Contact Lens Update
CLINICAL INSIGHTS BASED IN CURRENT RESEARCH

Where are we heading with contact lenses for presbyopes?

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When I first encountered the problem of “bifocal” contact lenses, I was decidedly not presbyopic and frankly, not very aware of what a nuisance that condition is for those affected by it. At that time, monovision was the *de-facto* gold standard and its performance, when rated on every visual performance measure, with the exception of stereopsis, was invariably reported as being better, or as good as, the available bifocals.[1-5]

Although not foolish enough to think that the challenge of improving this situation in favor of the alternatives to monovision was going to be an easy one, I did have confidence that, by the time it mattered to me personally, a full and effective solution would have been developed.

How disheartening then to read some quarter of a century later (by which time I have become a hardened and desperate presbyope), that in a well-conducted trial comparing monovision with a range of modern multifocal and bifocal contact lenses, nothing much has changed. According to this report, monovision remains better, or at worst statistically equivalent to, multifocal contact lenses on all the vision related measures investigated apart, once again, from stereopsis.[6]

Have we really made so little progress in creating options for managing the presbyope in all that time?

Is monovision is better or equivalent to multifocal contact lenses?

Before getting too depressed, it is worth considering some additional information. First, many of the vision tests involved in these studies were essentially acuity-based, and measures of this type function poorly as predictors of presbyopic satisfaction.[7] It may be then, that reliance on indicators which are insensitive to differences between the various modalities has meant that the advantages of one lens type over another have simply been missed.

This highlights the need for a precise, reliable, sensitive and objective method of assessing vision in these circumstances. Such a tool is seriously lacking and would be very beneficial in both clinical and research settings, so hopefully something effective will emerge in the near future.

In the meantime, clinicians may be well advised to increase their emphasis on subjective responses to help them judge the relative behavior of different lens types. For example, asking wearers to report their visual quality, perhaps on a 1-100 scale, appears to offer a more sensitive means of discrimination than does visual acuity6 and gives a better reflection of satisfaction with performance in general terms, as well as specifically for distance or near viewing.[7]

Eye care practitioners seem happy to fit multifocals

The second point is that if usage data are to be believed, modern day practitioners appear to have considerable confidence in the ability of multifocals to function as a successful presbyopic correction. In those countries where data are available, the proportion of multifocal contact lens fits has doubled in the last 15 years.[8, 9] Furthermore, clinicians appear to overwhelmingly prefer fitting multifocals to monovison, the fitting ratio being about 5 to 1 on average, worldwide.[8]

Some will, no doubt, take these two factors as evidence that life in the presbyopic contact lens universe is not so bad. After all, aren't eye care practitioners getting on and fitting multifocals pretty well, despite the fact that they can't measure any differences between the options? This would be a naïve view however.

Even the most enthusiastic of practitioners only manage to fit 50% of suitable candidates with a presbyopic contact lens option,[8] and as many as 40% of wearers who discontinue report vision problems as the primary reason.[10] Furthermore, the drop in the numbers of contact lens wearers with age is huge and especially occurs around the time of onset of presbyopia.[11] The reason for these inadequacies is surely performance-related, and so the need for better lens designs still persists.

Design hurdles

It has long been appreciated that, from the perspective of presbyopic correction, the fundamental characteristic of a contact lens, namely that it is in contact with the eye, is its main disadvantage. In contrast to spectacles, in which eye and lens move independently, contact lenses rotate *with* the eye. This makes it much more difficult to arrange for optically distinct portions of the lens to be sequentially aligned with the visual axis, as is required to achieve good distance or near vision. For this reason, translating bifocal lenses have been rarely produced and the market is dominated by simultaneous imaging designs, at least so far as soft lenses are concerned.

Over the years, the range of designs available in this category has been broad but lately is showing signs of convergence. Most of the major corporations operating in this space now offer a centre-near multifocal as their primary product. If we take the view that "great minds think alike," this phenomenon could be seen as an indication of maturity in the design process for simultaneous imaging lenses.

Thus, the currently available lens configurations represent a situation that is getting close to the best possible, given the underlying physics. That being so, significant further improvement is unlikely to accrue by continuing to follow this pathway in the future, and new directions are needed.

New directions in presbyopic corrections

One such possibility has recently been presented by lenses that use principles of extended depth of field. In its purest form, this approach uses a pinhole, or small diameter, aperture on the lens, to limit the pencil of rays incident on the retina. The presbyopic eye can then achieve useful vision over a broader range of distances than is possible unaided.[12] While sound enough in theory, there are some associated practical problems, including the cosmetically undesirable nature of the lens in situ. For these reasons, other inventors have taken different paths to achieving the same end. For example, a virtual pinhole can be created by rapidly ramping up positive power immediately peripheral to the small diameter, distance-powered central zone.[13] Lenses of this type are currently available in some markets and may soon be joined by those that seek to extend the acceptable range of defocus by manipulating higher order aberrations,[14] or adjusting the phase of the incident light.[15] While early data on some of these approaches have been encouraging,[16] far too few studies are available in the literature to give a sense of whether or not there are any advantages in vision terms.

Whatever the characteristics of the underlying optics though, all the lenses mentioned above fall broadly under the heading of simultaneous imaging; that is, they cause light from multiple distances in the visual field to arrive at the fovea, at the same time. The resulting overlay of the various images is typically associated with an array of well-known vision problems, including contrast reduction, flare and ghosting. Overcoming these drawbacks is critical to improving success rates, but has proved difficult in this design space. The obvious way forward is to move away from the limitations of simultaneous imaging and mimic the pre-presbyopic eye by having a lens that actively alters its focal length according to the distance of the object of regard. Abolishing presbyopia in this way is very attractive and appears to be the direction that future developments will have to take if significant performance improvements are to be achieved.

The patent literature shows that several inventors are indeed working along these lines. For example, at least two proposals have suggested that by creating fluid filled cavities within the lens, the pressure of the lower lid, on down-gaze, may be enough to pump liquid into the optic zone, from reservoirs located towards the bottom of the lens. The resulting change in refractive power would, it is claimed, support near vision.[17, 18] Whether this type of device would work effectively is not completely clear. Notwithstanding the problems that may be encountered in fabrication, it remains to be seen if eyelid pressure alone is sufficient to generate the rapid back and forth movement of fluid needed for adequate vision when looking successively from near to distant objects and back again. Nevertheless, conceptually similar devices are in clinical trials as intra-ocular lenses,[19] though, admittedly, this is different mechanically from traditional contact lenses.

Perhaps the approaches generating the most excitement are those based on equipping the lens with electro-optical components. Liquid crystal technology, for example, can create rapidly switchable refractive elements with a range of interesting properties[20] and it is easy to imagine how these could be the basis of functional bifocal or multifocal devices. Interest from industrial concerns in this and similar approaches has, not surprisingly, been considerable.[21, 22]

Challenges of new technologies for correcting presbyopia

Intriguing though these new technologies may be, several problems need to be solved if they are to present a mass market option for presbyopia. Not the least of these is how to provide the wearer with some convenient means of controlling the power of the lens when switching between near and distant targets. One possible strategy might be to provide each lens with a sensor that continuously monitors the distance to its fellow, in the other eye. When this changes, as it would during convergence, the relative proximity information could provide the input for circuitry that alters the focal power in the optic.[23, 24]

Whatever the nature of the active element in the lens, it will be desirable for its materials to have properties that closely mimic those of conventional contact lens polymers, particularly in key areas such as oxygen permeability and modulus of elasticity. On top of this, the various electronic components need to be encapsulated so as not to be affected by the moist environment in the tear film. Meeting these challenges will probably mean that, during the early stages of development, rigid or silicone rubber carriers, perhaps using scleral or haptic configurations, will be pressed into service. Eventually however, penetration of the mainstream market will inevitably demand that the whole lens acquire softer, more hydrogel-like characteristics. Maintaining a desirable range of performance characteristics in this format does not seem trivial.

With this background, a truly accommodating contact lens bifocal still appears some years from being widely available. If recent history in the field of micro-electronics has taught us anything however, it is that, with the right incentives, innovation can proceed at astonishing speed, and tomorrow very quickly becomes today. I certainly hope so; I don’t want to wait another 25 years.

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