

Comparative effectiveness of three myopia-control spectacle lenses in Chinese children: a real-world retrospective cohort study

Xiaoying Xing

xingxiaoyingeye@163.com

Suzhou Eye Hospital of Suzhou Vocational Health College

Ziyue Song

Suzhou Eye Hospital of Suzhou Vocational Health College

Qi Yu

Suzhou Eye Hospital of Suzhou Vocational Health College

Kou Zhang

Suzhou Eye Hospital of Suzhou Vocational Health College

Shiao Yu

Suzhou Eye Hospital of Suzhou Vocational Health College

Research Article

Keywords: Myopia control, Axial length, Defocus incorporated multiple segments, Highly aspherical lenslets, Diffusion optics technology, Single-vision spectacles, Real-world study

Posted Date: October 22nd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11294170/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Spectacle lenses based on three distinct optical principles - defocus incorporated multiple segments (DIMS), highly aspherical lenslets (HAL) and diffusion optics technology (DOT) - are now widely prescribed for myopia control, yet direct real-world comparisons of the three designs against single-vision (SV) spectacles remain scarce. This study compared their 1-year effectiveness in a routine clinical setting.

Methods

This single-center retrospective cohort study included 682 myopic children aged 6–16 years (right eyes; baseline spherical equivalent refraction [SER] ≤ 0 D) with baseline and approximately 1-year measurements of axial length (AL) and refraction: SV ($n = 131$), DIMS ($n = 167$), HAL ($n = 303$) and DOT ($n = 81$). The primary outcome was 1-year AL change; the secondary outcome was 1-year change in SER. Analysis of covariance (ANCOVA) was used to adjust for age, sex, baseline AL, baseline SER and baseline cylinder. Treatment response was categorized using published thresholds, and multivariable logistic regression estimated the odds of a good response versus SV.

Results

Adjusted mean 1-year axial elongation was 0.275 mm with SV, 0.191 mm with DIMS, 0.180 mm with HAL and 0.092 mm with DOT ($P < 0.001$). All three designs slowed axial elongation versus SV (DIMS: -0.084 mm, $P < 0.001$; HAL: -0.096 mm, $P < 0.001$; DOT: -0.183 mm, $P < 0.001$), and DOT was superior to both DIMS and HAL (both $P < 0.001$), corresponding to a 66% relative slowing versus SV. Adjusted SER progression was -0.735 D (SV), -0.540 D (DIMS), -0.532 D (HAL) and -0.424 D (DOT) ($P = 0.002$), with all three designs significantly reducing progression versus SV (all $P \leq 0.05$). The proportion of eyes with a good axial response was highest with DOT (70.4%), followed by HAL (58.1%), DIMS (56.3%) and SV (42.0%); adjusted odds ratios versus SV were 2.01 (95% CI 1.22–3.29, $P = 0.006$) for DIMS, 2.43 (1.54–3.83, $P < 0.001$) for HAL and 5.40 (2.84–10.28, $P < 0.001$) for DOT. Younger age independently predicted faster progression.

Conclusions

In this real-world cohort, all three myopia-control spectacle designs outperformed SV spectacles in slowing axial elongation. DOT lenses showed the largest treatment effect and the highest probability of a good response, while DIMS and HAL performed comparably. Prospective randomized head-to-head trials are warranted to confirm these findings.

Background

Myopia is the most common ocular refractive disorder worldwide, and its prevalence is projected to reach half of the global population by 2050, with approximately 10% affected by high myopia[1, 2]. Because axial elongation underlies myopia progression and the risk of sight-threatening complications - including myopic maculopathy, retinal detachment, cataract and glaucoma - rises steeply with axial length (AL) and dioptric power[3–5], slowing progression in childhood has become a major public health priority.

Among the available interventions, spectacle lenses are the most accessible and best accepted. The defocus incorporated multiple segments (DIMS) lens, which surrounds a clear central zone with an annular array of segments providing + 3.50 D of relative positive power, slowed myopia progression by 0.44 D and axial elongation by 0.34 mm over 2 years in a randomized clinical trial (RCT), with sustained efficacy reported over 6 to 10 years of follow-up[6–9]. Spectacle lenses with highly aspherical lenslets (HAL) create a three-dimensional volume of myopic defocus through 11 concentric rings of contiguous lenslets; they reduced progression by 0.80 D and elongation by 0.35 mm over 2 years, with durable benefit over 5 years and confirmation in a recent North American RCT that supported regulatory authorization[10–13]. Most recently, diffusion optics technology (DOT) lenses have introduced a contrast-modulation mechanism, embedding microscopic light-scattering elements that mildly reduce retinal contrast; the DOT 0.2 design slowed axial elongation by 0.13 mm and progression by 0.33 D over 3 years in the CYPRESS trial, with continued benefit in year 4[14, 15].

Although each design has been validated against single-vision (SV) spectacles, clinicians must choose among them in routine practice, and direct comparative evidence remains limited and inconsistent. A 1-year Chinese retrospective study reported greater efficacy for HAL than for DIMS[16], whereas 2-year European real-world data found the two designs clinically comparable[17], and a large French cohort detected only a small statistically significant advantage for HAL[18]. Real-world effectiveness of DIMS in Chinese clinical practice has also been demonstrated at scale[19]. Recently, a real-world study from northern China demonstrated particularly pronounced myopia-control efficacy for DOT lenses in Chinese children[20]. Notably, DOT - the only design based on contrast modulation rather than imposed defocus - has rarely been compared head-to-head with DIMS or HAL in the same population[21]. To inform this everyday clinical decision, we conducted a real-world retrospective cohort study comparing the 1-year effectiveness of DIMS, HAL and DOT spectacle lenses against SV spectacles in Chinese children and adolescents.

Methods

Study design and participants

This single-center, retrospective, real-world cohort study was conducted at Suzhou Eye Hospital of Suzhou Vocational Health College in China. Consecutive records of children who received spectacle

correction between December 2023 and March 2025 were screened. Myopic children (spherical equivalent refraction (SER) < 0 D) aged 6–16 years at baseline who had complete baseline and approximately 1-year (11–13 months) follow-up data for the right eye were eligible. Participants were grouped according to the spectacle type prescribed: conventional SV spectacles (SV group); DIMS-design multi-segment defocus spectacles (DIMS group); HAL-design lenslet spectacles (HAL group); or DOT-design contrast-modulation spectacles (DOT group). Children with a history of other myopia-control interventions (orthokeratology, multifocal soft contact lenses, atropine or low-level red-light therapy), ocular disease, or strabismus or amblyopia were excluded. The study adhered to the tenets of the Declaration of Helsinki and was approved by the institutional ethics review committee of Suzhou Eye Hospital of Suzhou Vocational Health College (SWYXLL202623); the requirement for informed consent was waived given the retrospective design.

Data collection and outcomes

As part of routine clinical care, AL was measured with IOLMaster 500 (Carl Zeiss, Germany) under non-cycloplegic status. In accordance with the standard clinical procedure of Suzhou Eye Hospital, cycloplegic (0.5% tropicamide + 0.5% phenylephrine hydrochloride; Sinqi, China) refraction was performed at the baseline (prescribing) visit, whereas follow-up refraction was performed under natural conditions using the fogging technique; all refractive measurements adhered to the maximum plus to maximum visual acuity (MPMVA) principle. SER was calculated as sphere plus half the cylinder power. The primary outcome was 1-year change in AL; the secondary outcome was 1-year change in SER. Consistent with published criteria, treatment response was categorized as good (axial elongation ≤ 0.20 mm/year or SER change ≥ -0.50 D/year), poor (≥ 0.40 mm/year or ≤ -0.75 D/year) or fair (in between)[22, 23].

Statistical analysis

All statistical analyses were performed using SPSS version 23 (IBM Corporation, Armonk, NY, USA) and R4.3.3 (r-project.org). Only right-eye data were analyzed, avoiding interocular correlation. Continuous variables are presented as mean $\pm$ standard deviation (SD) and were compared across groups using one-way analysis of variance (ANOVA) or the Kruskal-Wallis test as appropriate; categorical variables were compared using the chi-square test. The primary analysis used ANCOVA (multiple linear regression) of 1-year AL change and 1-year SER change, with treatment group as the factor and age, sex, baseline AL, baseline SER and baseline cylinder as covariates; adjusted (marginal) means were estimated at the cohort mean of each covariate. The three treatment-versus-SV contrasts were defined a priori as the primary comparison family (Bonferroni-adjusted alpha = 0.017), and the three pairwise contrasts among treatment lenses formed a secondary family (alpha = 0.017). For dichotomized treatment response (good versus non-good), multivariable logistic regression estimated odds ratios (ORs) with 95% confidence intervals (CIs) versus SV, adjusting for the same covariates. Relative percentage efficacy was

calculated from adjusted means as (SV change minus treatment change) divided by SV change. A two-sided *P* value < 0.05 was considered statistically significant.

Results

Baseline characteristics

A total of 682 children with baseline myopia ($SER \leq 0$ D) were included: SV ($n = 131$), DIMS ($n = 167$), HAL ($n = 303$) and DOT ($n = 81$). The sex distribution did not differ significantly among groups ($P = 0.692$), but mean age did (range 11.86–12.92 years; $P = 0.005$), the DOT group being the youngest. Baseline ocular characteristics also differed: axial length was similar across groups ($P = 0.103$), whereas baseline SER differed modestly ($P = 0.022$), with the DOT group the most myopic (-2.96 ± 1.88 D), and baseline cylinder differed significantly ($P < 0.001$) (Table 1).

Table 1 Baseline characteristics of the four groups (right eyes). SER, spherical equivalent refraction.					
Characteristic	SV (n = 131)	DIMS (n = 167)	HAL (n = 303)	DOT (n = 81)	P value
Male, n (%)	57 (43.5)	80 (47.9)	144 (47.5)	42 (51.9)	0.692
Age, years	12.92 $\pm$ 2.71	12.79 $\pm$ 2.21	12.44 $\pm$ 2.29	11.86 $\pm$ 1.88	0.005
Axial length, mm	24.28 $\pm$ 1.26	24.39 $\pm$ 0.93	24.39 $\pm$ 1.03	24.65 $\pm$ 1.09	0.103
SER, D	-2.31 $\pm$ 2.26	-2.40 $\pm$ 1.57	-2.26 $\pm$ 1.76	-2.96 $\pm$ 1.88	0.022
Cylinder, D	-0.94 $\pm$ 1.13	-0.65 $\pm$ 0.82	-0.53 $\pm$ 0.66	-0.85 $\pm$ 0.73	< 0.001
<i>Values are mean $\pm$ SD unless otherwise indicated. P values: chi-square test (sex); one-way ANOVA (all other variables).</i>					

Axial elongation

Unadjusted 1-year axial elongation was 0.267 ± 0.162 mm (SV), 0.185 ± 0.176 mm (DIMS), 0.181 ± 0.177 mm (HAL) and 0.115 ± 0.158 mm (DOT). After adjustment, mean elongation was 0.275 ± 0.015 mm (SV), 0.191 ± 0.013 mm (DIMS), 0.180 ± 0.009 mm (HAL) and 0.092 ± 0.019 mm (DOT), with a significant overall treatment effect ($F = 20.69$, $P < 0.001$; Table 2, Fig. 1). Each of the three myopia-control designs significantly slowed axial elongation versus SV (DIMS: mean difference -0.084 mm, 95% CI -0.122 to -0.046 , $P < 0.001$; HAL: -0.096 mm, -0.130 to -0.061 , $P < 0.001$; DOT: -0.183 mm, -0.230 to -0.136 , $P < 0.001$; Table 3). DOT was significantly more effective than both DIMS ($+0.099$ mm, 0.054 to 0.143 , $P < 0.001$) and HAL ($+0.087$ mm, 0.046 to 0.128 , $P < 0.001$), whereas DIMS and HAL did not differ significantly ($P = 0.462$). Relative to SV, adjusted efficacy in slowing axial elongation was 30.5% for DIMS, 34.5% for HAL and 66.5% for DOT. In the ANCOVA model, younger age ($\beta = -0.025$ mm/year per year

of age, $P < 0.001$) and longer baseline AL (beta = + 0.025 mm/year per mm, $P = 0.008$) were significantly associated with axial elongation.

Table 2
One-year changes in axial length and spherical equivalent refraction.

Group	n	AL change (mm), unadjusted	AL change (mm), adjusted	SER change (D), unadjusted	SER change (D), adjusted
SV	131	0.267 ± 0.162	0.275 ± 0.015	-0.669 ± 0.689	-0.735 ± 0.053
DIMS	167	0.185 ± 0.176	0.191 ± 0.013	-0.539 ± 0.591	-0.540 ± 0.045
HAL	303	0.181 ± 0.177	0.180 ± 0.009	-0.560 ± 0.573	-0.532 ± 0.034
DOT	81	0.115 ± 0.158	0.092 ± 0.019	-0.427 ± 0.540	-0.424 ± 0.066
<i>Unadjusted values are mean ± SD; adjusted values are marginal means ± standard error from ANCOVA adjusting for age, sex and baseline AL, SER and cylinder. Overall treatment effect: AL, $F = 20.69$, $P < 0.001$; SER, $F = 5.18$, $P = 0.002$.</i>					

Table 3
Post hoc pairwise comparisons of 1-year AL and SER changes from the covariate-adjusted models.

Comparison	AL difference, mm (95% CI)	P	SER difference, D (95% CI)	P
SV vs DIMS	-0.084 (-0.122 to -0.046)	< 0.001	+ 0.194 (+ 0.057 to + 0.332)	0.006
SV vs HAL	-0.096 (-0.130 to -0.061)	< 0.001	+ 0.202 (+ 0.077 to + 0.328)	0.002
SV vs DOT	-0.183 (-0.230 to -0.136)	< 0.001	+ 0.311 (+ 0.143 to + 0.479)	< 0.001
DIMS vs HAL	+ 0.012 (-0.019 to + 0.043)	0.462	-0.008 (-0.119 to + 0.103)	0.890
DIMS vs DOT	+ 0.099 (+ 0.054 to + 0.143)	< 0.001	-0.117 (-0.274 to + 0.040)	0.145
HAL vs DOT	+ 0.087 (+ 0.046 to + 0.128)	< 0.001	-0.109 (-0.254 to + 0.036)	0.141
<i>Positive SER differences indicate less myopic progression with the first-listed group. Differences versus SV form the pre-specified primary contrast family (Bonferroni-adjusted alpha = 0.017).</i>				

Refractive progression

Unadjusted 1-year SER change was -0.669 ± 0.689 D (SV), -0.539 ± 0.591 D (DIMS), -0.560 ± 0.573 D (HAL) and -0.427 ± 0.540 D (DOT). After adjustment, mean SER change was -0.735 ± 0.053 D (SV), -0.540 ± 0.045 D (DIMS), -0.532 ± 0.034 D (HAL) and -0.424 ± 0.066 D (DOT) ($F = 5.18$, $P = 0.002$; Table 2, Fig. 2). All three treatment groups showed significantly less myopic progression than SV (DIMS: $+0.194$ D, 95% CI $+0.057$ to $+0.332$, $P = 0.006$; HAL: $+0.202$ D, $+0.077$ to $+0.328$, $P = 0.002$; DOT: $+0.311$ D, $+0.143$ to $+0.479$, $P < 0.001$), and all three contrasts remained significant after Bonferroni correction for the primary contrast family (adjusted alpha = 0.017); no significant differences were detected among the three treatment designs (all $P > 0.05$). Adjusted relative efficacy versus SV was 26.5% for DIMS, 27.6% for HAL and 42.3% for DOT. Older age was independently associated with slower SER progression (beta = $+0.033$ D/year per year, $P = 0.003$), as were shorter baseline AL and less baseline myopia.

Treatment response

Based on the axial elongation threshold (good: ≤ 0.20 mm/year), the good-response rate was 42.0% with SV, 56.3% with DIMS, 58.1% with HAL and 70.4% with DOT, while poor responses (≥ 0.40 mm/year) fell from 19.8% (SV) to 3.7% (DOT) (Table 4, Fig. 3). Based on the SER threshold (good: ≥ -0.50 D/year), good-response rates were 47.2% (SV), 58.3% (DIMS), 56.5% (HAL) and 70.4% (DOT). In multivariable logistic regression, all three designs were significantly more likely than SV to achieve a good axial response (DIMS: OR 2.01, 95% CI 1.22–3.29, $P = 0.006$; HAL: OR 2.43, 1.54–3.83, $P < 0.001$; DOT: OR 5.40, 2.84–10.28, $P < 0.001$), as well as a good refractive response (DIMS: OR 2.11, 1.27–3.51, $P = 0.004$; HAL: OR 2.19, 1.38–3.48, $P = 0.001$; DOT: OR 4.05, 2.12–7.73, $P < 0.001$) (Table 5). Younger age predicted a lower likelihood of a good response (OR 1.36 per year for axial response, $P < 0.001$).

Table 4
Distribution of treatment response based on 1-year axial elongation and SER progression.

Group	AL good	AL fair	AL poor	SER good	SER fair	SER poor
SV	55 (42.0%)	50 (38.2%)	26 (19.8%)	58 (47.2%)	10 (8.1%)	55 (44.7%)
DIMS	94 (56.3%)	55 (32.9%)	18 (10.8%)	95 (58.3%)	12 (7.4%)	56 (34.4%)
HAL	176 (58.1%)	97 (32.0%)	30 (9.9%)	166 (56.5%)	30 (10.2%)	98 (33.3%)
DOT	57 (70.4%)	21 (25.9%)	3 (3.7%)	57 (70.4%)	5 (6.2%)	19 (23.5%)
Good axial response: ≤ 0.20 mm/year; poor: ≥ 0.40 mm/year. Good refractive response: ≥ -0.50 D/year; poor: ≤ -0.75 D/year. SER-based categories use the 661 eyes with valid refractive data.						

Table 5
Adjusted odds ratios for a good treatment response versus single-vision spectacles.

Lens vs SV	OR for good AL response (95% CI)	P	OR for good SER response (95% CI)	P
DIMS	2.01 (1.22 to 3.29)	0.006	2.11 (1.27 to 3.51)	0.004
HAL	2.43 (1.54 to 3.83)	< 0.001	2.19 (1.38 to 3.48)	0.001
DOT	5.40 (2.84 to 10.28)	< 0.001	4.05 (2.12 to 7.73)	< 0.001
<i>From multivariable logistic regression adjusting for age, sex, baseline AL, baseline SER and baseline cylinder. Good axial response: ≤ 0.20 mm/year; good refractive response: ≥ -0.50 D/year.</i>				

Discussion

In this real-world cohort of 682 myopic Chinese children and adolescents, all three contemporary myopia-control spectacle designs - DIMS, HAL and DOT - significantly slowed axial elongation relative to conventional SV spectacles after adjustment for baseline imbalances, and DOT demonstrated the largest effect, with a 66% relative reduction in axial elongation and over five-fold higher odds of a good response. To our knowledge, this is the first real-world study to place all three principal spectacle-lens platforms side by side in a single population, including the contrast-modulation DOT design alongside the two defocus-based lenslet designs[21, 24].

DIMS lenses were evaluated in a 2-year double-masked randomized trial in 183 Hong Kong children aged 8–13 years, which remains the pivotal evidence for this design. Over 2 years, cycloplegic myopia progression was -0.41 ± 0.06 D in the DIMS group versus -0.85 ± 0.08 D in the SV group, and axial elongation was 0.21 ± 0.02 mm versus 0.55 ± 0.02 mm, corresponding to 0.44 D and 0.34 mm of absolute treatment effect, or 52% and 62% relative slowing[6]. More recently, a 2-year multi-site interventional trial in 108 UK children reported model-adjusted changes of -0.35 D and 0.17 mm at 12 months and -0.57 D and 0.30 mm at 24 months, with 91% of wearers showing slower axial growth than the expected age- and ethnicity-matched rate, confirming that DIMS efficacy translates to Western populations in routine use[25]. Notably, a meta-analysis of six studies (1224 children, 80.1% of whom were from China) showed that DIMS slowed 12-month SER progression by a mean difference of 0.37 D and reduced axial elongation by 0.16 mm (both $P < 0.0001$)[26]. In our cohort, the adjusted 1-year axial elongation in the DIMS group was 0.191 mm, only 0.084 mm (95% CI -0.122 to -0.046) less than the SV group, a relative reduction of 30.5%; the adjusted SER progression was -0.540 D versus -0.735 D, a difference of 0.194 D (26.4%). These effects are directionally consistent with the trial data but smaller in absolute terms, consistent with the large-scale real-world study by Liu et al.[19]. Two factors most plausibly explain the difference. First, our cohort was comparatively old (mean baseline age near 12 years), and older children progress more slowly regardless of treatment, which compresses the between-group differences; the Hong Kong trial enrolled younger children who progressed about twice as fast. Second, wearing time and adherence in real-world settings are generally lower than in closely supervised trials, and compliance is known to modulate the efficacy of lenslet designs[10]. Our SV group also

progressed at only 0.275 mm/year, well below the 0.55 mm/year observed in the pivotal trial, which further narrows the room for measurable benefit.

The 1-year analysis of the Wenzhou randomized trial in 170 Chinese children aged 8–13 years reported a 0.23 mm difference in axial elongation and a 0.53 D difference in refraction versus single vision, corresponding to 64% and 67% relative slowing[27]. Real-world studies have been less uniform: a Chinese retrospective study found HAL superior to DIMS (adjusted 1-year axial elongation 0.17 mm versus 0.28 mm)[16], a large French cohort reported only a small, clinically marginal advantage of HAL over DIMS[18], and a European comparison found the two designs equivalent[17]. The largest real-world evaluation to date comes from the same Wenzhou group: in a retrospective, propensity-matched cohort of 3419 HAL and 10,846 single-vision users aged 3–18 years, HAL slowed 1-year myopia progression (–0.33 versus –0.63 D) and, in the 406 matched pairs with axial-length data, axial elongation by 0.18 mm (0.19 versus 0.37 mm; 95% CI 0.15–0.21, $P < 0.001$)[28]. Importantly, the benefit was confined to children aged 3–14 years with low-to-moderate myopia: no significant effect was seen in 15–18-year-olds or in children with high myopia ($SER \leq -6.00$ D)[28], a pattern consistent with the much slower progression of older children. In our cohort, the adjusted 1-year axial elongation in the HAL group was 0.180 mm, 0.096 mm (95% CI –0.130 to –0.061) less than SV, a relative reduction of 34.5%; the SER difference was 0.202 D (27.5%). Our axial estimate is strikingly close to the 0.19 mm reported in that matched cohort, and the smaller relative reduction we observed (34.5% versus 48.6%) is largely explained by our slower-progressing SV control (0.275 versus 0.37 mm), which in turn probably reflects the 'depletion of susceptibles' phenomenon described by those authors—fast progressors in clinical practice are commonly switched to more intensive treatments, leaving a control group with inherently slower progression. The same age-related boundary is directly relevant to our population: with a mean age near 12 years, our participants lie close to the upper limit of the age range in which HAL benefit remained demonstrable, which helps to explain why our estimates are smaller than those of the younger Wenzhou trial cohorts and why DIMS and HAL performed comparably in our hands. As with DIMS, less strictly controlled wearing behavior in routine practice may further attenuate the effect.

DOT lenses act by reducing retinal image contrast rather than by imposing peripheral myopic defocus, a mechanism rooted in the contrast theory of myopia, and their efficacy is supported by an increasing body of randomized and real-world data[14, 29]. In the CYPRESS trial, 12-month spherical equivalent progression was slowed by 0.40 D (74%) and axial elongation by 0.15 mm relative to control in North American children aged 6–10 years[14], with additional benefit still evident in year 4[15]. In the CATHAY trial, a 24-month randomized study conducted at five Chinese sites, the 12-month axial elongation was 0.09 ± 0.22 mm in the DOT group versus 0.35 ± 0.19 mm in the SV group (least-squares difference -0.26 ± 0.03 mm, $P < 0.0001$) and cycloplegic SER progressed -0.16 ± 0.51 D versus -0.64 ± 0.42 D (difference 0.48 ± 0.08 D, $P < 0.0001$)[30]. Our DOT group progressed only 0.092 mm in axial length, a value almost identical to the 0.09 mm reported in CATHAY, and our difference of 0.183 mm versus SV is of the same order as the trial estimate, if somewhat smaller, most likely because our cohort was older and progressed more slowly overall. The real-world evidence from northern China points in the same direction: in 162 children aged 7–12 years, DOT lenses slowed 1-year axial elongation by 70.7% relative

to single vision (0.12 ± 0.19 mm versus 0.41 ± 0.24 mm) and reduced SER progression by 82% (median change 0.00 D versus -0.76 D)[20]. The corresponding figures in our cohort were 66.5% and 42.3% for axial length and SER, respectively; the slightly smaller relative reduction is most plausibly explained by our older participants (mean 11.9 versus 9.4 years), who progress more slowly in any case. Our finding that 70.4% of DOT wearers achieved a good axial response and that poor responders fell from 19.8% to 3.7% is consistent with this picture, although the response thresholds and age ranges of the two studies differ. It is also worth emphasizing that the DOT group in our study was both the youngest (mean 11.86 years) and the most myopic (mean SER -2.96 D) at baseline, two characteristics that normally predict faster progression[22, 23]; the largest treatment effect emerging from this unfavorable baseline group argues against a selection-bias explanation and, if anything, suggests the benefit of DOT may be even greater in a more balanced population. At the same time, a recent 1-year real-world study found HAL and DOT comparable in efficacy[31], so the ordering we observed is not universal and should be confirmed prospectively before it informs lens selection.

Two further results deserve comment. First, younger age independently predicted faster axial elongation (-0.025 mm/year per year of age, $P < 0.001$) and a lower probability of a good response (OR 1.36 per year, $P < 0.001$), whereas older children showed slower SER progression (-0.033 D/year per year, $P = 0.003$). This pattern is consistent with the natural history of childhood myopia and with previous reports that age modifies treatment efficacy[32–36]; in the DIMS-versus-HAL comparison mentioned above, the advantage of HAL was confined to younger children[21], and in the northern China DOT cohort, 1-year axial elongation was negatively correlated with age in the DOT, combination and single-vision groups alike ($r = -0.22$, $P < 0.001$)[20]. Second, although all three designs significantly slowed SER progression relative to SV, pairwise differences among the designs were not significant for SER, in contrast to the significant DOT advantage for axial length. The most likely explanation is that our follow-up refraction was largely non-cycloplegic, which adds measurement variability and reduces the power to detect between-lens differences in refraction; axial length, being objective and accommodation-independent, is the preferred primary outcome in myopia-control research[37, 38]. The responder analysis is also worth noting in this respect: the odds of a good axial response relative to SV were 2.01 (95% CI 1.22–3.29) for DIMS, 2.43 (1.54–3.83) for HAL and 5.40 (2.84–10.28) for DOT, and because even modest annual reductions in axial elongation translate into a lower lifetime risk of high myopia[3, 39, 40], these differences are clinically relevant even where statistical significance is limited by sample size.

There are some limitations worth acknowledging. First, this was a retrospective, non-randomized, single-center study, so lens allocation reflected clinical judgement and family preference, and the groups differed at baseline, the DOT group being younger and more myopic in particular. We adjusted for measured covariates with analysis of covariance, but residual confounding from unmeasured factors such as outdoor time, near-work habits, parental myopia and prescribing patterns cannot be excluded; the findings should therefore be read as real-world associations rather than proof of causal superiority. Second, Follow-up refraction was largely non-cycloplegic, which limits confidence in the refractive comparison and is why our conclusions rest mainly on axial length. Third, compliance was not objectively monitored, and the groups were unbalanced in size, with only 81 children in the DOT group

against 303 in the HAL group. Fourth, we analyzed only the right eye, and the cohort was comparatively old, so the results may not transfer directly to younger, more rapidly progressing children. Most importantly, one year is too short to assess long-term efficacy, attenuation or rebound, and the fixed response thresholds do not account for age-dependent physiological eye growth. For these reasons we regard the present results as preliminary real-world evidence rather than a definitive ranking of the three designs; longer, age-stratified prospective studies with cycloplegic refraction and objective compliance measurement are needed to settle the question.

Conclusions

In routine clinical practice, DIMS, HAL and DOT spectacle lenses all slowed axial elongation significantly more than single-vision spectacles over 1 year in Chinese children and adolescents. DOT lenses showed the largest treatment effect and the highest probability of a good response, while DIMS and HAL performed comparably. These real-world findings support the preferential prescription of myopia-control spectacle designs over single-vision correction and highlight the need for randomized head-to-head trials - particularly including contrast-modulation designs - to establish the optimal optical strategy for individual children.

Abbreviations

AL

axial length

ANCOVA

analysis of covariance

CI

confidence interval

DIMS

defocus incorporated multiple segments

DOT

diffusion optics technology

HAL

highly aspherical lenslets

OR

odds ratio

RCT

randomized controlled trial

SD

standard deviation

SER

spherical equivalent refraction

SV

single vision.

Declarations

Ethics approval and consent to participate: The study adhered to the tenets of the Declaration of Helsinki and was approved by the institutional ethics review committee of Suzhou Eye Hospital of Suzhou Vocational Health College (SWYXLL202623). The requirement for informed consent was waived owing to the retrospective nature of the study. The institutional affiliation, the author list and the ethics approval number are to be completed by the submitting authors prior to submission.

Consent for publication: Not applicable.

Availability of data and materials: The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

Funding: No specific funding was received for this study.

Authors' contributions: Concept and design: XYX. XYX wrote the main manuscript text. Analysis and interpretation: XYX and ZYS. Data collection and management: QY, KZ and SAY. All authors contributed to the article and approved the submitted version.

Acknowledgements: Not applicable.

References

1. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, et al. Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050. *Ophthalmology*. 2016;123:1036-42.
2. Tan TE, Anees A, Chen C, Li S, Xu X, Li Z, et al. Retinal photograph-based deep learning algorithms for myopia and a blockchain platform to facilitate artificial intelligence medical research: a retrospective multicohort study. *Lancet Digit Health*. 2021;3:e317-e29.
3. Bullimore MA, Ritchey ER, Shah S, Leveziel N, Bourne RRA, Flitcroft DI. The Risks and Benefits of Myopia Control. *Ophthalmology*. 2021;128:1561-79.
4. Haarman AEG, Enthoven CA, Tideman JW, Tedja MS, Verhoeven VJM, Klaver CCW. The Complications of Myopia: A Review and Meta-Analysis. *Investigative Ophthalmology & Visual Science*. 2020;61.
5. Pan CW, Dong XX, Lanca C, Wang Y, Saw SM, He X, et al. Global perspectives on myopia and pathologic myopia: From environmental drivers to precision medicine. *Prog Retin Eye Res*. 2025;109:101415.

6. Lam CSY, Tang WC, Tse DY, Lee RPK, Chun RKM, Hasegawa K, et al. Defocus Incorporated Multiple Segments (DIMS) spectacle lenses slow myopia progression: a 2-year randomised clinical trial. *Br J Ophthalmol*. 2020;104:363-8.
7. Lam CS, Tang WC, Lee PH, Zhang HY, Qi H, Hasegawa K, 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;106:1110-4.
8. Lam CSY, Tang WC, Zhang HY, Lee PH, Tse DYY, Qi H, et al. Long-term myopia control effect and safety in children wearing DIMS spectacle lenses for 6 years. *Sci Rep*. 2023;13:5475.
9. Leung TW, Zhang HY, Chan KH, Lee PH, Liu KKK, Kwok YM, et al. Long-term axial elongation in myopic children wearing DIMS spectacle lenses: an 8-to-10-year observational study. *BMJ Open Ophthalmol*. 2026;11.
10. Bao J, Huang Y, Li X, Yang A, Zhou F, Wu J, et al. Spectacle Lenses With Aspherical Lenslets for Myopia Control vs Single-Vision Spectacle Lenses: A Randomized Clinical Trial. *JAMA Ophthalmol*. 2022;140:472-8.
11. Li X, Huang Y, Yin Z, Liu C, Zhang S, Yang A, et al. Myopia Control Efficacy of Spectacle Lenses With Aspherical Lenslets: Results of a 3-Year Follow-Up Study. *Am J Ophthalmol*. 2023;253:160-8.
12. Li X, Huang Y, Liu C, Chang X, Cui Z, Yang Q, 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. Shen J, Hunt C, Young G, Drobe B. Spectacle Lenses With Highly Aspherical Lenslets for Myopia Control: A Randomized Clinical Trial. *JAMA Ophthalmol*. 2026; doi:10.1001/jamaophthalmol.2026.3288.
14. Rappon J, Chung C, Young G, Hunt C, Neitz J, Neitz M, et al. Control of myopia using diffusion optics spectacle lenses: 12-month results of a randomised controlled, efficacy and safety study (CYPRESS). *Br J Ophthalmol*. 2023;107:1709-15.
15. Laughton D, Hill JS, McParland M, Tasso V, Woods J, Zhu X, et al. Control of myopia using diffusion optics spectacle lenses: 4-year results of a multicentre randomised controlled, efficacy and safety study (CYPRESS). *BMJ Open Ophthalmol*. 2024;9.
16. Guo H, Li X, Zhang X, Wang H, Li J. Comparing the effects of highly aspherical lenslets versus defocus incorporated multiple segment spectacle lenses on myopia control. *Sci Rep*. 2023;13:3048.
17. Lembo A, Schiavetti I, Serafino M, Caputo R, Nucci P. Comparison of the performance of myopia control in European children and adolescents with defocus incorporated multiple segments (DIMS) and highly aspherical lenslets (HAL) spectacles. *BMJ Paediatr Open*. 2024;8.
18. Najji R, Bullimore M, Resnikoff S, Bron AM, Naudin M, Giraud C, 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.
19. Liu J, Lu Y, Huang D, Yang J, Fan C, Chen C, et al. The Efficacy of Defocus Incorporated Multiple Segments Lenses in Slowing Myopia Progression: Results from Diverse Clinical Circumstances. *Ophthalmology*. 2023;130:542-50.

20. Li X, Ji Y, Fu Y, Liu S, Yin M, Wang J, et al. Improved efficacy of 0.01% atropine combined with diffusion optics technology lenses for myopia control in a real-world setting in Northern China. *Photodiagnosis Photodyn Ther*. 2026;58:105439.
21. Chen L, Sun L, Chen X, Liu J, Li J, Leung HY, et al. Comparison of effectiveness of four myopia control interventions in Chinese children: a real-world retrospective study. *Eye Vis (Lond)*. 2026;13.
22. Bullimore MA, Brennan NA. Myopia Control: Why Each Diopter Matters. *Optom Vis Sci*. 2019;96:463-5.
23. Yii FS. Emmetropic eye growth in East Asians and non-East Asians. *Ophthalmic Physiol Opt*. 2023;43:1412-8.
24. Bullimore MA, Saunders KJ, Baraas RC, Berntsen DA, Chen Z, Chia AWL, et al. IMI-Interventions for Controlling Myopia Onset and Progression 2025. *Invest Ophthalmol Vis Sci*. 2025;66:39.
25. McCullough S, Barr H, Fulton J, Jones S, Logan N, Nagra M, et al. Defocus Incorporated Multiple Segments (DIMS) spectacle lenses in UK children: Outcomes from a 2-year multi-site interventional trial. *Ophthalmic Physiol Opt*. 2025;45:1965-80.
26. Al-Shammari YM, Alkandari SA, Al-Shammari RM, Al-Mahdi Al-Kurdi M, Aljassar F. Defocus Incorporated Multiple Segments (DIMS) Spectacle Lenses Versus Single-Vision Lenses for Pediatric Myopia: A Systematic Review and Meta-Analysis. *Am J Ophthalmol*. 2026;286:90-7.
27. Bao J, Yang A, Huang Y, Li X, Pan Y, Ding C, et al. One-year myopia control efficacy of spectacle lenses with aspherical lenslets. *Br J Ophthalmol*. 2022;106:1171-6.
28. Liu C, Cui Z, Zhang H, Fang X, Huang Y, Chen H, et al. Real-World Efficacy of Spectacle Lenses with Highly Aspherical Lenslets in Slowing Myopia Progression-A Retrospective, Propensity-Matched Cohort Study. *Ophthalmic Physiol Opt*. 2026; doi:10.1007/s44402-026-00039-x.
29. Guggenheim JA, Terry L. Mechanism of optical treatments for myopia: Are lenslets joining the DOTs? *Ophthalmic Physiol Opt*. 2025;45:337-9.
30. Chen Z, Yang X, Liu L, Li L, Li X, Hill JS, et al. Randomized clinical trial of Diffusion Optics Technology spectacle lenses in a Chinese population (CATHAY): 12-month results. *Ophthalmology Science*. 2026; doi:10.1016/j.xops.2026.101150.
31. Pan S, Zhang P, Song D, Yao J, Lou B, Jing J. Comparable myopia control efficacy of highly aspherical lenslets and diffusion optics technology spectacle lenses: a one-year real-world cohort study. *BMC Ophthalmol*. 2026;26.
32. Farassat N, Heinrich SP, Lagreze WA, Nagel N. Temporal trends in refractive error among children and adolescents in Germany - a large-scale analysis of spectacle sales data from dispensing opticians from 2001 to 2025. *Front Public Health*. 2026;14:1854832.
33. Zhang Z, Mu J, Yang Y, Dai Y, Duan J. Influence of dynamic changes of ocular biometric parameters on new-onset myopia in Chinese children: a 4-year cohort study. *Sci Rep*. 2025;15:28474.
34. Chen L, Sun L, Liu J, Chen Y, Li J, Lin D, et al. Age Modifies the Comparative Effectiveness of DIMS Versus HAL Spectacle Lenses for Myopia Control: A Real-World Study. *Transl Vis Sci Technol*. 2026;15:10.

35. Wang S, Huang K, He X, Wang Z. Comparison of myopia control efficacy between single vision and highly aspherical Lenslet spectacle lenses in children with low myopia: a 1-year retrospective study. *Front Med (Lausanne)*. 2026;13:1770828.
36. Akagun N, Altiparmak UE. Real-World Effectiveness of DIMS Spectacle Lenses for Myopia Control in a Turkish Pediatric Population: A Retrospective Study Using Age-Specific Physiological Growth Curves. *Children (Basel)*. 2025;12.
37. Dahlmann-Noor AH, Freemantle N. Pinpointing precision: axial length and refraction in paediatric myopia trials-a mixed methods study. *Trials*. 2026; doi:10.1186/s13063-026-09884-0.
38. Chen J, Liu S, Zhu Z, Bulloch G, Naduvilath T, Wang J, et al. Axial length changes in progressive and non-progressive myopic children in China. *Graefes Arch Clin Exp Ophthalmol*. 2023;261:1493-501.
39. Zhou T, Zhang X, Zheng Y, Wang J, Jiang Y, Yu H, et al. Defining the critical axial length threshold for transition from physiological growth to pathological fundus structural remodeling in adolescent myopia. *Front Cell Dev Biol*. 2026;14:1938535.
40. Clark RA, Wong RK. Spherical Equivalent Refraction Versus Axial Length for Monitoring Childhood Myopia and Estimating Disease Risk: A Systematic Review and Meta-Analysis. *Am J Ophthalmol*. 2026;286:235-47.

Figures

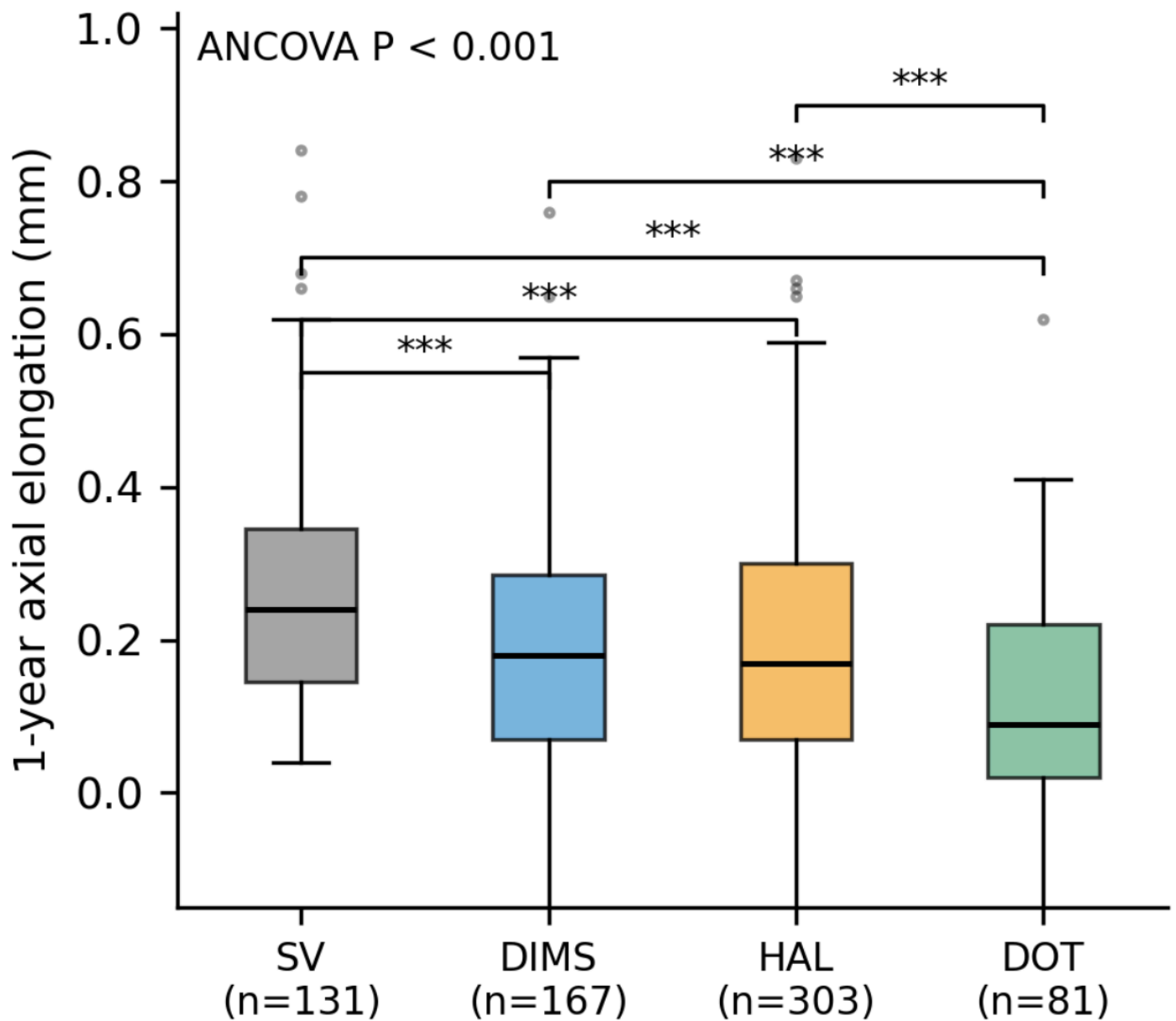


Figure 1

One-year axial elongation by group.

*Tukey-style box plots (median, interquartile range, 1.5x IQR whiskers). ANCOVA adjusted for age, sex and baseline ocular parameters identified a significant overall treatment effect ($P < 0.001$). Post hoc contrasts: all three lens designs versus SV, DIMS vs DOT and HAL vs DOT all $P < 0.001$ (***) ; DIMS vs HAL not significant.*

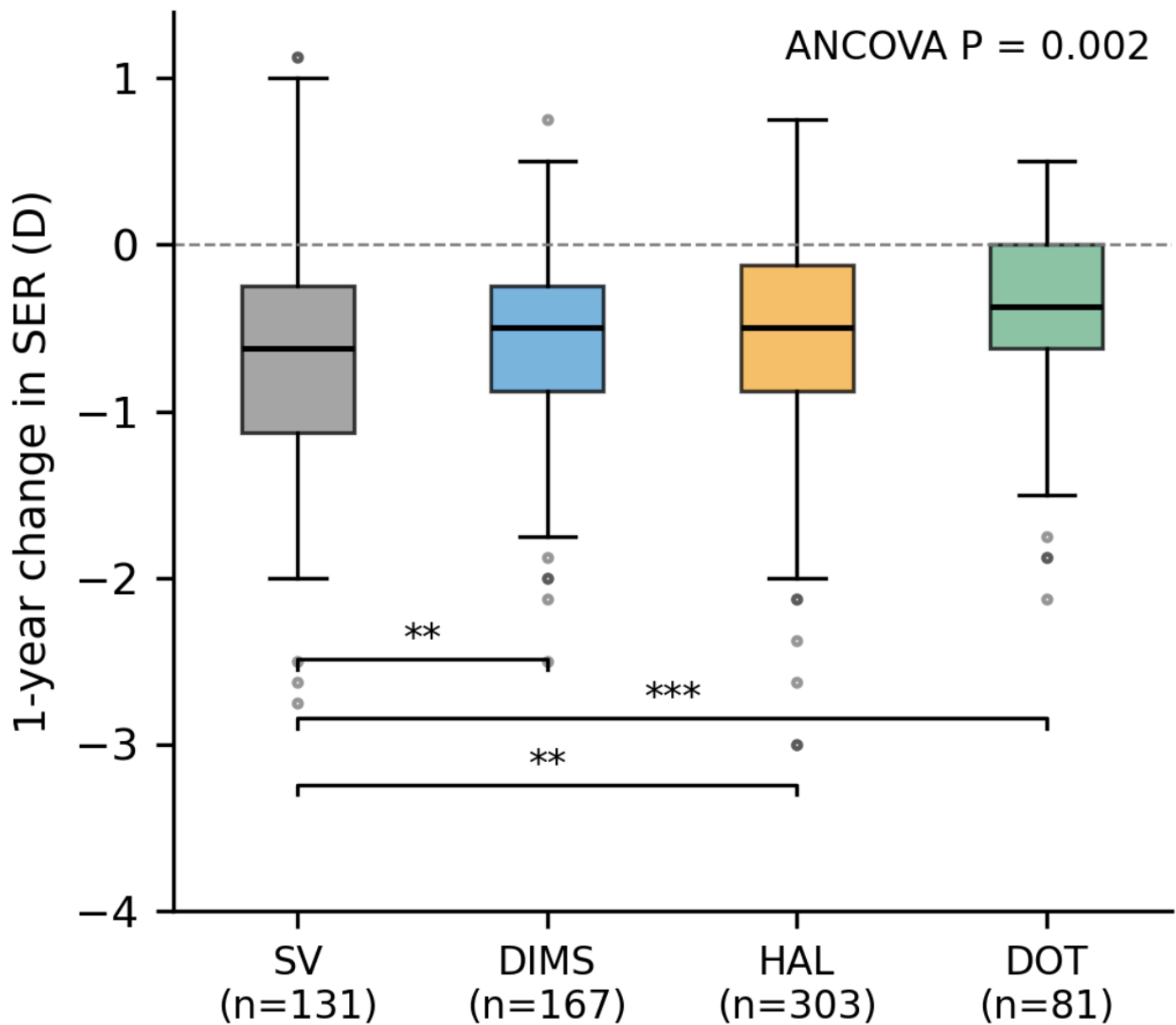


Figure 2

One-year change in spherical equivalent refraction by group.

Negative values denote myopic progression. Overall ANCOVA treatment effect $P=0.002$; SV vs DOT $P<0.001$ (***), SV vs DIMS $P=0.006$ (**) and SV vs HAL $P=0.002$ (**), all three surviving Bonferroni correction.

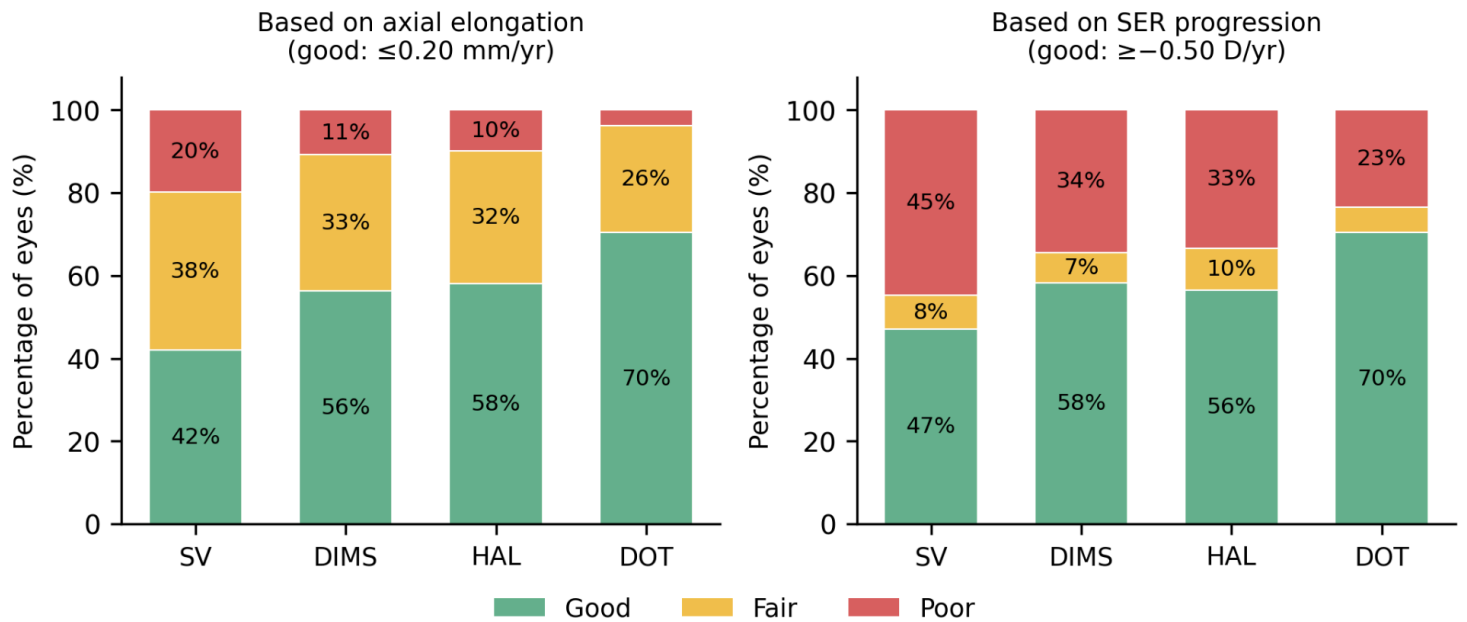


Figure 3

Distribution of treatment response categories.

Stacked bars show the percentage of eyes in each response category. Logistic regression confirmed significantly higher odds of a good response versus SV for all three designs for both the axial and the refractive outcome.