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# Comparative Effectiveness of Myopia-control Spectacle Lenses: Clincial setting Performance from a Retrospective Cohort Study

*Sandra C. Ganesh, MD,[1] Marta Armentano, MD, PhD,[2] Shilpa G. Rao, MD,[1] Priya Sakthivel, MD,[1] Jogitha, MD,[1] Sasikala Elizabeth, MD,[1] Amrutha Sindhu, MD,[1] Padmavathy A. Sivakumar,[3] Ludovico Alisi, MD, PhD,[2] Kalpana Narendran, MD[1]*

**Purpose:** To compare the clincial setting effectiveness of three myopia control spectacle lenses, defocus incorporated multiple segments (DIMS), highly aspherical lenslet target (HALT), and cylindrical annular refractive elements (CARE), versus single-vision lenses (SVLs) in attenuating axial elongation and myopic refractive shift in children.

**Design:** A single-center, retrospective cohort study.

**Participants:** A total of 899 subjects (1780 eyes) aged 6–16 years with cycloplegic spherical equivalent (SE) between −0.50 D and −9.00 D. Subjects were divided into four groups based on prescribed eyewear: SVL (n = 446 eyes), DIMS (n = 523 eyes), HALT (n = 295 eyes), and CARE (n = 516 eyes).

**Methods:** Data were extracted from electronic medical records. Longitudinal changes in axial length (AL) and SE refraction were analyzed using linear mixed-effects models to compare progression rates among the lens types, adjusting for baseline age, sex, parental myopia, and the baseline value of the respective outcome variable.

**Main Outcome Measures:** Annualized rate of progression in AL (mm/year) and SE (D/year).

**Results:** The mean age of our cohort was 12.18 ± 2.73 years, and the mean follow-up time was 12.49 ± 5.71 months. All myopia control lenses significantly slowed AL elongation compared to the SVL group (0.193 mm/year). The adjusted annual AL progression was 0.098 mm/year for DIMS, 0.088 mm/year for CARE, and 0.054 mm/year for HALT ($P < 0.001$ for all vs. SVL). Highly aspherical lenslet target lenses demonstrated significantly greater efficacy in slowing AL elongation compared to both DIMS ($P < 0.001$) and CARE ($P$ value $< 0.001$). All myopia control lenses also significantly reduced myopic SE progression (−0.370 D/year for SVL) with rates of −0.107 D/year for DIMS, −0.106 D/year for CARE, and −0.073 D/year for HALT. However, pairwise comparisons among the three myopia control lens types for SE progression did not reach statistical significance ($P > 0.13$).

**Conclusions:** Highly aspherical lenslet target, DIMS, and CARE effectively slowed progression versus SVL, with HALT showing the greatest AL control. While the retrospective design warrants cautious interpretation, results support the use of all three lenses. Future prospective head-to-head studies are needed to clarify durability and optimal combination strategies.

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Myopia has reached epidemic proportions worldwide, with prevalence rising dramatically, especially among children and adolescents. Nearly 30% of the global population was myopic in 2020, and projections indicate that by 2050, about 50% (5 billion people) will be affected.[1] Early-onset myopia and high myopia are becoming commonplace.[2] Progressive axial elongation in myopia sharply increases the lifetime risks of retinal detachment, myopic maculopathy, glaucoma, and early cataract. The global myopia boom, therefore, represents a serious public health challenge, translating into measurable losses in quality of life and productivity, with major implications for eye care services and blindness prevention efforts. Early intervention to slow myopia progression in children is critical to reduce the burden of high myopia and its sequelae later in life.[3] In response to the myopia crisis, a range of evidence-based myopia control strategies has been developed. International consensus guidelines emphasize a multifaceted approach integrating behavioral, pharmacologic, and optical interventions. Increasing time spent outdoors (at least 1–2 h daily) in childhood has been shown to delay myopia onset and is widely recommended as a preventive measure.[4] Once myopia is established, therapeutic interventions aim to slow its progression.

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International consensus reports, such as those by the International Myopia Institute, recognize low-dose atropine as an effective pharmacological intervention for progressive myopia. However, regulatory approval varies by region, and atropine is not universally available. Moreover, it can cause mild photophobia or accommodative symptoms at higher doses, and its long-term use requires adherence to nightly eye drops.[5–7]

Optical interventions represent an attractive nonpharmacologic approach to myopia control. Historically, conventional spectacles (single vision or bifocals) provided little or no benefit in slowing myopia progression. Multifocal glasses or progressive addition lenses have shown only modest slowing effects in clinical trials, primarily in subsets of children with specific focusing or convergence deficiencies. Similarly, under-correction of myopia has proven ineffective or even counterproductive.[7] In contrast, specialized optical treatments that alter the retinal image profile have demonstrated meaningful efficacy. Orthokeratology (overnight corneal reshaping) and multifocal contact lenses (e.g., dual-focus or peripheral defocus soft lenses) are now well-established myopia control methods.[8] Despite their efficacy, contact lens–based interventions may not be suitable for all pediatric patients due to age, handling, or infection risk considerations.[9] This has driven a demand for novel spectacle lens solutions that are safe, passive, and more easily adopted by children and families.[5] Different technologies of myopia control glasses have been implemented, but all of them, while differing in optical design, share a common therapeutic principle: they impose a myopic defocus signal across the peripheral or intermediate visual field while providing clear central vision, thereby modulating eye growth.[5]

The defocus incorporated multiple segments (DIMS–Hoya, MiyoSmart) incorporates a central clear optical zone (9 mm) surrounded by a mid-peripheral "treatment zone" (approximately 33 mm in diameter) composed of a honeycomb structure with 396 microlens segments (each 1.03 mm in diameter). Each segment provides +3.50 diopters of myopic defocus relative to the central prescription, a signal posited to modulate ocular growth.[10,11]

Building on similar principles, Highly Aspherical Lenslet Target (HALT–Essilor, Stellest) technology uses a constellation of numerous aspherical micro-lenslets embedded in the lens periphery, which consists of 1021 high-plus lenslets spread over 11 rings surrounding a central clear zone (9 mm). It is believed that this creates a "volume of myopic defocus" that helps slow down the progression of myopia by defocusing light in the mid-peripheral retina. The aspheric design of the lenslets ensures a smooth and continuous defocus profile.[12,13]

The cylindrical annular refractive element (CARE) lens represents another advanced optical strategy for myopia control. The CARE lenses employ a technology termed Cylindrical Annular Refractive Elements (MyoCare, henceforth referred to as CARE, Zeiss Vision Care). The CARE lens design features two main components: (1) a central circular zone with a diameter of 7 mm that corrects the distance refractive error and (2) a treatment zone that surrounds this central area and extends to the edge of the lens. This treatment zone includes cylindrical annular refractive elements alternating with zones that correct for the distance refractive error. The cylindrical microstructures have a nominal power of +9.2 D, resulting in an average additional surface power of +4.6 D. These annular rings alternate between zones that focus light on the retina and zones that focus slightly in front of the retina, thereby providing simultaneous competing defocus stimuli across the retinal surface. The resultant myopic defocus signal has been shown to effectively slow axial growth of the eye.[14,15]

The present retrospective study was designed to compare the clincial setting efficacy of three such spectacle interventions, DIMS, HALT, and CARE lenses, against conventional single-vision lenses (SVLs). We aim to inform clinical practice on the relative performance of emerging myopia control spectacles and to contribute to the optimization of individualized myopia management for children at risk of high myopia and its complications.

## Methods

This single-center, retrospective analysis was conducted at Aravind Eye Hospital (Coimbatore, Tamil Nadu, South India). The Institutional Review Board/Ethics Committee of Aravind Eye Hospital approved the protocol (approval number: RET202500515), and the study adhered to the tenets of the Declaration of Helsinki. Owing to the retrospective design and use of deidentified data, the requirement for written informed consent was waived.

Electronic medical records of consecutive children referred to the Myopia Clinic at Aravind Eye Hospital, Coimbatore, between September 2022 and June 2025 were reviewed. Data extraction was performed manually from the hospital's electronic medical record system (Aravind EMR Aurolab). Records were systematically filtered based on the extraction of specific variables, including age, cycloplegic refraction, spectacle prescription history, and documented use of pharmacological myopia control (atropine). Eligible participants were 6–16 years of age at baseline with a cycloplegic spherical equivalent refraction between −0.50 D and −9.00 D. Included patients were naïve to myopia control spectacles and were prescribed one of the following lens types in routine care: SVL (control), DIMS, HALT, or CARE. Patients were required to maintain the same lens technology throughout the observation period; those who switched lens types were excluded. Moreover, patients had complete baseline data with at least 1 follow-up ≥6 months (baseline defined as the date of prescription of the myopia control or single-vision spectacles). Exclusion criteria were current or past use of atropine at any concentration; keratoconus or other corneal anomalies that could compromise visual acuity; developmental delay or other neurological or psychiatric conditions that could compromise cooperation; pathological or syndromic myopia; prior ocular surgery; or retinal pathologies.

Collected variables included demographics (age, sex, parental myopia defined as a binary variable, yes or no if the patient had at least 1 parent with myopia), best-corrected visual acuity, cycloplegic refraction, spherical equivalent (SE), and axial length (AL). Axial length was measured with the IOL Master 700 (Carl Zeiss Meditec) or Lenstar 900 (Haag-Streit) powered with Lenstar

Myopia Software (HOYA). Cycloplegic autorefraction was performed with a desktop autorefractor (model KR-8800; Topcon Corporation). Cycloplegia in our clinic was induced with two drops of 1% cyclopentolate and one drop of 0.5% tropicamide instilled 5 min apart; refraction was performed approximately 30 minutes after the second cyclopentolate drop. Spherical equivalent was calculated as sphere + $\frac{1}{2}$ cylinder.

All measurements were obtained by trained personnel following departmental standard operating procedures.

## Statistical Analysis

All statistical analyses were performed using R Studio statistical software (version 2025.09.0 + 387, Integrated Development Environment for R. Posit Software, PBC, URL: http://www.posit.co/) with library tidyverse, lmerTest, and emmeans. A $P$ value of $<0.05$ was considered statistically significant for all analyses.

Baseline demographic and clinical characteristics were summarized using mean ± standard deviation for continuous variables and counts (n, %) for categorical variables. Analysis of variants was used for continuous patient-level variables, while the chi-squared test was employed for categorical variables. To correctly account for the intereye correlation when comparing baseline ocular parameters, a simple linear mixed model with a random intercept for each subject was utilized to derive an overall $P$ value for the group effect (Tukey method or Bonferroni correction were employed for multiple comparisons). To quantify the magnitude of baseline imbalances between treatment groups, standardized mean differences (SMDs) were calculated for all baseline covariates to quantify the magnitude of imbalance between treatment groups.

To model the longitudinal change in AL and SE, linear mixed-effects models were implemented. This approach was chosen for its ability to appropriately handle the nested data structure (repeated measurements within two eyes per subject).

The models included the following as fixed effects: lens type, time from baseline (in years), and the two-way interaction between lens type and time, which was the primary effect of interest. The coefficient of this interaction term was the primary outcome of interest, representing the difference in the annualized rate of progression (slope) between each defocus lens group and the control group. To adjust for baseline imbalances inherent in the study design, the models were also controlled for the baseline value of the respective outcome variable (i.e., baseline AL or baseline SE), age at baseline, sex, and parental myopia. A random intercept was included for each subject (ID) to account for subject-specific variation and the nonindependence of observations from the same individual (intraclass correlation coefficient = 0.96 at baseline for AL).

Following the main analysis, post hoc pairwise comparisons of the estimated annual progression rates (slopes) among all lens types were conducted using the method of estimated marginal means. $P$ values for these pairwise comparisons were adjusted for multiple comparisons using the Tukey method. Model assumptions of normality and homoscedasticity of residuals were assessed graphically.

To further contextualize the treatment effects against an external benchmark, observed progression rates were compared to the age-normative progression predicted by the Brennan et al meta-regression model for non-East Asian children.[16] For each treatment group, the expected annual axial elongation was calculated using the published formula: $\alpha = exp(0.362 - 0.158\ x\ Age)$. The age input for the formula was the group's mean baseline age adjusted for its mean follow-up duration (the mean age at the midpoint of the observation period), as recommended for longitudinal data.

Furthermore, a secondary analysis was conducted to investigate the incidence of AL regression, defined as a decrease of more than 0.05 mm from baseline to the final follow-up visit. A generalized linear mixed-effects model with a binomial distribution and a logit link function was used to model the probability of this binary outcome. The model included lens type and follow-up duration as a fixed effect and a random intercept for each subject to account for intereye correlation. Results were reported as odds ratios with their corresponding 95% confidence intervals (CIs).

# Results

The study included a total of 899 subjects, contributing 1780 eyes, with an overall mean age of 12.18 ± 2.73 years and a mean follow-up time of 12.49 ± 5.71 months. The cohort was divided into four treatment groups based on the prescribed spectacle lens type. The baseline analysis comprised 446 eyes in the standard SVL group, 523 eyes in the DIMS group, 295 eyes in the HALT group, and 516 eyes in the CARE group.

The baseline demographic and ocular characteristics of the study population, stratified by lens type, are presented in Table 1.

Significant baseline differences were observed among the treatment groups for most characteristics, as is common in retrospective studies with large sample sizes ($P < 0.05$ for all except parental myopia).

To better assess the clinical magnitude of these imbalances, global SMDs were calculated to quantify the overall variation across the four study groups. This analysis revealed SMDs exceeding 0.1 for several variables, indicating baseline imbalances. Re-expressing these standardized differences in original units clarifies their clinical context: the SMD of 0.225 for age corresponds to an approximate mean difference of 0.6 years (approximately 7 months) across groups, while the SMD of 0.168 for sex reflects a variation in female prevalence of roughly 10% points. Regarding ocular parameters, the SMD of 0.236 for AL corresponds to a mean difference of 0.23 mm, whereas the largest imbalance was observed for SE (SMD = 0.451), corresponding to a mean difference of 0.73 D. These clinically relevant baseline differences confirm the necessity of the multivariable adjustment strategy employed in our longitudinal models to mitigate confounding.

## Longitudinal Change in Axial Length

The linear mixed-effects model revealed a significant effect of time and lens type on AL progression. The control group wearing SVL demonstrated a mean adjusted axial elongation of 0.193 mm/year (95% CI [0.180, 0.207]). All three defocus lens technologies significantly reduced this rate of progression ($P < 0.001$ for all lens types).

The estimated annual progression for the DIMS group was 0.098 mm/year (95% CI [0.089, 0.107]), with a mean difference versus SVL of −0.095 mm/year (95% CI [−0.111, −0.079]; $P < 0.001$). The CARE group showed an annual progression of 0.088 mm/year (95% CI [0.076, 0.100]), with a mean difference versus SVL of −0.105 mm/

Table 1. Summary of Demographic and Baseline Characteristics of the Population

| Lens Type | Number (Eyes) | Age | Sex F | BCVA | Axial Length | Spherical Equivalent | Myopia Parents | Follow-Up |
|---|---|---|---|---|---|---|---|---|
| SVL | 446 | 12.8 ± 2.41 | 254 (56.9%) **a, b** | 0.03 ± 0.07**a,b** | 24.3 ± 0.986 **ab** | −2.99 ± 1.78 | 132 (29.6%) | 10.97 ± 3.43**a** |
| DIMS | 523 | 11.7 ± 2.86 **a** | 246 (47.0%)**c** | 0.04 ± 0.08**c** | 24.5 ± 0.992**ac** | −3.62 ± 1.77**a** | 156 (29.8%) | 14.44 ± 7.01**b** |
| HALT | 295 | 12.3 ± 2.62 **b** | 165 (55.9%)**a, c** | 0.04 ± 0.08**a,c** | 24.6 ± 0.976**c** | −3.76 ± 1.72**a** | 96 (32.5%) | 13.48 ± 9.96**b** |
| CARE | 516 | 12.1 ± 2.80 **a, b** | 270 (52.3%)**b, c** | 0.02 ± 0.06**b** | 24.2 ± 0.937**b** | −2.49 ± 1.24 | 123 (23.8%) | 11.28 ± 4.16**a** |
| *P* Value | - | <0.001 | 0.011 | <0.001 | <0.001 | <0.001 | 0.219 | <0.001 |

BCVA = best-corrected visual acuity; CARE = cylindrical annular refractive elements; DIMS = defocus incorporated multiple segments; HALT = highly aspherical lenslet target; SVL = single vision lenses.
Within columns, values sharing the same letter (a, b, c) are not statistically different from each other based on post hoc pairwise comparisons.

year (95% CI [−0.123, −0.087]; $P < 0.001$). The HALT technology was the most effective, with an estimated annual progression of 0.054 mm/year (95% CI [0.042, 0.066]) and a mean difference versus SVL of −0.139 mm/year (95% CI [−0.158, −0.121]; $P < 0.001$) (Table 2).

Post hoc pairwise comparisons of the defocus lenses confirmed a clear hierarchy of efficacy. The HALT lens was found to be significantly more effective than both the DIMS lens (mean difference = −0.044 mm/year; $P < 0.001$) and the CARE lens (mean difference = −0.034 mm/year; *P* value <0.001). No statistically significant difference was found between the efficacy of the DIMS and CARE lenses (*P* value = 0.510).

Among the covariates in the model, older age at baseline was significantly associated with a slower rate of axial elongation ($\beta = -0.0076$ mm per year of age; $P < 0.001$). No significant association was found between parental myopia and the rate of axial elongation in our adjusted model ($\beta = 0.007$ mm; *P* value = 0.23). Its inclusion in the model served to adjust for baseline differences between the nonrandomized treatment groups.

## Comparison to the Expected Progression Rate (Brennan Formula)

To validate our findings against an external benchmark, we compared the adjusted axial elongation rates from our model with the age-normative progression rates predicted by Brennan et al (Fig 1). The SVL control group, with a mean observation age of 13.3 years, showed an observed progression of 0.193 mm/year, which was slightly faster than its predicted rate of 0.174 mm/year. In contrast, all myopia control lenses demonstrated substantial efficacy relative to their predicted age-matched trajectories. The observed annual progression for the DIMS group (0.098 mm/year) was less than half of its predicted rate (0.206 mm/year). An even greater effect was seen for the CARE group, with an observed progression of 0.088 mm/year compared to a predicted rate of 0.198 mm/year. The HALT group showed the largest deviation from its expected progression, with an observed elongation of only 0.054 mm/year against a predicted rate of 0.189 mm/year. These results indicate that the observed treatment effects represent a clinically meaningful suppression of axial growth beyond what would be expected for untreated children of the same age.

Table 2. Model-Estimated Annual Progression Rates for Axial Length (mm/year) for Each Lens

| Lens Type | Annual Axial Length (mm/year) | 95% CI | P Value |
|---|---|---|---|
| SVL | 0.193 | 0.180−0.207 | - |
| DIMS | 0.098 | 0.089−0.107 | <0.001 |
| HALT | 0.054 | 0.042−0.066 | <0.001 |
| CARE | 0.088 | 0.076−0.100 | <0.001 |

CARE = cylindrical annular refractive elements; CI = confidence interval; DIMS = defocus incorporated multiple segments; HALT = highly aspherical lenslet target; SVL = single vision lenses.

## Longitudinal Change in Spherical Equivalent

The control group wearing SVL demonstrated a mean adjusted myopic progression of −0.370 D/year (95% CI [−0.397, −0.342]). All three defocus lens technologies were found to significantly reduce this rate of myopic shift compared to the control group ($P < 0.001$ for all comparisons).

The estimated annual refractive progression for the DIMS group was −0.107 D/year (95% CI [−0.125, −0.089]), with a mean difference versus SVL of +0.263 D/year (95% CI [0.230, 0.296]; $P < 0.001$). The CARE group showed an annual progression of −0.106 D/year (95% CI [−0.131, −0.082]), with a mean difference versus SVL of +0.264 D/year (95% CI [0.227, 0.300]; $P < 0.001$). The HALT group showed an annual progression of −0.073 D/year (95% CI [−0.098, −0.048]), with a mean difference versus SVL of +0.297 D/year (95% CI [0.260, 0.334]; $P < 0.001$) (Table 3).

However, in contrast to the findings for AL, post hoc pairwise comparisons did not reveal any statistically significant differences in efficacy among the three defocus lens technologies ($P > 0.13$ for all comparisons). It is pertinent to note that baseline SE exhibited a moderate imbalance across groups (mean difference of 0.73 D). While the linear mixed model included this variable as a covariate to adjust for the disparity, this baseline difference

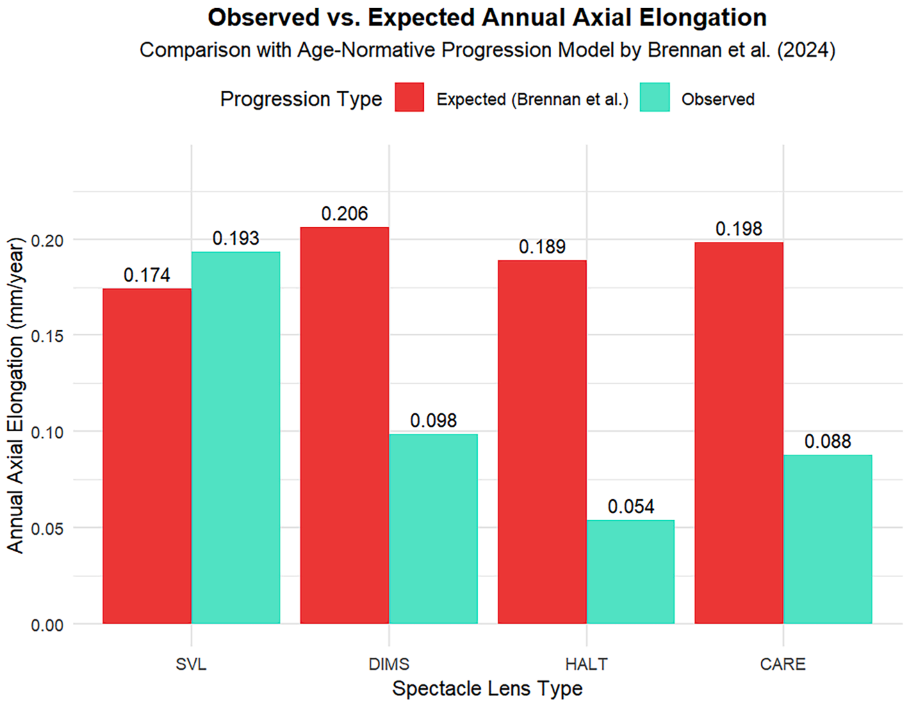

**Figure 1.** Bar chart of the predicted progression via Brennan's formula and the observed progression: CARE, DIMS, HALT, and SVL. CARE = cylindrical annular refractive elements; DIMS = defocus incorporated multiple segments; HALT = highly aspherical lenslet target; SVL = single vision lenses.

represents a potential source of residual variability specific to this refractive outcome. In the fully adjusted model, no significant association was found between the rate of refractive progression and age at baseline (*P* value = 0.612), sex (*P* > 0.20), or parental myopia (*P* value = 0.786).

## Incidence of Axial Length Regression

The incidence of AL regression (>0.05 mm) was also analyzed to determine if any lens type was associated with this outcome. Descriptively, a higher proportion of eyes in the defocus lens groups exhibited regression compared to the control group.

However, after accounting for intersubject variability in the generalized linear mixed model, these trends did not reach statistical significance. The odds of regression for the DIMS lens group were 3.14 (95% CI [0.23, 42.55]; *P* value = 0.39), for the HALT group were 6.38 (95% CI [0.47, 87.50]; *P* value = 0.165), and for the CARE group were 5.63 (95% CI [0.47, 67.25]; *P* value = 0.172) times that of the control group (Table 4). Follow-up duration was not significantly associated with the likelihood of regression (*P* = 0.847).

Table 3. Model-Estimated Annual Progression Rates for Spherical Equivalent (Diopters/Year) for Each Lens

| Lens Type | Spherical Equivalent Progression (Diopters)/Year | 95% CI | P Value |
|---|---|---|---|
| SVL | −0.370 | −0.397, −0.342 | - |
| DIMS | −0.107 | −0.125, −0.089 | <0.001 |
| HALT | −0.073 | −0.098, −0.048 | <0.001 |
| CARE | −0.106 | −0.131, −0.082 | <0.001 |

CARE = cylindrical annular refractive elements; CI = confidence interval; DIMS = defocus incorporated multiple segments; HALT = highly aspherical lenslet target; SVL = single vision lenses.

## Discussion

Our retrospective study describes and compares the outcomes of 3 different designs of myopia control glasses: HALT (Essilor), DIMS (Hoya), and CARE (ZEISS). Each one of the lenses attenuated axial elongation and refractive progression compared with SVLs. After multivariable adjustment in linear mixed-effects models, our results suggest that HALT is the most effective in reducing myopia progression in terms of AL, compared to DIMS and CARE. In terms of SE, no significant differences were found among the three myopia control lenses (*P* > 0.13). While the point estimate for HALT was smallest (−0.073 D/year) compared to DIMS (−0.107 D/year) and CARE (−0.106 D/year), these differences did not reach statistical significance in our cohort. All three controlling glasses were superior compared to SVL, which showed an SE annual progression rate of −0.370 D/year. Similarly, considering the changes in AL, we found HALT to be the most impactful, leading to an annual progression rate of 0.0541 mm/year,

Table 4. Odds Ratio of the Axial Length Regression

| Lens Type | OR | 95% CI | *P* Value |
|---|---|---|---|
| SVL | 1 | - | - |
| DIMS | 3.14 | 0.23–42.55 | 0.39 |
| HALT | 6.38 | 0.47–87.5 | 0.165 |
| CARE | 5.63 | 0.47–67.25 | 0.172 |

CARE = cylindrical annular refractive elements; CI = confidence interval; DIMS = defocus incorporated multiple segments; HALT = highly aspherical lenslet target; OR = odds ratio; SVL = single vision lenses.

outperforming DIMS (0.098 mm/year) and CARE (0.088 mm/year), and corresponding to around a 72% reduction versus SVL (0.193 mm/year). Pairwise contrasts confirmed HALT > DIMS and HALT > CARE for AL control; DIMS and CARE did not differ significantly from each other. Collectively, these data suggest a consistent hierarchy of spectacle performance within routine care, with HALT conferring the greatest short-term attenuation of axial growth in our setting. In the last decades, the field of myopia control strategies has become a hot topic, and many retrospective studies and clinical trials have been published. Our findings broadly align with randomized evidence and large clincial setting datasets. For HALT, a 2-year randomized trial showed substantial reductions versus SVL in both spherical equivalent progression (−0.80 D) and axial elongation (−0.35 mm),[17] while a 3-year study demonstrated sustained efficacy and benefit even in kids who used SVL for over 2 years and then were switched to HALT, reinforcing the durability of the effect beyond year 2.[18]

In DIMS, the original randomized program and extended follow-up reported clinically relevant slowing of both SE and AL, with an enduring third-year effect versus historical controls, confirming that spectacle-based myopic defocus remains efficacious with continued wear.[19,20] With respect to CARE, early randomized controlled trial (RCT) evidence demonstrated a significant reduction in axial elongation at 1 year (difference ∼0.09 mm vs. SVL), with a smaller and statistically borderline effect on spherical equivalent progression. European multicenter randomized data showed larger 12-month differences (−0.21 D in SE and −0.14 mm in AL vs. SVL), supporting generalizability to non-Asian populations. These randomized results are directionally consistent with our clincial setting estimates.[21,22] Direct randomized evidence, including all three designs, is still scarce. A recent Indian RCT directly comparing DIMS, HALT, and CARE reported comparable efficacy for DIMS and HALT and a modestly lower effect for CARE at 12 months, an ordering compatible with our axial-length hierarchy (HALT best; DIMS ≈ CARE).[23] Clincial setting comparative cohorts also tend to favor HALT over DIMS. A Chinese clinical database analysis found less SE progression and less axial elongation at 1 year with HALT than DIMS. Children wearing HALT lenses showed a mean SE change of −0.34 D compared with −0.63 D in the DIMS group, corresponding to 0.29 D less myopic progression. Axial length increased by 0.17 mm with HALT and 0.28 mm with DIMS, indicating 0.11 mm less elongation in the HALT group.[24] A large French longitudinal cohort likewise observed slightly less progression with HALT than DIMS overall; although statistically significant, the authors judged the magnitude not clinically meaningful.[25]

Furthermore, we compared our findings against an established, external benchmark for myopia progression. The observation that our SVL control group progressed at a rate of 0.193 mm/year, closely mirroring its predicted rate of 0.174 mm/year from the Brennan model.[16] This comparative analysis reinforces our primary findings. The substantial suppression of axial growth observed for the defocus lenses—with HALT lenses showing an observed progression of 0.054 mm/year against an expected 0.189 mm/year—provides strong evidence that their efficacy is not simply an artifact of comparison against our internal control group. This method of benchmarking each group against its own age-adjusted expected trajectory directly mitigates concerns that baseline imbalances confounded the study's conclusions. However, these comparisons must be interpreted with caution. The Brennan et al model was developed primarily from East Asian and Caucasian populations, and its categorization of South Asian children as "non-Asian" may not fully capture the specific genetic and environmental factors influencing myopia progression in our Indian cohort. Furthermore, while the Brennan model excluded high myopes, our clincial setting dataset included a broader range of myopia, which could also influence the expected progression rates. Therefore, while this comparative analysis provides context, the primary conclusions of our study remain grounded in the internally validated comparisons.

In our cohort, the proportion of eyes showing AL regression (>0.05 mm) was descriptively higher with defocus spectacle designs than with SVL, yet the adjusted odds did not reach statistical significance, with wide CIs. This pattern is consistent with published articles that report AL shortening or stabilization under optical myopia-control interventions. In clincial setting DIMS spectacle wearers, a small but non-negligible fraction (around 2%–3%) exhibited clinically significant AL shortening after prolonged wear, supporting that negative AL changes can occur.[26] Complementary evidence from contact-lens modalities shows a larger phenomenon, with extended depth-of-focus lenses, >40% of children had AL stabilization or reduction at 1 year, and AL shortening correlated with choroidal thickening, suggesting a physiological substrate rather than measurement noise.[27] Likewise, large orthokeratology datasets show long-term AL shortening in a minority of wearers (∼16% beyond 1 year). The effect is age-dependent and occurs mainly in the first 2 years. Smaller cohorts suggest that early AL shortening predicts better long-term control.[28,29]

Taken together, these data suggest that modest negative AL changes are an expected finding in some children on optical treatments, likely mediated by choroidal expansion and, in the case of orthokeratology, corneal remodeling. In spectacle-based defocus therapy, structural contributions are smaller, so observed regressions may be rare and small in magnitude, proximate to instrument repeatability; our use of a >0.05 mm threshold was intended to exceed typical measurement noise. Our nonsignificant trend therefore aligns with broader literature. Defocus spectacles may increase the likelihood of transient AL shortening relative to SVL, but the effect size is modest, and studies, including ours, may be underpowered to detect it after adjustment. Future prospective work with standardized diurnal timing, repeated AL measures per visit, and concurrent choroidal metrics could clarify the prevalence, mechanisms, and prognostic value of AL regression under spectacle-based myopia control.[26]

Our study strengths include a large pediatric cohort and modeling choices that appropriately address repeated measures and intereye correlation, with adjustment for baseline imbalances (age, sex, baseline AL and SE, parental myopia). Nonetheless, while our adjusted analyses provide evidence for the superior clincial setting effectiveness of HALT lenses in attenuating axial elongation, this conclusion must be interpreted with the caution inherent to observational data. These findings should be viewed as complementary to, rather than a replacement for, evidence from RCT. They robustly reflect the outcomes observed in a routine clinical setting but do not imply the same level of causal inference as an RCT. Future prospective, randomized studies are warranted to confirm this observed hierarchy of effectiveness in a controlled environment. Wear-time, compliance, and environmental covariates (near-work, outdoor time) were not systematically available, which may attenuate or inflate relative effects. Specifically, regarding the moderate imbalance in baseline SE, we acknowledge that multivariable adjustment relies on the assumption of linearity and may involve model extrapolation if the distribution of refractive error differs substantially between groups (e.g., fewer high myopes in the single-vision control group). Alternative analytical approaches, such as propensity score matching, could have been employed to ensure a strictly balanced distribution of baseline covariates. However, propensity score matching would have necessitated excluding a significant proportion of subjects outside the region of common support, thereby reducing sample size, statistical power, and the generalizability of our findings to the broader clinical population. We therefore prioritized a regression-based adjustment to utilize the full cohort while recognizing that estimates for patients at the extremes of the refractive distribution should be interpreted with awareness of this limitation. Finally, our 13-month mean follow-up limits inference on durability. A longer follow-up will be optimal to identify if all these lenses can maintain their myopia control over the years or if they reach a plateau after some time of use. However, published extensions suggest sustained efficacy with continued wear.[20] All three myopia-control spectacle designs outperformed SVL in routine care. Where available, HALT may offer the greatest short-term attenuation of axial elongation, with DIMS and CARE providing meaningful alternatives that may be selected according to patient-specific factors, access, and cost. The absence of a significant difference between DIMS and CARE for AL in our dataset (despite a trend) underscores that any of the three designs reduces structural myopia progression relative to SVL.

## Conclusions

In a large, clincial setting pediatric cohort, HALT, DIMS, and CARE all slowed myopia progression versus SVL, with HALT showing the largest attenuation of axial elongation and the smallest SE shift over 1 year. In our adjusted analyses, DIMS and CARE performed similarly. These findings are concordant with randomized and clincial setting literature and support the integration of myopia-control spectacles into first-line pediatric management. The HALT lenses were associated with the greatest reduction in axial elongation. While these findings suggest HALT may be particularly effective for axial growth suppression, this conclusion should be interpreted with caution, given the study's retrospective nature. These results support the use of all three lens types, with the choice potentially guided by the primary goal of treatment. Longer follow-up and prospective head-to-head studies will clarify durability, effect modifiers, and optimal sequencing or combination with atropine.

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[1] Paediatric Ophthalmology and Strabismus, Aravind Eye Hospital, Coimbatore, Tamil Nadu, India.

[2] Department of Sense Organs, Sapienza University of Rome, Rome, Italy.

[3] Department of Statistics, Aravind Eye Hospital, Coimbatore, Tamil Nadu, India.

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Author Contributions:

Conception and design: Ganesh, Elizabeth, Sindhu, Jogitha, Sakthivel, Rao, Narendran

Data collection: Ganesh, Elizabeth, Sindhu, Jogitha, Sakthivel, Rao, Narendran

Analysis and interpretation: Armentano, Sivakumar, Alisi

Obtained funding: N/A

Overall responsibility: Ganesh, Armentano, Alisi

Abbreviations and Acronyms:
**AL** = axial length; **CI** = confidential interval; **CARE** = cylindrical annular refractive elements; **DIMS** = defocus incorporated multiple segments; **HALT** = highly aspherical lenslet target; **RCT** = randomized controlled trial; **SVLs** = single-vision lenses; **SE** = spherical equivalent; **SMDs** = standardized mean differences.

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Correspondence:
Marta Armentano, MD, PhD, Department of Sense Organs, Sapienza University of Rome, Piazzale Aldo Moro 5, 00185, Rome, Italy. E-mail: marta.armentano@uniroma1.it.

## 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. Sankaridurg P, Tahhan N, Kandel H, et al. IMI impact of myopia. *Invest Ophthalmol Vis Sci*. 2021;62:2.
3. Jonas JB, Ang M, Cho P, et al. IMI prevention of myopia and its progression. *Invest Ophthalmol Vis Sci*. 2021;62:6.
4. Németh J, Tapasztó B, Aclimandos WA, et al. Update and guidance on management of myopia. *Eur J Ophthalmol*. 2021;31:853−883.
5. Lawrenson JG, Huntjens B, Virgili G, et al. Interventions for myopia control in children: a living systematic review and network meta-analysis. *Cochrane Database Syst Rev*. 2025;2:CD014758.
6. Tapasztó B, Flitcroft DI, Aclimandos WA, et al. Myopia management algorithm (Annexe). *Eur J Ophthalmol*. 2024;34:952−966.
7. Bullimore MA, Saunders KJ, Baraas RC, et al. IMI-interventions for controlling myopia onset and progression 2025. *Invest Ophthalmol Vis Sci*. 2025;66:39.
8. Choi KY, Cheung JK, Wong GT, et al. Myopia Control Efficacy and Long-Term Safety of a Novel Orthokeratology Lens (MESOK Study)-A Randomized Controlled Clinical Trial Combining Clinical and Tear Proteomics Data. *J Clin Med*. 2023;12:3210.
9. Kam KW, Yung W, Li GKH, et al. Infectious keratitis and orthokeratology lens use: a systematic review. *Infection*. 2017;45:727−735.
10. Carlà MM, Boselli F, Giannuzzi F, et al. Overview on defocus incorporated multiple segments lenses: a novel perspective in myopia progression management. *Vision (Basel)*. 2022;6:20.
11. Neller B, Neller K, Schwahn H, et al. Effect of defocus incorporated multiple segments (DIMS) spectacle lenses on myopia progression in children: a retrospective analysis in a German real-life clinical setting. *BMC Ophthalmol*. 2024;24:403.
12. Li X, Huang Y, Liu C, et al. Myopia control efficacy of spectacle lenses with highly aspherical lenslets: results of a 5-year follow-up study. *Eye Vis (Lond)*. 2025;12:10.
13. Bao J, Yang A, Huang Y, et al. One-year myopia control efficacy of spectacle lenses with aspherical lenslets. *Br J Ophthalmol*. 2022;106:1171−1176.
14. Chen X, Wu M, Yu C, et al. Efficacy of cylindrical annular refractive elements (CARE) spectacle lenses in slowing myopia progression over 2 years. *Am J Ophthalmol*. 2025;278:203−211.
15. Chen X, Wu M, Yu C, et al. Slowing myopia progression with cylindrical annular refractive elements (CARE) spectacle lenses-year 1 results from a 2-year prospective, multi-centre trial. *Acta Ophthalmol*. 2024;103:929−938.
16. Brennan NA, Shamp W, Maynes E, et al. Influence of age and race on axial elongation in myopic children: a systematic review and meta-regression. *Optom Vis Sci*. 2024;101:497−507.
17. Bao J, Huang Y, Li X, et al. Spectacle lenses with aspherical lenslets for myopia control vs single-vision spectacle lenses: a randomized clinical trial. *JAMA Ophthalmol*. 2022;140:472−478.
18. Li X, Huang Y, Yin Z, et al. Myopia control efficacy of spectacle lenses with aspherical lenslets: results of a 3-Year Follow-Up study. *Am J Ophthalmol*. 2023;253:160−168.
19. Lam CSY, Tang WC, Tse DY, et al. Defocus incorporated multiple segments (DIMS) spectacle lenses slow myopia progression: a 2-year randomised clinical trial. *Br J Ophthalmol*. 2020;104:363−368.
20. Lam CS, Tang WC, Lee PH, et al. Myopia control effect of defocus incorporated multiple segments (DIMS) spectacle lens in Chinese children: results of a 3-year follow-up study. *Br J Ophthalmol*. 2022;106:1110−1114.
21. Liu X, Wang P, Xie Z, et al. One-year myopia control efficacy of cylindrical annular refractive element spectacle lenses. *Acta Ophthalmol*. 2023;101:651−657.
22. Alvarez-Peregrina C, Sanchez-Tena MA, Villa-Collar C, et al. Clinical evaluation of MyoCare in Europe − the CEME study group. Clinical evaluation of MyoCare in Europe (CEME) for myopia management: one-Year results. *Ophthalmic Physiol Opt*. 2025;45:1025−1035.
23. Gupta V, Saxena R, Dhiman R, et al. Comparative evaluation of different (peripheral defocus based) spectacle designs in preventing myopia progression: a double-blinded randomised clinical trial. *Ophthalmic Physiol Opt*. 2025;45:1505−1511.
24. Guo H, Li X, Zhang X, et al. Comparing the effects of highly aspherical lenslets versus defocus incorporated multiple segment spectacle lenses on myopia control. *Sci Rep*. 2023;13:3048.
25. Najji R, Bullimore M, Resnikoff S, et al. The real-world effectiveness of defocus incorporated multiple segments and highly aspherical lenslets on myopia control: a longitudinal study from the French myopia cohort. *BMJ Open Ophthalmol*. 2025;10:e002142.
26. Chun RKM, Wong KYQ, Lam CSY, et al. Real-world outcomes of defocus incorporated multiple segments lenses on

retarding axial elongation in myopic children and adolescents. *Front Med (Lausanne)*. 2025;11:1416286.

27. Hazra D, Yotsukura E, Oyama S, et al. Axial length stabilization or reduction in over 40% of patients wearing extended depth-of-focus contact lenses. *J Clin Med*. 2025;14:1750.
28. Hu Y, Ding X, Jiang J, et al. Long-term axial length shortening in myopic orthokeratology: incident probability, time course, and influencing factors. *Invest Ophthalmol Vis Sci*. 2023;64:37.
29. Wang A, Yang C, Shen L, et al. Axial length shortening after orthokeratology and its relationship with myopic control. *BMC Ophthalmol*. 2022;22:243.