, Inc.), as their mechanism—depth of field increase, similar to pinhole cameras—is well-established, and their adjustability and reversibility have been demonstrated.

Within the lens-based technique category, I have not been convinced of the real restoration of some accommodation with accommodating IOLs, and hence I no longer use them in my surgeries. Hopefully, improvements in design and accommodation efficiency may occur and lead to a new and more effective generation of IOLs in the near future.

I believe that there are no good or bad techniques, but rather good and bad candidates for a specific surgical technique. Matching the patient with the right technique is the main condition for the success of any refractive surgery.

LESSONS IN INDICATIONS AND CONTRAINDICATIONS

Several dissatisfied patients have been referred to me after clear lens extraction and implantation with multifocal IOLs. In most of these cases, the poor functional outcome could be explained by the operating surgeon's lack of attention to or ignorance of preoperative contraindications such as uncontrolled corneal astigmatism or undiagnosed optic neuropathy or macular disease. However, in some

of these cases I could not find any good explanation to account for the patient's subjective disappointment; objective refraction and visual acuity testing seemed satisfactory.

These patients had something in common: Preoperatively, they had excellent corrected distance UCVA (20/15 or better) and near BCVA. Instead of experiencing what cataract patients usually gain after surgery—sharpening of contrast and acuity and brightening of colors—these patients, with no visual disturbance other than spectacle dependence, noticed only the side effects of multifocal correction.

The lesson from these cases is that it is difficult to satisfy presbyopic patients with low ametropia levels, clear lenses, and optimal visual performance with spectacle or contact lens correction before surgery.

On the other hand, when a patient shows numerous cortical spokes within the anterior or posterior lens cortex at slit-lamp examination, I predict that the level of scatter present in this eye is probably much worse than it will be after lens extraction and replacement by a diffractive IOL, even if the BCVA is close to or even equal to 20/20. The anarchic scatter and light absorption of the early opacified crystalline lens is significantly more detrimental to distance vision than the organized diffraction and better light transmission provided by a modern diffractive IOL. That is to say, in patients with significant crystalline lens light scatter (in whom low-contrast visual acuity is reduced but maximal-contrast acuity is preserved), the retinal photoreceptors will receive more light after crystalline lens extraction and diffractive IOL implantation than they do preoperatively because of crystalline lens absorption and forward- and back-scatter.

This would explain the success of multifocal IOLs in patients who have what is today labeled *early cataract*, or at least significant light scatter from the crystalline lens preoperatively. This may also explain the failure of even well-executed multifocal cornea-based surgery in such eyes, as the addition of the light dispersion caused by corneal multifocality and lens scatter may make the total amount of scatter excessive.

Quantifying the level of scatter with the HD Analyzer (Visiometrics) can provide the physician with objective evidence of early cataract. The clinician can then propose a multifocal IOL in patients with preserved BCVA but somewhat reduced vision quality. Patients who complain of early scatter (eg, glare, difficulty driving at night) and show obvious loss of transparency in the crystalline lens should be considered good candidates for lens-based surgery.

Patients with poor binocular vision such as low amblyopes are usually discouraged from getting presbyopia-correcting surgery. In these patients, I rather think that monovision correction should be encouraged. I have had satisfactory results with this technique in this type of patient. The weaker, amblyopic eye can be targeted with residual myopic refraction to permit unaided near vision. Contact-lens testing preoperatively is useful when possible to assess the efficiency and the patient's tolerance of this method.

THE IDEAL SURGERY

The ideal presbyopic correction would restore accommodation, rendering elasticity to the human lens and capsule. We are still far from this goal today, despite experimental advances in phaco-ersatz techniques and the recent introduction of laser-assisted cataract surgery.

Before we reach the ideal goal of true restoration of accommodation, there is one significant leap that must become part of any multifocal strategy: The pupil dynamics and preoperative wavefront aberration profile must both be taken into account. Surprisingly, pupil dynamics and the preoperative ocular wavefront characteristics are not considered in current or proposed excimer laser multifocal ablation profiles. There is no universal multifocal algorithm for presbyopia compensation; therefore, one should start by investigating the preoperative wavefront profile and related pupil conditions. Some patients exhibit a natural level of multifocality preoperatively. A degree of innate negative spherical aberration due to a highly prolate cornea would tend to facilitate near vision by making the eye's refraction more myopic with pupil constriction. In such an eye, less multifocality should be induced than in another eye that has a lower degree of innate multifocality.

The pupil dynamic is another key factor that is ignored; it not only controls the amount of light admitted into the eye under a given illumination condition, but it also governs which parts of the corneal surface (or IOL) refract light effectively. The diameter of the pupil varies between distance/dim-light and near/bright-light conditions, and the amplitude and characteristics (center shift) of pupil size variations differ widely among patients. With colleagues, I have been doing some theoretical calculations, and we have developed patented algorithms that will allow design and optimization of multifocal correction, based not only on the patient's visual needs but also on pupil dynamics and preoperative wavefront characteristics. Simply put, this algorithm allows one to determine the optimum cocktail of HOAs for specific pupil dynamics, in order to induce the desired multifocal effect and preserve distance vision. I hope that these theoretical considerations will be incorporated soon into real presbyopic refractive multifocal corrections. ■

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