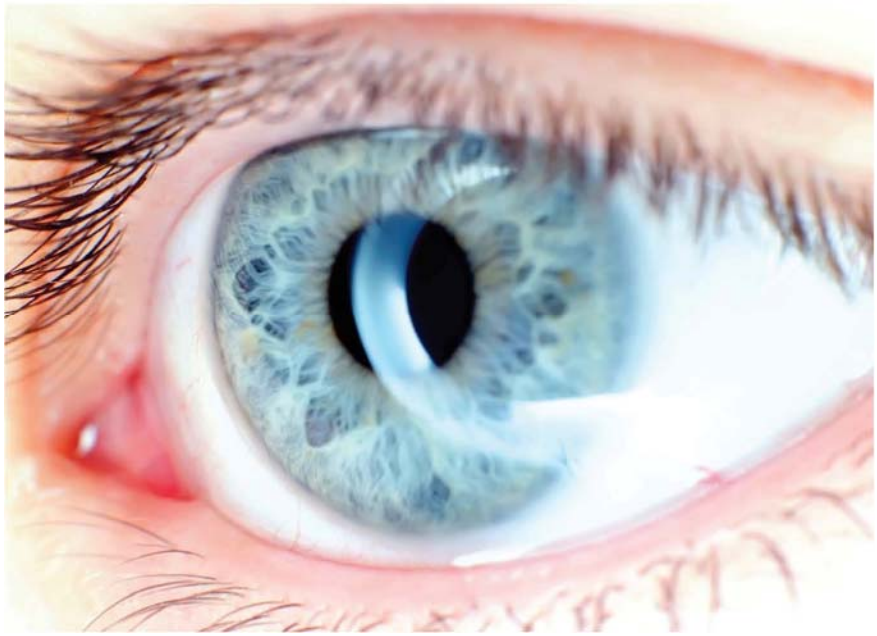
The decline of vision with age is a universal complaint. But Prof Dan Reinstein explains how treatment techniques are turning back the clock on ageing eyes with presbyopia

Ever decreasing circles

Presbyopia will affect all of us at some point in our lives, occurring in 100% of the population. The condition occurs as the eyes age, losing ability to change the focus of the eye to zoom from distance to near objects. It's an entirely natural process resulting in gradual visual impairment, but one which ensures treatment is always in demand.

The process starts from birth as the crystalline lens grows in size and is an unavoidable part of ageing. While the progressive decline continues throughout a lifetime, the lessened capacity of the lens only presents itself as a complaint around the mid-40s when it has a discernable impact on vision. At this stage, the eye has lost a noticeable ability to change from distant focusing to viewing an up-close object. The result is that the residual focusing power of the crystalline lens cannot provide sufficient near vision, and treatment becomes necessary, traditionally in the form of reading glasses or multifocal glasses.



The Far Future

So what options are available for the growing number of sufferers, as the ageing population increases? Of course the ideal solution would be to repair the ability of the crystalline lens to accommodate, but as yet no procedure has been able to reverse presbyopia and restore the natural focusing mechanism of the eye. There is ongoing research on techniques to achieve this, but clinical applications won't be available for at least 10 to 20 years.[1]

Current treatments focus on compensating for the lack of accommodation by providing a different refractive power at distance and near. The challenge of such treatment options is to provide both distance and near vision while simultaneously maintaining optical quality, with particular regard to contrast sensitivity and night vision preservation.

Traditional non-surgical methods of refractive correction for presbyopia include the use of dedicated reading glasses, bifocal, or varifocal glasses, monovision contact lenses or multi-focal contact lenses. But these treatments come with their own problems. Research studies have indicated that multi-focal glasses impair depth perception and edge-contrast sensitivity at critical distances for detecting obstacles in the environment.[2]

While in varifocal lenses, there is a corridor of continuously changing lens power and optimal vision is only obtained when looking though this corridor and directly facing the object of focus. Outside this corridor, the vision is distorted and peripheral vision is reduced. For these reasons, older people are more likely to fall when wearing multi-focal glasses.[3]

Vision through bifocal lenses is the 3rd greatest risk factor for falls in the elderly. This effect is more pronounced in high prescriptions, particularly for high astigmatism and so a number of patients are unable to adapt to this mode of correction.

Monovision contact lenses

The most widely used non-spectacle method of presbyopia correction is the use of contact lenses through the creation of monovision. In this technique, the eyes are dissociated by focusing one eye for distance vision and one eye for near vision (see illustration). However, the large image disparity between the two eyes causes several limitations to the quality of overall vision. Although binocular distance visual acuity remains optimal with monovision contact lenses, subjective quality of vision is decreased. There is no change in distance visual acuity because the dominant eye is able to suppress the blurred image from the near vision eye to provide good binocular vision.

However, the loss of fusion between the two eyes affects subjective quality of vision and patients complain of halos,

glare, haze and starburst. The severity of these symptoms increases with increasing power difference between the distance eye and the near eye; the older, the more difference required.[4]

Further, as one eye is focused for near and the fellow eye for distance vision, another limitation of monovision is the gap in the range of clear vision at intermediate distance[5] (computer, TV). Reduced stereopsis is considered to be the major limitation to monovision correction; both distance and near stereopsis have been shown to decrease with monovision correction.[4, 6] Binocular contrast sensitivity has also been shown to decrease with progressive increase in contact lens power in the near eye.[7] The combination of these limitations means that monovision correction can only be tolerated by between 59-67% of patients.[5]

Laser treatments

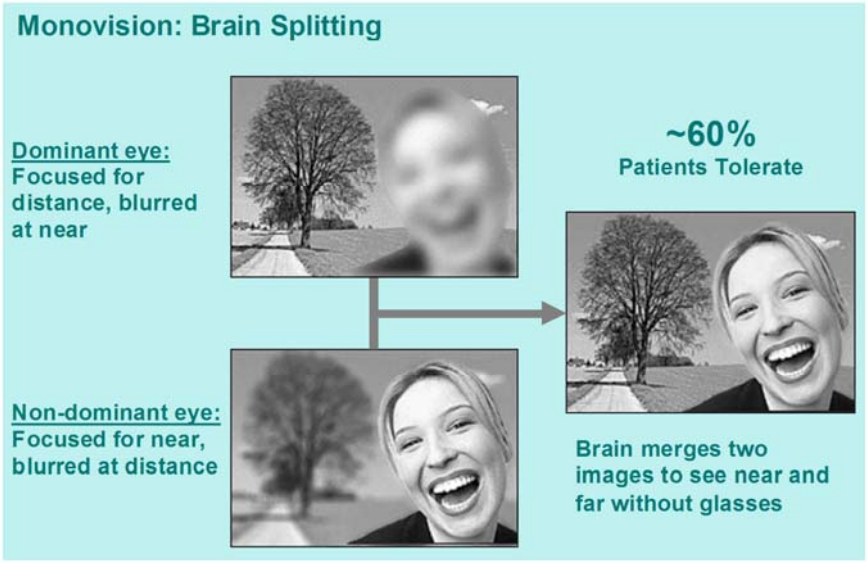
One surgical method of refractive correction for presbyopia is laser refractive surgery. Traditionally, the principles used for monovision contact lenses have been applied to refractive surgery, focusing the dominant eye for distance vision and the non-dominant eye for near vision. However, many of the same limitations found with monovision contact lenses applied to monovision induced by refractive surgery, including loss of fusion and stereoacuity.[8]

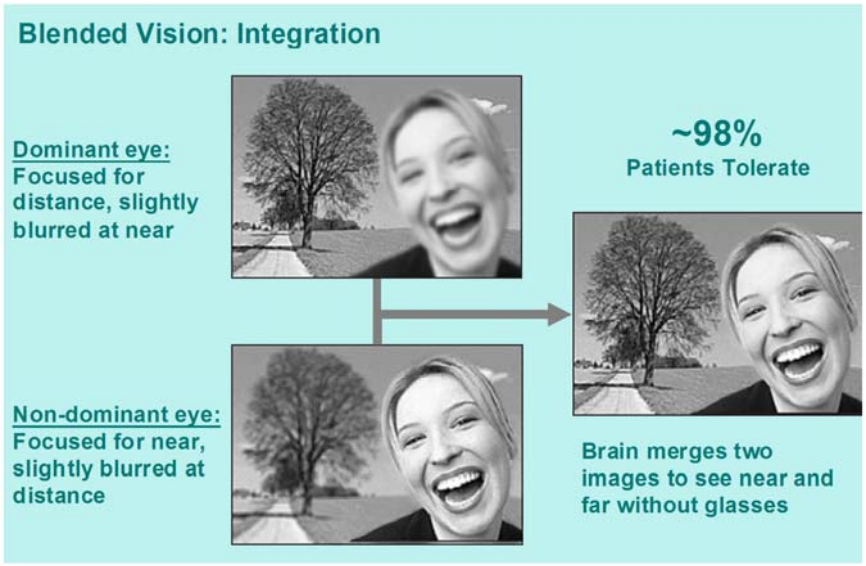
Surprisingly, monovision induced by refractive surgery can be tolerated by a higher proportion of patients (92%) than monovision induced by contact lenses.[9] It is unclear whether this might be due to the difficulty of reversing the procedure and the increased time for adaptation. Early outcomes for monovision induced by refractive surgery show that 76% of patients could read 20/20 (6/6) at distance and 95% of patients could read 20/25 (J2) at near.[10]

Recently, with the advances made in laser eye surgery, experimental approaches have been used to create a number of different multi-focal ablation profiles. In such techniques, either a central corneal area is steepened for near vision leaving the mid-peripheral cornea for far vision or vice versa.

While an overall improvement in visual acuity has been recorded for both near and distance vision, safety and quality of vision have been compromised.[11] It has been reported that 20% of eyes lost two lines of best-corrected visual acuity at distance and 52% of eyes lost two lines of best-corrected visual acuity at near, while only 48% of eyes achieved 20/20 uncorrected visual acuity.[11]

Further, by creating discontinuous optics between the central and the mid-peripheral cornea, contrast sensitivity was decreased and patients have reported night vision disturbances.





Lens implants

In addition to laser techniques, a popular method of correcting presbyopia is to perform intra-ocular surgery, removing the patient's crystalline lens and replacing it with a multi-focal or accommodating intra-ocular lens implant.[12] These lenses aim to correct both distance and near vision through a series of diffractive or refractive circular bands, each band alternating between distance and near vision correction. Clinically, multi-focal lenses do increase the range of vision from distance to near, but there are a few shortcomings.

First, there is a limited range to the vision inherent to the type of lens used. As a result, the patient may experience gaps in the vision where poor visual focus is found.

Second, multi-focal lenses have discontinuous optics and create more than one image to enable both distance vision and near vision correction. This has been shown to reduce contrast sensitivity[13] and increase night vision disturbances, with approximately, 4-8% of patients experiencing serious night vision disturbances.[14,15] This is particularly evident in patients with large pupils or where the inserted lens is misaligned or tilted.

In addition, these methods ignore the fact that presbyopes under 65 years in age may have some remaining accommodation which is sacrificed when the crystalline leans is replaced by an intra-ocular implant.

New approaches

New developments suggest the possibility of a laser surgical technique with significantly less disadvantages than both intra-ocular implants and existing laser refractive surgeries. Recent laser refractive surgery approaches focus on modifying the asphericity of the cornea[16] to increase the depth of focus of the eye, which has the advantage of maintaining more natural continuous optics.

Research in this area was adopted by Professor Reinstein in 2003 in collaboration with Carl Zeiss Meditec (Jena, Germany), and aims to improve on the concept of asphericity to develop non-linear aspheric profiles. The approach adopts a less extreme method of monovision which also allows the combined correction of presbyopia and any existing refractive error to be more effective.

Ideally, the depth of focus would be increased so that one eye can see clearly continuously from near distances to far distances. As this is not possible, the new concept increases the depth of focus of each eye separately, with one eye focused more for distance vision and one eye focused more for near vision. But unlike the traditional monovision approach the increase in depth of focus is such that the range of clear vision achieved by the distance eye and the near eye overlap at intermediate distances (see illustration).

The major advantage of this method is in creating a zone of fusion, where the brain can merge the images of the two eyes. Therefore, much less suppression is required and there is no dissociation between the eyes. This has been proved by measuring better distance visual acuity binocularly than monocularly, which demonstrates the neural binocular summation of the images from the two eyes.[17] The technique not only facilitates the tolerance of this mode of correction, it also maintains or improves contrast sensitivity and prevents night vision disturbances.

Termed 'Laser Blended Vision' rather than monovision (because there is fusion between the two eyes at mid-distances) the mode of correction has shown a 98% tolerance rate since its first deployment in 2003. In addition, when distance and near vision were measured post-operatively no eye lost two lines of best-corrected visual acuity.

In myopes, 98% of patients without correction could read 20/20 at distance and 92% could read J2 at near (equivalent to a computer font size of six and used for applications such as medicine bottle labels). In hyperopes, 93% of patients without correction could read 20/20 at distance and 82% could read J2 at near.

Laser Blended Vision can be applied to patients who have already had cataract surgery and are implanted with monofocal IOL lenses.

Future developments

Advances in the treatment of presbyopia have brought a multitude of refractive corrective options to the patient, and techniques are constantly improving. While most procedures are efficient in enhancing the ability of achieving distance and near correction, many also come with significant side effects and drawbacks.

Currently it seems that the best outcomes, lowest complications rates and least side effects are afforded by non-linear aspheric refractive corneal surgery by Laser Blended Vision. This technique offers clear advantages of better refractive accuracy, no night vision disturbances, better centration, no reduction in contrast sensitivity, and fewer surgical risks. For the opening chapter of the millennium, blended vision looks set to offer the best chance to help restore the youthful functionality which presbyopia deteriorates.

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