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Presbyopia Surgery

Decision Making, Particularly in Patients Who Have Previously Undergone Refractive Surgery

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Presbyopia correction is considered by many to be the "holy grail" of modern ophthalmology. Several techniques have been developed to overcome the inevitable decline of accommodative capability in the population that has reached the age of 40 years.

The rate of decline in "near" visual capability is faster than in 100 other human biological functions on a statistically significant basis. In particular, the accommodative amplitude diminishes 1.5 to 2 times faster than the bone fracture threshold, the concentration of striate myelin, or the regenerative power of damaged DNA.[1] Given the previous statement, it is certain that the majority of the population will eventually need visual aid to cope with near-vision difficulties, and a high percentage will require surgical intervention to enjoy spectacle independence.

As discussed in earlier chapters in this section, many different techniques have been proposed to overcome this accommodative decline, such as techniques that address the cornea, the sclera, and the crystalline lens. The aim of these techniques is to correct presbyopia in either in a static manner, by extending depth of focus (DOF) and providing pseudoaccommodation (eg, by monovision or multifocality), or in a dynamic manner (pseudophakic accommodation) using A-IOLs or other procedures that aim to partially restore natural accommodation. Presumably, dynamic pupil size reductions and small lens oscillations might also play a role in further extending DOF.

A number of parameters should be taken under consideration when choosing a presbyopia-correcting technique for a given patient. The patient's individuality and needs should be analyzed thoroughly to ensure successful treatment and, most importantly, patient satisfaction. The equation (suitable technique = patient satisfaction) becomes more complex when dealing with patients who have previously undergone refractive surgery. Successful solution of this equation requires that time be spent with the patient before any surgery to fully understand his or her needs and, of course, deep knowledge of the currently available surgical techniques and visual performance evaluation methods.

Static Presbyopia Correction

Monovision

As discussed in Chapter 16, the concept of monovision, in which the dominant eye is corrected for far vision while the nondominant eye is corrected for near vision, represents the earliest surgical attempt to overcome the problem of presbyopia. Monovision

Pallikaris IG, Plainis S, Charman WN.
Presbyopia: Origins, Effects, and Treatment (pp. 239-244).

can be achieved either by corneal refractive surgery (LASIK monovision[2]) or by monofocal IOL implantation.[3] Optimized ablations have been performed recently, combining the concept of micro-monovision with the induction of aberrations that can increase DOF, resulting in a satisfactory visual result at all distances (see Chapters 21 and 22).[4,5]

To include monovision as a method of choice when correcting presbyopia, a preoperative spectacle or contact lenses trial should be implemented to ensure the patient can tolerate the anisometropia that will be deliberately created. It is preferable to carry out the trial with contact lenses and to extend the period of wear to a couple of days so that patients can properly assess the adequacy of monovision for meeting their visual needs. The success rate in pseudophakic patients is high overall, varying from 64% to 100%.[6]

The main limitations of the monovision technique relate to reduced stereopsis due to anisometropia, problems related to blurred vision during night driving, and the lack of a third focal length for vision at intermediate distances (eg, with computer screens). Occupational factors should also be taken under consideration. Monovision could cause a binocular vision anomaly to decompensate; therefore, the preoperative screening should include an assessment of orthoptic function. Myopes usually tolerate monovision more easily than hyperopes.

The ideal candidates for monovision correction are low myopes in their fifth decade of life who experience presbyopia but at the same time, due to their underlying refractive error, retain some degree of useful near visual ability.

A recent study[7] has concluded that, with induced anisometropia of -1.50 or -2.00 D, a functional binocular visual acuity in all distances is provided. However, because stereovision with -2.00 D or more of anisometropia is substantially impaired, approximately -1.50 D can be considered to be ideal for a successful outcome.

In general, monovision is a well-tolerated technique for most patient groups. A careful preoperative screening should rule out patients who cannot tolerate monovision after clinical trial, professional drivers or other professionals whose work requires excellent stereopsis, and patients with orthoptic problems.

Multifocality

Currently, the creation of multifocality is the most popular surgical treatment for the management of presbyopia. The concept of multifocality implies the sharing of light between several focus points that can be found in different distances (ie, far, near, and sometimes intermediate). Multifocality can be created at the level of the cornea by performing multifocal LASIK ablations (see Chapters 21 and 22), through CK and other collagen modification techniques (such as INTRACOR; see Chapter 24), or at the level of the lens by multifocal, refractive, and diffractive IOL implantation (see Chapter 18).

PresbyLASIK[8] uses 3 different ablation profiles and, by inducing multifocality of the cornea, achieves simultaneous distance and near vision restoration. It is an alternative method of presbyopia correction for those patients who do not want to submit themselves to the risks of an intraocular surgery. PresbyLASIK is ideal for low to moderate presbyopia and ametropia varying between +4.00 and -4.00 D.

Conductive keratoplasty,[9] laser thermal keratoplasty (with Holmium:YAG laser),[10] and intrastromal femtosecond laser-based procedure (INTRACOR)[11] can also be applied to treat presbyopia. The target group of patients for these procedures is presbyopic emmetropes or patients with low hyperopia and low hyperopic astigmatism. Dominant-eye determination preoperatively is of extreme importance because failure to identify this eye might result in dominant, instead of nondominant, eye treatment and patient dissatisfaction. Patients with severe dry eye or other ocular surface problems should be excluded, and an ultrasound pachymetry measurement of at least 550 μm is an essential precondition. Patients must be informed in detail about the probability of astigmatism induction and regression of the result, especially before CK is performed and before deciding to proceed.[12]

Multifocal IOL implantation is another treatment option, resulting in satisfactory vision, for both distant and near, without the use of spectacles.[13] Every multifocal IOL provides at least 2 dioptric powers, usually separated by a 4.00-D interval to provide a 3.00-D interval at the spectacle plane, with 2 images of the same object forming on the retina. The defocused image causes a loss in contrast of the focused image, thus reducing modulation.[14,15] Patient selection must be meticulous because multifocal lenses always result in reduced contrast sensitivity and may also cause dysphotopic phenomena such as glare, halo, and problematic night vision. Professional drivers or patients with high corneal astigmatism must be discouraged. High hyperopes might face difficulties due

to large positive angle kappa values[16] that can create multifocal intolerance. Intraocular lens power calculations should be extremely accurate to ensure an optimal result. Clinical entities such as glaucoma, diabetic retinopathy, and age-related macular degeneration are direct contraindications. Finally, patients who are to receive multifocal IOLs must be made aware that neuroadaptation to the newly created visual conditions might take up to 6 months and that, during those months, they have to be patient, as their vision will be temporarily problematic. Recently, a modified monovision approach has been preferred for those patients who experience difficulties with bilateral implantation of multifocal IOLs. The multifocal IOL in the dominant eye is replaced by a monofocal IOL, and the multifocal IOL is retained in the nondominant eye. Despite the difficulties in adaptation, multifocal IOLs provide an excellent option for low myopes or hyperopes with low-grade cataracts.

Dynamic Presbyopia Correction (Pseudophakic Accommodation)

The more ambitious approaches for the management of presbyopia include the restoration of accommodation capability through such methods as scleral bands or by A-IOL implantation (see Chapters 19, 26, and 27).

Scleral expansion bands insertion aims to restore the normal function of the ciliary muscle, thus facilitating accommodation.[17] This technique is considered rather invasive and, unfortunately, the accommodative results are unpredictable or nonexistent; therefore, it is not widely practiced.

Accommodative IOLs attempt to offer to patients satisfactory near vision by restoring, to some degree, a dynamic component of the ocular ability for near vision. Several A-IOL designs are available, but they all attempt to take advantage of the continuing activity of the ciliary muscle to change the axial position or power of the implanted lens, thus facilitating near vision and providing some degree of "pseudophakic accommodative" capability.[18]

The target group for A-IOL implantation coincides with the multifocal IOL group. Accommodative IOLs should provide improved intermediate vision and fewer disturbances during night driving when the pupil diameter is large. However, any initial active accommodation offered by the A-IOL might decline with capsular fibrosis. Postoperative patient training is important for the achievement of the maximum degree of pseudophakic accommodation. Although, at best, only limited success has been achieved with current designs of the A-IOL, the hope is that further improvements will lead to high-quality, spectacle-independent, near vision.

Newer Presbyopia-Correcting Techniques

Corneal Inlays

Implantation of corneal inlays (see Chapter 23) is a fast-developing technique for the management of presbyopia. The optical concept is modified monovision, with the nondominant eye yielding near vision through a multifocal or stenopaic approach. Certain advantages, such as the minimally invasive and reversible nature of the procedure and the easy learning curve, have increased the popularity of inlay implantation. A unilateral insertion of the inlay in the nondominant eye can be microkeratome-assisted[19,20] or femtosecond-laser assisted.[21,22]

Three different types of inlays with similar mechanisms of action are currently available.

1. The Flexivue Microlens (Presbia, Los Angeles, CA) is a small transparent hydrophilic lens that acts by changing the refractive index of the central cornea.
2. The KAMRA (AcuFocus, Inc, Irvine, CA) is a small-diameter diaphragm with a central hole that has a stenopaic effect.
3. The Vue+ (Revision Optics, Lake Forest, CA) is a small hydrogel inlay, which changes the anterior curvature of the central cornea. The selected inlay is placed in the nondominant eye.

Ideal candidates for inlay implantation are emmetropic presbyopes with normal, everyday expectations. This technique is suitable for postrefractive surgery patients as well, and its reversibility makes it an easier suggestion to patients, as removal is an option in cases of dissatisfaction. Corneal clarity and absence of corneal dystrophies are, of course, essential elements to be taken into consideration in the decision-making process. The presence of cataract is usually a contraindication. Patients should be informed in detail about the possible need for inlay exchange (higher power needed) in the future, as the residual natural accommodative amplitude declines with time.

Other Methods

The concepts of lens refilling and femtosecond-laser photodisruption of the crystalline lens (see Chapters 27 and 28) are currently under investigation and have not yet been fully validated or introduced in everyday clinical practice. If further work proves that these methods are viable in humans, it may be that patients willing to experience the benefits and possible drawbacks and complications of a newly introduced technology could be considered as candidates for these procedures.

Lens Refilling

The concept of lens refilling is based on the principle that an injectable material could replace the crystalline lens after lens removal, simulating the properties of the lens itself and allowing accommodative capability in the presence of capsular and zonular integrity and ciliary muscle function. The presence of cataract is a prerequisite for patients who, in the near future, will undergo this kind of innovative procedure, which is showing promising results in preliminary studies in animal models.[23]

Femtosecond Laser Photodisruption

The idea of renewal of the crystalline lens through laser photodisruption has been under investigation[24] for quite a while. The arrival of the femtosecond laser era has provided new options in the effort for accommodation restoration. The initial clinical studies included patients presenting the following criteria: (1) age between 45 and 60 years, (2) previously electing to undergo refractive cataract surgery, (3) corrected distance visual acuity (CDVA) of 20/40 or better, and (4) a cataract assessed at no greater than grade 2. For safety reasons, only one eye was treated. The results of these studies have, so far, been disappointing, with no evidence for any real improvement in amplitude of accommodation (see Chapter 27). Although cataract formation after treatment was not an issue in animal models,[25] the risk of possible cataract formation must be explained to any future patients prior to surgery.

Postrefractive Surgery Patients—Considerations

Postrefractive surgery patients comprise a group that requires special attention. In this group, patients were already motivated to be spectacle-independent, and they are not willing to compromise and start using near visual aids after they reach presbyopic age. A variety of techniques can be successfully applied to postrefractive surgery patients at the level of the cornea or at the level of the crystalline lens.

Cornea-related techniques include CK and corneal inlays implantation. A study by Tomita et al[26] demonstrated that CK is an equally safe and effective technique for nonLASIK and postLASIK patients. Studies conducted by Pallikaris[21] and Yilmaz et al[19] have proven that both Flexivue Microlens and AcuFocus ACI-7000 (currently named Kamra) intracorneal inlays can be implanted in postLASIK patients without any intra- or postoperative complications.

Monofocal IOLs using the monovision approach and multifocal and accommodative IOLs can be implanted in postrefractive surgery patients. A difficulty that surgeons must face when dealing with such patients is accurate IOL power calculation. Intraocular lens power for cataract surgery in a patient who has had prior refractive surgery remains challenging. Several issues contribute to miscalculations of IOLs after refractive surgery.[27] The most important factors are the induced alterations in anterior and posterior corneal curvature and the effective index of refraction. These factors could lead to miscalculations of IOL measurements. Several indirect (clinical history method, contact lens overrefraction, intraoperative autorefraction, and vertexed IOL power method) and direct (linear-regression models) methods of keratometric power estimation after refractive surgery have been developed to overcome this drawback. Light-adjustable IOLs (see Chapter 9) may be helpful in this context in the future, by allowing IOL power to be corrected postoperatively.

Nomogram

General guidelines that can be followed include the following:

- For patients aged 40 to 45 years, CK, LASIK monovision, or presbyLASIK are considered the appropriate approaches.
- For emmetropes aged 45 to 60 years, corneal inlays and INTRACOR are ideal solutions.
- Low myopes and hyperopes aged 45 to 55 years can be treated by CK, LASIK monovision, or presbyLASIK.

- Myopes and hyperopes older than 55 years are better managed through refractive lens exchange and monovision with multifocal or accommodative IOL implantation.
- Patients older than age 60 years should undergo refractive lens exchange, regardless of their underlying refractive error.

SUMMARY

The development of new, constantly improving, sophisticated techniques for the management of presbyopia offers patients the opportunity of leading a spectacle-free life. As technology is evolving, so are patients' needs. Today's patients are motivated for spectacle-independence to improve their quality of life, and most of them are already informed about the available surgical options. Deciding on the best-available solution for each patient requires the formation of an algorithm based on individual patient parameters such as occupation, age, gender, personality, lifestyle, and the type and degree of the initial ametropia. By following certain rules and adopting an algorithm suitable for any given patient, surgeons will have the ability to provide a customized treatment that will optimize the final result. Careful review of all the parameters and selection of the most appropriate technique, especially in patients who have previously undergone refractive surgery, will bring a satisfactory outcome that meets patients' needs and expectations.

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