Clinical & Refractive Optometry is pleased to present this continuing education (CE) article by Farrah Sunderji OD entitled, *New Spectacle Lens Designs Specifically for the Management of Juvenile-Onset Myopia*. In order to obtain a 1-hour Council of Optometric Practitioner Education (COPE) approved CE credit, please refer to the questionnaire at the end of this article for complete instructions.

New Spectacle Lens Designs Specifically for the Management of Juvenile-Onset Myopia

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Abstract:

Evidence from studies around the world indicate an alarming increase in both the prevalence and severity of myopia among children, with consequences of higher risk of adult eye diseases including glaucoma, cataract and retinal detachment. Two main theories of juvenile-onset myopia include the Accommodative Lag theory and the Peripheral Defocus theory. The accommodative lag theory has given rise to the use of traditional bifocal and Progressive Addition Lenses (PALs) to slow down myopic progression. Studies show these lenses are effective in children with near esophoria, a sub-segment of relatively low prevalence. Overall, however, traditional spectacle lenses have a low efficacy of myopic reduction in children. The peripheral defocus theory postulates that hyperopic blur on peripheral retina is the main stimulus for myopia onset and progression. Novel spectacle lenses specifically designed for juvenile-onset myopia management have been developed based upon both the Accommodative Lag and Peripheral Defocus theory. Wearer trials of various lens design options were conducted to identify the specific design features that lowered the lag of accommodation in myopes and resulted in a statistically and clinically significant slowdown of myopia progression. New spectacle lenses specifically designed for myopic children offer a practical and well-accepted modality for myopia management that can be prescribed concomitantly with other treatment options.

Prevalence and Impact of Myopia

Over recent decades myopia has become quite prevalent. According to some estimates there are more than 1.6 billion myopic people worldwide[1]. This number is projected to rise to roughly half the world's population; 2.5 billion by 2020. It has been reported that over 50% of children 11 to 13 year-olds living in urban populations across East Asia have myopia.[2] Prevalence of myopia has also been on the increase in the developed Western world. For example, in the USA among 12 to 54 year-olds the incidence of myopia has increased from 25% in 1971 – 72 to 42% in 1999 – 2004[3]. A meta-analysis of the population-based, cross-sectional studies from the European Eye Epidemiology (E3) Consortium revealed a near doubling of prevalence of myopia in young adults (47.2% in those aged 25 – 29 years old) compared to that in middle to older age group (27.5% in the 55 – 59 years old).[4] In highly urbanized East Asian population centres like Singapore, Hong Kong and Taiwan, recent reports find prevalence reaching and exceeding 80% to 90%.[5] It appears that myopia is not just becoming more common but also the progression of refractive error after onset is getting faster reaching higher levels of myopia.[6]

In a pilot study of a suburban region in Ontario Canada by Yang et al. (2018) to determine the prevalence of myopia, proportion of uncorrected myopia and pertinent environmental factors among children aged 6 to 13 years, the myopia prevalence increased from 6% at ages 6–8 to 29% at ages 11–13.[7] Even with the well developed government insured health care system in Ontario Canada, which covers regular eye health examinations for those under 19 years, 34.5% of the myopic children were uncorrected for myopia. Myopia has direct economic and social burdens. It increases the risk of eye diseases, including glaucoma, cataract, and retinal detachment, with a clear dose-response relationship with increased risks at higher levels of myopia.[8] Optometric practitioners and the optical device industry are responding to this perturbing development though public service awareness programs, informed optometric practice initiatives and new device options to manage the progression of juvenile-onset myopia.

Causes of myopia

The key parameters of eye geometry determining optics are the length of the vitreous chamber and the anterior chamber, the curvature of the cornea and the thickness of the crystalline lens. The shape and size of these elements evolves in early life from infancy until mid-teenage years. In some cases this may continue evolving beyond juvenile stage showing that the mechanisms regulating the development of the eye remain active well into adulthood.

It usually takes around 18 months for the infant's eyes to evolve into the state of clinical emmetropia (refractive error of around +1 D). After this stage is reached the geometrical parameters of the eyeball continue to evolve but typically do so in synchrony with each other maintaining the nearly emmetropic refractive state of the eye. In some children, the fine balance between corneal curvature, length of the vitreous chamber and possibly the thickness of the crystalline lens is disrupted with the vitreous chamber starting to grow considerably faster than the rate of the compensating corneal flattening and crystalline lens thinning, which leads to the development of myopia. This start of the lopsided development of the eye marking the disruption of a normal emmetropisation process usually coincides with the beginning of schooling.

Although the causes of myopia are not very well understood, a number of risk factors have been identified. Some of these risk factors, such as parental myopia, point to genetic causes, while others (e.g. association with near work and lack of outdoor activities) implicate environmental factors. Among six child activities studies by Yang et. al. including number of hours the child spent per week on reading, watching TV, using a computer, indoor sport activities and outdoor activities, only outdoor time was a statistically significant factor to lower the odds of myopia. One additional hour of outdoor time per week lowered the odds of myopia by 14.3%.[7] The Genes in Myopia (GEM) study has concluded that both genetic and environmental factors play a role.[9]

There is considerable evidence from animal studies that the mechanism regulating the growth of the eye relies on visual feedback, although the details of its functioning are not yet entirely understood.[10,11,12,13] It is widely believed that the eye growth is stimulated by the presence of hyperopic blur on the retina when the image focus falls behind the retina. It has been argued, on the basis of some experiments with rhesus monkeys, that it is not just the part of the image falling on the fovea that can drive the eye growth but the focal properties over the entire retina are important with the periphery playing a decisive role, possibly due to the larger number of neurons per degree of arc in the peripheral retina.[14]

Accommodative Lag Theory of Myopia

One of the main causal theories of myopia progression in juveniles is hyperopic blur on the retina during near vision tasks due to Accommodative Lag (AL). AL is the gap between the required accommodation for a given near object distance and the actual accommodation engaged by the person. This has led to the idea of using bifocal or progressive addition lenses (PALs) on children to reduce accommodative demand with the hope of reducing accommodative lag and consequently slowing down the progression of myopia.[2]

Many studies testing the effect of bifocal lenses on myopic children have shown that bifocals had little effect on progression of myopia relative to single vision lenses (SVLs) in a general population. However, in a subgroup of children with near esophoria, bifocal lenses appeared to slow down progression of myopia by about 0.20 D/year, which amounted to roughly 40% reduction compared to average progression rate of 0.50 D/year in the control group wearing SVLs.[15,16]

One of these studies carried out with the executive bifocal lenses of 1.00 D and 2.00 D addition initially showed no reduction of myopia in a general population of myopic children. Re-analysis of the data revealed a 0.20 D/year reduction in myopia progression for children with esophoria.[17] A more recent study with executive bifocals used two types of bifocal lenses: a standard e-line with +1.50 D addition and a prismatic +1.50 D addition bifocal that had 3Δ base-in prism in the reading segment to reduce the potential positive lens-induced exophoria.[18] Only children with a high rate of myopia progression over the previous 12 months (≥ 0.5 D) were included in the trial, which resulted in a mean initial progression rate of around -1 D per year at baseline. After 3 years of wear, the bifocal and prismatic bifocal lenses reduced progression of myopia by 0.81 D (39%) and 1.05 D (51%) respectively. Ancillary analysis has shown that standard bifocals were effective only in children with high AL, while prismatic bifocals have also effectively slowed progression of myopia when accommodative lag was low. It appears that the much higher efficacy of the executive bifocal lenses in this trial resulted from the selection of exclusively fast progressing myopes which accounted for around 50% of all patients screened for recruitment.

A similar selection criterion was earlier employed in the first trial of progressive addition lenses to slow down progression of myopia in Hong Kong schoolchildren using standard adult Essilor NZ2 progressive additional lenses with +1.50 D addition and +2.00 D addition fitted 1 mm higher than the manufacturer specified fitting position to facilitate access to the near zone[19]. The children wearing +1.50 D addition and +2.00 D addition progressed in their myopia 0.47 D (38%) and 0.57 D (46%) less respectively over 2 years than children wearing control single vision lenses. The children included in the trial had shown at least -0.4 D/year progression rate before being enrolled in the study. Since none of the later progressive lens trials with myopic children had shown such strong slowing effect of PALs, it appears that selecting only fast progressors had a considerable impact on the trial results, as was already noted above for one of the executive bifocal studies.

Encouraged by the Leung & Brown (1999) study outcomes, other groups of researchers set out to replicate their results with different progressive lenses and different populations of myopic children. Edwards et al. (2002) reported on a better controlled study with a larger sample size of somewhat younger children wearing a SOLA MC PAL +1.50 D addition adapted to juvenile use (short progression length and wide distance and near viewing zones) in Hong Kong.[20] After 2 years of wear the observed difference in progression of the mean sphere equivalent values between the PAL wearing group and the SVL wearing control group was 0.14 D (11% reduction). In the subgroup of esophores there was a larger difference of 0.37 D (29% reduction) but neither result was statistically significant (p>0.1).

By far the biggest and the longest running trial aiming to show the slowdown of myopia progression in children wearing progressive addition lenses was run by the COMET group (2004) in USA[21]. This study used a Varilux Comfort +2.00 D addition lens fitted 4 mm higher than the manufacturer recommendation to help children access the near zone more easily. The first clinical results for this trial were published after 3 years of lens wear. The main reported finding was a 0.20 D (14%) reduction in progression of sphere equivalent refraction (SER) with the PAL compared to single vision lenses (SVLs) over 3 years. Most of the slowdown for the PAL wearers occurred in the first year (0.18 D or 30% reduction) with virtually no effect in the following years. These results were highly statistically significant due to the very large sample size recruited but were not clinically significant since the dioptric value of the average reduction in myopia per year in the PAL group was quite modest. A more detailed analysis of children with different risk factors has shown that children with large accommodative lag combined with near esophoria had a more clinically meaningful treatment effect of 0.64 D (37% reduction) over 3 years.[22]

Several other trials of PALs versus SVLs in myopic children have been run in China and Japan with similar outcomes – low efficacy of PALs in the overall population of myopic children and more effective slowing of myopia in children with near esophoria.[23,24,25] The relatively low prevalence of esophoria in a general population and in the population of myopic children would appear to limit the applicability of the bifocal or PAL treatment modality.[26,27] However, targeting this treatment to fast progressing myopes may offer tangible benefits to the group that is most in need of a solution.[28]

Peripheral Defocus Theory

An alternative theory of myopia hypothesized the role of hyperopic blur on peripheral retina as the main stimulus for myopia onset and progression. Some 40 years ago in a survey of peripheral refractions in Dutch commercial and military pilots, it was discovered that 77% of emmetropic pilots that displayed compound (tangential and sagittal) relative hyperopia in their peripheral refraction profiles, later become myopic.[29] Recently, doubts regarding the interpretation of the results have been raised.[30]

Cyclopleged peripheral refractions at 30° nasally of 822 children in the Orinda Longitudinal Study of Myopia (1993) have found that myopes had an average relative hyperopic shift of SER in the periphery of 0.80 ± 1.29 D, while both emmetropes and hyperopes displayed an average relative myopic shift in the periphery compared to their central refractive state.[31] This has led to the idea that to stop myopia from progressing one needs to correct not just central (foveal) vision but also peripheral vision, which may require a different, relatively more positive, prescription (see Figure 1). A method of altering the relative curvature of field using lenses derived from this idea has been patented in the USA and other countries by Vision CRC (US patent 7,025,460).

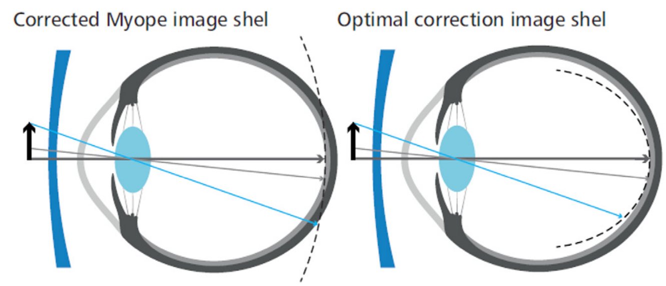


Figure 1. As a consequence of eye shape and/or aspheric optical surfaces, "corrected" myopic eyes often experience significant hyperopic defocus across the visual field. By increasing the effective curvature of field, it would be possible to correct central errors and either correct peripheral errors or induce peripheral myopic defocus.

Smith et al. (2009) have demonstrated that the artificially induced peripheral hyperopic defocus can lead to axial myopia in infant rhesus monkeys.[32] Some years before this research had been become known, some practitioners started trialling bifocal contact lenses with the central zone dedicated to distance correction and relative plus power in the outer zone(s) on myopic children to see if their myopia progression could be slowed down or even arrested. Initially Thomas Aller in Berkley, USA and Edwin Howell in Melbourne, Australia reported great success with such lenses in slowing down progression of myopia in dozens of children by as much as 80% or more with the reduction effect persisting for at least 2 or 3 years.[33] Later a considerable number of trials with control groups have been published. The early results from the first clinical studies with proper control groups have demonstrated more modest efficacy in slowing down progression of myopia. A University of Auckland group (2009) has reported the 0.24 D slowing of myopia progression over 10 months of wearing the dual-focus soft contact lens marketed in Hong Kong as MiSight™ daily disposable soft contact lens by CooperVision, compared to single vision soft contact lenses.[34] Furthermore, a large-scale international trial of MiSight™ has run for 4 years and has been reported at conferences but not published yet.

Although bifocal contact lenses are showing considerable promise for the control of myopia, their mechanism of action is not clear. Bifocal contact lenses tend to create two images on the retina, which could send conflicting signals to the eye growth triggering neurons in the retina. Furthermore, one study has reported that these types of lenses have a profound

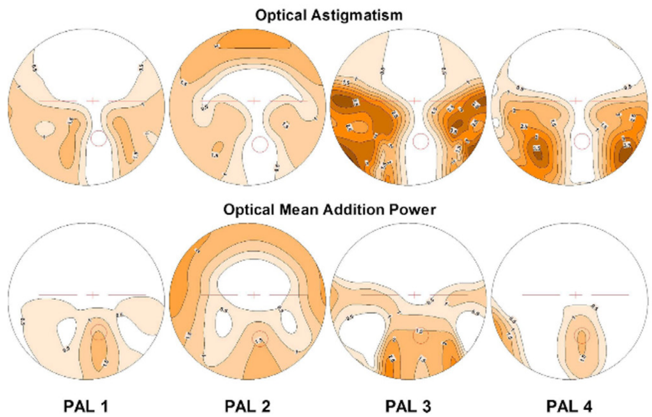


Figure 2. The ray traced optical astigmatism and optical mean addition power distributions for the four PAL designs tested. The contours are displayed over the circular zone of 50 mm diameter in the lens front surface scan coordinates. Each contour represents 0.50 D change in power. PAL 4 design shows less optical astigmatism above the 180 line and more focused addition power in the near area.

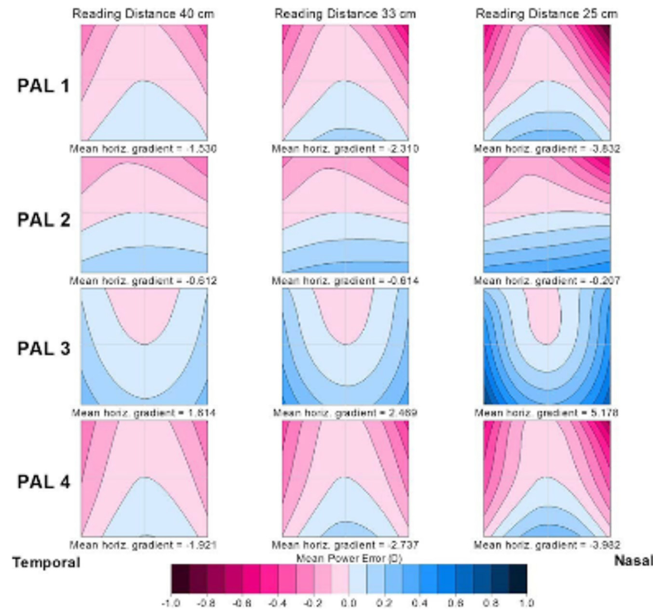


Figure 3. The contour plots of the mean power error distribution on the reference plane in the object space for each of the four PALs and three near target distances tested. The ray tracing has been carried out on the perfectly accommodating static eye gazing at the center of the target stimulus marked by the intersection of the gray lines. The extent of the object field is 185 mm horizontally and 170 mm vertically.

impact on the accommodation function of the wearer.[35] They appear to turn accommodative lags to accommodative leads in both myopes and emmetropes. So, their effect could be explained by factors other than correction of peripheral blur on the retina.

It may be of interest to note that orthokeratology or corneal reshaping by the overnight wear of custom designed hard contact lenses, which has shown great promise in slowing down myopia progression in the Stabilization of Myopia via Accelerated Reshaping Technology (SMART) trial, is believed by some researchers to be effective through the management of peripheral hyperopic blur. These hard contact lenses flatten the central portion of the cornea leaving the periphery little changed, which makes the cornea highly aspheric with relative plus power in the periphery. This could cancel the peripheral hyperopic shift observed in most myopic eyes and thus potentially send a stop signal for the growth of the eye. This interpretation is controversial according recent studies.[36,37]

New Specific Spectacle Lens Designs for Myopia Management

Currently, two new spectacle lens designs specifically developed for juvenile-onset myopia management are available in the Canadian market. Carl Zeiss Vision has been engaged in myopia control research for over 20 years to develop spectacle lenses with accommodation lag management technology. Additionally, in a collaboration with Vision CRC since 2007 on the development of spectacle lenses for peripheral blur management, that, in addition to providing optimal correction of myopic ametropia, may also contribute to slowing down progression of myopia in children. As a result of this research and collaboration, two new Zeiss products based upon the main theories of myopia have been made available in selected markets. ZEISS MyoKids Pro (MyoKids Pro), which applies the principles of Accommodative Lag management, and ZEISS MyoVision Pro (MyoVision Pro) which applies the principles of peripheral defocus management of myopia.

New Lens Designs Based on Accommodated Lag

Progressive addition spectacle lenses (PALs) have been investigated in order to assess their influence on the progression of myopia. Most studies using PAL spectacles to assess their influence on myopia progression found a reduction in progression of around 30% in the first year when compared to wearers of SVLs. The effect often waning or saturating in the following years.[38] One study did not find any statistically significant effect of a 1.50 D addition PAL on the progression of myopia even in the first year.[39] A separate study testing the same lens a few years later recorded a 21% retardation of myopia progression (adjusted for confounding variables) after 2 years with no evidence of effect saturation after 12 months.[42]

In earlier days, standard progressive lenses with long corridor lengths developed for presbyopes have been used.[40,41] Later on, new PAL designs adapted for juvenile use with shorter corridors making it easier for children to access the addition power, have been developed and tested.[42,43] Hasebe et al. investigated the influence of the addition power and the positive asphérization of the distance zone of the PAL on

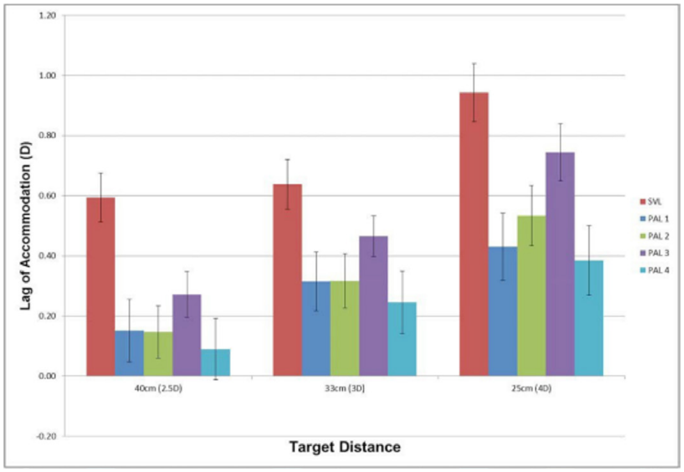


Figure 4. Mean LA for the spherical equivalent refractive error, separated for the three target distances, for the five lenses (SVL and PALs). SVL, red; PAL 1, blue; PAL 2, green; PAL 3, violet; PAL 4, turquoise. Error bars: 61 SEM.

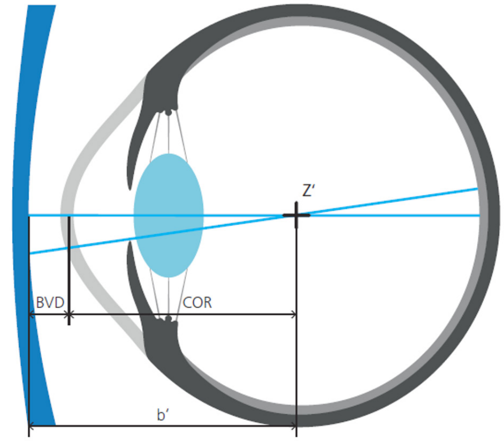


Figure 5: Elements of child anatomy taken into account for optical optimization of lens design.
Z′ = eye`s center of rotation b′ = vertex-center of rotation
BVD = corneal back vertex distance COR = cornea-center of rotation distance

their efficacy to provide retardation of myopia progression.[44] A minimum of 1.50 D addition was required to get an initial efficacy of 30% in the first year.

Carl Zeiss Vision engaged in research to improve the accommodation lag management technology. Assuming that AL does play a role in stimulating excessive elongation of the eyeball resulting in progressing myopia, it is of interest to find the means of reducing the Lag of Accommodation (LA) in myopes. It has been known that accommodative responses (ARs) can be elicited by stimuli imaged not just on the fovea but also on the peripheral retina.[45] This opens a possibility of modulating ARs with aspherized lens designs that change the peripheral focal properties of the visual field. It has already been shown to be possible with bifocal contact lenses and contact lenses with varying amounts of spherical aberration worn by young myopic subjects.[35,46]

Recently this topic was also investigated with multifocal contact lenses.[47] In a study conducted in cooperation with the Institute for Ophthalmic Research, Eberhard Karls University Tübingen, Zeiss investigated the feasibility of this approach with progressive spectacle lenses, which offer the possibility of aspherizing the area adjacent to the near vision zone without affecting the wearer's distance vision quality.[48] For this purpose, it was investigated if the accommodative lag in myopes is different between a single vision lens (SVL) and the progressive addition lens PAL 2 (see Figure 2) , clinically trialed for its ability to reduce progression of myopia, and if differences exist in accommodative lag between PAL 2 and other PALs with the same addition power (1.50 D).

The influence of spherical SVL and four different designs of PALs (see Figure 2) that differ in the near zone width (PAL 1) or that have different signs and magnitude of horizontal gradients of mean power (see Figure 3) adjacent to their near vision zones (PAL 3 and PAL 4) on the accommodative response was investigated for different near viewing distances (40, 33, and 25 cm) in 31 subjects, aged 18 to 25 years.

The SVL correction resulted in insufficient accommodative response for the near object viewing distances tested. PAL 2 did significantly reduce accommodative lag for all near object distances tested. The PAL design with a more negative horizontal mean power gradient (PAL 4) provided a lower lag of accommodation when compared with PAL 2 at the shortest object distance of 25 cm ($P < 0.03$) and was able to reduce the lag of accommodation to a level below the depth of focus for the higher near working distances tested (see Figure 4).

The conclusion was that designs of PALs with more negative horizontal mean power gradients adjacent to the near zone are the most effective in lowering the lag of accommodation in myopes. This made them good candidates for myopia management lens applications. The PAL 4 lens design was the basis for a lens product launched by Zeiss as a myopia management lens for children called ZEISS MyoKids. This lens design has been fully implemented in the ZEISS Freeform calculation and production environment, enabling optical improvements by taking into account position of wear attributes for customization of the design for specific patients and providing high-quality replication of the design features. These additional features are marketed as MyoKids Pro.

The default ADD is 1.50D, however a range of ADDs are available from 1.00 to 2.50 in 0.25D steps. This feature enables practitioners' flexibility to fine-tune the ADD to the patient's needs based on previously worn spectacles or for more accurate individual patient binocular vision balance and near vision tasks demand.

In a recent survey (2017) of Alberta parents by the Alberta Association of Optometrists, children spend an average of more than five hours a day using digital devices at home and at school every day.[49] Further, 41 per cent of infants/toddlers, 76 per cent of elementary school-aged children and 96 per cent of teenagers own at least one digital device. The intensive use of handheld digital devices frequently requires holding them closer than printed media, often as close as 20 cm from the eyes.[50] In part this is because such devices are small and often must be held in two hands for a more comfortable and stable body posture. Myopic children have a special visual behaviour combined with a shorter working distance and different eye vs. head declination ratio, compared to adults.[51] Furthermore, children's spectacles position of wear can be different from the adult's for obvious anatomic reasons (e.g. face and eyes proportions and distance of the lenses from the eye's cornea and the centre of rotation). In addition, children's ethnicity can influence face-form (e.g. Asian cheek bones and nose average shape being different from the Caucasian ones etc.). For these reasons, MyoKids Pro utilizes proprietary technology to optimize near vision zone positioning, corridor length and inset to fit children's specific needs. Proprietary technology optionally available ensures the optics are optimized for updated standard position of wear and frame data for the 6–12 years old children. Freeform technology enables all of the age-specific parameters in the lens design including PD, BVD, pantoscopic and wrap angle, and the cornea to centre-of-eye-rotation distance are taken into account to optimize the optical performance for growing children's eyes (Fig. 5).

In wearer trials conducted by institutes in Guagzhou and HongKong, 91% of children reported being satisfied with the clear vision in all directions, and 91% of children adapted to the new test lenses in less than 1 week (even 40% within 1 day or less).[52]

Optionally the lenses can be ordered with the measured individual position of wear and ergonomic parameters of the child, including a custom reading distance, replacing the default values during the calculation process for a more accurate and personal optical optimization. These are recommended when the position of wear or reading distance are unusual or for increased accuracy of the inset.

New Lens Design based on Peripheral Defocus

Since spectacle lenses do not rotate with the eye like contact lenses do, development of highly aspheric lens designs that would be effective in correcting the peripheral hyperopic shift and would not be difficult for children to adapt to poses considerable challenges. Carl Zeiss Vision, in collaboration with Vision CRC developed around 25 novel lens designs to achieve this goal and about half of these designs have been tested on children for acceptance and/or efficacy to slow down progression of myopia.

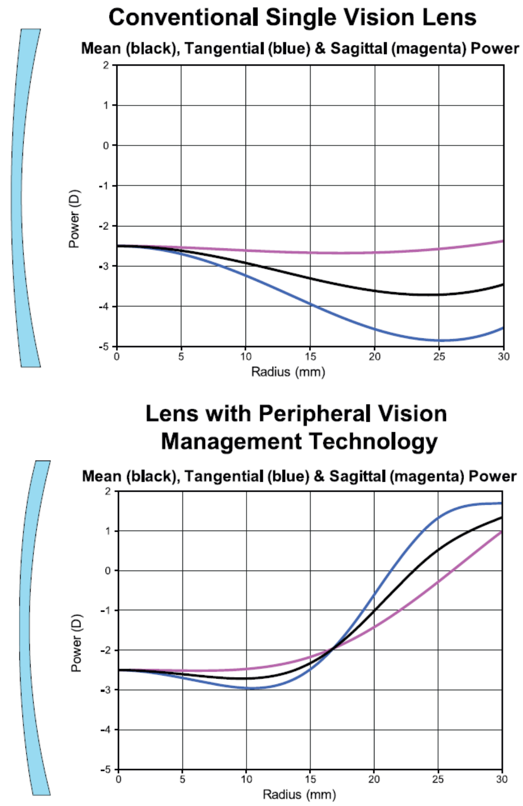
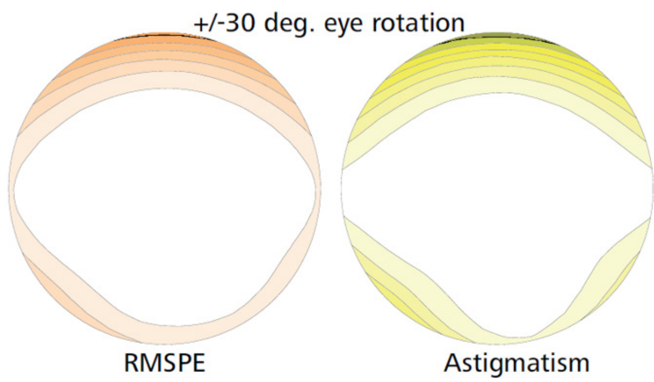


Figure 6. Comparison of ray traced power profiles along the horizontal meridian for a static eye having the central -2.5 DS prescription looking through the optical centre of a 3 D base spherical lens (Control lens C) and a lens with peripheral vision management technology (test lens D) trialled at the Zhongshan Ophthalmic Centre. The vertical section of the two lenses is also displayed.

In the first clinical trial conducted at the Zhongshan Ophthalmic Centre in Guangzhou, China on 210 myopic children and juveniles aged between 6 and 16 years old, the efficacy of 3 new designs was compared to standard 3 D base spherical single vision lenses.[53] Of the three tested designs two were rotationally symmetrical so-called Radial Refractive Gradient (RRG) lenses with different size of the central clear aperture for foveal vision and different levels of peripheral plus power (lenses A and B). The third test design (lens D) was a more complex asymmetric design with a dual near umbilic rising power profile along the horizontal meridian. The aim of this design was to preferentially correct the peripheral hyperopic shift along the horizontal meridian where most of the hyperopic shift is observed without adding too much peripheral astigmatism. The comparison of the tangential, sagittal and mean power profiles along the horizontal meridian ray traced for a static eye looking through the optical centre of the spherical 3 D base lens and the asymmetrical lens D is shown in Figure 6. These lens designs also have an extended nasally inset clear zone in the lower portion of the lens with no addition power (Figure 7). Hence, they do not offer any relief for the accommodative demand during near vision tasks viewed through the lower portion of the lens.



Astigmatism Figure 7. Root mean square power error (RMSPE) and astigmatism in the asymmetric lens D ray traced for the roving eye and infinite object distance. Contours are in 0.5 D increments starting at 0.5 D.

After 12 months wear of the three test lenses and one control lens, radically different responses to the test lenses depending on children's parental history of myopia have emerged. [53] The children with no myopic parents have progressed the least with the spherical control lenses. On the other hand, the children with at least one myopic parent have progressed less with the test lenses compared to controls, and the effect was more pronounced in younger children 6 to 12 years of age. Of the three test lenses, the reduction of myopia progression based on cycloplegic auto-refraction measurement of SER was statistically significant in the subgroup of younger children 6 to 12 years of age with at least one myopic parent, wearing the asymmetric design D. These children have slowed down in their myopia progression by 0.30 D (30% reduction) compared to controls in the same subgroup (after adjustment for differences in confounding factors such as age, gender and parental myopia between the groups wearing test lenses and controls). This result was statistically significant and the 0.30 D/year retardation is clinically significant, as it is larger than the minimum increment of 0.25 D in prescription Rx. The 12 months trial results have been described in detail by Sankaridurg et al. (2010).

The asymmetric lens D was launched by Zeiss to select markets in Australasia as a myopia management product called ZEISS MyoVision. This represented the first step toward controlling myopia through peripheral vision management with spectacle lenses.

The first important upgrade, called the ZEISS MyoVision Pro, entered the global market, including the Canadian market, in 2018. The MyoVision design has been fully implemented in a proprietary freeform calculation and production environment, enabling optical improvements and high-quality replication of the design features, and a larger range of materials ranging from 1.5 to 1.67 refractive index.

The MyoVision Pro lens, similar to the MyoKids Pro lens, can be ordered with the measured individual position of wear parameters of the child, replacing the default values during the calculation process for an even more accurate and personal optical optimization (e.g. recommended when the position of wear is unusual or for increased accuracy).

Conclusions

The need to manage myopia is driven by the growing prevalence of myopia amongst children, with spectacle lenses remaining the most common, practical and benign option. Spectacle lenses solutions may also be used in combination with other myopia management protocols (e.g. in conjunction with 0.01% atropine drops).

The two principal models available to us today are the "Accommodative Lag Theory" and the "Peripheral Defocus Theory". The Accommodative Lag theory has given rise to the use of PAL and bifocal spectacle lenses by practitioners for many years. Efficacy of traditional spectacle lenses vary among different trials and subgroups. It depends on the correct use of the addition power areas to deliver accommodation relief, especially with progressive lenses. This is difficult to achieve especially for children without a specific and dedicated design. Children are reluctant to wear bifocal lenses with visible segments and compliance is low and drop-out rates are high.

The Peripheral Defocus theory is based on more recent research and is applied through novel single vision lens designs which are comfortable to wear and cosmetically acceptable to children. Potential efficacy is inherent in the design, with children needing simply to view through the clear central aperture of the design, but results are still under investigation.

Since outdoor play is generally recognized as an important adjunctive therapy for myopia management, protection of children's eyes to the potential harm of UV radiation is also recommended. The availability of UV protection options, ideally up to 400 nanometers, in both clear and sunglass lenses are an important consideration for the practitioner and can be achieved through wearing glasses.

New specifically designed lenses for myopia management provide eye-care practitioners with a choice of convenient solutions that covers the needs of myopic children and can adapt to different wearer profiles: from a previous solution point of view, a lifestyle point of view, and a binocular vision balance point of view. An AL based design, such as MyoKids Pro, may be best suited for patients previously wearing PALs and for those patients showing high accommodative lag and esophoria. The design based on the Peripheral Defocus theory (MyoVision Pro) may be more suited to patients who desire the easy wearing and adaptation properties of SVLs as required, for example, in children participating in dynamic and outdoor activities and for those not able to adapt to progressive lenses.

References

1. Holden BA, Fricke TR, Wilson DA et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology 2016; 123: 1036–1042.

2. He 2008, IMC 12 presentation, Cairns, Australia

3. Vitale, S., Sperduto, R.D. & Ferris III, F.L. (2009). Increased prevalence of Myopia in the United States Between 1971 – 1972 and 1999 – 2004. Arch. Ophthalmol., 127(12), 1632 – 1639.

4. Williams, K.M., Bertelsen, G., Cumberland, P. et al. (2015). Increasing Prevalence of Myopia in Europe and the Impact of Education. Ophthalmology 122(7), 1489 – 1497.

5. Rudnicka AR, Kapetanakis V V, Wathern AK, et al. Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: implications for aetiology and early prevention. Br J Ophthalmol. 2016;100:882–890.

6. Morgan IG, French AN, Ashby RS, Guo X, Ding X, He M, Rose KA. The epidemics of myopia: Aetiology and prevention. Prog Retin Eye Res. 2018 Jan; 62:134-149.

7. Yang M, Luensmann D, Fonn D, Woods J, Jones D, Gordon K, Jones L,. Myopia prevalence in Canadian school children: a pilot study. Eye (2018) 32:1042–1047

8. Marcus, M. W.; de Vries, M. M.; Montolio, F. G. J.; Jansonius, N. M. Myopia as a Risk Factor for Open-Angle Glaucoma: A Systematic Review and Meta-Analysis. Ophthalmology 2011, 118 (10), 1989–1994.e2.

9. Dirani, M., Chamberlain, M., Shekar, S.N., Islam, A.F., Garoufalis, P., Chen, C.Y., Guymer, R.H., Baird, P.N. (2006). Heritability of Refractive Error and Ocular Biometrics: The Genes in Myopia (GEM) Twin Study. Invest. Ophthalmol. Vis. Sci., 47(11), 4756 – 4761.

10. Stone, R.A. & Flitcroft, D.I. (2004). Ocular Shape and Myopia. Ann. Acad. Med. Singapore, 33, 7 – 15.

11. Wallman, J. & Winawer, J. (2004). Homeostasis of eye growth and the question of myopia. Neuron, 43, 447 – 468.

12. Norton, T.T. (1999). Animal Models of Myopia: Learning How Vision Controls the Size of the Eye. ILAR Journal, 40(2).

13. Wildsoet, C.F. (1997). Active emmetropization – evidence for its existence and ramifications for clinical practice. Ophthalm. Physiol. Opt., 17, 279 – 290.

14. Smith III, E.L., Kee, C., Ramamirtham, R., Qiao-Grider, Y., Hung, L.F. (2005). Peripheral vision can influence eye growth and refractive development in infant monkeys. Invest. Ophthalmol. Vis. Sci., 46, 3965 - 3972.

15. Goss, D.A. (1994). Effect of spectacle correction on the progression of myopia in children – a l iterature review. J. Am. Optom. Assoc., 65, 117 – 128.

16. Goss, D.A. & Grosvenor, T. (1990). Rates of Childhood Myopia Progression with Bifocals as a Function of Nearpoint Phoria: Consistency of Three Studies. Optom. Vis. Sci., 67(8), 637 – 640.

17. Grosvenor, T., Perrigin, D.M., Perrigin, J. & Maslovitz, B. (1987). Houston Myopia Control Study: A Randomized Clinical Trial. Part II. Final Report by the Patient Care Team. Am. J. Optom. Physiol. Opt., 64(7), 482 – 498.

18. Cheng, D., Woo, G.C., Drobe, B. & Schmid, K.L. (2014). Effect of Bifocal and Prismatic Bifocal Spectacles on Myopia Progression in Children – Three-Year Results of a Randomized Clinical Trial. JAMA Ophthalmol.132(3):258 – 264.

19. Leung, J.T. & Brown, B. (1999). Progression of myopia in Hong Kong Chinese school children is slowed by wearing progressive lenses. Optom. Vis. Sci.,176(6), 346 – 354.

20. Edwards, M., Wing-hong, Li R., Lam, C.S., Lew, J.K., Yu, B.S. (2002). The Hong Kong Progressive Lens Myopia Control Study: Study Design and Main Findings. Invest. Ophthalmol. Vis. Sci., 43(9), 2852 – 2858.

21. Gwiazda, J., Hyman, L., Hussein, M., Everett, D., Norton, T.T., Kurtz, D., Leske, M.C., Manny, R., Marsh-Tootle, W., Scheiman, M. (2003). A randomized clinical trial of progressive addition lenses versus single vision lenses on the progression of myopia in children. Invest. Ophthalmol. Vis. Sci., 44(4), 1492 – 1500.

22. Gwiazda, J.E., Hyman, L., Norton, T.T., Hussein, M.E.M., Marsh-Tootle, W., Manny, R., Wang, Y., Everett, D., and the COMET Group (2004). Accommodation and Related Risk Factors Associated with Myopia Progression and Their Interaction with Treatment in COMET Children. Invest. Ophthalmol. Vis. Sci., 45(7), 2143 – 2151.

23. Hao, C., Wang, X., Zhe, Z. & Bao, J. (2006). The effect of progressive addition lenses on slowing evolutive myopia on Chinese children. Poster P025 at the International Myopia Conference 11 in Singapore, Ophthal. Physiol. Opt., 26(Suppl. 1), 41.

24. Yang, Z., Lan, W., Ge, J., Liu, W., Chen, X., Chen, L., Yu, M. (2009). The effectiveness of progressive addition lenses on the progression of myopia in Chinese children. Ophthalmic Physiol. Opt., 29(1), 41 – 48.

25. Hasebe, S., Ohtsuki, H., Nonaka, T., Nakatsuka, C., Miyata, M., Hamasaki, I., Kimura, S. (2008). Effect of progressive addition lenses on myopia progression in Japanese children: a prospective, randomized, double-masked, cross over trial. Invest. Ophthalmol. Vis. Sci., 49(7), 2781 - 2789

26. Montés-Micó, R. (2001). Prevalence of General Dysfunctions in Binocular Vision. Ann. Ophthalmol., 33(3), 205 – 208.

27. Walline, J.J., Mutti, D.O., Zadnik, K., Jones, L.A. (1998). Development of Phoria in Children. Optom Vis Sci., 75(8), 605-610.

28 Hasebe S, Jun J, Varnas SR. Myopia control with positively aspherized progressive addition lenses: a 2-year, multicenter, randomized, controlled trial. Invest Ophthalmol Vis Sci. 2014 Sep 30;55(11):7177-88.

29. Hoogerheide, J., Rempt. F. & Hoogenboom, W.P.H. (1971). Acquired Myopia in Young Pilots, Ophthalmologica, 163, 209 – 215.

30. Rosen et al. (2012). Have We Misinterpreted the Study of Hoogerheide et al. (1971)? OVS 89(8):1235-1237.

31. Mutti, D.O., Sholtz, R.I., Friedmann, N.E. & Zadnik, K. (2000). Peripheral refraction and ocular Shape in Children. Invest. Ophthalmol. Vis. Sci., 41, 1022 – 1030.

32. Smith III, E.L., Hung, L-F. & Huang, J. (2009). Relative peripheral hyperopic defocus alters central refractive development in infant monkeys. Vision Research, 49, 2386 – 2392.

33. Aller 2008 and Howell 2008 reports to IMC 12, Cairns, Australia

34. Anstice, N. (2009). Dual-focus inhibition of myopia evaluation in New Zealand, Thesis (Ph.D. – Optometry & Vision Science), University of Auckland, Abstract.

35. Tarrant, J., Severson, H. & Wildsoet, C.F. (2008). Accommodation in emmetropic and myopic young adults wearing bifocal soft contact lenses. Ophthal. Physiol. Opt., 28, 62 – 72.

36. Chelvin C. A. Sng, Xiao-Yu Lin, Gus Gazzard, Benjamin Chang, Mohamed Dirani, Laurence Lim, Prabakaran Selvaraj, Kit Ian, Bjorn Drobe, Tien-Yin Wong, Seang-Mei Saw; Change in Peripheral Refraction over Time in Singapore Chinese Children. Invest. Ophthalmol. Vis. Sci. 2011;52(11):7880-7887.

37. David A. Atchison, Shi-Ming Li, He Li, Si-Yuan Li, Luo-Ru Liu, Meng-Tian Kang, Bo Meng, Yun-Yun Sun, Si-Yan Zhan, Paul Mitchell, Ningli Wang; Relative Peripheral Hyperopia Does Not Predict Development and Progression of Myopia in Children. Invest. Ophthalmol. Vis. Sci. 2015;56(10):6162-6170

38. Berntsen DA, Sinnott LT, Mutti DO, Zadnik K. A randomized trial using progressive addition lenses to evaluate theories of myopia progression in children with a high lag of accommodation. Invest Opthalmol Vis Sci. 2012;53:640–649.

39. Edwards MH, Li RW-H, Lam CS-Y, Lew JK-F, Yu BS-Y. The Hong Kong progressive lens myopia control study: study design and main findings. Invest Ophthalmol Vis Sci. 2002;43:2852– 2858

40. Gwiazda J, Hyman L, Hussein M, et al. A randomized clinical trial of progressive addition lenses versus single vision lenses on the progression of myopia in children. Invest Ophthalmol Vis Sci. 2003;44:1492–1500.

41. Leung JT, Brown B. Progression of myopia in Hong Kong Chinese schoolchildren is slowed by wearing progressive lenses. Optom Vis Sci. 1999;76:346–354.

42. Yang Z, Lan W, Ge J, et al. The effectiveness of progressive addition lenses on the progression of myopia in Chinese children. Ophthalmic Physiol Opt. 2009;29:41–48.

43. Hasebe S, Jun J, Varnas SR. Myopia control with positively aspherized progressive addition lenses: a 2-year, multicenter, randomized, controlled trial. Invest Ophthalmol Vis Sci. 2014;55:7177–7188.

44. Hasebe S, Ohtsuki H, Nonaka T, et al. Effect of progressive addition lenses on myopia progression in Japanese children: a prospective, randomized, double-masked, crossover trial. Invest Ophthalmol Vis Sci. 2008;49:2781–2789.

45. Neil Charman W, Radhakrishnan H. Peripheral refraction and the development of refractive error: a review. Ophthalmic Physiol Opt. 2010;30:321–338.

46. Theagarayan B, Radhakrishnan H, Allen PM, Calver RI, Rae SM, O'Leary DJ. The effect of altering spherical aberration on the static accommodative response. Ophthalmic Physiol Opt. 2009;29:65–71.

47. Ozkan J, Fedtke C, Chung J, Thomas V, Bakaraju RC. Short term adaptation of accommodative responses in myopes fitted with multifocal contact lenses [published online ahead of print June 20, 2016]. Eye Contact Lens Sci Clin Pract. doi:10.1097/ICL.0000000000000299.

48. Schilling T, Ohlendorf A, Varnas SR, Wahl S. Peripheral design of progressive addition lenses and the lag of accommodation in myopes. Invest Ophthalmol Vis Sci. 2017;58:3319–3324.

49. Alberta Association of Optometrists (2017). Children digital eye strain key messages.

50. Bao J, Drobe B, Wang Y, Chen K, Seow EJ, Lu F. Influence of Near Tasks on Posture in Myopic Chinese Schoolchildren. Optom Vis Sci. 2015 Aug;92(8):908-15.

51. Bjorn Drobe, Eu Jin Seow, Jinhua Bao, Yuwen Wang, Fan Lu; Near Vision Posture in Myopic Chinese Children. Invest. Ophthalmol. Vis. Sci. 2011;52(14):2701.

52. 90 % of children adapt to the new test lenses in less than 1 week, 50% of them adapt to the test lenses in less than 1 day, based on acceptance wearer trial, n=111 myopic children, supervised by The Hong Kong Polytechnic University, Hong Kong, 2017; 92 % of children adapt to the new test lenses in less than 1 week, 33 % of them adapt to the test lenses in less than 1 day, based on acceptance wearer trial, n = 141 myopic children, supervised by Sun Yat-Sen University Vision Department of Eye Health, Guangzhou, China, 2017; on average 91 % and 40 % of children adapt to the test lenses in less than 1 week and 1 day respectively (n = 252 myopic children, HK, China, 2017).

53. Sankaridurg, P., Donovan, L., Varnas, S., Ho., A., Chen, X., Martinez, A., Fisher, S., Lin, Z., Smith III, E.L., Ge, J. & Holden, B.A. (2010). Spectacle Lenses Designed to Reduce Progression of Myopia: 12-Month Results, Optom. Vis. Sci., 87(9), pp. 631 - 641.

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QUESTIONNAIRE

New Spectacle Lens Designs Specifically for the Management of Juvenile-onset Myopia

1 Which of the following is not a complication of myopia?
- ❑ cataract
- ❑ glaucoma
- ❑ strabismus
- ❑ retinal detachment

2 Many studies have shown little to no effect of bifocal spectacles on myopia progression, with the exception of which subgroup?
- ❑ Children with near esophoria
- ❑ Children with near exophoria
- ❑ Children with two high myope parents
- ❑ Female children with intermittent exotropia

3 Generally, how long does it take for infant's eyes to evolve into the state of clinical emmetropia?
- ❑ 12 months
- ❑ 14 months
- ❑ 16 months
- ❑ 18 months

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4 By what % are the odds of myopia lowered by spending one additional hour of out-door time per week, according to a Canadian pilot study by Yang et al. (2014)?
- ❑ 24.3%
- ❑ 14.3%
- ❑ 10.4%
- ❑ 7.3%

5 According to the long-running study by Gwiazda et al. (COMET group) published in 2004, which of the following statements is true?
- ❑ Most of the slowdown for the PAL wearers occurred in the first year (0.18 D or 30% reduction)
- ❑ The slowdown of myopia continued into the 2nd and 3rth year of the study
- ❑ The sample size recruited was too small to show any reduction of myopia to be statistically significant
- ❑ The dioptric value of the average reduction in myopia per year in the PAL group was clinically significant

6 Which causal theory of myopia gave rise to the clinical use and study of Progressive Addition Lenses and bifocals for myopia?
- ❑ Genetic theory
- ❑ The Accommodative Lag theory
- ❑ The Peripheral Defocus theory
- ❑ The Environmental theory

7 In a 1971 study of Dutch Pilots, what % of emmetropic pilots displayed compound relative hyperopia in their peripheral refraction profile?
- ❑ 77%
- ❑ 67%
- ❑ 57%
- ❑ 47%

8 Which of the following statements about the Peripheral Defocus theory of myopia is not true?
- ❑ Smith et al. (2009) demonstrated that artificially induced peripheral hyperopic defocus can lead to axial myopia in animal studies
- ❑ Corneal reshaping by the overnight wear of custom designed hard contact lenses is believed by some researchers to be effective through the management of peripheral hyperopic blur
- ❑ Hyperopic blur on peripheral retina is the main stimulus for myopia onset and progression
- ❑ Hyperopic blur on the fovea is the main stimulus for myopia onset and progression.

9 According to a study by Sankaridurg et al. (2010) on spectacle lens designs based upon the Peripheral Defocus theory, which of the following statements is not true?
- ❑ Children with no myopic parents have progressed the least with the spherical (SVL) control lenses.
- ❑ The children in the asymmetric design lens group slowed myopia progression by 0.30 D (30% reduction) compared to controls
- ❑ The result in the asymmetric design group was not clinically significant
- ❑ The effect of myopia reduction was greatest in the 6-12 year cohort

10 Which of the following age-specific position of wear factors are not optimized by Freeform technology?
- ❑ PD
- ❑ Pantoscopic tilt and wrap angle
- ❑ BVD
- ❑ Rx accuracy to 0.10 D