New options for presbyopic correction

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New treatment techniques are emerging for patients considering alternatives to spectacles and contact lenses for the correction of presbyopia. With an ageing population and the growing demand for presbyopic correction, patients are increasingly likely to visit their eye care practitioner for advice on their suitability for treatment. This article will discuss the various options on offer with an overview of the anticipated visual outcome for each method.

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Learning objectives
To understand the patient’s expectations and aspirations with regard to surgical vision correction (Group 1.2.1)

Learning objectives
To be able to explain the implications of presbyopia to patients (Group 1.2.4)

About the author
Fred Proctor graduated from the University of Ulster in 1998 and for the last 8 years has been working in laser eye surgery clinics. He is currently working in Optilase, which fits more Kamra vision inlays than any other clinic in Europe.
Introduction
Presbyopic patients have historically lacked sufficient options to restore near vision, with the majority resigned to using spectacles for these tasks. It is expected that there will be over two billion presbyopes worldwide by 2020, and in response to this growing demand, a number of therapeutic options are becoming available, including corneal inlays and ablation techniques.

Kamra inlay
The corneal inlay with the greatest regulatory approvals is the Kamra corneal inlay (AcuFocus, Inc.) It is commercially available in 49 countries and has been implanted in nearly 20,000 patients worldwide, including ophthalmologists and optometrists.

The Kamra inlay is only 3.8mm in diameter and 5μm thick and designed to sit in a surgically created pocket in the corneal stroma. It works by extending the depth of focus through a 1.6mm aperture in the centre of the implant, which provides an unobstructed pathway for focused light to reach the retina (see Figure 1).

It functions in a similar way to viewing through a pinhole. The opaque device is made of polyvinylidene fluoride (PVDF) and nanoparticles of carbon. It has 8,400 micro-perforations set in a pseudorandom pattern to maximise nutrient flow while minimising visual symptoms (see Figure 2, page 54). PVDF is highly biocompatible and has been used in intraocular lens (IOL) haptics for over 20 years. The micro-perforations allow the free flow of glucose and other metabolites, maintaining the health and high metabolic rate of the corneal epithelial cells.

The implant is virtually undetectable to the naked eye, even in light coloured eyes and can only be seen in bright light at a close-up, oblique angle, or if the patient’s pupil size is less than 3.8mm. The inlay does not impair ophthalmic assessment of the eye after it has been fitted; corneal diagnostics, gonioscopy and anterior chamber angle imaging can all be achieved with the crystalline lens easily viewed through a dilated pupil, enabling assessment of lens opacities (see Figure 3). High quality retinal images using optical coherence tomography and fundus photography can still be obtained following the procedure. Comparative studies for visual field screening have shown no difference between pattern standard deviation scores for implanted and non-implanted eyes, with no localised constrictions or scotomas and GHT calculations were not impacted.

The Kamra inlay can be used to treat a wide range of patients including emmetropes, ametropes, post-LASIK patients and monofocal pseudophakes.

Pocket Emmetropic Kamra implantation (PEK) is the procedure used to treat naturally occurring presbyopia in emmetropic patients. The technique uses a femtosecond laser to create a lamellar pocket in the stroma at a depth of 200–250μm. The inlay is inserted into the pocket and centred over the visual axis.

Planned LASIK Kamra – two-step implantation (PLK2) can be used to manage patients with both ametropia and presbyopia. A standard LASIK procedure is performed first in both eyes. A minimum of one month after LASIK surgery, the femtosecond laser is used to make a corneal pocket in the non-dominant eye at least 200μm deep in the cornea and a minimum of 100μm below the previous LASIK interface. An average myopic shift of -0.60D should be accounted for in the non-dominant eye of these patients.

Post-LASIK Kamra implantation (PLK) is used to address presbyopia in post-LASIK patients. This procedure, similar to PLK2, requires creation of a femtosecond laser pocket at least 200μm deep in the cornea and a minimum of 100μm below the previous LASIK interface. The same average myopic shift noted in PLK2 patients should be considered for post-LASIK patients as well.

Across all three procedures, mean near visual acuity scores at 12 months are typically 0.1 and 0.2 LogMAR, following a rapid improvement over the first two to three months. Mean distance uncorrected visual acuity (UCVA) in the treated eye is around 6/6. Distance stereoacuity scores

Figure 1 Kamra inlay design

Inlay Design

- 3.8mm diameter
- 1.6mm aperture
- 5µm thick
- 8,400 holes (5–11µm)

Made from polyvinylidene fluoride (PVDF)
the microlens may be incorporated into concurrent and post-LASIK treatment plans, or to manage presbyopia following cataract surgery.

As with other multifocal corrections, including IOLs and contact lenses, patients treated with the PFM require time for neural adaption. This is due to the simultaneous retinal images created by the multifocality of the design, and symptoms of glare and haloes may be reported during the adaptation phase. It is advisable to offer these patients a multifocal contact lens trial pre-operatively to demonstrate the effect and determine the likelihood of adaptation.

In a Greek study, 15 patients had the implant placed inside a corneal tunnel created with a femtosecond laser and were followed-up for a 12 month period.4 Near UCVA increased from a mean of 20/50 at baseline to 20/25 at three months and stable through 12 months. Distance UCVA in the treated eye decreased from 20/20 at baseline to 20/30 at three months and then remained stable. Binocular distance UCVA was 20/20 at baseline and remained unchanged after surgery.

### Raindrop Near Vision Inlay
The Raindrop Near Vision Inlay (Revision Optics) works by reshaping the cornea of the non-dominant eye using an implant made of a proprietary micro-porous hydrogel material. The inlay is 2mm in diameter and 30μm thick and is placed under a 150μm femtosecond laser-generated flap to manipulate the anterior curvature of the cornea. The presence of the inlay creates a prolate effect that improves near and intermediate vision, while permitting distance vision through the peripheral cornea. Data from 20 patients with the hydrogel inlay implanted in the non-dominant eye shows that all subjects achieved near UCVA of 0.3 LogMAR or better by week one and at one year, mean monocular and binocular near UCVA was better than 0.1 LogMAR.7 Prospective patients may be given a multifocal contact lens trial for a few days to assess tolerance of simultaneous vision prior to treatment. It is possible that the implant may lose its effect over time due to presbyopia progression and epithelial remodelling.

### Icolens
The Icolens (Neoptics AG) is a hydrophilic polymer lens that improves vision via a bifocal mechanism with a range of powers for both the periphery (near vision) and central (distance vision) zones. The peripheral powers range from +1.50D to +3.00D with central zones available in plano, +0.50D, and +1.00D. The inlay is placed in a femtosecond laser-created pocket at a depth of 300μm. Clinical
trial data for 36 patients implanted with the Icolens showed a mean gain of 3.49 lines of LogMAR monocular near UCVA in the treated eye with a loss of 1.75 ± 1.56 (Mean ± SD) lines of monocular distance UCVA, and a gain of 0.33 ± 1.12 lines for binocular distance UCVA.8 While the inlay does come in multiple powers, allowing for customisation and central distance correction, 15% of patients reported glare with the Icolens.9

**Intracor**

The Intracor procedure (Technolas Perfect Vision) uses a femtosecond laser to create five concentric rings and eight radial cuts to alter the curvature of the cornea, making it slightly more hyper-protalate. The first concentric rings are created in a small central zone of the cornea, steepening the curvature to improve vision for near tasks. Outside of the central near zone, the cornea gradually changes shape to expand depth of focus for intermediate tasks such as computer work. The peripheral area of the cornea maintains its original shape for distance vision. The Intracor procedure is a minimally invasive treatment performed directly into the stroma without the need for any tissue removal. Corneal thickness remains essentially unchanged and the epithelium is not affected, reducing the risk of infection and other complications associated with flap creation used in other procedures. However, at this time, there is no method for enhancing or correcting the procedure if the patient is not satisfied with their result. In the longest follow-up to date, outcome measures at 18 months revealed that median near UCVA improved significantly from 0.7 LogMAR preoperatively to 0.2 LogMAR following treatment. All 83 eyes had improved near UCVA, with minimal or no change in distance UCVA.10

**Supracor**

Supracor (Technolas Perfect Vision) is a bilateral, rather than unilateral, laser treatment that precisely reshapes the cornea to restore near vision, while simultaneously treating hyperopia or myopia if necessary. The treatment involves creating a thin flap on the surface of the eye and then reshaping the cornea employing optimised algorithms, correcting presbyopia while minimising aberrations within the pupil region. Supracor is particularly effective at correcting presbyopia in hyperopic patients. In a prospective, multicentre, clinical study of 46 eyes in 23 patients, 87% achieved binocular near UCVA of Jaeger 2 or better at six months post-operatively; 96% of patients had distance UCVA of 0.8 or better.11 A subjective patient questionnaire showed high levels of patient satisfaction and spectacle independence, with 96% able to read newspapers, text messages and menus without spectacles.

**Conclusion**

With the emergence of several contemporary methods for presbyopic correction, optometrists will inevitably be seeing these patients in practice, both prospectively and post-treatment. This article provides the eye care practitioner with a basic understanding of the different procedures available. Early results from these techniques hold much promise and the growing demand for this type of presbyopic correction will inevitably increase in the future.