Cataract Surgery—Considerations When Planning Monovision

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Several pseudophakic options are available to surgeons who would like to offer a solution to their patients' presbyopia. These include spectacles combined with monofocal intraocular lenses (IOLs), multifocal IOLs, accommodating IOL's, and monovision.

Many surgeons attempt to custom fit a particular solution to an individual patient depending on factors such as his or her lifestyle, personality, and occupation. The approach recommended here is based on the authors experience and as such is believed to provide the greatest likelihood of success as defined by patients' satisfaction, with the least amount of compromise in their quality of vision. Despite many technological advances, modest monovision remains an excellent choice. It can be offered in the form of corrective laser surgery for phakic patients, but is most often performed as pseudophakic monovision in patients undergoing cataract surgery or in older patients with significant hyperopia undergoing refractive lens exchange.

Traditional Monovision Versus Modest Monovision

Monovision in pseudophakia is a term used to describe the intentional correction for distance vision or emmetropia in one eye and myopic defocus in the fellow eye for near. The term monovision encompasses a wide range of myopic defocus in the near eye and the terminology can be confusing. The term *mini monovision* may be used when the anisometropia is set at 0.75 D to 1.00 D; *modest monovision* at 1.25 D to 1.50 D; and *traditional monovision* at 1.75 D to 2.50 D. When even smaller amounts of myopic defocus such as −0.5D or less are targeted in one eye then the term *Micro monovision* would be appropriate.

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Neurophysiology

The neurophysiology between the different levels of anisometropia is distinctive and whilst monovision is a suitable term for traditional Monovision, *Blended Vision* may be a better term for lower levels of anisometropia where binocular vision is retained with an increase in binocular depth of focus and decreased spectacle independence.

Monovision in pseudophakia was traditionally aimed at achieving emmetropia in the dominant eye but creating a myopic defocus for near vision in the non-dominant eye. Interocular suppression of the blurred image in this scenario is dependent on higher cortical function. The neurophysiology, however is quite distinctive between *traditional monovision*, where the level of myopia in the eye targeted for near vision is in the range of −2.00 D, and *modest monovision*, where the targeted degree of myopia is −1.25 D. −2 D myopic defocus in the near eye provides excellent unaided near vision and in a study published by Ito and Shimizu in 2009 provided better reading ability than refractive mutifocal IOLs [1]. The authors however, cautioned that careful patient selection was required with specific attention to issues of ocular dominance.

Contact lens studies have demonstrated that contrast sensitivity may be reduced with monovision. [2] With binocular viewing, the reduction in contrast for near increases as the myopic defocus approaches 2.0 dioptres and then improves again with higher levels. We can therefore minimize the reduction in contrast by limiting the myopic defocus to −1.5 dioptres.

A significant reduction of Titmus Stereoacuity test is evident in patients who have undergone refractive surgery and can be demonstrated at levels of anisometropia 2.00 dioptres and greater [3]. Once again this suggests that exceeding −1.5 dioptres of myopic defocus in the near eye should only be considered cautiously in patients considering monovision in pseudophakia. It is valuable to routinely assess stereocuity in patients with modest monovision and found that the impact is minor, 67 s (Modest Monovision) versus 63 s (Distance Vision Both eyes) of arc as long as the anisometropia is less than 1.5 Diopters.

Strong ocular dominance or rivalry may result in asthenopia, particularly when the anisometropia is greater than 2.0 D [4]. Strong rivalry may be problematic in monovision and once again we should limit the myopic defocus unless a patient has been a successful contact lens wearer at this level of monovision prior to cataract surgery to avoid this problem. Although total spectacle independence is less frequent with a lower level of myopia, limiting the anisometropia to approximately −1.25 D reduces the likelihood of a reduction in binocular contrast sensitivity, asthenopia, and loss of stereoacuity that can occur with higher levels of anisometropia. A clinical experimental study by Naeser et al. [5] suggested that −0.25 and −1.25 D pseudophakic monovision may be the optimal choice to provide spectacle independence and provided an extended range of clear vision for with the least compromise for binocular visual functions.

Neuroadapation is a term used to describe the period often required for patients to adapt to the nature of their vision and for the perception of dysphotosia to diminish after cataract surgery with multifocal implants. This phenomenon is less evident after modest monovision. The majority of patients hadapt within one week and problems in this respect are extremely rare. The reasons for the rapid adjustment to the nature of modest monovision is that the images are spatially congruent and therefore binocular fusion can occur which is more physiological than the monoptic suppression which is required to deal with the conflicting images which are inherent with multifocal vision.

Optics and IOLs

Spectacles

Monofocal intraocular lens implants provide a single plane of focus. If emmetropia is achieved for distance in both eyes, reading glasses with an add power ranging from two to three dioptres will be required for near vision after surgery. If we look critically at the quality of vision achieved with spectacles whether in the form of progressive, bifocal or separate reading glasses, they do provide excellent acuity with high contrast sensitivity, perfect stereo-acuity and do not create significant dysphotopsia or unwanted optical images. These patients, however, are functionally dependent on optical aides. Published data on the expectations of patients prior to cataract surgery suggests a paradox [6]. The vast majority do expect to wear reading glasses but a similar proportion rate spectacle independence as being very important following cataract surgery.

Multifocal Intraocular Lenses

One of the most widely practiced strategies to provide unaided distance and near vision following cataract surgery is the use of multifocal implants. These implants are based on diffractive or refractive optics that provide more than one focal plane. The optical principle is to provide simultaneous focus for near and distance vision. Central cortical processing allows most individuals to ignore the blurred image and concentrate on the image of regard. The superimposition of the defocused image, however, results in reduced contrast sensitivity compared to monofocal IOLs. A review of the literature comparing the results of multifocal IOLs [7] confirmed reduced contrast sensitivity as well as associated dysphotopsia, such as haloes, particularly when driving at night. Multifocal IOLs perform well in visual tasks when involving high contrast targets in photopic conditions such as the measurement of Snellen visual acuity but Intermediate acuity is deficient with earlier generations of bifocal multifocal IOLs. Redistribution of light energy from the near focus to the intermediate range has largely addressed this issue with trifocal

multifocal IOLs. Trifocal IOLs are reported to be associated with fewer halos, less glare, and less loss of light energy to higher orders of diffraction than earlier bifocal multifocal designs. They therefore provide good Snellen acuity and Stereo-acuity but the modulation transfer function remains impaired and, together with dysphotopsia, remain important compromises compared to spectacles for near vision.

Accommodative Intraocular Lenses

An alternative to multifocal implants is accommodative intraocular lenses. These include lenses with hinged and anteriorly vaulted haptics as well as dual optic implants which have a greater potential for accommodation. In theory, these lenses would be an attractive alternative to multifocal implants as they do not have the same adverse effects on contrast sensitivity and incidence of dysphotopsia. The efficacy of this type of lens however is questionable. A comprehensive review [8] concluded that published objective data showed limited forward translation with accommodative lenses and that convincing psycho visual data demonstrating efficacy was lacking. Furthermore, the fixation characteristics and PCO prevention of many current accommodative lens designs has proved to be less predictable than conventional IOLs.

Monofocal IOLs

The defocus curve for a monofocal lens has a single focus for distance and provides reasonable intermediate acuity but inadequate unaided near vision. A diffractive mutifocal implant, in contrast, has two peaks providing good vision for distance and near, but lacks intermediate acuity. Monovision provides an additional focus for near in the second eye and the combined through focus curve is not dissimilar to the normal accommodative response.

In the absence of a true accommodating IOL, IOL monovision remains the preferred choice for many surgeons in the management of presbyopia among the cataract population. Annual ASCRS clinical surveys [9] indicate that IOL monovision is the number one modality for the management of presbyopia in cataract surgery. A recent thought-provoking article published in Eyeworld 2021 “What IOL would you Choose?” [10] discussed the results of a 29-question survey submitted to ophthalmic surgeons on which IOL they would select for themselves if they personally required cataract surgery. Despite the many articles on multifocal implants in the literature and high profile in meetings and new journals, the vast majority (93%) of respondents reported that quality was the most important criteria for their eye surgery. A monofocal (34.5%) intraocular lens was the IOL selected by the majority of surgeons for their own surgery followed by monovision (26.8%) as a close second. Although 67% of the respondents indicated they regularly used presbyopia correcting IOLs, only half of these respondents would have selected a presbyopia correcting IOL for themselves.

Extended Depth of Focus IOLs

The term Extended Depth of Focus (EDoF) was first coined by this author in 2012 to describe a modified monofocal lens design that utilised 4th and 6th order positive spherical aberration to extend the depth of focus whilst maintaining optical quality [11]. Positive spherical aberration (SA) and myopic defocus interact in a synergistic fashion such that the combined modulation transfer function (MTF) is enhanced. In addition, when combined with modest monovision of −1.25 D the defocus curves of the distant and near eye have a greater overlap maintaining the features of binocular vision and as well as providing greater near acuity for the same level of myopic defocus.

In recent years the term "extended depth of focus" has been applied to several IOLs based on different optical principles such as negative SA, low add diffractive bifocal and trifocal IOLs, and phase shift technology. The term therefore does not describe a homogeneous group of IOL models and features such as the presence or absence of dysphotopsia depends on the optical principles. In addition, not all of these IOLs are well suited for use in combination with myopic defocus as in monovision. Depending on the optical technology even minor myopic defocus can increase unwanted images or compromise MTF.

History

Monovision as a method of prescribing optical aids was first proposed in 1958 by Richard Westsmith, MD [12], and has been widely practiced with contact lenses since the 1960's with success in approximately 80% of cases [13]. Typically, two dioptres of induced myopia in the non-dominant eye is employed by practitioners who practice monovision with contact lens correction. From the contact lens literature, monovision presents several potential problems. Patients with high ocular dominance are often not able to fully suppress the blurred image. In particular high contrast, high frequency images proved to be troublesome particularly in low illumination. Finally there may be interference with monocular function and reduced stereo acuity.

Monovision is also widely practiced in patients undergoing refractive surgery. Generally, patients 40 years or older undergoing LASIK are offered monovision as an alternative to having both eyes corrected for distance. The experience of the author concurs with the results published in the literature which suggests that patients are highly satisfied with monovision correction after LASIK in the presbyopic age group [14]. Interestingly, the data suggests that patients corrected for distance in both eyes were equally happy to those who selected monovision emphasizing the importance of counseling patients and involving them in deciding what form of correction is most important.

Monovision can be an effective solution for unaided near vision for pseudophakic patients. Surprisingly there is a paucity of published studies in the

literature but what is available demonstrates a very high success rate. In a study published by Greenbaum [15], 92% of patients achieved 20/30 and J1 unaided acuity with a 90% acceptance rate. This raises the question whether modifying the degree of intended myopia in monovision for pseudophakia could increase patients' satisfaction and the overall acceptance rate. As indicated previously, visual acuity testing with high contrast targets such as Snellen acuity is insufficient to explain patient satisfaction, so more information is required to identify the limitations and recommend which patients are eligible for monovision as a strategy in cataract surgery.

Required Myopic Defocus for Monovision in Pseudophakia:

We have all been surprised to encounter patients in the waiting room who have had bilateral monofocal intraocular lens implants and have excellent unaided distance acuity, quite happily reading the newspaper without glasses after cataract surgery. This observation piqued significant interest and when looking at the refractive outcome in a series of such patients to identify what degree of myopic defocus was required for adequate near vision. In this audit unaided near and distance acuity as well as the spherical equivalent refractive error was recorded. This study was performed approximately 20 years ago so this group of patients was intended to be emmetropic targeted with a minimal amount of residual myopia to assist with near vision. The mean spherical equivalent of myopia of this group of patients was −0.38 dioptres with the majority of patients clustered between 0 and −0.50 dioptres. This minor level of myopia provided excellent unaided distance acuity typically 20/20 or 20/25 which was expected but the unaided near vision N10 (J6) or decimal 0.33 to 0.4, which is the print size of novels and magazines was surprising.

Examination of the patients who ended up more myopic at −1.00 dioptres revealed that distance acuity was reduced to 20/30 or 20/40 but the unaided near vision improved to N5(J2) or 0.67 equivalent to the smallest type in general use. The results suggested that pseudo-accommodation with monofocal implants does exist and −1.00 to −1.50 dioptres of myopia should be sufficient for the majority of near vision tasks. Binocular summation is also a feature of monovision correction, in that near acuity improved by approximately one line with binocular compared to monocular testing. These results proved helpful in planning a strategy to avoid the limitations of traditional monovision which usually aims at a myopic defocus of −2.00 dioptres in the non-dominant eye.

In order to evaluate the strategy of modified monovision in more detail Barett and Finkelman conducted a prospective study on monovision in pseudophakia [16]. In this study the first eye was targeted for emmetropia and if achieved, the second eye had a target refraction of −1.25 dioptres. The important outcomes measured included the unaided near and distance acuity, spherical equivalent refractive error, as well as a modified V14 questionnaire to evaluate the level of spectacle independence and patient satisfaction after surgery. Despite the fact that only 27% achieve total spectacle independence, patients are rarely dissatisfied with their results.

The unaided acuity achieved was encouraging in that 80% of patients achieved N6 (J2) and 100% (J3) or better binocular near acuity. Similarly, the unaided distance acuity was excellent with 80% 20/20 and 100% 20/30 or better unaided binocular distance acuity. The mean spherical equivalent refractive error in the distance eye was −0.19 dioptres and for the near eye −1.36 dioptres.

To assess the need for glasses or contact lenses after surgery, patients were asked to rate their need for contact lenses or glasses after surgery. The scale runs from 0. to 10 where 0 is "I am completely free from glasses or contact lenses" and 10 is "totally dependent on glasses or contact lenses." The average score was 1.3 demonstrating that the vast majority of patients considered themselves spectacle independent. On a similar scale, patients were asked to estimate their satisfaction or dissatisfaction after surgery where 0 is "not satisfied at all" and 10 "very satisfied." An average score of 9.9 indicated that the vast majority of patients were highly satisfied with the refractive outcome.

In a prospective study comparing modest monovision to diffractive multifocal implants performed at Moorfields Eye Hospital in London [17], patients with multifocal IOLs reported a much higher level of total spectacle independence (71%) than those with modest monovision (25%), but 6% of patients in the study required a lens exchange—all in the multifocal group. It is interesting to speculate that one of the reasons for the disassociation of spectacle independence and satisfaction following multifocal implantation is that spectacles typically do not improve reading ability in the absence of significant refractive error**.** In contrast, reading glasses are of assistance to almost all patients with modest monovision for particular visual tasks.

It is possible that surgeons overestimate the importance of total spectacle independence as an index of patients' satisfaction after undergoing cataract surgery. Patients typically rank quality of vision and the avoidance of dysphotopsia as more important than total spectacle independence when judging their satisfaction after cataract surgery.

Incorporating Modest Monovision in Your Practice

Having offered modest monovision to all patients who are suitable for many years, one can therefore. often fail to appreciate that this could be daunting to surgeons who were unfamiliar with this technique. The principles are often not taught in a systematic fashion during training, courses are lacking and industry has not supported education in this area as there has not been a commercial product associated with modest monovision.

The requirements for achieving success with modest monovision include precise planning, skilled phaco surgery and postoperative care. These principles are common to all modern cataract surgery regardless of the type of implant. An unfortunate misconception is that residual astigmatism assists with extending focal range and this is particularly relevant to modest monovision [18, 19].

The best outcomes in terms of spectacle independence with modest monovision is when post op residual astigmatism is within 0.5 D. This is best achieved with Toric IOLs targeting close to zero residual astigmatism both for the emmetropic distance eye and the more myopic eye targeted for monovision. Patient satisfaction is very high but there are inherent limitations and compromises with any presbyopic solution and patients need to be counselled appropriately.

Patient selection is not restricted to the same extent as multifocal IOLs but remains an important consideration. Testing for dominance is not critical with the modest levels of anisometropia suggested for modest monovision when performing cataract surgery but should be considered in the context of clear lens extraction.

Contraindications are few but these must be understood to avoid patient dissatisfaction as well as strategies to address patient dissatisfaction.

Compromises

Perhaps the most important compromise with modest monovision with target of −1.25 D near eye is the occasional need for spectacles.

These are often required for reading small print and this should be clearly explained to patients when discussing the pseudophakic options to address presbyopia. In addition, to near visual tasks, spectacles may occasionally be required for driving, particularly at night. This is less common than the need for reading glasses and is largely dependent on the refractive outcome and acuity in the distance eye.

As mentioned earlier, total spectacle independence at the expense of quality of vision may not be a priority for many patients. There appears to be an increasing awareness of the value of preserving quality of vision, providing excellent unaided distance and intermediate acuity whilst accepting occasional correction for near vision with the popularity of extended depth of focus IOLs.

When considering the refractive target for near, a lens power may not be available for the exact target of −1.25 D as IOLs are often only available in 0.5 D steps. In this scenario one should typically select the next higher lens power e.g. targeting −1.35 D rather than accepting a target of −1.0 D but should also take the patient's expectations into account. Spectacle independence is more likely by targeting the slightly higher target for myopia in the near eye as in this example.

If a patient has worn contact lenses successfully, one should usually consider a slightly higher target of −1.5 D rather than −1.25 D, as they are more likely to be satisfied with the reading provided by this level of myopic defocus.

The strategy of an extended depth of focus IOL designed for modest monovision reduces the compromises associated with modest monovision as it provides additional near acuity for the same level of myopic defocus with less impact on distance acuity and steroacuity.

Patient Selection and Counselling

Attempting to explain to patients the impact of multifocal implants and screen for unsuitable patients is demanding, and not always successful. In contrast, the process is relatively straight forward with modest monovision—if 6/9 or better unaided vision for distance is obtained in the first eye the option of modest monovision can be easily demonstrated to patients with the addition of a +1.25 D spherical lens in the trial frame using their recently operated eye.

Occupation, personality, and refractive error are not critical screening factors in selecting patients suitable for modest monovision. Multifocal IOLs may not be well suited to discriminating individuals such as architects or engineers. These professions, however, are acceptable candidates for modest monovision, as are artists and truck drivers—spectacles can be worn, if necessary, for activities such as night driving, if required.

Minor levels of defocus created by astigmatism, posterior capsular opacification, and macular dysfunction have a limited impact on visual acuity with modest monovision compared with multifocal implants. Modest monovision is therefore a robust optical solution that is impacted less with the decline in macula function and the expected shift to ATR astigmatism that is inevitable with age. Visual acuity can always be improved with addition of spectacles in these circumstances if required.

Testing for Dominance

Tests for ocular dominance prior to cataract surgery can be classified as motor sighting dominance or sensory dominance tests.

A motor sighting test relies on patients' preference for one eye over the other when viewing a target—e.g. the "hole-in-the-card" test or "pointing at a target" test. The latter is the most straightforward test to use in the clinic. Simply ask the patient to point at a letter on the Snellen chart whilst lining up his vison with the pointing fingertip. Then cover each eye in turn and observe which eye the patient is using for this task by observing for fixation changes and asking the patient to observe if the image jump is greater when one or the other eye is covered.

Sensory dominance relies on patient comfort/preference when viewing through a 1.0 D lens with one eye or the other. Short-term viewing has little utility and a contact lens test for a two-week period is more informative. Contact lens testing can also be misleading as limited tolerance to the contact lens may be reported as discomfort unrelated to sensory perception.

More sophisticated testing using synoptophores with stereo-targets or Haidinger brushes can be considered but are not always practical in a clinical setting.

Sighting dominance [20, 21] has also been shown to be ambiguous and cross dominance is not uncommon. Furthermore testing for dominance in the presence of significant cataract can be unreliable so this is longer performed routinely. This is

quite different when considering monovision in the context of refractive surgery in the 5th decade, or in a hyperopic patient considering clear lens extraction. In both of these scenarios dominance should be determined and a contact lens trial recommended.

One of the reasons for preferring modest monovision is that it does not appear that dominance is a critical issue with this level of defocus. Similarly, there was no preference for myopic defocus in the near eye rather than the distance eye (so called cross-dominance) in a clinical study of modest monovision published by Fuxiang Zhang [22].

Contraindications

Disruption of Binocular Fusion

Modest monovision is not an ideal term as indeed binocular function is maintained.

Situations where binocular fusion is absent or functionally impaired should therefore be avoided. These include motility disorders such as tropias, large phorias, monofixation syndrome and convergence insufficiency.

The presence of cataract may be referring physicians or optometrists rather than pre-existing diplopia due to a motility disorder. Monovision should be avoided as the symptoms will still be present and correction with prisms may be more difficult. The presence of dense cataracts may also reduce acuity to the extent that pre-existing diplopia is not noted and only become manifest after cataract surgery.

Screening for motility disorders is therefore important in cataract surgery and monovision avoided in this context. It is always worth checking the existing spectacles for prism and questioning the patient directly, if suspicious.

Extreme monovision, however, with a target of ~ -3.0 D in one eye can be considered as a method to manage intractable diplopia after cataract surgery where surgical alignment is not considered feasible or desirable [23].

Mild phoria is acceptable for monovision, but only if this is not associated with symptoms, and within 10 diopters of exophoria [24].

Modest levels of anisometropia may not be associated with amblyopia or monofixation syndrome but this may be masked in the presence of a dense cataract. Performing surgery initially in the suspect eye typically will reveal if this is a problem. Even when amblyopia is not evident if one eye has historically significantly been more myopic in the order of 2.0 D it is worth maintain this as the more myopic eye for near vision when considering modest monovision and targeting slightly more myopia than usual e.g. −1.50 D.

Monofixation syndrome refers to a small angle deviation with suppression of the deviated eye and the presence of binocular peripheral fusion [25]. The absence of foveal fusion that characterizes monofixation syndrome can occur in strabismic and orthotropic eyes [26]. Patients with monofixation may appear orthophoric, and

diagnosis requires a stereopsis test, 4-diopter base out prism test and/or Worth 4-Dot fusion at a distance of 6 m is required to make the diagnosis. These tests may be difficult to perform in the presence of a dense cataract and poor vision. Questioning the patient about a history of diplopia, patching and avoiding selecting an eye which is reported as always been weaker may be helpful in inadvertently choosing a non-fixating eye for distance. Fixation switch diplopia can occur if monovision is performed and the balance of stable asymptomatic monofixation syndrome is disrupted.

Blowout fractures of the orbit may be associated with entrapment of the muscle. Even when treated surgically downgaze may elicit diplopia even though this may be absent in the primary position of gaze. These patients may therefore may not be suitable candidates for monovision.

In addition to more common phorias and tropias there are several systemic conditions that can involve the ocular muscles and may preclude consideration of monovision. These include Myasthenia Gravis, Graves' Disease and Multiple Sclerosis. Parkinson's disease can impact saccades as well as pursuit and is associated with convergence insufficiency.

Impaired Acuity

Modest monovision requires at least 6/9 unaided acuity in the distance eye and this can easily be determined after cataract surgery if the eye with the denser cataract has surgery performed initially. Reduced acuity due to amblyopia is considered a contraindication to modest monovision.

The vision may be impaired due to co-existing morbidity such as diabetic retinopathy, epiretinal membrane or age-related macular degeneration—these patients are not suitable candidates for monovision.

Glaucoma is not, in itself, a contraindication to modest monovision as long as the visual field is not significantly impaired. Extensive visual field defects due to glaucoma or stroke (including hemianopia) would exclude patients from being suitable for monovision.

The unaided acuity may be 6/12 or less due to an unintended refractive outcome in the first eye intended for distance vision and the majority of these patients will prefer to be targeted for distance in their second eye. Others, however, may find their distance vision quite adequate despite a small unintended residual myopia of ~ -0.5 D. They may desire more near vision and therefore be suitable for modest monovision.

Poor Comprehension

The most common situation where modest monovision should be avoided is circumstances where the patient may not fully understand the nature of the compromise involved. Situations where this may occur include dementia, language difficulties or simple lack of comprehension. These patients are likely not to recall why one eye is more blurred for distance and the other for near when each eye is occluded in turn.

Management of Dissatisfied Patients

Despite the contraindications listed for monovision, these are not frequently encountered and indeed are common to other presbyopia correcting IOLs such as multifocals. Although extremely uncommon, like any presbyopic solution there may be dissatisfied patients. In a period spanning two decades of monovision, the author has encountered only three cases where the decision had to be reversed.

(1) The First Case had bilateral cataract surgery performed elsewhere with an unexpected refractive outcome in the second eye. The refraction in the first eye (OD) was +0.05/−0.25 × 84° and in the second eye (OS) −3.50/−0.50 × 243°. Lasik was performed in the more myopic eye aiming for emmetropia and ended up with a satisfied and grateful patient with refraction of −0.25 sphere and unaided acuity of 6/5.
(2) The second case referred was a high myope with a preoperative refraction of −14.25 spherical equivalent in both eyes. Despite ending up close to emmetropia in the dominant right eye (0.00/−0.50 × 26°) the patient never felt quite comfortable with the myopia in the second eye (−2.25/−1.75 × 155°). The patient had a dry eye and so the level of myopia in the myopic eye was reduced with PRK, eliminating the astigmatism with a final correction of −1.25 D. This proved to be sufficient for near vision and the patient was very happy with the outcome.
(3) The last case was a 42-year-old patient in whom Lasik was performed aiming for −1.00 in the non-dominant eye. This patient was slightly under corrected ending up more myopic than intended with −1.50 sphere in the non-dominant eye (OS). Her major problem, however, was distance acuity in the dominant eye which also ended more myopic than intended with −0.50/−0.50 × 230. The more myopic eye was re-treated aiming for emmetropia leaving the minor level of myopia in dominant eye to assist with near vision. Once again, the patient was very satisfied with the final result.

There are valuable lessons to be learned from each of these patients in regard to modest monovision.

The first case reinforced how important it is for the outcome of any presbyopic correction to meet or exceed patients' expectations. The second case is an example where anisometropia more than 2 diopters was problematic but reducing the level to −1.25 D proved to be successful. The final case is relevant to all presbyopic solutions and illustrates how the importance of achieving excellent unaided distance acuity in determining patient satisfaction. If modest monovision is targeted it is extremely rare to encounter dissatisfied patients and the examples illustrate the relative ease with which problems can be resolved.

Monovision is reversible with spectacle correction and patients understand these can be utilised at any time they feel necessary if they have trouble with small print or driving at night. In the rare instance where modest monovision is not adequately tolerated the refractive status can be reversed with laser correction as illustrated in these cases or alternatively with a piggyback IOL.

Surgeons who are often unaccustomed to using monovision in their practice are often uncertain as the best way to incorporate the solution in their practice. Many surgeons such as Zhang who practice monovision attempt to vary the myopic defocus according to the patient's hobbies, lifestyle or occupation [27]. Maloney suggested an approach where he classified functional vision into different zones and discusses with patients their preference in relation to these zones to help determine lens power selection and the degree of intended monovision [28]. Zone 1 consists of activities requiring small print whilst zone 5 emphasizes distance acuity with low illumination with recommendations of −2.00 dioptres for zone 1, −1 dioptres for zone 2 and −0.50 for zone 3.

This author's preference however is based on the principle that a monofocal lens provides additional depth of focus, −1.25 dioptres of myopic defocus is well tolerated for monovision and satisfies near vision requirements in the majority patients. The reality is that the expected outcome may vary from −1 to −1.50 D and this range is still likely to provide a useful range of intermediate and near vision.

If a patient is accustomed to monovision with contact lenses prior to cataract surgery then the targeted myopic defocus can be increased to −1.5 D. A slightly higher target level of myopic defocus of −1.5 D should also be considered for patients who were able to read unaided prior to cataract surgery due to longstanding myopia.

Surgeons planning pseudophakic monovision require accurate IOL power calculation methods that can be applied to both the distance eye and the near eye. Earlier studies have suggested that targeting a myopic outcome may be less accurate and we confirmed this in a recent study that demonstrated that reduced refractive accuracy can be anticipated to some extent when targeting a low level of myopia typical for monovision. The accuracy of prediction for myopic targets in our study varied with different formulae. The Barrett Universal II, Hill-RBF 2.0, and Holladay I formulas were the least affected by this phenomenon, but the Holladay I was less accurate overall for both distance and near eyes in this study [29].

The results of the study suggested that when planning a myopic outcome, cataract surgeons should use the Haigis, SRK/T, and Hoffer Q formulas with caution. The Barrett Universal II and Hill-RBF 2.0, however, offered a reliable option for a patient desiring a refractive outcome of myopia in one eye for monovision.

The approach is relatively simple and can be condensed to the "ABCDs of Monovision."

Address the Alternatives

First, address the alternatives. Tell patients that a monofocal implant provides the best quality of vision but requires reading glasses. Explain that a multifocal lens can provide spectacle independence but at the expense of contrast sensitivity and possibly with the induction of glare and halos. Conclude by saying that the outcome with accommodating lenses remains relatively unpredictable.

Broach Monovision

Then speak in further detail about the possibility of monovision and explain that optimal quality of vision can be obtained at any time, with spectacle correction. Although intermediate acuity is excellent, explain that typically some correction will be required for the sustained reading of small print. Caution patients that the option of modest monovision does require achieving excellent unaided distance acuity in the first eye.

Choose Distance

One should almost always operate on the eye with the denser cataract first and target emmetropia. Although correcting the dominant eye for distance is favourable, particularly for a refractive lens exchange, this is not a major issue for cataract patients. If a patient has the denser cataract in an eye that has always been significantly more myopic then one should still operate on this eye first but alter the routine and target myopic defocus, rather than alter the relative anisometropia to which the patient has become accustomed.

Demonstrate Defocus

If the first eye achieves at least 20/30 unaided visual acuity, one should then demonstrate the amount of myopic defocus with a +1.25 D lens and a trial frame. This is so that patients can appreciate the impact of the targeted myopia on their distance acuity as well as the level of near vision that they will achieve. In practice, more than 50% of patients elect to have modest monovision.

Conclusion

Modest monovision continues to be an attractive solution to presbyopia and should be considered a "premium" solution. It requires expert surgery and biometry, knowledgeable selection of IOLs, and the utilization of toric implants to reduce astigmatism. The popularity of the technique is increasing, and future complementary options include the concept of a monofocal IOL with an extended depth of focus. Together with a modest level of monovision, this technology could increase the level of spectacle independence while retaining the blended or binocular nature of modest monovision with less impact on stereoacuity.

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