CHAPTER 12

PRESBYOPIA

Presbyopia (from the Greek *presbys*, literally meaning "old man" and *ops*, meaning "sight") is a refractive condition, in which the accommodative ability of the eye is insufficient for near vision work due to ageing [120]. This is due to hardening of the lens and a reduction of the elastic capsule. This condition usually occurs when the amplitude of accommodation has decreased to below 4D, generally between the ages of 42 to 48 in people living in Europe and North America. People living in hot climates become presbyopic sooner [138].

Options for contact lens correction of presbyopia include the following:

- Single-vision contact lenses worn in combination with reading glasses
- Monovision, one eye is corrected optimally for distance vision and one eye for near vision. There are several modifications of this option that will be discussed later in this paper
- Bifocal soft and rigid gas permeable (RGP) contact lenses, in which separate corrections for distance and near vision are provided
- Multifocal soft and GP contact lenses, in which corrections for greater than two distances are provided (that is, distance, intermediate and near corrections)

Worldwide monovision and multifocal contact lens fitting represent only eleven per cent (11%) of all contact lenses fitted [149]. Many presbyopes, ask for and may prefer contact lenses for correction of their presbyopia, especially the current more active population, in whom vanity is an important factor and spectacle correction restricts their visual freedom. Likewise, progressive addition spectacle lenses (PALs) often require numerous head movements to find the optimum position for intermediate tasks, such as computer use, due to the varying corrective powers present during any eye movement. Of the estimated 1.5 billion presbyopes in the world [150, 151], only an estimated 2.2% wear multifocal or bifocal contact lens designs and many patients discontinue contact lens use as they enter presbyopia. Therefore, when it comes to contact lens correction, the presbyopia population is seriously underserved creating an excellent opportunity for the contact lens practitioner.

Prior to making the decision that a presbyopic patient is a good candidate and with the knowledge that there are normal ocular physiological changes that occur with age that can impact contact lens wear, it is important to perform a comprehensive preliminary evaluation. This evaluation should include a thorough history, tear film testing, anatomical measurements, eyelid assessment, refraction, eye dominance and corneal curvature evaluation. If the patient is then deemed to be a good candidate, the contact lens options should be presented and discussed, along with their possible compromises and based on the patient's responses and perceived motivation, a decision pertaining to the presbyopic contact lens option that is most likely to be successful can be made [88].

IMPORTANT FACTORS FOR PRESBYOPIC PATIENT SELECTION [152]

High Probability for Success

- Definite need for a visual correction
- Current contact lens wearer
- Tear BUT ≥ 10 seconds
- Good ocular health
- History of successful contact lens wear

Moderate Probability for Success

- Very low ametropia or emmetropia
- New wearer but motivated; aware of possible vision compromise
- Tear BUT between 6 and 9 seconds
- Large pupil size (> 5 mm in room illumination): limits available choices for correction
- Low lower lid and/or flaccid lids: rules out segmented lens designs

Low Probability for Success

- New wearer with very low ametropia or emmetropia, unwilling to accept vision compromise
- Unrealistic expectations
- TBUT ≤ 5 seconds (repeated measurements)
- Poor hygiene
- Poor manual dexterity
- Irregular corneas

SINGLE-VISION CONTACT LENS WEAR AND READING GLASSES

The combination of reading spectacles and single vision RGP or soft contact lenses provides the benefits of optimum vision at distance and near, ease of fit and limited expense. Typically, this option consists of plus power reading spectacles, although progressive addition lenses (or variable focus reading lenses) to be worn over distance power contact lenses may be indicated in older patients requiring intermediate correction. Many patients feel inconvenienced by the frequent application and removal of spectacles for their intermediate and near tasks. In addition, an important motivating factor for contact lens wear, especially with current lens wearers is the minimal or non-use of spectacles. Therefore, the disadvantages of this option in combination with the ongoing introduction of improved contact lens multifocal designs, makes this a less popular and less desirable option for the presbyopic patient.

MONOVISION

Monovision is a method of correcting presbyopia where one eye is focused for distance vision and the other for near. In most cases, monovision involves the creation of acquired anisometropia. With spectacle lenses this can cause optical problems including differential prismatic effects [153]. Monovision is therefore particularly well suited for refractive corrections that are situated in the corneal plane or closer to the nodal point of the eye. In recent years, monovision has almost exclusively involved contact lenses, but the subject has received renewed interest with the increase in the number of people undergoing refractive surgery [153]. Monovision was used as a form of presbyopic contact lens correction in the late 1950s, but it remains a popular form of contact lens correction for presbyopia. The success rate for monovision is between 70 and 76% [154] or 59–67% in adapted wearers [153] and it is dependent on the ability of the brain to suppress blur from the defocused eye [154]. The advantages of monovision include [88, 152]:

- Ease of fitting
- Changing one lens only for present lens wearers
- Less expense to patient and practitioner
- Uninterrupted vision out of each eye separately
- Avoidance of some of the problems experienced with multifocal contact lenses, including ghost images and fluctuating vision due to change of pupil size

The most common advice given is to test sighting ocular dominance and to prescribe the distance lens to the sighting dominant eye [153]. This procedure also seems to be the norm in monovision following corneal refractive surgery and in monovision pseudophakia [153]. Indeed, an early and thought-provoking paper listed seven different methods which could be used to determine the eye to be used for distance [155]. The distance eye is selected as the one that:

- Would require the maximum addition if corrected for near
- Has the minimum plus to blur finding at distance
- Has the best acuity for distance
- Has the worst acuity for near
- Is the sighting dominant eye
- On occlusion, would cause the greatest loss in confidence during activities involving movement and distance judgements
- Appears to be non-dominant in a reading exercise

Benjamin and Borish, 1994 suggested that the most relevant technique is adding plus to blur. With this method, the distance eye is selected as the eye that requires the least amount of plus for the patient to detect blur at distance under binocular conditions [139]. Meyler, in a recent textbook advocated using the 'swinging plus' in which the patient walks around the room holding a plus power trial lens equal to the required add over one eye, repeating the procedure over the other eye. This is also beneficial for simulating the potential impact of monovision on the quality of vision. The eye that the patient deems more comfortable with the over-plus correction will be the eye corrected for near [89, 152]. A review of different techniques used to determine ocular dominance can be found in a 2007 article by Bruce Evans – Monovision: A Review [153].

The authors most popular method for establishing ocular dominance is to have the patient extend both of their arms in front of them, forming an aperture with the fingers from both hands ("hole in the hand test"). The patient is then instructed to centre a distant target in the opening formed by their hands. Whichever eye is found to be in alignment with the object when they are alternatively closed, is the dominant eye [152].

Disadvantages/Problems

A major problem with monovision is a decrease in stereopsis. One group of authors found that stereopsis changed from 87 to 124 seconds of arc [154]. Comparing monovision with bifocal lens, it was found that stereopsis changed from 50 seconds of arc with bifocal contact lenses to 200 with monovision [156]. Another study found 79 seconds of arc difference between monovision and multifocal contact lenses [157]. Several studies have demonstrated that stereoacuity loss increases with increasing monocular addition [153]. Monovision users also have a loss of contrast sensitivity and distance vision tasks can be compromised [153]. An increase in anisometropia of 0.50D or more and as much as 1.25D has been found in 29% per of monovision wearers [158].

Driving with monovision has been a controversial topic, in part resulting from the ocular physiological changes that occur with age. Older individuals pose the largest threat to road safety, having the highest crash rate per distance travelled [159]. It could be concluded, that monovision should add to the problems that presbyopic patients have while driving, especially at night and in fact, as many as 80% of monovision patients have reported problems with night driving [153]. This would be especially true with glare. In addition, monovision wearers have a very difficult time suppressing headlight glare while driving at night, with one-third of the subjects experiencing glare while night driving. Monovision patients should be advised to avoid driving or operating dangerous machinery during the first two to three weeks of adaptation [153].

There is a report of an aviation accident in which three passengers were injured when the pilot was wearing a monovision correction. This accident greatly heightened consumer awareness of possible compromises with this form of correction [160]. Finally, monovision is inevitably limited by the inability to incorporate an intermediate correction without compromising distance or near vision [153].

Patient Selection

The age and near addition of the patient are predictive of success, with lower addition patients (+1.25 to +2.00D) being more successful than higher addition power patients. The lifestyle and visual needs of the patient must be evaluated when considering monovision. If prolonged and critical distance vision is desirable, monovision is not a good option. Likewise, if depth perception is important to a given occupation, for example; with construction workers, monovision would not be recommended. Individuals who desire the benefit of being able to change viewing distances constantly and still remain focused, such as those in occupations like teaching, the performing arts, public speaking and sales could benefit from monovision lens wear [152, 153].

Monovision could cause a binocular vision anomaly to decompensate, so the pre-fitting screening should include an assessment of binocular function [153]. Esophoria at distance, a reduction in near point visual acuity and stereopsis have also been shown to indicate poor acceptance, as monovision results in an esophoric shift in eye posture [152]. The patient's personality, expectations, attitudes and tolerance to blur and discomfort are important for success in monovision. Introverted males tend to reject monovision most frequently. Whereas, the most successful patients were laid-back and optimistic [152].

Lens Selection and Fitting Considerations

Both RGP lenses, due to their resultant visual performance, wettability and oxygen permeability and silicone hydrogel lens materials lend themselves to monovision. Due to the greater tendency of dryness and surface deposition with hydrogel lenses, a disposable (daily to monthly) lens is essential for long-term success. If handling is challenging to the new monovision wearer, the rigidity of RGP lenses would make them a preferable option.

Typically, the full distance and near powers are prescribed. It is also recommended to perform tests of binocular vision to determine the effect of monovision on stereopsis. It is important to strongly encourage—if not require—the patient to have an over-spectacles for use while driving and for any other critical distance visual tasks [152]. Although full adaptation to monovision may take two to three weeks, patients should be told that it may take as long as four to six weeks. If difficulty in adapting is experienced (that is, head- aches, eyestrain and blurred vision), switching the near and distance-corrected eyes should be considered. If this is not successful, a bifocal or multifocal lens should be recommended [152].

Summary of the Most Important Factors for Successful Monovision Lens Wear [88, 89, 152–154]

- Monovision is most successful in early presbyopic patients [161] and those individuals who are optimistic in nature. People who are realistic about the visual limitations and anyone who does not require long periods of critical distance vision adapt well to monovision
- The proper eye for near vision should be selected. Often, this is the non-dominant eye and/or the eye in which vision is reduced relative to the other eye. If anisometropia is present, the eye with higher myopia should be considered for near, all other factors being equal
- The indicated addition power should be demonstrated to patients so that they can obtain a realistic impression of the resulting blur
- Binocular vision testing should be performed to determine the effect of monovision on stereopsis
- It is recommended to prescribe the full amount of correction and avoid the temptation of prescribing less plus power in the near-corrected eye and/or prescribing more plus power in the distance-corrected contact lens
- Patients should be strongly encouraged. If not required, to obtain a pair of driving spectacles (that is, minus correction in the lens over the near-corrected eye) to wear for driving or any other critical distance tasks

BIFOCAL AND MULTIFOCAL CONTACT LENSES

Bifocal and multifocal contact lenses may represent the most underserved and potentially the largest growing and profitable modality for contact lens practice. Nevertheless, there is reluctance by practitioners to fit bifocal and multifocal contact lenses. This appears to pertain to several factors including expense and perceived complexity of the designs, as well as the ultimate chair time involved if multiple fittings and re-fittings are necessary [152]. As a result, patients are often unaware that this option exists. The visual performance provided at multiple distances by many of these designs is an important benefit to patients who have been provided with this option by practitioners willing to fit it [152].

Terminology

Numerous terms have been ascribed for the definition of different bifocal/multi- focal lens designs. The most common terms in use today are 'simultaneous vision' and 'alternating vision' lenses [88, 152]. Simultaneous vision lenses have multiple powers positioned within the pupil at the same time. Therefore, light rays from both distance and near targets are imaged on the retina. Many popular hydrogel and RGP multifocal designs are based on this principle. To be successful, the patient will selectively suppress the most blurred images that are not desirable for a given task [88, 152]. Therefore, this concept functions on the basis of blur interpretation and/or blur tolerance of superimposed multiple images on the retina formed by the various powers of the lens. For true simultaneous vision, the primary vision-correcting regions must remain within the pupillary boundary in all positions of gaze and provide equally bright images, the distance and near areas of the lens should cover nearly equal areas of the pupil. There are three designs available that use the simultaneous vision principle [152]:

- Aspheric
- Concentric/annular
- Diffractive

Aspheric lens designs have a gradual change of curvature along one of their surfaces (anterior or posterior) based on the geometry of conic sections. The rate of flattening (or eccentricity) is greater (and sometimes much greater) than with single vision lens designs, thereby creating an increase in plus power toward the periphery of the lens. Some designs are centre near, meaning that the highest plus power is in the geometrical centre and that the power decreases towards the periphery of the lens [152].

Concentric or annular designs are structured with a small, typically two-thirds to three-fourths the size of the pupil in normal room illumination, central annular zone that, in most cases, provides the distance power with the near power present on the annulus that surrounds the distance zone. There are also several centre-near designs available. Both aspheric and concentric designs tend to shift up naturally or translate during near gaze. Therefore, a greater near power effect is achieved. Both designs are available in RGP and soft lens materials and they could be centre near or centre distance. Centre near designs favour distance vision in low illumination and near vision in high illumination due to the increase/decrease in pupil size. Centre distance designs favour near vision in low illumination and distance vision in in high illumination due to the increase/decrease in pupil size [88].

Diffractive designs are the only simultaneous vision lenses, exhibiting true equality of near and distance powers. These designs function through a central zone, that focuses images at distance by refraction of light and at near through diffraction principles created by the zone echelettes. As equal amounts of light pass through both the distance and near elements of the lens, diffractive designs are truly pupil-independent. This design is available only in hydrogel lenses and is not currently being marketed in the South Africa. To be successful, it is important for all simultaneous vision lens designs to exhibit good centration with little movement on blinking.

Alternating vision pertains to lens designs, in which translation or vertical movement of the lens results in only one zone of vision in front of the pupil at any given time. Therefore, ideally the distance zone will be in front of the pupil in straight ahead gaze and the near section will be in front of the pupil in near gaze. This consists of an intentional shifting of the lens from distance to near gaze and vice versa. These designs are typically prism ballasted to weight the lens to keep the various powers in their proper positions on the eye. Some of these designs are also truncated to assist in lens stability. These designs rely on the lids to push the lens upward with inferior gaze. There are several forms of these designs in RGP lens materials including crescent, executive and decentred concentric shapes. Translation is much easier to obtain with an RGP design, due to the smaller diameter and thicker inferior edge profile. All commonly used translating designs are available in RGP materials [88, 152].

Multifocal and Bifocal Prescribing and Fitting Considerations [88, 89, 152]:

- Mention the multifocal/bifocal option prior to the patient entering presbyopia
- When discussing correction options with the presbyopic patient, multifocal and bifocal lenses should be emphasised. Likewise, patients should be aware that some compromises may still exist, and lens exchanges may be necessary to provide for a successful fit and vision
- Fit individuals who have great potential to be successful, such as highly motivated existing contact lens wearers before fitting more challenging patients
- Use loose trial lenses or flipper bars for over-refracting to provide a more natural environment
- Check vision binocularly to simulate a real-world environment
- Allow sufficient time for the lenses to settle prior to evaluating the lens-to-cornea fitting relationship—usually 15 to 20 minutes is sufficient
- When the lenses have been dispensed (and/or with the diagnostic lenses in combination with the over-refraction), patients should walk around the office and perform common visual tasks (look at a computer, read a magazine, look at a distance et cetera) and indicate the visual tasks that they are pleased with and those that they feel could be improved
- When choosing a frame for spectacle wearers with presbyopia and inadequate vision without spectacles, I will often insert a trial/diagnostic multifocal contact lens which helps the patient choose frames, but more importantly gives him/her the opportunity to experience multifocal contact lenses. This will often translate into a sale of lenses in addition to spectacles

- Always attempt to satisfy the patient's primary visual goals but also indicate to them that occasional spectacle use may be necessary to meet all their visual demands
- Do not hesitate to prescribe unequal additions to obtain satisfactory vision at all distances. A 'modified multifocal' approach in which one eye is slightly over plussed at distance, may allow the patient to obtain all their visual goals
- Have available multiple RGP and soft lens diagnostic sets/inventories and be willing to try different types of lenses on a given patient to achieve success

Type of Patient and Suggested Lens Selection

Table 31: Selection of presbyopic correction according to patients visual needs [152]

Type of patient	Recommended lens
Spherical refractive error; current soft lens wearer	Soft multifocal/bifocal
Low to high add with high visual demand at near, distance or both	Translating RGP bifocal
Lower lid a. Critical vision demand b. Non-critical vision demand	Aspheric GP multifocal Soft multifocal
Less than 5 mm pupil diameter a. Critical vision demand b. Non-critical vision demand	Translating RGP multi(bi)focal Soft multifocal
High intermediate (computer) visual demands	Aspheric GP or soft multifocal
Early presbyopia; successful single vision contact lens wearer	Monovision
Occasional lens wearer	Spherical silicone hydrogel or monovision silicone hydrogel lens wear

Which Contact Lens Modality is Best for Presbyopia?

The answer to this question is very much patient dependent. Some patients may enjoy monovision, while others simply cannot adapt and the same goes for multifocal or bifocal lenses. From experience, I have found that if a patient cannot adapt to the lenses within the first 20–30 minutes, it is unlikely that they will adapt to the lenses over a longer period of time. However, with the introduction of daily disposable multifocal lenses, it is now possible to fit patients that use these lenses for occasional wear when they do not feel like using spectacles. Very little chair time is required to fit disposable multifocal lenses and there are enough options to satisfy most almost everyone's needs. However, practitioners are often reluctant to offer these options to their patients and loose an important practice growth opportunity.

Rajagopalan, 2006 conducted a study comparing monovision, different multifocal/bifocal contact lenses and progressive addition spectacle lenses (PALs). For the contact lens-wearing groups, subjects wearing RGP multifocals provided the best binocular high and low contrast acuity followed by soft bifocal wearers. There was relative parity between the binocular high and low contrast acuity with PALs and RGP multifocal wearers. Monovision acuity and measured binocularly was determined to be lower than the other three groups with this difference being most significant with high contrast acuity. Among contact lens-wearing groups, it was observed that RGP multifocal lens wearers experienced the lowest amount of monocular disability glare followed by soft bifocal wearers and monovision wearers. Subjects wearing soft bifocal lenses and monovision demonstrated slightly reduced binocular contrast sensitivity at all spatial frequencies. In the contact lens groups, RGP multifocal lens wearers had the highest binocular contrast sensitivity at all spatial frequencies. This was on parity with PAL wearers, except at the highest spatial frequency at which PAL wearers had better vision [162].