LEARNING DOMAINS

CLINICAL PRACTICE

SPECIALTY: CONTACT LENS OPTICIANS

COMMUNICATION

PROFESSIONAL GROUPS

Dispensing opticians — CPD PROVIDER — General Optical Council

Optometrists — CPD PROVIDER — General Optical Council

Contact lens opticians — CPD PROVIDER — General Optical Council

CPD CODE: C-106952

MCQs AVAILABLE ONLINE: Friday 1 December 2023

CLOSING DATE: 8 March 2024

ANSWERS PUBLISHED: April 2024

This CPD session is open to all FBDO members and associate member optometrists. Successful completion of this CPD session will provide you with a certificate of completion of one non-interactive CPD point. The multiple-choice questions (MCQs) are available online from Friday 1 December 2023. Visit **www.abdo.org.uk**. After member login, scroll down and you will find CPD Online within your personalised dashboard. Six questions will be presented in a random order. Please ensure that your email address and GOC number are up-to-date. The pass mark is 60 per cent.

CPD CODE: C-106952

Understanding extended depth of focus (EDOF) contact lenses

By Philip Thompson FBDO CL MBCLA

Is the concept of extended depth of focus (EDOF) new? In relation to contact lenses, the answer is 'yes' – reasonably so. EDOF contact lenses have been available in the UK since February 2019 when NaturalVue, with its propriety design, came to market. Since then, several Brien Holden Vision Institute (BHVI) EDOF design lenses have been introduced.

If we were to consider the opening question in terms of photography, then the answer would be a firm 'no'. While most photographers would probably refer to this as 'depth of field' rather than EDOF, it does help us to understand what it means in optometric terms.

If we capture a photograph with the aperture (f-stop) set as wide as possible, we get a very short depth of field. For example, the subject in **Figure 1** appears to stand out – but everything behind the point of focus is blurred. In the case of a close-up or portrait, this is desirable in order to make the subject appear to 'leap out' of the photograph. The dragonfly in **Figure 1** was captured with the f-stop set at f2.8, as wide as possible, to create this short depth of focus.

In terms of relating this to our vision, it is similar to viewing a near object with single vision (reading) lenses. This gives a short depth of focus – with anything beyond this range becoming increasingly blurred. Conversely, when we close the aperture down to the smallest available, we get the opposite effect.

In **Figure 2**, where the aperture was set to f22, the pebbles in the foreground are just 30cm from the camera and in clear focus. The horizon, some four to five miles away, is also clear – along with everything in between. In photographic terms, this is an extended depth of field and is the best analogy we can highlight when talking about EDOF contact lenses.

HOW DO WE DEFINE EDOF?

Let's start with depth of focus (DOF). DOF is the range of clear vision along the visual axis over which an image may be focused and perceived as clear. It stands to reason that all lenses have a DOF. For example:

- **SINGLE VISION:** by definition, single vision lenses have one focal point and therefore a short DOF
- **ZONAL MULTIFOCAL:** these lenses usually have two focal points, which the patient needs to translate between to change focus, and each has a short DOF
- **EDOF:** these lenses have a wider range of clear vision along the visual axis

FIGURE 1: Short depth of focus photograph

FIGURE 2: Extended depth of field photograph

To help us visualise the way the light behaves within the eye, we can see from light ray traces how a zonal multifocal (**Figure 3**) and an EDOF lens (**Figure 4**) differ.

The zonal lens (**Figure 3**) produces two focal points, which have a short DOF, and around each of those is a 'halo' created by the alternative focal point. The intermediate zone is a combination of both focal points and therefore doesn't produce a clear image. With the EDOF lens (**Figure 4**), you can see that the area of focus is extended such that distance, intermediate and near would all be clear with only a very diffuse halo effect being produced – giving the patient clear, uninterrupted vison at all distances.

This is further demonstrated when we look at what is happening at the retinal plane (**Figure 5 and 6**). The zonal lens produces 'hot spots' of focus that cause ghosting, whereas the EDOF lens has a clear central area with a very diffuse halo that is less than 20 per cent of the zonal lens halo. This becomes important when used for myopia management as two of these products are indicated for this use (*see later*).

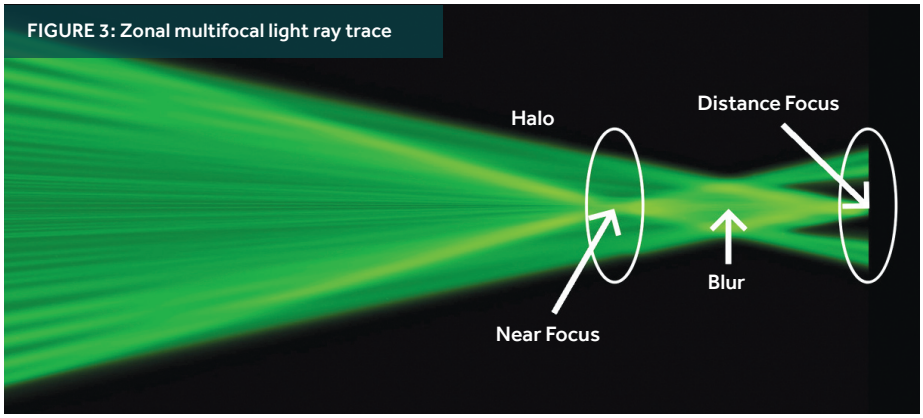

FIGURE 3: Zonal multifocal light ray trace

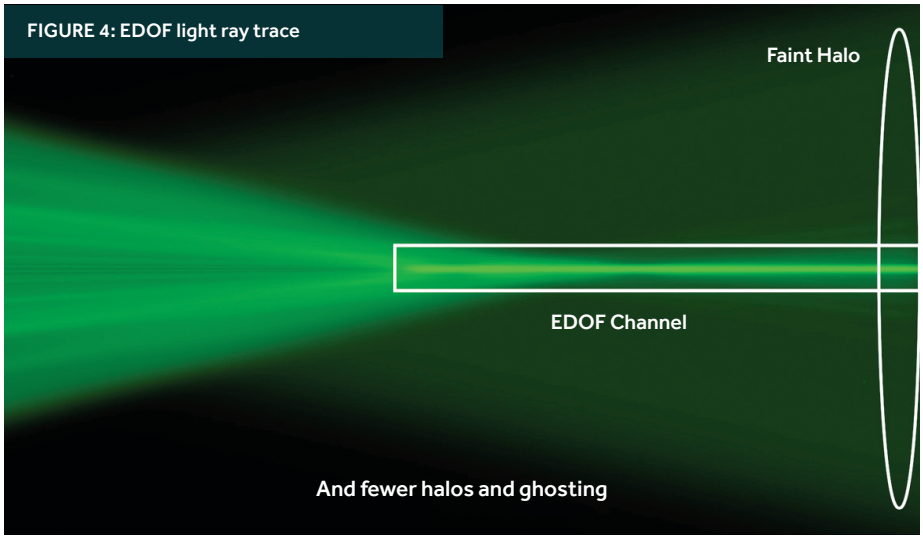

FIGURE 4: EDOF light ray trace

CURRENT EDOF DESIGNS

In essence, there are currently just two EDOF designs available on the market today: the proprietary design of the NaturalVue Enhanced Multifocal 1 Day lens manufactured by Visioneering Technologies (VTI) and distributed in the UK by Positive Impact; and the BHVI design.

The BHVI itself doesn't make these lenses but rather the design is sold under licence. The Institute has issued one licence for each of the following EDOF contact lenses:

- Seed 1dayPure daily disposable soft contact lens from UltraVision
- EDOF frequent replacement soft contact lens from Mark'ennovy (includes Mylo)
- SynergEyes iD rigid hybrid contact lens design

Taking each of these lenses in turn, NaturalVue Enhanced Multifocal 1 Day is made from etafilcon A with a design update (hence enhanced). It is 30 per cent thinner than the original design, with an ultra-tapered edge and a patented Triple Tear Lubrication and a UV filter.

Mark'ennovy's EDOF design (including Mylo) is a proprietary silicone hydrogel material with a high water content and UV filter. It comes in a wide range of powers and fits, and includes a toric version.

The UltraVision Seed 1dayPure EDOF lens uses the company's Zwittertronic material SIB (SEED Ionic Bond) which contains both positive and negative ions resulting in electrical stability. This stability ensures high water content whilst keeping out dust and impurities.

The SynergEyes iD lens (single vision and EDOF) has proprietary materials of petrafocon A (Dk 130) for the GP centre and larafilcon A (Dk 84) for the silicone hydrogel skirt. These are bonded using a unique patented covalent process. A covalent bond forms when the difference between the electronegativities of two atoms is too small for an electron transfer to occur to form ions. The shared electrons located in the space between the two nuclei are called bonding electrons and form the 'glue' that joins the materials. In essence, once joined at this molecular level, the materials cannot come apart.

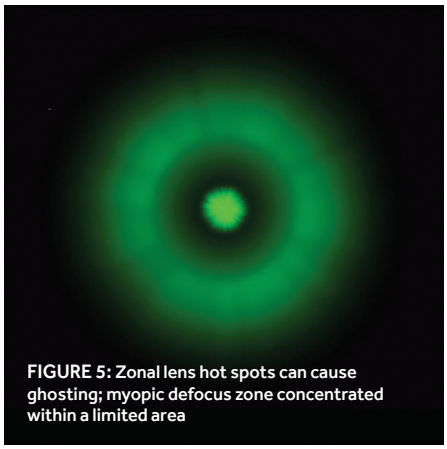

FIGURE 5: Zonal lens hot spots can cause ghosting; myopic defocus zone concentrated within a limited area

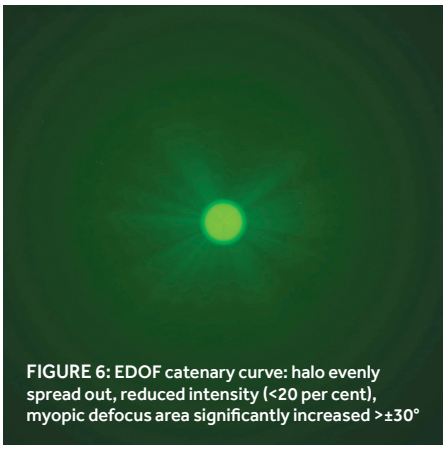

FIGURE 6: EDOF catenary curve: halo evenly spread out, reduced intensity (<20 per cent), myopic defocus area significantly increased >±30°

FIGURE 7: Archway, St Louis, USA

FIGURE 8: Winter Gardens, Sheffield, UK

DIFFERENT DESIGN MECHANISMS

The NaturalVue and BHVI designs produce their EDOF functionalities in quite different ways. The former is based around catenary curves, while the latter is a non-monotonic and aperiodic design.

CATENARY CURVE DESIGN

In architectural terms, catenary curves have been used for many years. Prime examples can be seen in the famous St Louis Archway (**Figure 7**) and, closer to home, the Winter Gardens in Sheffield (**Figure 8**). These curve forms are incredibly strong and are purely mathematical in shape.

More recently, catenary technology has been used in astronomical telescopes and microscopes, where the need for high resolution optics is essential. This principle was applied to the design of the NaturalVue contact lens, and is given the term Neurofocus Optics.

The graph shown in **Figure 9** defines the power profile of a NaturalVue lens with the catenary curve inverted. The centre of the lens, the lowest point on the curve, has the distance prescription. Within five microns of the centre, there is a change in relative plus power to between +6.00 and +8.00 dioptres, which is uninterrupted and rapidly applied.

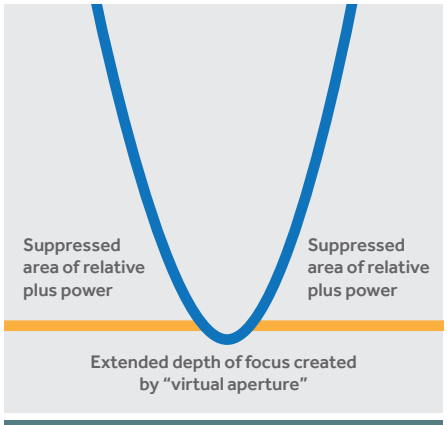

FIGURE 9: Power profile of a NaturalVue lens

None of this plus power is there as an Add for near vision, but is designed to induce a large amount of myopic defocus. This suppression of the peripheral stimulus creates a 'virtual pinhole' effect that gives the EDOF, but doesn't limit the patient's peripheral perception. This catenary design allows the lens to encompass all spectacle additions up to a +3.00 Add in one design.

NON-MONOTONIC AND APERIODIC DESIGN

The BHVI lens uses a non-monotonic (varying power profile) and aperiodic (no discrete zones) design. Although the design has what we may term 'concentric rings', they are not in the form we would normally describe as a concentric design, i.e. a lens that has alternating distance and near powers with a discrete change between each power, alternating and repeating across the optic zone of the lens.

As the power profile image and graph in **Figure 10** shows, the relative plus changes as we move to the edge of the optic zone. The zones vary in size and the change of power between zones is more gradual.

Unlike NaturalVue with its catenary design, the BHVI design uses three separate designs – low, mid and high – to encompass all spectacle additions. However, these shouldn't be mistaken as Adds as in traditional zonal multifocal lenses because they don't behave in the same way – as will be seen in the fitting descriptions below.

It should be noted that in both designs, EDOF lenses are shown to be more robust for pupil changes, aberrations and decentration[1] – including angle kappa – and so may have greater potential for success with these patients.

MYOPIA MANAGEMENT WITH EDOF DESIGNS

In general, in this article, the author has discussed EDOF lenses for presbyopia, however, within the two designs and four products listed earlier, two are indicated (CE marked) for myopia management. They are VTI's NaturalVue contact lens and Mark'ennovy's Mylo contact lens.

As well as genetics[2] and outside time (or lack thereof) with increased screen usage[3-5], routine corrections causing hyperopic defocus[6] has long been held as a driving factor in myopia amongst children and young adults. Creating plus in the periphery gives the desired myopic defocus but can cause visual disturbance.

Although NaturalVue has high plus in the periphery of the lens, the defocus is spread out over a wide area (defocus covers greater than ±30˚ of retina) with the visual disturbance softened to less than 20 per cent of the 'hot spots' of a traditional design.

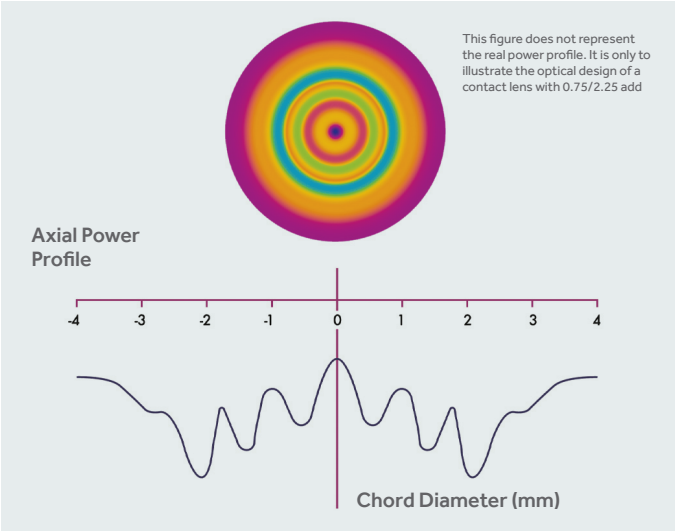

FIGURE 10: BHVI EDOF design

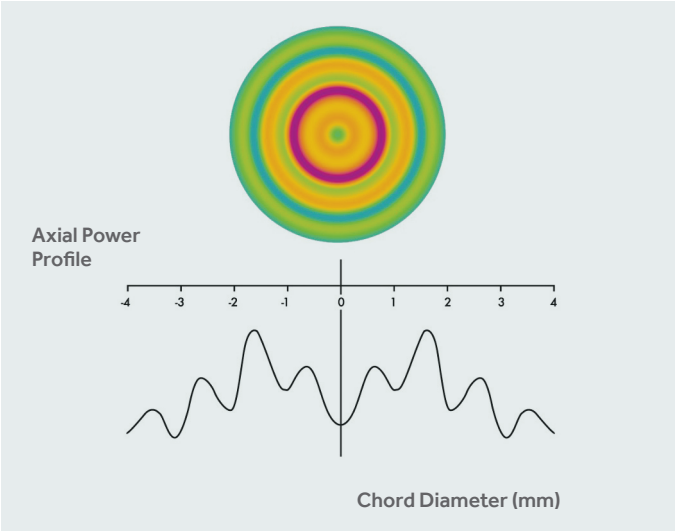

FIGURE 11: Mylo power profile

The catenary curve generates an extremely high magnitude of myopic defocus but is smooth and gentle in intensity, which preserves visual quality and visual comfort. The long and narrow EDOF channel can reduce accommodative demand and address accommodative dysfunctions.

As can be seen in **Figure 11**, the Mylo power profile, although varying due to the non-monotonic design, largely keeps all peripheral defocus within the eye making this a good candidate for myopia management. Both products have a number of studies associated with them that provide a guide to their effectiveness; and whilst the remit of this article is to give information on EDOF designs, it is worth considering the highlights of these studies.

NaturalVue has a retrospective case series analysis[7] of 196 subjects across a six-year period and 15 real-world practices. In this study, 95 per cent of subjects showed a decrease in refractive error change (and therefore their myopia progression), with 78 per cent showing a decrease of 70 per cent or more. At all points in time, the average amount of myopia progression observed was ≤ 0.25D from baseline, and the average refractive error change slowed by 0.85D (or 85 per cent) as compared to baseline from six to 72 months.

Axial length was measured during the last four years of this study, and the average axial length change was approximately 0.10mm per year through 47 months of follow-up (considered to be similar to normal eye growth). VTI has started an randomised-controlled trial (PROTECT) and the recently published the one-year results show a 69 per cent reduction in refractive error and 59 per cent reduction in axial length growth.

With the Mark'ennovy Mylo lens, a study was presented at the British Contact Lens Association clinical conference in June 2023, which is currently being peer reviewed by the *American Journal of Ophthalmology*. The efficacy in this recent study compares more favourably to the BHVI studies done by Padmaja Sankaridurg *et al*[8] – demonstrating a 45 per cent reduction in refractive change -0.62D vs -1.13D (P<0.001) and a 44 per cent reduction in axial length progression as 0.37mm vs 0.66mm respectively (P<0.001).

FITTING EDOF LENSES FOR PRESBYOPIA

The manufacturers of the following four products offer their own unique methods for getting the best results, and from the author's experience it is recommended that eyecare practitioners follow the fitting guides provided. (*NOTE: this article does not cover all fitting and troubleshooting aspects of these lenses.* ***For full details, contact the manufacturer directly.***)

EDOF contact lenses behave quite differently to traditional designs and so the approach of best vision sphere with maximum plus used by many manufacturers of these lenses will lead you in the wrong direction. One of the key factors for success with EDOF lenses is to consider them as distance lenses and to maximise that area of vision first. The lenses will create the EDOF within the eye that allows vision at all other distances and so, in general, if the area of EDOF is in the correct plane, all other working distances fall into place.

VTI NATURALVUE

VTI requires that a practitioner becomes accredited to fit NaturalVue contact lenses, which will ensure they achieve greater success from the off. It is key to get the maximum minus, without over-minusing, and then the use VTI's calculator app the work out the correct initial lens (**Figure 12**).

Refract to 20/15

Check that the patient is not overplussed by using the binocular Red/Green (Duochrome test) 1 CLICK INTO GREEN

Use the best corrected spectacle refraction (BCSR) with the full cyclinder component

Enter the full spectacle refraction into the NaturalVue Multifocal QuickStart Calculator

FIGURE 12: NaturalVue lens power selection process

SPECTACLE ADD (DS)	DOMINANT EYE	NON-DOMINANT EYE
Up to +1.25	Low	Low
+1.50 to +1.75	Mid	Mid
+2.00 to +2.50	Hi	Mid

TABLE 1: Seed 1day Pure EDOF Add power selection guide

MARK'ENNOVY MYLO

For Mark'ennovy's EDOF contact lens (including Mylo), the recommended fitting approach is to utilise an online calculator. This requires accurate Ks and horizontal visible iris diameter – as this lens is completely customisable.

ULTRAVISION SEED 1DAYPURE

For UltraVision's Seed 1dayPure, it is recommended that the power be determined using the sphere (or average sphere) of the spectacle prescription (but not 'pushing plus'). Ascertain dominance using a sensory method and fit a low, mid or high design according to the spectacle add based on **Table 1**.

Note that if differing EDOF designs are being used, the higher design is fitted to the dominant eye. This may seem counter-intuitive when compared to fitting zonal lenses, where the high add is usually fitted to the non-dominant eye, however, it has to be remembered that in the case of EDOF, low, mid and high relate to the design and not to an Add.

SYNERGEYES ID

The SynergEyes iD EDOF lens is unique amongst these products in that it is a hybrid lens, using a rigid gas permeable (RGP) lens centrally adjoined to a silicone hydrogel skirt using a patented hyperbond junction (**Figure 13**)[9].

Because of the nature of an RGP lens, it can correct corneal astigmatism (in this case up to -6.00DC) using the tear lens created under the RGP portion. Therefore, just as with any RGP lens, rotation isn't a factor for correcting the cylindrical component of the prescription – and the patient is purported to always have clear stable vision. Because the RGP is supported by the skirt, it always sits centrally and doesn't translate with blink, moving more like a soft lens, and the EDOF component is the BHVI design.

The 'iD' in the lens name stands for 'individually designed' having the back optic zone radius (BOZR) available in 0.01mm increments and 12 linear skirts independent from the BOZR. On the face of it, it would seem to be a complicated product and only for those who regularly fit RGP lenses. However, it is fitted entirely empirically from K readings, HVID and spectacle prescription.

With a high first lens success rate (88 per cent) quoted by the manufacturer, the first lenses received could well be the only lenses required for this potentially complex patient.

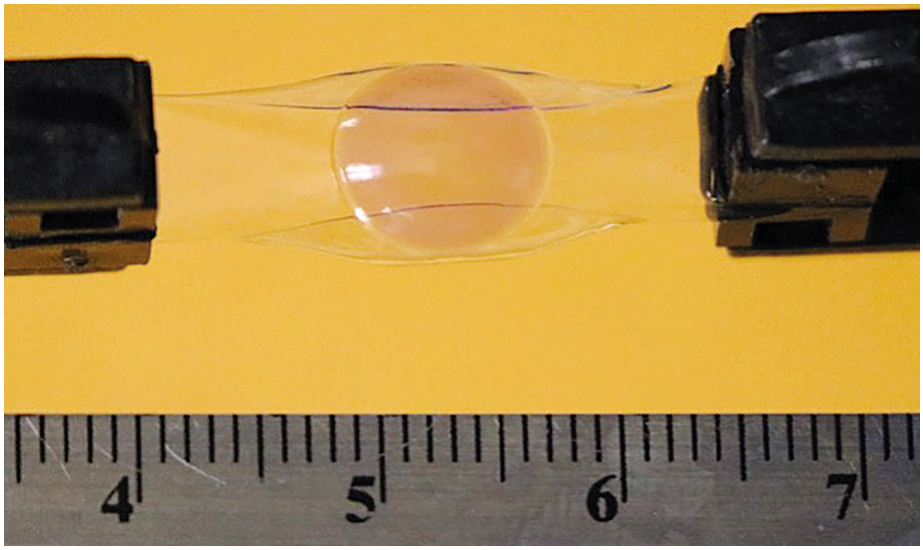

FIGURE 13: SynergEyes iD EDOF hyperbond junction

Understanding extended depth of focus (EDOF) contact lenses

SUMMARY

Contact lens manufacturers often refer to the 'ageing population' – keen for us to fit more multifocal designs. With an increasingly active older population, offering contact lenses as part of a range of products to correct their vision should be our approach. However, multifocal contact lenses have never gained the traction they deserve because of adaption issues – especially for higher Add designs – and the reluctance of practitioners to spend a good deal of chair time for, all too often, little reward or potential 'drop-out' down the road. And with the onset of myopia quoted to affect half the world's population by 2050[10], using every means of treatment possible is a must for any modern practice.

EDOF technology is a genuine step change in the optics of a contact lens and offers lenses that allow patients to see clearly at all distances (including intermediate) with little or no ghosting – even with high spectacle additions. They are less susceptible to visual problems caused by decentration and are not pupil dependant. They require a different approach to fitting and troubleshooting, and following the fitting guides or speaking to the professional services team of your preferred supplier will yield greater success for you and your patients.

Let's not forget the young people we see, as these lenses are also proven to be effective as part of a myopia management treatment portfolio.

REFERENCES

1. Bakaraju RC, Ehrmann K, Ho A. Extended depth of focus contact lenses vs. two commercial multifocals: Part 1. Optical performance evaluation via computed through-focus retinal image quality metrics. *J. Optom.* 2018;11:10-20.

2. Jiang SA *et al*. Association of parental myopia with higher risk of myopia among multiethnic children before school age. *JAMA Ophthalmol*. 2020;138(5):501-509.

3. Enthoven CA, Tideman JWL, Polling JR, Yang-Huang J, Raat H, Klaver CCW. The impact of computer use on myopia development in childhood: The Generation R study. *Preventative Medicine* 2020;132(5):105988. doi: 10.1016/j.ypmed.2020.105988.

4. Grzybowski A, Kanclerz P, Tsubota K, Lanca C, Saw SM. A review on the epidemiology of myopia in school children worldwide. *BMC Ophthalmology* 2020;14;20(1):27. doi: 10.1186/s12886-019-1220-0.

5. Huang HM, Chang DS, Wu PC. The association between near work activities and myopia in children. A systematic review and meta-analysis. *PLoS ONE* 2015;10(10).

6. Peripheral hyperopia explanation summarised from: Gifford P and Gifford KL. The future of myopia control contact lenses. *Optom. Vis Sci.* 2016;93(4):336-343; Smith EL, Kee C, Ramamirtham R, Qiao-Grider Y and Hung L. Peripheral vision can influence eye growth and refractive development in infant monkeys. *Investigative Ophthalmology & Visual Science.* 2005;46(11):3965; and Cooper J, Schulman E, Jamal N. Current status on the development and treatment of myopia. *Optometry* 2012;83(5):179-199.

7. Benoit DP, Dillehay SM. New clinical evidence through six years: NaturalVue Multifocal for myopia management. Poster. American Academy of Optometry, Boston. 4 November 2021. Available at: http://www.aaopt.org

8. Sankaridurg P *et al*. Myopia control with novel central and peripheral plus contact lenses and extended depth of focus contact lenses: two-year results from a randomized clinical trial. *Opthalmol. Physiol. Opt.* 2019 Jul;39(4):294-307. doi: 10.1111/opo.12621.

9. Trinh T, Doan OD, Ekaterina Kolozhvari MS, Rosa Lee MS, Hernandez R. Evaluating the strength of the junction between RGP and SiHy in SynergEyes hybrid contact lens. Poster. BCLA clinical conference 2017.

10. Holden BA *et al*. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology* 2016;123(5):1036-1042.

PHILIP THOMPSON has 40 years' experience in the optical industry. As professional services director for Positive Impact (PI), he is involved with the SynergEyes range of hybrid contact lenses including launching the SynergEyes iD range in the UK. He also delivers training across a range of PI's Dry Eye Zone products. In February 2019, PI was selected as the supplier and now distributor of NaturalVue Enhanced Multifocal 1 Day disposable lenses and Phil is involved in direct one-to-one training on fitting this product.

Previously, Philip has managed the general running of a small independent six-practice optical group, along with coaching the branch teams for greater performance in all aspects of their optical business. He worked with a leading UK optical chain as a regional manager, and in 2010 completed a Nottingham University Business School Management Development Programme.

He has successfully implemented specialist contact lens services, such as orthokeratology and complex RGP fitting into Batemans Opticians (now part of the Vision Express group). In 2007, he became a licensed trainer for Krauthammer, a globally renowned coaching, consulting and training company. He also continues to see patients and has delivered in-practice CPD sessions on behalf of PI.

LEARNING OUTCOMES FOR THIS CPD ARTICLE

DOMAIN: Communication

2.1: *Communicate the concept of extended depth of focus to patients and parents/carers in a way they can understand.*

DOMAIN: Clinical Practice

5.3: *Be aware of developments in extended depth of focus research and optical design and consider how this may influence the care you provide.*

7.5: *Consider developments in extended depth of focus optics when providing care for presbyopic patients and for those at risk of progressing myopia.*

DOMAIN: CL speciality

Develop an understanding of extended depth of focus contact lenses and consider how this may be applied to support informed choice and management options for presbyopia patients and for those at risk of progressing myopia.

PLAN YOUR CPD TODAY

*For all the latest available CPD from ABDO, visit **www.abdo.org.uk.** All online and face-to-face interactive CPD events open for booking can be found on the Events pages. CPD articles and recorded lectures can be accessed in your personal membership area. Resources to help you plan and reflect on your CPD are available in the Professional Development Toolbox. GOC registrants are now responsible for submitting their own CPD and points are no longer uploaded by providers. **On successful completion of this CPD session, log into your MyGOC account and follow the steps to submit this session using your certificate of completion as evidence. For more information on the new GOC CPD scheme, visit www.optical.org***