# 14

# CORRECTION OF PRESBYOPIA WITH CONTACT LENSES

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Presbyopia is the name given to the condition occurring when the age-related decrease in the ability of the eye to focus on objects at close distances makes near work difficult. The progressive decline in the amplitude of accommodation starts to occur from the second decade of life and falls almost linearly with age, to reach 0 at approximately 50 to 55 years of age. This is in contrast to other aspects of visual performance, which only start to show decline after the age of approximately 50 years (see Chapters 9 and 10). This sobering loss of adequate amplitude of accommodation to carry out normal, everyday near tasks at the productive age of 40 to 45 years can currently be relieved using a range of corrective spectacle lenses (see Chapter 13). Providing a satisfactory means of correcting presbyopia with contact lenses has, however, long been a major challenge, due to the difficulty of producing complex lens designs capable of providing sharp distance and near vision for every single visual task.

Prescriptive modalities for correction of presbyopia with contact lenses include (1) single-vision contact lenses for distance correction worn in combination with reading glasses; (2) monovision, with one eye being corrected optimally for distance and the fellow eye for near; (3) gas-permeable (GP) contact lenses offering alternating vision (image); and (4) soft and GP contact lens designs (ie, diffractive, bifocal, varifocal, multifocal) offering simultaneous vision (image)[1,2] correction for a wide range of distances by extending depth of focus (DOF).

Despite the efforts of the contact lens industry in producing a remarkable range of improved contact lens designs for presbyopes during the past decade, the contact lens market potential for presbyopia correction appears to be relatively untapped. It is reported[3] that the majority of presbyopic contact lens patients (63%) are still fitted with nonpresbyopic corrections. Simultaneous-image designs represent only 29% of all fittings, whereas monovision corrections represent only 8% of the fittings worldwide.

## SPECTACLES VERSUS CONTACT LENSES

This scenario possibly represents the simplest modality available for correcting those patients who started wearing contact lenses prior to the onset of presbyopia. The presbyope is fitted with contact lenses for distance correction, over which reading spectacles are worn for near tasks. In some cases, where intermediate vision is required (eg, use in an office environment or at a computer workstation), occupational progressive addition lenses could be prescribed (see Chapter 13).

Pallikaris IG, Plainis S, Charman WN.
*Presbyopia: Origins, Effects, and Treatment* (pp. 127-138).

The solution of single-vision contact lens correction combined with reading spectacles provides optimal vision for both distance and near, and introduces the least amount of confusion at near. However, the prospect of wearing spectacles for near work does not appeal to patients who wish to avoid any spectacle use. This is particularly the case for existing contact lens users who have previously experienced minimal use of spectacles. On the other hand, this mode of correction may be favored by patients who experience problems with other correction modalities or by patients who have been fitted with single-vision contact lenses that provide improved oxygenation and comfort but that are not yet available in bifocal or multifocal designs.

## MONOVISION CORRECTION

Monovision is a popular method for correcting presbyopia, where one eye (usually the dominant eye) is corrected for distance vision and the other for near (see Chapter 15 for a review of the methods used to determine the eye to be corrected for distance). Because anisometropia acquired with spectacle lens use can cause differential prismatic effects and aniseikonia,[4] it is particularly well-suited to refractive corrections that are placed on the corneal plane (eg, contact lenses, corneal refractive surgery, and intracorneal inlays; see Chapters 15 and 20) or closer to the nodal point of the eye (ie, IOLs).

Monovision utilizes the capacity of the brain to process the focused retinal image from one eye, while suppressing the other eye's unwanted out-of-focus image. However, this suppression occurs at the expense of stereoacuity. Provided the reading addition is not too high, the overlapping DOF of the 2 eyes allows reasonable acuity to be achieved over a range of distances.[5] To maximize the useful dioptric range of acceptable vision and increase the chances of reasonable stereopsis, the difference in powers between the distance and near corrections should be minimized (Figure 14-1). A reduction in the difference between distance and near corrections can be accomplished by using both positive and negative DOF for each eye (ie, "push the plus" in the "far" eye and "push the minus" in the "near" eye). If either eye is placed at the peak, its DOF is lost on one side. However, if prolonged and critical clear distance vision is desirable, depending upon the patient's lifestyle and visual needs, one might consider opting for the peak for the eye fitted for distance.

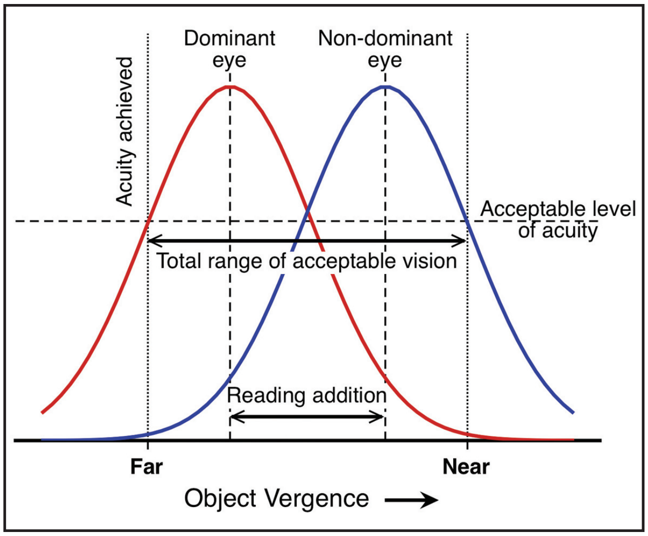


**Figure 14-1.** Monovision success depends on using the overlapping depth-of-focus (DOF) of the 2 eyes to achieve reasonable acuity over a range of distances. Using both positive and negative DOF for each eye allows a minimal difference in powers between the distance and near corrections. (Adapted from Charman WN. Theoretical aspects of monovision contact lens correction. *Optician.* 1980;179(5):9-22.)

When higher reading additions are used, resulting in significant power differences between the distance and near corrections, an impairment of binocularity normally occurs. This may result in a significant loss of stereopsis. It has been reported that stereoacuity is degraded with monovision contact lens wear to 124 arcsec[6] or even to 200 arcsec,[7] with the loss in stereo performance being more pronounced the higher the monocular addition.

The main advantages of monovision include reduced cost to the patient (only single-vision lenses are required) and simplicity of fitting for the eye care practitioner (ie, only 1 lens needs to be changed for current lens wearers, and the near addition can be changed at any time). Monovision works well with many patients, and the success rate has been reported to be between 70% and 76%.[6] Patient age and near addition represent the best predictors for success, with younger presbyopes and lower additions (<1.50 D) resulting in higher acceptance ratios. Other factors that may affect success in monovision include gender, with female monovision wearers being more enthusiastic than males, and patients' tolerance to blur, which appears to be related to personality and attitude.[8] In cases of strong ocular dominance, interocular blur suppression may be impaired, thus limiting the success rates of monovision.

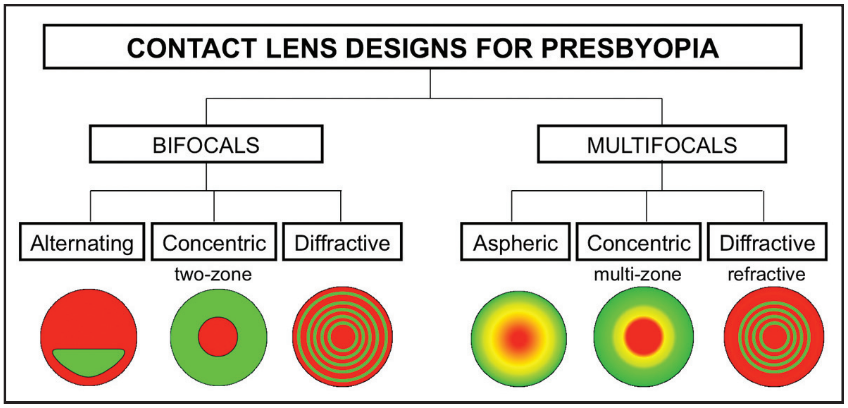


**Figure 14-2.** Contact lens designs for presbyopia correction. Red, green, and yellow colors represent the areas for distance, near, and intermediate vision, respectively. The concentric and aspheric designs illustrated have a central distance correction; designs with center near correction are also available. Note that the distance and near powers of the diffractive lens are superimposed over the full optic zone.

A variety of "modified" or "enhanced" methods of monovision correction have been proposed. These may involve fitting the dominant eye with a single-vision correction (for distance or near, depending on the viewing requirements of the patient) and the fellow eye with some form of bifocal or multifocal correction.

No one monovision approach has achieved widespread acceptance in clinical practice, and this approach represents only 8% of the presbyopic contact lens fittings worldwide.[3] However, the higher rates (approximately 20% to 25%) observed in the United States and United Kingdom markets imply that other factors, such as lack of fitting skills, may form the primary barriers to prescribing monovision.

## ALTERNATING-IMAGE (VISION) CORRECTION

Alternating-image correction is commonly performed with bifocal GP contact lenses, which mimic the design of spectacle bifocals in that they are manufactured with 2 distinct sectors of different refractive power—one for distance and another for near—placed at the top and bottom of the lens, respectively (Figure 14-2). These lenses can be fitted so that the lens and eye movements are decoupled, which facilitates their use as "translating bifocals." Their natural resting point in "straight-ahead" gaze places the distance zone in front of the pupil. As the wearer looks down, the lower lid pushes ("translates") the lens up, aligning the pupil with the lower half of the lens containing the near add.

Alternating GP lenses should not rotate on the eye, otherwise the 2 distinct areas for distance and near vision will no longer align with the eye in its straight-ahead and down-gaze positions, respectively. Therefore, centration and orientation, which are essential, are optimized by incorporating base-down prism ballast and/or lens truncation. When good translation is achieved, these lenses provide excellent quality of vision for both distance and near visual demands. Some alternating lenses also incorporate a segment for intermediate-vision correction (ie, trifocals).[9]

Successful fitting of these lenses requires achieving inferior centration and minimal movement on blink, with rapid recovery after blink. Whereas the upper lid produces most translation, the lower lid has to retain the lens and prevent it from slipping behind the lid, thereby not translating. Alternating lenses are fitted to give corneal alignment. The vertical diameter of the lens should be 2 mm or less than the distance from the lower lid to the superior limbus to allow sufficient translation. The segment height should be 1.3 to 1.5 mm below the visual axis in the straight-ahead position. Truncation allows the lens to align with the lower lid, restricting rotation and aiding translation.

In practice, the effectiveness of alternating (translating) bifocal GP lenses may be limited by the modest amount of on-eye lens movement that can be achieved. Excessive after blink lens movement, rotational instability, large pupil diameters, or a near zone located too high can result in the near portion of the lens occupying a significant part of the pupil when distant objects are viewed.

## SIMULTANEOUS-IMAGE (VISION) CORRECTION

In simultaneous-image correction, light rays corresponding to (1) both distance and near corrections (bifocal, 2-foci) or (2) distance, near, and intermediate corrections (multifocal, multiple foci) are imaged onto the retina. In each case, the retina receives both in-focus and out-of-focus images, and the brain must select the in-focus stimulus, while suppressing out-of-focus stimuli. In contrast to monovision, in-focus and out-of-focus rays are imaged onto the same retinal field. The spread of light from the out-of-focus ("unwanted") images impairs the contrast of the focused ("desired") image, resulting in a retinal image of reduced contrast (ie, reduced modulation transfer function) compared with that formed by a single-vision lens.[10]

The extent of contrast loss is dependent on the relative amounts of in-focus to out-of-focus light incident onto the retina. With many simultaneous image lens designs, this balance varies when the pupil dilates or constricts under dimmer or brighter lighting conditions, respectively.[11] Thus, any change in pupil diameter will influence the compromise between near and distance vision offered by the lens design (with the exception of diffractive lenses, see below), so that any particular diameter of lens central zone will be optimal only for a specific pupil diameter. Performance with simultaneous-image contact lens designs may also be influenced by the inherent aberrations of the eye, such as spherical aberration.[12,13]

As in monovision correction, functionality of simultaneous image correction is governed by the principles of blur adaptation, blur tolerance, and suppression of superimposed multiple images on the retina, which occurs at cortical level. It is clear that the effectiveness of any simultaneous image contact lens design should be judged in terms of the enhancement that it produces over the natural DOF of the eye (see Chapter 3).

Simultaneous-image correction can be achieved at present with (1) diffractive; (2) concentric or annular bifocal/varifocal; and (3) multifocal or varifocal lens designs (see Figure 14-2).

## Diffractive Design

A diffractive contact lens is designed to provide a bifocal effect over the full lens aperture by using the zero- and the first-order light from a blazed zone plate with parabolic profile on the back surface of the lens,[14,15] so that a tear layer is sandwiched between the diffractive surface of the lens and the cornea. The basic diffractive design consists of a saw-tooth pattern of concentric, annular, Fresnel-type diffractive echelettes (Figure 14-3A) designed to ensure that diffracted light arrives at the same time at both the distance and near foci of the lens. This enables the distance power of the bifocal to be determined by the carrier lens and near power to be provided by the diffractive profile. The height of the facet, typically approximately 3 µm, determines the split of light between distance and near images.[14] The "add power" is proportional to $m\lambda/r_m^2$, where $r_m$ is the radius of the $m^{th}$ diffractive zone and $\lambda$ is the wavelength, so that higher additions require smaller concentric diffractive zones.

In a normal diffractive bifocal, the step heights at the edge of each diffractive zone are the same for all zones so that, to a reasonable approximation, the split of light between the near and distant foci is

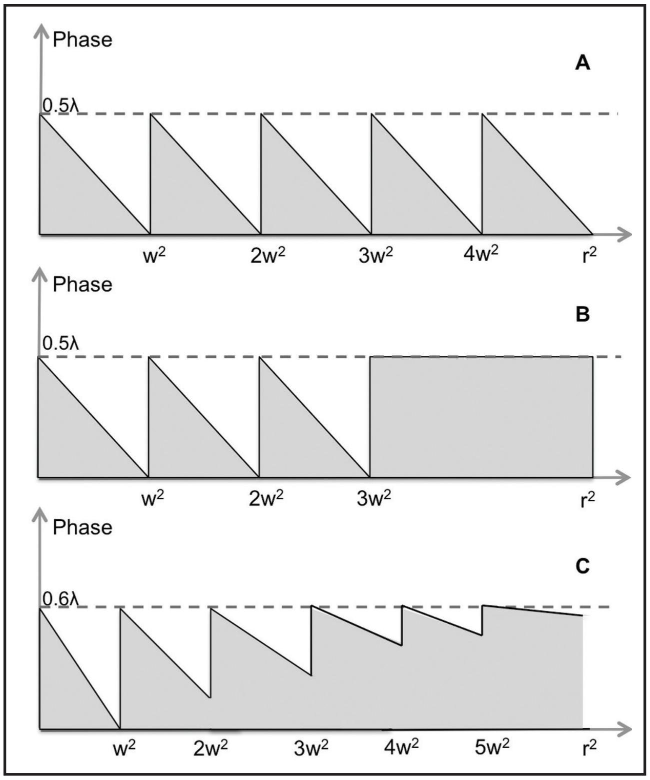


**Figure 14-3.** Surface diffractive profiles in radius-squared ($r^2$) space; the profile zone width (w) and the phase shift specify the add power of the bifocal and the intensity distribution of light (wavelength λ) focused on each of the image planes. (A) Standard diffractive bifocal with a saw-tooth profile, which splits light equally between distance and near focal points. (B) A diffractive bifocal with refractive periphery. (C) A diffractive bifocal with a variable (apodized) step profile. The 2 latter profiles offer pupil-dependent multifocal correction. The actual step heights (*h*) required in the surface of the lens to achieve the phase differences depend on the refractive indices of the lens material ($n_L$) and the tear layer between the lens and cornea ($n_T$) ie, phase difference in wavelengths = $(n_L - n_T) \times (h \div \lambda)$. (Adapted from Cohen AL. Diffractive bifocal lens designs. *Optom Vis Sci.* 1993;70(6):461-468.)

independent of pupil diameter. In a typical diffractive bifocal, approximately 40% of the light passing through the pupil is diffracted into the distance (zero order) images and 40% of the light is diffracted into the near (first order) images. As a result, the distance and near powers are each effective over the full useful area of the lens. The remaining light is either diffracted into unwanted orders (16%) or scattered (4%), with both of these effects leading to a significant decrease of low-contrast visual acuity and a degree of flare in dim light conditions.[10] Because the diffractive add power is proportional to wavelength, these lenses contribute longitudinal chromatic aberration of the opposite sign to that found in the naked eye.

The basic bifocal design may be modified to include both a diffractive profile and a refractive surface within the optic zone (Figure 14-3B). The diffractive bifocal design has the major theoretical advantage that the retinal image quality is not influenced by variations in pupil size, as all parts of the optic zone contribute to both the distance and near images.

By minor modifications in manufacturing technology, it is possible to adjust the relative proportions of diffracted light contributing to the near and far images on the retina, according to the visual demands.[16] In “apodized” designs (Figure 14-3C), the step heights are reduced with increasing diameter zones in the lens. Thus, the optics of this design of diffractive lens are pupil-size dependent—for a small pupil the lens behaves like a “standard” bifocal where, as the pupil diameter increases, light passes through the outer zones, and the step heights become progressively smaller. The latter reduces diffraction efficiency (to 0 when the step height is 0). Hence, increasing amounts of light go into just one of the foci (the distant one), favoring distance vision. Diffractive designs of contact lenses have appeared in both GP and soft materials in the past, but only a soft version is still commercially available. Although the performance of soft lenses is almost independent of pupil diameter, their main weakness is the significant fraction (approximately 20%) of contrast-reducing light that fails to contribute to either the distance or the near image.

## Concentric or Annular Design

Concentric or annular ring bifocal lenses incorporate a small central circular zone, which is intended either for distant or near viewing, surrounded by one or more rings of near or distant correction, respectively (see Figure 14-2). If there are multiple rings surrounding the central zone, they usually alternate between the near and distance prescription. Such lenses are available in both GP and soft materials. In some cases, the diameter of the central annulus can be chosen from several alternatives to enhance either distance or near vision according to the individual patient’s needs.

Early soft concentric designs, which continue in use today, consist of 2 discrete zones of distant and near power, being described as biconcentric. A central segment of approximately two-thirds the diameter of the pupil in normal room illumination (ie, approximately half the area of the pupil) is intended for distance or near viewing, with the surrounding area containing the near or distance corrective power, respectively. As with all simultaneous designs, good lens centration and minimal amount of blink-induced lens movement are needed for successful fitting and performance. Decentration will produce an asymmetric retinal point-spread function and an orientation-dependent optical transfer function.[17]

The performances of both center-near and center-distance designs show a great dependency on pupil size and lighting conditions, as these disturb the equilibrium between distance and near vision. This means that any particular diameter of the central zone is optimal for a specific pupil diameter or lighting condition. Any deviations from this equilibrium may degrade modulation transfer, especially at medium and high spatial frequencies.[10]

Most center-near lenses have central zone diameters of less than 3 mm. If a range of near zone sizes is available, then fitting a larger near diameter in the nondominant eye will be expected to improve near vision. If a bilateral fit of center-near lenses does not provide good distance vision, a modified monovision approach can be adopted. Fitting the dominant eye with a center-distance lens or, alternatively, with a smaller diameter center-near lens would be expected to have a beneficial effect for distance viewing. On the other hand, when a center-distance soft lens is fitted in both eyes, distance vision tends to be good. Near vision, however, might be impaired. Enhancement of near vision can again be achieved by adopting the modified monovision approach, which in this case consists of fitting 1 eye only (usually the dominant eye) with a center-distance lens and the fellow eye with a center-near lens.

A multizone concentric design with alternating distance and near power zones would be expected to partially reduce the strong dependency of

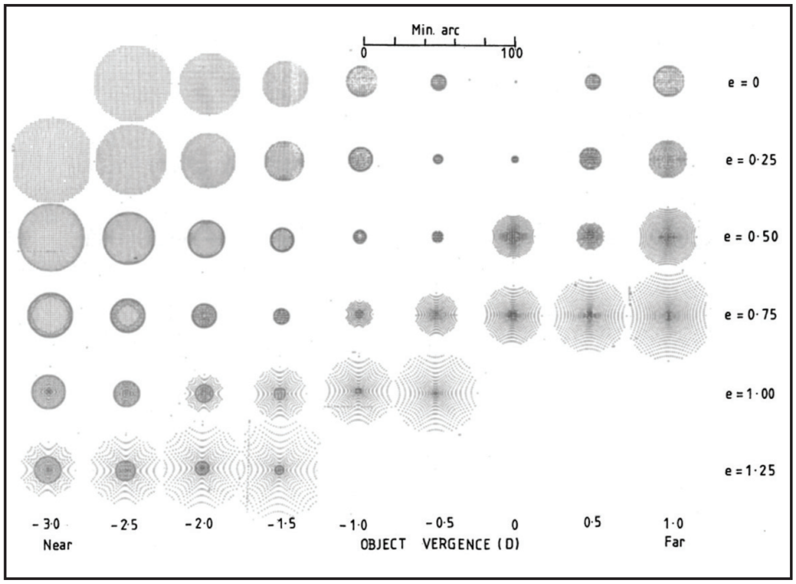


**Figure 14-4.** Theoretical retinal point-spread functions ("blur patches") for a 6-mm pupil obtained by geometrical ray-tracing for a lens with 1 spherical and 1 conicoidal surface. The paraxial focus had been set at an object vergence of 0 in all cases. The e-values of the surface are as indicated (e = 0 corresponds to a spherical surface, 0<e<1.0 corresponds to an ellipsoid, e = 1.0 to a paraboloid, and e>1.0 to a hyperboloid). The cases shown all produce positive spherical aberration, where the marginal power of the lens becomes more positive, so that the most compact image tends to move toward nearer object distances as the e-value increases; however, the "distant" image retains a compact core. The angular scale indicates equivalent visual angles in the object field. Note that an acceptable blur image should not exceed 10 arcmin in diameter, as this requires visual acuity of approximately 20/50 (6/9). (This figure was published in *Int Cont Lens Clinic*, vol 15(3), Charman WN, Walsh G, Retinal images with centred aspheric varifocal contact lenses, pp 87-93, Copyright Elsevier (1988).)

biconcentric designs on lighting conditions and pupil size. The width and spacing of the zones are based on the variation within the presbyopic population of pupil size with illumination level.

In GP materials, concentric designs have been manufactured with several annular optical zones, each having the same refractive power but with the power progressively changing from the central to peripheral zones. Normally, distance and near powers are located in the center and periphery of the lens, respectively. These lenses are intended to provide a mixture of simultaneous and alternating images. They require some translation (<1 to 2 mm), although not as much as pure alternating designs. In center-distance designs, apart from good centration, a slight upward lens movement as the wearer looks down is expected to enhance near vision.

A major advantage of concentric lenses, when compared with alternating lenses, is that the distance and near portions of the lens can be used even when the lens rotates. Thus, they do not require stabilization (ie, prism ballast and/or truncation). Furthermore, some designs incorporate concentric rings of intermediate power, thus also providing intermediate vision.

## Multifocal or Varifocal Design

Multifocal or varifocal contact lenses form a further option for the presbyopic patient. These designs involve a progressive, rotationally symmetric, gradation of power from the center to the edge of the lens optical zone. This is achieved by the use of at least one aspheric surface. Although many variations on the asphericity profile are possible, in the contact lens context, the term is most frequently used to describe a conicoidal surface, which is used to produce progressively greater power either toward the lens center (center-near) or the periphery (center-distance). The aspheric surface and the power profile are determined by the degree of departure from a spherical curve. One way of specifying this is by the eccentricity (e) value, which describes the rate of change of surface curvature with distance from lens axis.[10,18] Thus, by altering the e-value, the manufacturer can produce differing effective near additions, with higher e-values resulting in higher additions and better near vision.

Any variation of zonal power is equivalent, by definition, to spherical aberration. As a result, multifocality is now accomplished in soft aspheric contact lenses by incorporating controlled spherical aberration—negative in center-near and positive in center-distance designs. However, such a variation of lens power is likely to produce a degradation of the overall optimal retinal image in comparison with that provided by a single-vision correction. Moreover, the loss of optimal image quality, as computed using the retinal point-spread function or the through-focus modulation transfer function, is expected to be more pronounced the higher the eccentricity of the conicoidal surface and the associated spherical aberration (Figure 14-4).

However, it can be argued that, although the "best" image on the retina is degraded by the increased spherical aberration, this is outweighed by the increase in the focal range over which the image remains acceptable (ie, increased depth of focus). Moreover, if the aspheric surface gives negative spherical aberration, the smaller pupil diameter associated with near vision helps to improve the quality of the perceived image. This may be the case for aspheric designs offering low to medium "additions" (low to moderate e-values), but, as seen in Figure 14-4, high e-values result in significant, and perhaps unacceptable, reductions in retinal image quality. To achieve more effective near additions, bi-aspheric surfaces have been designed, in which the power profile is discontinuous, with the near portion (~2.5 mm in diameter) in center-near designs showing higher e-values (higher amounts of negative spherical aberration) compared with the outer portion of the lens (Figure 14-5).[19]

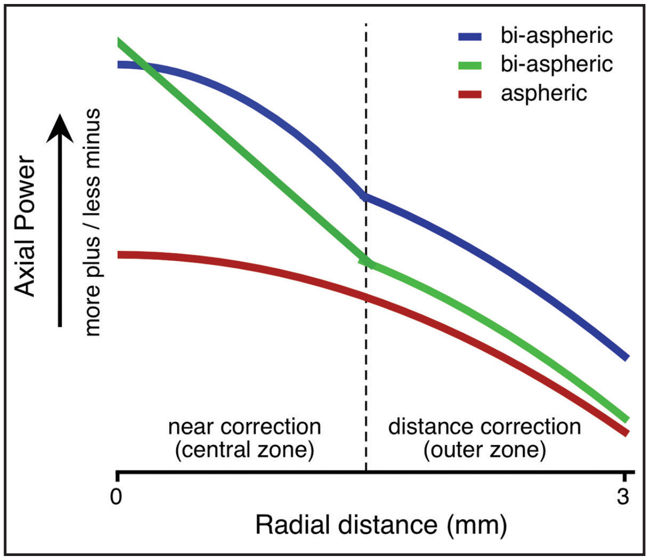


**Figure 14-5.** Axial power profiles used in center-near designs of multifocal contact lenses, offering a pupil-dependent increase in the depth of focus (DOF). Low amounts of DOF can be achieved by smooth, single-aspheric power profiles, whereas bi-aspheric profiles can result in higher amounts of DOF.

It is evident that centration is very important for multifocal contact lenses. With decentration, the image structure changes markedly, resembling that produced by conventional oblique astigmatism. The effect of decentration is more pronounced for distance vision and for larger pupil diameters. It is expected that the performance at near with center-near aspheric soft contact lenses, exhibiting negative spherical aberration, would be limited by the interaction of the aberration of the lenses with the inherent positive spherical aberration found in the average normal eye. These interactions are expected to reduce the effective add of any center-near lens.[12,20]

GP lenses with aspheric designs are classified depending on eccentricity or whether they are back- or front-surface aspherics. Similar to soft lenses, adequate centration is essential for successful fitting in GP multifocal designs, thus large diameters tend to work well. These lenses need to move slightly on the eye to bring the distance and near areas of the lens in front of the pupil, although not as much as is necessary in bifocal lenses due to their smaller optical zones. Therefore, these lenses have some performance limitations in patients with large pupils.

When prescribing GP back-surface aspheric lenses, the fitting must be substantially steep centrally, together with midperipheral alignment, which can sometimes result in corneal steeping (Figure 14-6A). Front-surface aspheric designs are normally used when additional add power is required or when unacceptable corneal steeping occurs with back-surface aspheric lenses. In these cases, additional add power can be incorporated in the front surface, thus providing fitting closer to alignment (Figure 14-6B).

An upper lid located below the superior limbus might facilitate GP lens positioning and centration. If the lower lid is below the inferior limbus, the lens is likely to decenter inferiorly, affecting lens translation. Large palpebral apertures (ie, >12.5 mm) are also likely to result in poor fittings due to poor lens movement and centration. Some GP lenses are made of a combination of patented designs (eg, concentric and aspheric). The fitting of these lenses is primarily governed by the design of the back surface of the lens.

# DISCUSSION

## Decision Making

The performance of all contact lens designs for the correction of presbyopia seems to be primarily dependent on the extension of the DOF provided to counteract the loss of accommodation, compared with the DOF with uncorrected vision. Apart from monovision, the effective DOF with contact lens correction may be mainly correlated with the power profile of the lens, but it is also expected to be affected by a number of other factors, such as pupil size, inherent ocular aberrations,[21] binocular summation,[22] and personality characteristics (eg, tolerance to blur).[8]

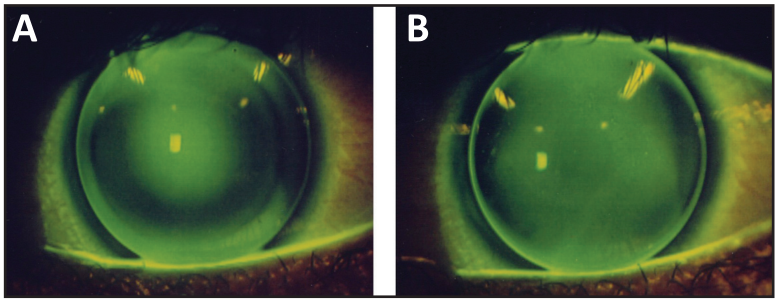


**Figure 14-6.** On-eye fitting of (A) a backsurface and (B) a front and back surface aspheric GP contact lens.

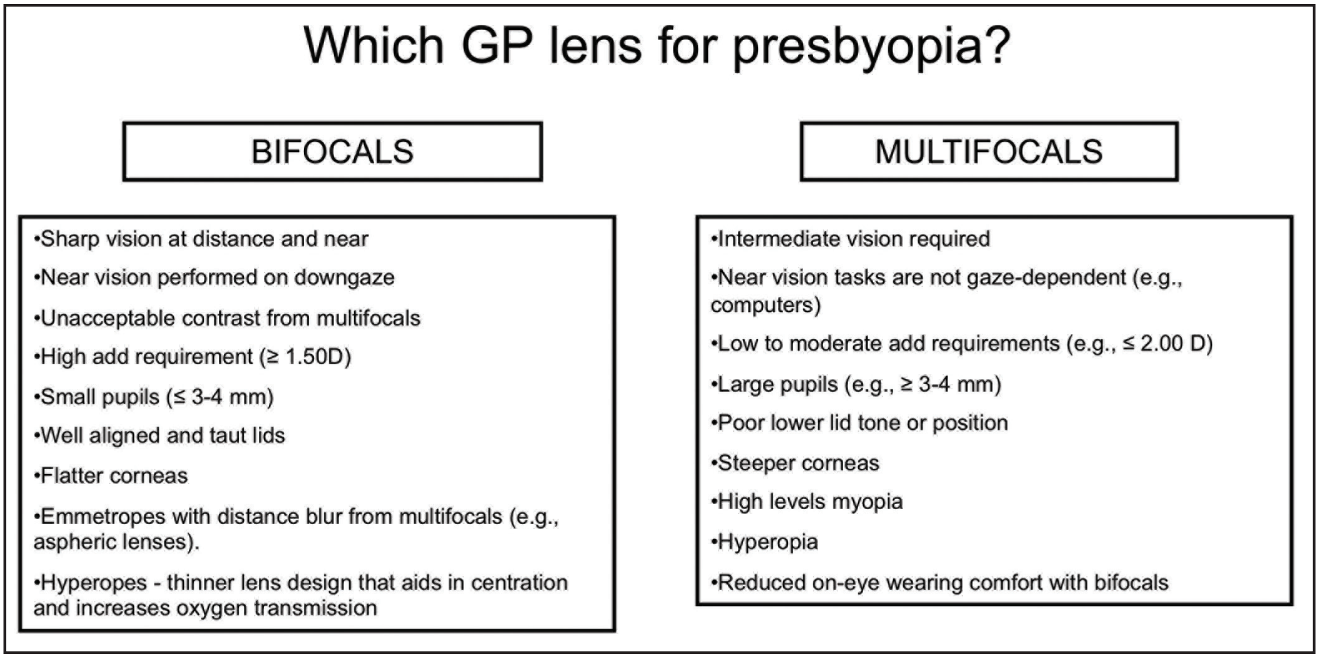
Another factor that possibly influences acceptance and success of the contact lens designs used in presbyopia correction is adaptation to blur, which is a neuronal characteristic of the visual system (see Chapter 10). Blur has a different physiological basis in monovision compared with simultaneous-image correction. In monovision, the brain has to suppress one of the nonidentical stimuli falling on corresponding regions in the 2 eyes. Rather than cooperative fusion into a single, coherent percept, the 2 images compete for perceptual dominance (known as binocular rivalry), resulting in only 1 of the images being favored for objects at different distances.

In simultaneous-image correction, the brain ideally has to select 1 stimulus falling on a receptive field while suppressing an out-of-focus stimulus imaged on the same retinal field.[23] Hypothetically, simultaneous viewing of in-focus and out-of-focus images must degrade vision, but many studies have shown that these lenses are effective.[24,25] One explanation offered is that perceptual processes, such as binocular summation, help the interpretation of the blurred images, enabling such "degraded" images to play an important role in the visual process. It has recently been shown that binocular viewing improves visual perception of out-of-focus images to a much greater extent than it does for in-focus images.[26] This contrasts with monovision correction in which perceptual summation from the 2 eyes is expected to be minimal.

Monovision lens wear can be beneficial for patients who seek to change viewing distances constantly and still remain focused, such as those in occupations of teaching, performing arts, public speaking, and sales, among others.[27] Monovision can also be advantageous for patients who have discontinued multifocal contact lens wear due to unacceptable vision. However, high-risk, visually demanding tasks, such as operating machines or driving in low lighting conditions, should be carried out with caution by the newly fitted monovision lens wearer. Alternatively, patients should be advised to use either 2 distance lenses or spectacles that incorporate the distance correction over the near eye when performing critical distance visual tasks.

Alternating lenses are particularly indicated when sharp distance and near vision is required, and no compromise in stereopsis at both distance and near can be tolerated. However, if intermediate vision is required and/or adequate comfort cannot be achieved with alternating designs, concentric bifocals or multifocal lenses are recommended. Patients who do not have excessive intermediate visual demands or have large pupils and therefore are not good candidates for aspheric multifocal lens wear, might be good candidates for trifocal alternating lenses. In addition, patients with higher add requirements, limited tolerance to blur, and high motivation are expected to benefit from alternating vision (image) lenses.

The major advantage of simultaneous-image lens designs is that their performance does not require special orientation. Good lens centration and relatively limited lens movement are necessary prerequisites for a successful visual outcome, as excessive post-blink movement will result in fluctuations of vision. However, the most common drawback of simultaneous-image lenses seems to be the interaction of light-dependent changes in pupil diameter with lens design (varifocal/annular). It is only in diffractive bifocals that the split between distance and near effects is independent of pupil diameter. Pupil size changes in varying light conditions and viewing distances; therefore, lens design, centration. and movement may affect lens performance. In center-distance designs, distance acuity will be improved when pupil diameter becomes smaller, but with corresponding deterioration of near vision. On the other hand, a larger pupil diameter will allow more light to enter through the periphery of the optic zone, thus improving near vision at the expense of distance vision. The opposite situation can be seen with center-near lens designs, whereas distance acuity will be better for large pupil diameters and near vision will be enhanced when the pupil constricts.



Which GP lens for presbyopia?

BIFOCALS

- Sharp vision at distance and near
- Near vision performed on downgaze
- Unacceptable contrast from multifocals
- High add requirement (≥ 1.50D)
- Small pupils (≤ 3-4 mm)
- Well aligned and taut lids
- Flatter corneas
- Emmetropes with distance blur from multifocals (e.g., aspheric lenses).
- Hyperopes - thinner lens design that aids in centration and increases oxygen transmission

MULTIFOCALS

- Intermediate vision required
- Near vision tasks are not gaze-dependent (e.g., computers)
- Low to moderate add requirements (e.g., ≤ 2.00 D)
- Large pupils (e.g., ≥ 3-4 mm)
- Poor lower lid tone or position
- Steeper corneas
- High levels myopia
- Hyperopia
- Reduced on-eye wearing comfort with bifocals

**Figure 14-7.** General guidelines for the selection of the most appropriate GP lens for presbyopia correction. Note: these are general guidelines, which might not necessarily work well with certain lens designs or with certain manufacturers' recommendations.

In GP materials, both back- and front-surface concentric designs are available, although the latter are more commonly fitted. Front-surface concentric designs are fitted to give corneal alignment. Distance and near viewing can be enhanced in each eye by increasing and decreasing the central areas of the lens, respectively. On the other hand, back-surface concentric designs require a steep central fit. Limitations in the use of these lenses include inadequate translation and induced corneal steeping. When the patient complains of fluctuating vision, the lens should be examined for excessive movement and/or a high position for the near zone. High-riding lenses may occur with flat fittings. In patients with narrow palpebral apertures, resulting in high-riding lenses, reduction of the lens diameter should be considered. When near vision is poor, evaluation of the near portion in downgaze should be undertaken. Reduced translation on downgaze might occur with tight fittings or when the lower lid is flaccid or low relative to the lower limbus. In the latter case, larger lens diameters and near portions are recommended.

## Soft or Gas-Permeable Lenses?

Today, soft contact lenses dominate most markets, representing more than 90% of new fits, with silicone hydrogels accounting for 39% of new soft lens fits.[28] The relatively recent development and introduction of silicone hydrogel multifocal lenses allow for sufficient oxygen transmission, alleviating the hypoxia-induced effects of lens wear, maintaining normal corneal metabolic activity, and offering the opportunity of extended or continuous use.

Nevertheless, it is well-established that GP lens materials have excellent performance in terms of safety[29] and visual quality.[30,31] Currently, there are several modern GP multifocal options for presbyopia correction. General guidelines for the selection of the most appropriate GP lens for presbyopia correction are provided in Figure 14-7. Many of these lenses are now fitted empirically, and initial lens selection is driven by practitioner-friendly fitting software or by providing the manufacturer with refractive and corneal data for lens calculation. The current trend is to use large-diameter lenses to improve lens centration and comfort. The use of corneal anesthetics and initially fitting the patient on an extended-wear basis for 1 day to 1 week are recommended to minimize the initial adaptation period. By initially fitting patients on an extended-wear basis, the adaptation period is overcome within the first overnight wear of the lenses, leading to comfort levels similar to those found with soft contact lens wear.[32] After the initial adaptation has been achieved, patients can be instructed to use their lenses on a daily-wear basis. Furthermore, a recent study has shown that GP lenses require only one additional patient appointment and the use of one additional diagnostic lens to achieve an optimal lens fit as compared to fitting soft lenses.[33]

The increase in population aging throughout the 20th century and the further increase expected in the current century implies a boost in the number of presbyopes requiring a satisfactory means of visual correction with contact lenses. Successful fitting of contact lenses for correcting presbyopia usually requires the trial of different lens materials and powers and sometimes lens designs. The selection of the most appropriate lens design should be determined according to the occupational needs, hobbies, and motivation of patients. The different options available and their limitations should always be explained to the patient, and patient expectations need to be realistic. However, the motivation, positive attitude, and expertise of the lens fitter also play key roles in the final outcome.

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