DOI: https://doi.org/10.4038/jcosl.v30i2.100

Review article

Modern approaches to childhood myopia control: A review

Quresh B. Maskati[1]

The Journal of the College of Ophthalmologists of Sri Lanka 2024; 30: 79-87

Abstract

Childhood myopia is a rising global public health concern. High myopia carries serious lifetime risks of vision loss from myopia-associated ocular diseases, making myopia control a public health priority. Over the past 20 years, extensive research has produced a number of useful methods for managing childhood myopia, including more time spent outdoors, atropine eye drops, dual-focus and multifocal contact lenses, orthokeratology lenses, and specialty spectacle lenses. Although the effectiveness of these approaches varies, there is mounting evidence that they may help children with myopia, even though none can totally stop myopia progression. The US Food and Drug Administration currently approves only dual-focus contact lenses for myopia management in the US. Global regulatory clearance of these therapies would enable widespread, early intervention in children at risk and may lower the chance of vision loss from myopia-related issues later in life.

Keywords: myopia control, childhood myopia, progressive myopia, atropine, spectacle lenses, dims, halt, care, axial elongation, refractive error, combination therapy, myopia management, paediatric ophthalmology, optical interventions, low-dose atropine, myopia progression.

Introduction

Myopia, or near-sightedness, is a serious public health issue that is becoming more common and severe globally. It is estimated that 31% of people worldwide currently have myopia, and this number could increase to 40-50% by 2050[1,2]. Myopia is a major risk factor for several eye diseases, including retinal detachment, cataracts, glaucoma, and myopic macular degeneration (MMD), raising public health concerns[3]. Even people with low to moderate myopia have a considerable risk of these complications, but those with high myopia are at much greater risk[4]. As a result, the scientific community has called for myopia to be recognized as a disease[4]. The rising prevalence of myopia could result in a public health emergency.

MMD is currently a leading cause of blindness in middle-aged and older persons in East Asia[4]. Estimates suggest that, if current trends continue, MMD will increase the global burden of blindness and visual impairment fivefold by 2050[5]. Myopia also carries significant economic consequences, including lost productivity, reduced quality of life, and increased hazards to eye health.

Most myopia begins in early childhood and advances quickly throughout adolescence[6], sometimes continuing into adulthood. This is mainly due to excessive and aberrant axial eye growth, which increases vulnerability to a variety of ocular diseases. Traditional myopia management techniques, such as corrective lenses and refractive surgery, restore clear vision but do not reduce axial elongation or its associated risks[7].

Recent years have seen a surge in research and development of interventions to control myopia onset and progression in children. These include increased time outdoors, atropine eye drops, dual-focus, bifocal, multifocal, and orthokeratology lenses, and specialized spectacle lenses[8]. Delaying myopia onset by one year is expected to reduce final myopia by at least 0.75 D[9], and slowing progression by as little as 1 D reduces the risk of developing MMD by 37%, retinal detachment by 23%, posterior sub-capsular cataract by 17%, open-angle glaucoma by 16%, and visual impairment by 20%[10].

Modern myopia therapies are anticipated to deliver major public health benefits by lowering the prevalence of high myopia and reducing the risks of vision loss due to myopia-related disorders. Unfortunately, none of the available treatments can totally stop axial elongation or myopia progression. Continued research is crucial to develop safe and efficient treatments that best regulate eye growth. This review summarizes current evidence-based treatments for myopia control in children.

[1]*Consultant Ophthalmologist, Cornea and Refractive Surgery, India.*

Environmental and behavioural interventions

outdoor time and sunlight exposure

Robust evidence indicates that increased time spent outdoors significantly reduces the risk of myopia onset and may slow its progression, independent of near work, parental history, or ethnicity[11]. Multiple studies have identified reduced outdoor exposure and greater educational demands as key environmental risk factors. The protective role of higher ambient light intensity and the spectral composition of sunlight is thought to promote retinal dopamine release and modulate eye growth[12]. Randomized controlled trials (RCTs) show that daily increases in outdoor time typically 40 to 120 minutes, can lower the incidence of new myopia cases and offer modest refractive benefits[13]. For example, a large Chinese study demonstrated a 16% reduction in myopia incidence with an additional 40 minutes outdoors per day[14], while a Taiwanese school policy mandating 80 minutes of daily outdoor activity reduced both myopia incidence and progression in non-myopic children[15]. The protective effect appears linked to the outdoor environment itself rather than physical activity. Implementation may face challenges due to academic pressure, weather, and seasonality, but promoting outdoor activity could offer dual benefits for myopia prevention and academic performance.

Near work and screen time

Excessive near work, especially involving digital devices, has emerged as a significant behavioural risk factor for myopia, especially after the COVID-19 pandemic. Studies like the Generation R cohort report an elevated myopia risk associated with increased screen exposure and reading time in children. Surveillance during the pandemic confirmed accelerated myopia progression in younger children (ages 6-8), coinciding with increased screen-based learning[16]. While direct RCT evidence is limited, interventions to reduce continuous near work, such as regulated screen time and monitoring tools are being explored, especially in East Asian schools. These strategies are low-cost, pose no safety concerns, and may complement optical or pharmacological interventions, but broader implementation requires greater awareness among educators, policymakers, and parents.

Pharmacological management

Atropine

Despite decades of use, the exact mechanism and site of atropine's anti-myopia effect remain unclear. It was once believed to work through cycloplegia, but later research showed atropine prevents experimental myopia even in animals without accommodative systems, suggesting a non-accommodative mechanism. Atropine is thought to affect signalling cascades that control axial elongation in the retina, choroid, and sclera. It may increase retinal dopamine, modulate GABA transporter expression, and enhance nitric oxide signalling. Atropine has been shown to thicken the choroid, change scleral protein expression, and decrease peripheral hyperopic defocus in humans, all of which may help prevent axial elongation. It also modifies photoreceptor activity, diurnal ocular cycles, and retinal responses to defocus, and reduces relative peripheral hyperopia[17]. These effects suggest atropine controls several elements within the ocular growth regulatory pathway.

Atropine's effectiveness is dose-dependent: higher concentrations (0.5%-1%) provide better control but are linked to more adverse effects such as photophobia, cycloplegia, and a large rebound after stopping the medication. Major trials like LAMP and CHAMP indicate that low-dose atropine (0.01%-0.05%) has a good safety profile and moderate effectiveness[18]. Treatment response may be affected by ethnic and formulation-related differences; for example, research in Asian populations indicates greater efficacy even at lower doses, while similar doses produced little benefit in Western cohorts[19]. The ATOM studies' long-term safety data are reassuring, showing no rise in ocular problems 10-20 years after therapy[20].

Spectacle lenses for myopia control

Limitations of traditional designs

Conventional spectacle-based strategies, such as under-correction, over-correction, part-time wear, and basic bifocals or progressive addition lenses (PALs), have shown limited to no efficacy in controlling myopia progression in children.

Under-correction, Overcorrection, and Part-Time Wear
Multiple RCTs have shown that under-correction either fails to slow or may accelerate myopia progression[21]. Overcorrection, particularly in children with intermittent exotropia, leads to faster progression. Part-time spectacle wear does not alter progression trajectories. A unique study using mono-vision (under-correcting the non-dominant eye) showed a potential reduction in progression in that eye, but required consistent monocular defocus, challenging to maintain in practice.

PALs and Executive Bifocals

PALs and executive bifocals, while commonly used, show modest or inconsistent efficacy. In the COMET study, PALs with +2.00 D addition slowed progression

by just 0.20 D and axial elongation by 0.11 mm, leading investigators to advice against routine use in clinical practice. In COMET2, even in children with esophoria and accommodative lag, the treatment effect was a modest 0.28 D over 3 years. Other PAL trials show similar limited impact, with effects diminishing after the first year[22]. Subgroup analysis in COMET suggested that children with both low accommodative response and near esophoria may benefit more. Trials of executive bifocals show mixed results; some found no significant benefit, while Cheng et al. reported meaningful benefits with executive and prism bifocals versus single-vision lenses, including reduced axial elongation[23]. These lenses may be considered for select subgroups but are not first-line for all children.

Myopia progression control: mechanisms and theories

Spectacle lenses for myopia control function differently from traditional bifocals or PALs. Rather than creating a single focused image for near vision, these lenses often manipulate the retinal image to generate multiple images or zones of defocused light, aiming to modulate eye growth signals and slow axial elongation.

Defocus incorporated multiple segments (DIMS) lenses

DIMS lenses use a central optical zone for distance correction, surrounded by a mid-peripheral zone filled with small circular segments (+3.50 D) arranged in a honeycomb pattern. Each lenslet introduces myopic defocus, resulting in multiple foci in front of the retina. This design provides clear central vision and imposes myopic defocus during both distance and near viewing. A two-year clinical trial found that DIMS lenses reduced myopia progression by 50-60% and axial elongation by 0.21 mm compared to 0.55 mm in the single vision group. Notably, 21.5% of children in the DIMS group showed no progression, versus only 7% in the control group[24].

Cylindrical annular refractive element (CARE) technology

CARE lenses employ micro-cylinders arranged in concentric patterns around a central clear aperture to induce high-order aberrations in the peripheral retina. Two variants Care and Care-S differ in central zone size and surface power. A two-year, multi-centre RCT demonstrated that both CARE and CARE S lenses slowed myopia progression and axial elongation compared to single vision lenses in children aged 6-13 years. At 24 months, children wearing CARE and CARE S lenses showed approximately 0.40 and 0.44 D less progression in spherical equivalent and 0.17 and 0.20 mm less axial elongation, respectively, than those wearing standard spectacles. The lenses were well tolerated, with no significant differences in adaptation between groups[25]. Although it is difficult to directly compare treatments without a multi-arm trial, CARE

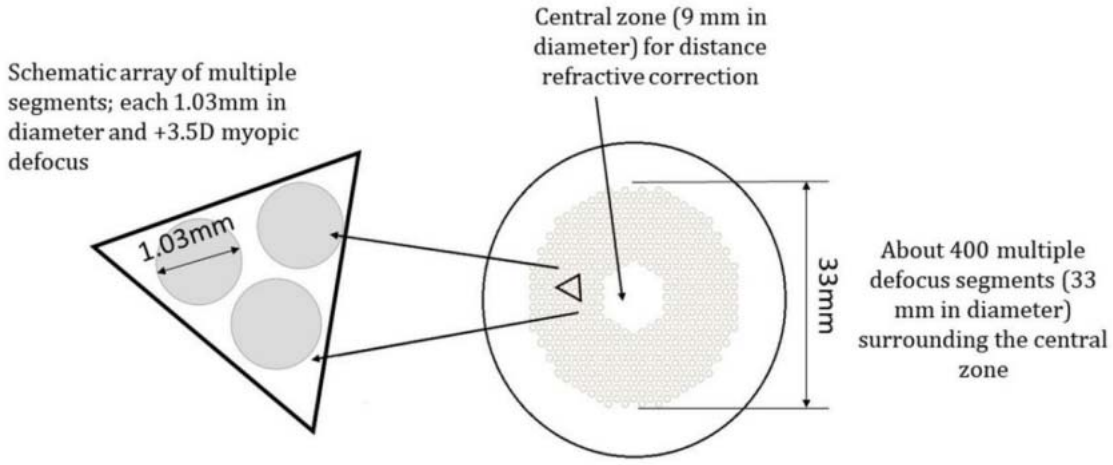

Figure 1. *The design of the Defocus Incorporated Multiple Segments (DIMS) spectacle lens. Figure courtesy of Lam CSY, Tang WC, Tse DY, et al*[24].

lenses seem to be less effective than other myopia control spectacle lens designs over the course of one and two years (Refer to Figure 4 & Figure 5).

Figure 2. *Within the specific aperture range of the lens, the annular micro-cylinder array is centred on the geometric centre of the lens, 1-the occupied area with annular micro-cylinders, and 2-the spacing of two adjacent micro cylinders. Image courtesy of Liu et al Liu, X, Wang, P, Xie Z, Sun M, Chen M, Wang J, et al[26].*

Diffusion optics technology (DOT) lenses

DOT lenses represent a paradigm shift, targeting retinal contrast rather than optical defocus. Thousands of microscopic diffusers, each about one-tenth of a millimetre wide, are distributed across the lens surface except for a small central clear zone. These diffusers scatter light, reducing the contrast differential between adjacent photoreceptors and thereby modulating retinal contrast signals.

Clinical trials have shown promising results. Rappon et al.[27] reported a 74% reduction in refractive error progression (-0.40D) and a 50% reduction in axial elongation (0.15mm) in children aged 6-10 years compared to SV controls. A three-year, multi-site study by Chalberg et al.[28] confirmed sustained benefits, with DOT lenses showing less progression in both refractive error and axial length compared to standard lenses.

Highly aspherical lenslet target (HALT) technology

HALT technology represents a significant evolution in spectacle lens design for myopia control. Unlike earlier dual-focus or multifocal lenses that create discrete planes of defocus, HALT lenses employ a complex arrangement of hundreds of highly aspherical lenslets distributed in concentric rings around a central clear optical zone. HALT lenses feature a central optical zone (typically 9 mm in diameter) that corrects distance refractive error, ensuring clear central vision. Surrounding this zone, the lens surface is densely populated with over 1,021 contiguous, highly aspherical lenslets, each approximately 1.12 mm in diameter. These lenslets are arranged in concentric rings, with each ring containing lenslets of varying asphericities. The aspherical geometry of each lenslet is carefully calculated to continuously deviate light rays in a nonlinear manner, creating a three-dimensional "volume" of myopic defocus in front of the retina at any eccentricity. This volume of myopic defocus (VoMD) serves as a robust signal to slow axial elongation and, consequently, myopia progression.

The density of the lenslets is such that they occupy about 40% of the total lens surface area, while the remaining spaces maintain single vision (SV) correction. The result is a lens that provides clear central vision and a broad, continuous zone of volume of myopic defocus, without the abrupt transitions or image jumps characteristic of traditional bifocal or multifocal designs, ensuring that, regardless of gaze direction or pupil size, the retina receives a consistent inhibitory signal for axial elongation.

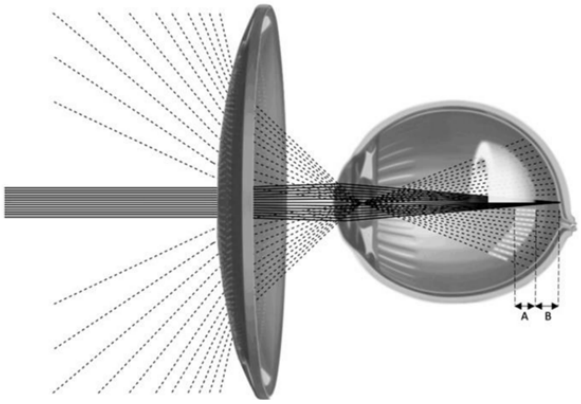

Figure 3. *Illustration of the study device providing a volume of myopic defocus (VoMD) (white shell) in front of the retina through 11 concentric rings of contiguous lenslets (A=depth of VoMD and B=distance from the retina). The calculations for the lenslets were based on the modified Atchison eye model[32] using a retinal shape modified to match the peripheral refraction data of Chinese children[33-35]. Spectacle lenses with highly aspherical lenslets (A=0.7 mm and B=1.2 mm), spectacle lenses with slightly aspherical lenslets (A=0.3 mm and B=1.0 mm) (illustrated and authorised by Dr. Damien Paille from R&D AMERA, Essilor International).*

Recent multi-centre randomized controlled trials have demonstrated that HALT lenses are highly effective, often surpassing earlier designs in both efficacy and consistency. Clinical studies have consistently demonstrated the efficacy of HALT lenses in slowing myopia progression in children. In a one-year randomized controlled trial by Bao et al., children wearing HALT lenses showed a 70% reduction in refractive error progression and a 60% reduction in axial elongation compared to those wearing single vision lenses. A two-year clinical trial involving 157 subjects further confirmed these findings. Children in the HALT group experienced a myopia progression of -0.66D and an axial elongation of 0.34 mm, compared to -1.46D and 0.69 mm in the single vision group. Notably, children who wore the lenses for at least 12 hours per day showed even greater benefits, with HALT wearers demonstrating a reduction of 0.99D in refractive error and 0.41 mm in axial length compared to the single vision group[29].

Long-term follow-up studies have provided additional evidence for the sustained efficacy of HALT lenses. In a five-year trial by Li et al., children who had previously participated in a two-year HALT study were compared to a control group using extrapolated single vision lenses (ESVL). Over five years, the HALT group showed a myopia progression of -1.27 ± 0.14D and an axial elongation of 0.67 ± 0.06 mm, compared to ?3.03 ± 0.18D and 1.40 mm in the ESVL group. This represents a 1.75D slower progression and a 0.73 mm reduction in axial elongation, effectively preventing approximately three years of myopia progression and reducing the incidence of high myopia[30].

These results are at least comparable to, and sometimes better to, those seen with DIMS and CARE technologies. (Refer to Figure 4 & Figure 5).

HALT lenses maintain their effectiveness across a broader range of baseline refractive errors and ages, and even in children with rapid prior progression. The continuous myopic defocus delivered by HALT lenslets is thought to provide a more physiologically natural and sustained inhibitory signal to eye growth, reducing the risk of adaptation or "escape" seen with discrete or patterned defocus.

Advantages of HALT over other designs include:

- Uniform myopic defocus at all gaze angles.
- Minimal visual disruption, with optimized balance between myopia control and visual clarity.
- High rates of adaptation and comfort in children.
- Demonstrated efficacy across diverse populations and refractive error ranges.

Given the compelling clinical data and unique optical advantages, HALT technology is rapidly emerging as the preferred spectacle lens design for myopia control. In indirect head-to-head comparisons, HALT lenses consistently match or outperform DIMS and CARE lenses in slowing both refractive progression and axial elongation, while offering superior comfort and visual quality (Figure 4 & Figure 5).

Comparative efficacy of myopia control spectacle lenses in slowing myopic progression

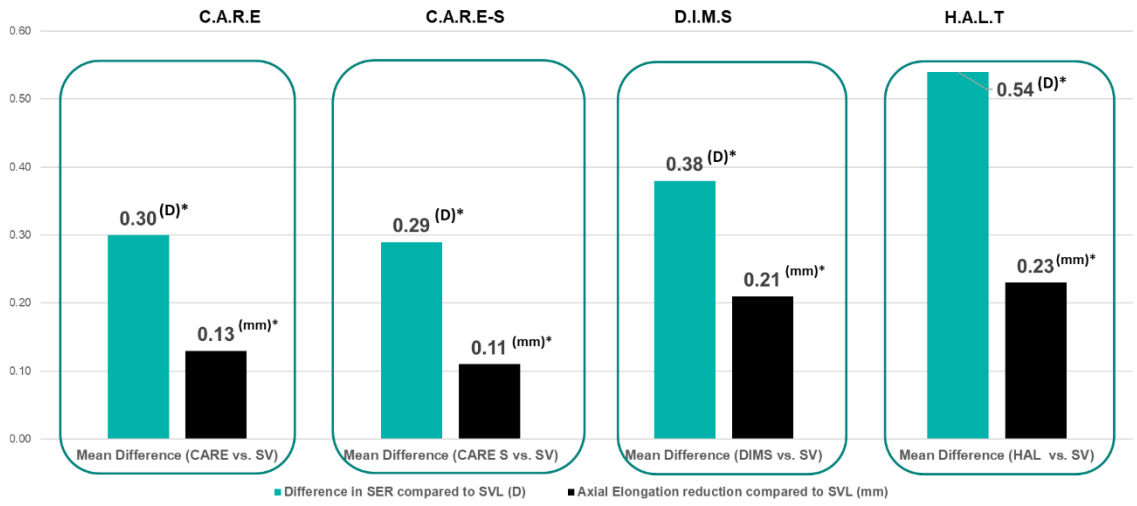

Figure 4. *One-year Myopia Control Efficacy of Spectacle Lenses (INDIRECT COMPARISON)*[26,24,29].

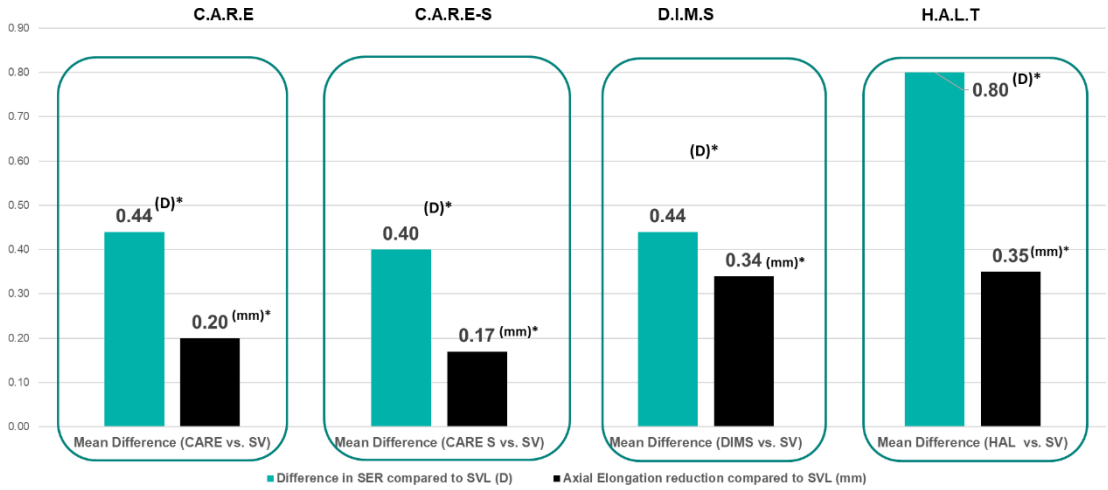

Figure 5. *Two-year myopia control efficacy of spectacle lenses (INDIRECT COMPARISON)*[25,24,29].

Bar graph illustrating the mean reduction in myopic progression among children fitted with different myopia control lenses, CARE, CARE-S, DIMS, and HAL compared to single vision lenses (SV/SVL). Two key outcome measures are presented: Change in Spherical Equivalent Refraction (SER, in diopters [D]), indicated by turquoise bars and reduction in Axial Elongation (in millimetres [mm]), indicated by black bars. Each pair of bars represents the mean difference in outcomes between the treatment group and the SV/SVL control group. Among the lenses evaluated, HAL (Highly Aspherical Lenslets) demonstrated the greatest efficacy with a mean SER difference of 0.80 D and axial elongation reduction of 0.36 mm compared to SV/SVL. CARE and DIMS lenses also showed significant, though comparatively lesser, efficacy in both parameters.

Abbreviations: SV/SVL = Single Vision Lens; SER = Spherical Equivalent Refraction; CARE = Cylindrical Annular Refractive Elements; DIMS = Defocus Incorporated Multiple Segments; HAL = Highly Aspherical Lenslets.

Note: This is an indirect comparison across different clinical studies; variations in study design, population, and follow-up duration may influence comparative outcomes.

Discussion

Advancements and comparative efficacy of myopia control spectacle lenses

Early lens designs: Bifocals and PALs

Traditional bifocals and progressive addition lenses (PALs) were among the first spectacle options explored for myopia control. Designed to reduce accommodative lag, these lenses aimed to address the notion that excessive near-work accommodation drives myopia progression. However, clinical studies found only modest benefits, with most reporting a 20-50% reduction in myopia progression compared to standard single vision lenses.

Key drawbacks included:

- **Limited Peripheral Defocus:** Bifocals and PALs created sectorial or localized defocus, often only in the superior retina, leaving nasal and temporal regions under-corrected.
- **Narrow Clear Zones:** The small central correction area (9-33 mm) sometimes led to tunnel vision and incomplete retinal coverage.
- **Binocular Disruption:** Prismatic effects and abrupt power transitions could interfere with binocular vision in children.
- **Visual Quality Issues:** Peripheral zones occasionally reduced contrast sensitivity and gaze stability, especially during off-centre viewing.

Second-Generation Lenses: DIMS and CARE

Defocus Incorporated Multiple Segments (DIMS) and Cylindrical Annular Refractive Element (CARE) lenses represented a significant advance by providing simultaneous myopic defocus across the retina. Despite these improvements, both DIMS and CARE share important limitations:

- **Fixed-Power Defocus:** Their single-plane, fixed-power elements adapt may not be able to the steeper peripheral curvature of highly myopic eyes.

- **Surface Coverage:** Over half the lens is devoted to treatment, reducing clear vision area and potentially affecting peripheral clarity.
- Visual Side Effects: Some users report peripheral blur, reduced contrast, and early adaptation symptoms like eyestrain or dizziness.

The optical challenge: adapting to the prolate eye

As myopia progresses, the eye becomes more prolate, with increased peripheral curvature and hyperopic defocus, key drivers of further axial elongation. Fixed-power designs like DIMS and CARE may fail to fully address these changes, potentially limiting long-term effectiveness.

HALT Lenses: adaptive, volumetric defocus

Highly Aspherical Lenslet Target (HALT) technology, as seen in Stellest lenses, marks a major step forward. These lenses use over 1,000 aspherical lenslets arranged in concentric rings, with a power gradient from +3.50D to +5.50D and progressive asphericity. This creates a three-dimensional "volume" of myopic defocus dynamically matching the peripheral retinal steepening seen in progressive myopia.

Key advantages:

- **Dynamic Volume of Myopic Defocus:** The aspheric, graded lenslets provide multi-planar defocus, closely adapting to the peripheral steepening in myopic eyes.
- **Optimized Lens Area:** Only 40% of the lens is used for treatment, maximizing clear vision with minimal visual disruption.
- **Exceptional Clinical Outcomes:** The estimated myopia control efficacy of HAL lenses over six years was 1.95 D for SER and 0.81 mm for AL, compared to Extrapolated SVL controls [31]. Over five years, only 5% of HAL users progressed more than -2.5 D (vs. 64% in controls), and the incidence of high myopia (SER ≤6.00 D) was 9% in HAL versus 38% in controls [30]. HAL's efficacy was sustained in teenagers and young adults up to 19 years old.
- **Excellent Visual Quality:** These lenses preserve visual acuity at all distances and show high patient acceptance, with few adaptation symptoms.

Combination therapy: specialized spectacles with other myopia treatments

Theoretical rationale and clinical evidences

Combining spectacle lenses designed for myopia control with low-dose atropine is theoretically advantageous because these interventions are believed to act via different mechanisms. Atropine modulates retinal signalling and possibly scleral remodelling, while spectacle lenses such as DIMS or HALT provide optical defocus to slow axial elongation. This mechanistic diversity suggests the potential for additive or synergistic effects when treatments are combined.
Combining specialized myopia-control spectacle lenses with low-dose atropine (LDA) enhances treatment efficacy, as these interventions target eye growth through distinct mechanisms. For example, in children who responded inadequately to LDA alone, the addition of Highly Aspherical Lenslet Target (HALT) spectacles significantly reduced both spherical equivalent and axial length progression with spherical equivalent progression dropping from -0.60 D to -0.06 D at six months, and axial elongation from 0.24 mm to 0.06 mm while a notable proportion of children even experienced a hyperopic shift in axial length (Xiangrong et al., 2025)[32]. Similarly, studies in European children comparing DIMS spectacles, LDA, and their combination found that combined therapy resulted in slower myopia progression than either treatment alone, though axial elongation benefits were less consistently superior (Nucci et al., 2023)[33]. Overall, combining spectacle lenses with atropine offers superior myopia control, especially for children with inadequate response to monotherapy.

Conclusion

The rising prevalence of childhood myopia is a significant global health challenge, with serious implications for vision and quality of life. While no single intervention can completely halt myopia progression, a combination of environmental, pharmacological, and advanced optical strategies can substantially reduce risk. Increased outdoor time, judicious use of low-dose atropine, and innovative spectacle lens designs such as utilizing HALT technology offer promising avenues for myopia progression control. Ongoing research and broader regulatory approval are needed to ensure early and effective intervention, ultimately reducing the burden of myopia-related vision loss worldwide.

References

1. Liang J, Pu Y, Chen J, et al. Global prevalence, trend and projection of myopia in children and adolescents from 1990 to 2050: a comprehensive systematic review and meta-analysis. *Br J Ophthalmol*. 2025; **109**: 362-71.
2. 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**: 1036-42.
3. Flitcroft DI. The complex interactions of retinal, optical and environmental factors in myopia aetiology. *Prog Retin Eye Res*. 2012; **31**(6): 622-60.
4. Ohno-Matsui K, Wu PC, Yamashiro K, Vutipongsatorn K, Fang Y, Cheung CMG, et al. IMI Pathologic Myopia. *Invest Ophthalmol Vis Sci*. 2021; **62**(5): 5.
5. Fricke TR, Jong M, Naidoo KS, et al. Global prevalence of visual impairment associated with myopic macular degeneration and temporal trends from 2000 through 2050: systematic review, meta-analysis and modelling. *Br J Ophthalmol*. 2018; **102**: 855-62.
6. Chen M, Shu Q, Li F, Li L, Fan X. The whole life cycle myopia management. *Asia-Pacific Journal of Ophthalmology*. 2025: 100161.
7. Pugazhendhi S, Ambati B, Hunter AA. Pathogenesis and prevention of worsening axial elongation in pathological myopia. *Clinical Ophthalmology*. 2020; **18**: 853-73.
8. Tariq F, Mobeen R, Wang X, Lin X, Bao Q, Liu J, Gao H. Advances in myopia prevention strategies for school-aged children: a comprehensive review. *Frontiers in Public Health*. 2023; **11**: 1226438.
9. Bullimore MA, Brennan NA. Myopia: An ounce of prevention is worth a pound of cure. *Ophthalmic and Physiological Optics*. 2023; **43**(1): 116-21.
10. Bullimore MA, Ritchey ER, Shah S, Leveziel N, Bourne RR, Flitcroft DI. The risks and benefits of myopia control. *Ophthalmology*. 2021; **128**(11): 1561-79.
11. French AN, Ashby RS, Morgan IG, Rose KA. Time outdoors and the prevention of myopia. *Experimental Eye Research*. 2013; **114**: 58-68.
12. Landis EG, Park HN, Chrenek M, He L, Sidhu C, Chakraborty R, Strickland R, Iuvone PM, Pardue MT. Ambient light regulates retinal dopamine signaling and myopia susceptibility. *Investigative Ophthalmology and Visual Science*. 2021; **62**(1): 28-28.
13. Lingham G, Mackey DA, Lucas R, Yazar S. How does spending time outdoors protect against myopia? A review. *British Journal of Ophthalmology*. 2020 May; **104**(5): 593-9.
14. He X, Sankaridurg P, Wang J, Chen J, Naduvilath T, He M, Zhu Z, Li W, Morgan IG, Xiong S, Zhu J. Time outdoors in reducing myopia: a school-based cluster randomized trial with objective monitoring of outdoor time and light intensity. *Ophthalmology*. 2022; **129**(11): 1245-54.
15. George AS, George AH, Shahul A. The Myopia Epidemic: A Growing Public Health Crisis Impacting Children Worldwide. *Partners Universal International Research Journal*. 2023; **2**(3): 120-38.
16. Kneepkens SC, de Vlieger J, Tideman JW, Enthoven CA, Polling JR, Klaver CC. Myopia risk behaviour related to the COVID?19 lockdown in Europe: The generation R study. *Ophthalmic and Physiological Optics*. 2023; **43**(3): 402-9.
17. Upadhyay A, Beuerman RW. Biological mechanisms of atropine control of myopia. *Eye & Contact Lens*. 2020; **46**(3): 129-35.
18. Eppenberger LS, Grzybowski A, Schmetterer L, Ang M. Myopia control: are we ready for an evidence based approach?. *Ophthalmology and Therapy*. 2024; **13**(6): 1453-77.
19. Simonaviciute D, Grzybowski A, Lanca C, Pang CP, Gelzinis A, Zemaitiene R. The effectiveness and tolerability of atropine eye drops for myopia control in non-Asian regions. *Journal of Clinical Medicine*. 2023; **12**(6): 2314.
20. Repka MX. Atropine eye drops for myopia control in childhood-more long-term data, please. *JAMA Ophthalmology*. 2024; **142**(1): 23-4.
21. Russo A, Boldini A, Romano D, Mazza G, Bignotti S, Morescalchi F, Semeraro F. Myopia: mechanisms and strategies to slow down its progression. *Journal of Ophthalmology*. 2022; **2022**(1): 1004977.
22. Scheiman MG. PALs for children: can they slow myopia? The use of multifocal lenses for treating vision problems in children is not a new concept, but how useful are progressive addition lenses for this population?. *Review of Optometry*. 2008; **145**(3): 55-60.
23. Kaphle D, Atchison DA, Schmid KL. Multifocal spectacles in childhood myopia: Are treatment effects maintained? A systematic review and meta-analysis. *Survey of Ophthalmology*. 2020; **65**(2): 239-49.
24. Lam CS, Tang WC, Tse DY, Lee RP, Chun RK, Hasegawa K, Qi H, Hatanaka T, To CH. Defocus Incorporated Multiple Segments (DIMS) spectacle lenses slow myopia progression: a 2-year randomised clinical trial. *British Journal of Ophthalmology*. 2020; **104**(3): 363-8.
25. Chen X, Wu M, Yu C, Ohlendorf A, Li W, Liu N, Yang Y, Li L, Sankaridurg P. Efficacy of cylindrical annular refractive elements (CARE) spectacle lenses in slowing myopia progression over 2 years. *American Journal of Ophthalmology*. 2025 Jun 13.
26. Liu X, Wang P, Xie Z, Sun M, Chen M, Wang J, Huang J, Chen S, Chen Z, Wang Y, Li Y. One-year myopia control efficacy of cylindrical annular refractive element spectacle lenses. *Acta Ophthalmologica*. 2023; **101**(6): 651-7.
27. Rappon J, Chung C, Young G, Hunt C, Neitz J, Neitz M, Chalberg T. Control of myopia using diffusion optics

spectacle lenses: 12-month results of a randomised controlled, efficacy and safety study (CYPRESS). *British Journal of Ophthalmology.* 2023; **107**(11): 1709-15.

28. Chalberg T, Laughton D, Hill J, Tasso V, Young G, Hunt C, Neitz J, Neitz M. Control of myopia using diffusion optics spectacle lenses: efficacy and safety study (CYPRESS) 42-month results. *Investigative Ophthalmology & Visual Science.* 2023; **64**(8): 50922-92.

29. Bao J, Huang Y, Li X, Yang A, Zhou F, Wu J, Wang C, Li Y, Lim EW, Spiegel DP, Drobe B. Spectacle lenses with aspherical lenslets for myopia control vs single-vision spectacle lenses: a randomized clinical trial. *JAMA Ophthalmology.* 2022; **140**(5): 472-8.

30. Li X, Huang Y, Liu C, Chang X, Cui Z, Yang Q, Drobe B, Bullimore MA, Chen H, Bao J. Myopia control efficacy of spectacle lenses with highly aspherical lenslets: results of a 5-year follow-up study. *Eye and Vision.* 202; **12**(1): 10.

31. EssilorLuxottica. Myopia control efficacy of spectacle lenses with highly aspherical lenslets: results of a 6-year follow-up study. 2025. Data on file.

32. Sim BX, Loh KL, Htoon HM, Sri Y, Balakrishnan M, Lin PC, Sim RZ, Lam CS, Chia AW. Additive Effect of Highly Aspherical Lenslet Target Spectacles to Children Inadequately Controlled by Atropine Monotherapy. *Ophthalmology Science.* 2025; **5**(4): 100753.

33. Nucci P, Lembo A, Schiavetti I, Shah R, Edgar DF, Evans BJ. A comparison of myopia control in European children and adolescents with defocus incorporated multiple segments (DIMS) spectacles, atropine, and combined DIMS/atropine. *PLoS One.* 2023; **18**(2): e0281816.

34. Sng CC, Lin XY, Gazzard G, Chang B, Dirani M, Chia A, Selvaraj P, Ian K, Drobe B, Wong TY, Saw SM. Peripheral refraction and refractive error in Singapore Chinese children. *Investigative Ophthalmology and Visual Science.* 2011; **52**(2): 1181-90.

35. Li SM, Wang N, Zhou Y, Li SY, Kang MT, Liu LR, Li H, Sun YY, Meng B, Zhan SY, Atchison DA. Paraxial schematic eye models for 7-and 14-year-old Chinese children. *Investigative Ophthalmology and Visual Science.* 2015; **56**(6): 3577-83.

36. Chen X, Sankaridurg P, Donovan L, Lin Z, Li L, Martinez A, Holden B, Ge J. Characteristics of peripheral refractive errors of myopic and non-myopic Chinese eyes. V*ision Research.* 2010; **50**(1): 31-5.