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Article

Effect of Defocus Incorporated Multiple Segments Spectacle Lens Wear on Visual Function in Myopic Chinese Children

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Purpose: To compare visual function of myopic children who had worn either defocus incorporated multiple segment (DIMS) spectacle lenses or single vision (SV) spectacle lenses over two years.

Methods: We included 160 Chinese myopic (−1 diopter [D] to −5 D) children aged 8 to 13 years in a randomized clinical trial; they wore either DIMS lenses (DIMS; $n = 79$) or regular SV spectacles lenses ($n = 81$) full time for 2 years. Visual function, including high-contrast visual acuity (VA) and low-contrast VA at distance and near, binocular functions, and accommodation, before, during, and after 2 years of spectacle wear were assessed when both groups wore SV corrections. Changes of visual function between the two groups and within groups were compared.

Results: There were no statistically significant differences in the 2-year visual function changes between DIMS and SV groups (repeated measures analysis of variance with group as factor; $P > 0.05$). Statistically significant improvement in the best-corrected distance high-contrast VA ($P < 0.001$) and stereoacuity score ($P < 0.001$) were found after DIMS lens wear over 2 years. Similar findings were observed after SV spectacle lens wear. For both the DIMS and SV groups, there were statistically significant decreases in accommodative lag, monocular and binocular amplitude of accommodation after two years ($P < 0.01$), but not in the changes in distance low-contrast VA, near high-contrast VA, near low-contrast VA, or phoria.

Conclusions: Although changes in some visual function were shown during 2 years of DIMS lens wear, similar changes were found with SV lens wear. Wear of DIMS spectacle lenses for 2 years does not adversely affect major visual function when children return to SV corrections.

Translational Relevance: DIMS spectacle lenses did not cause any adverse effects on visual function.

Introduction

Myopia prevalence is increasing around the world at an alarming rate. If present trends continue, 50% of the world's population is predicted to be myopic by 2050 and nearly 1 billion people will probably become high myopes.[1,2] In Asian countries, the prevalence is reaching epidemic proportions with 70% to 80% of teenagers being myopic.[1,3,4] The risk of developing ocular pathologies, such as myopic macular degeneration, retinal detachment, glaucoma, and cataract, increases significantly with an increasing magnitude of myopia.[4–7] It is crucial, therefore, to control the level of myopia progression early in life to decrease the risk of developing myopia-related ocular complications. Myopia has emerged as a worldwide public health issue and is identified as one of the immediate priorities by the World Health Organization's Global Initiative for the Elimination of Avoidable Blindness.[8,9]

Several clinical methods are currently used for myopia control in children. These include atropine,[10–13]

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bifocal or multifocal soft contact lenses,[14–18] orthokeratology,[19–22] progressive addition spectacles (PALs),[23–27] and bifocal and prismatic bifocal spectacles.[28] Each treatment has its advantages and disadvantages, with varying levels of efficacy in slowing myopia progression.[29,30] None of the treatments has as yet been successful in completely stopping myopia progression or development.

The use of atropine eye drops in high concentration (1%) has been shown to be highly successful in decreasing the rate of progression, but the associated side effects, such as cycloplegia and pupil dilation, influence visual function.[10,29,30] Such side effects are minimized with lower concentrations of atropine (0.01%), but this amount does not slow axial elongation significantly.[11,12] Although overnight orthokeratology improves unaided visual acuity (VA) in the daytime, it increases higher order aberration and decreases low contrast VA.[31–33] Changes in accommodative responses have been reported when using varifocal spectacles or contact lenses. One study reported that children with high accommodative lag showed decreased accommodative lag by about 25% when wearing PAL spectacles of 2 diopters (D) addition.[34] Other authors found that both emmetropic and myopic children showed a lead in accommodation during wear of bifocal soft contact lenses, but myopes tended to accommodate less.[35] It has also been reported that children wearing multifocal contact lenses with a +2.5 D center distance addition exhibited reduced accommodative responses and more exophoria at increasingly higher accommodative demands than those children wearing single vision (SV) contact lenses.[36] These studies have demonstrated the existence of changes in visual function during the wear of myopia control lenses, but have rarely reported whether any changes occurred after lens wear. It is unclear whether any of these myopia control methods may have caused long-term or sustained changes in visual function, although the visual system has been shown to adapt to changes in the optics of the eye over time.[37–40]

Defocus incorporated multiple segments (DIMS) spectacle lenses are designed for childhood myopia control. DIMS lenses are now commercially available and under the name MiYOSMART. They are already being used by clinicians to manage myopia progression in young children in Asian countries, such as Hong Kong, China, and Singapore. Each DIMS spectacle lens comprises a hexagonal central zone of distance refractive correction surrounded by an annular zone with dense microlens segments of 3.5 D addition, so that it simultaneously provides myopic defocus and clear vision for the wearers (Figure).

Our double-blind, randomized clinical trial has reported that daily wear of DIMS spectacle lenses slows myopia progression and axial elongation in myopic children by 52% and 62%, respectively, over 2 years compared with wear of regular SV spectacle lenses.[41] Visual performance of myopic children wearing DIMS lenses has been reported and compared with that for similar children wearing SV lenses.[41] The results indicated that, when wearing the lenses, there were no significant differences between two lens types in influencing vision and accommodation. However, whether long-term wear of DIMS lenses affects the visual function of these children after discontinuation of the treatment is not known. In principle, such an effect is possible. If DIMS wear decreases changes with age in axial length, it may also influence other biometric parameters affecting the optical characteristics of the retinal image in a way that decreased visual performance when correction returns to SV lenses. Additionally some form of neuroadaptation may occur during DIMS wear, which compensates for optical deficiencies in the retinal image.[37–40] Although advantageous during DIMS wear, this adaptation might degrade visual performance. The current study therefore aimed to compare the 2-year changes in visual function in myopic children who normally wore either DIMS lenses or regular SV spectacle lenses to determine whether wearing DIMS lenses results in a change in visual function.

Methods

Study Design

This was a 2-year randomized controlled clinical trial of DIMS lenses conducted at the Centre for Myopia Research, The Hong Kong Polytechnic University, Hong Kong (Clinicaltrials.gov ref no.: NCT02206217). The recruited children were randomly assigned to wear either DIMS spectacle lenses or regular SV spectacle lenses for 2 years. All children had comprehensive eye examinations in which their refractive error and axial length were measured and monitored at baseline and every 6 months for 2 years. In addition, their visual function was assessed in the same follow-up visits over 2 years. In the present article, visual function at baseline and 6-month intervals over 2 years in both groups of the children were compared while both groups of children wore SV distance prescription to determine whether wearing DIMS lenses results in a change in visual function. The clinical trial was approved by the Human Subjects Ethics Subcommittee of The Hong Kong Polytechnic

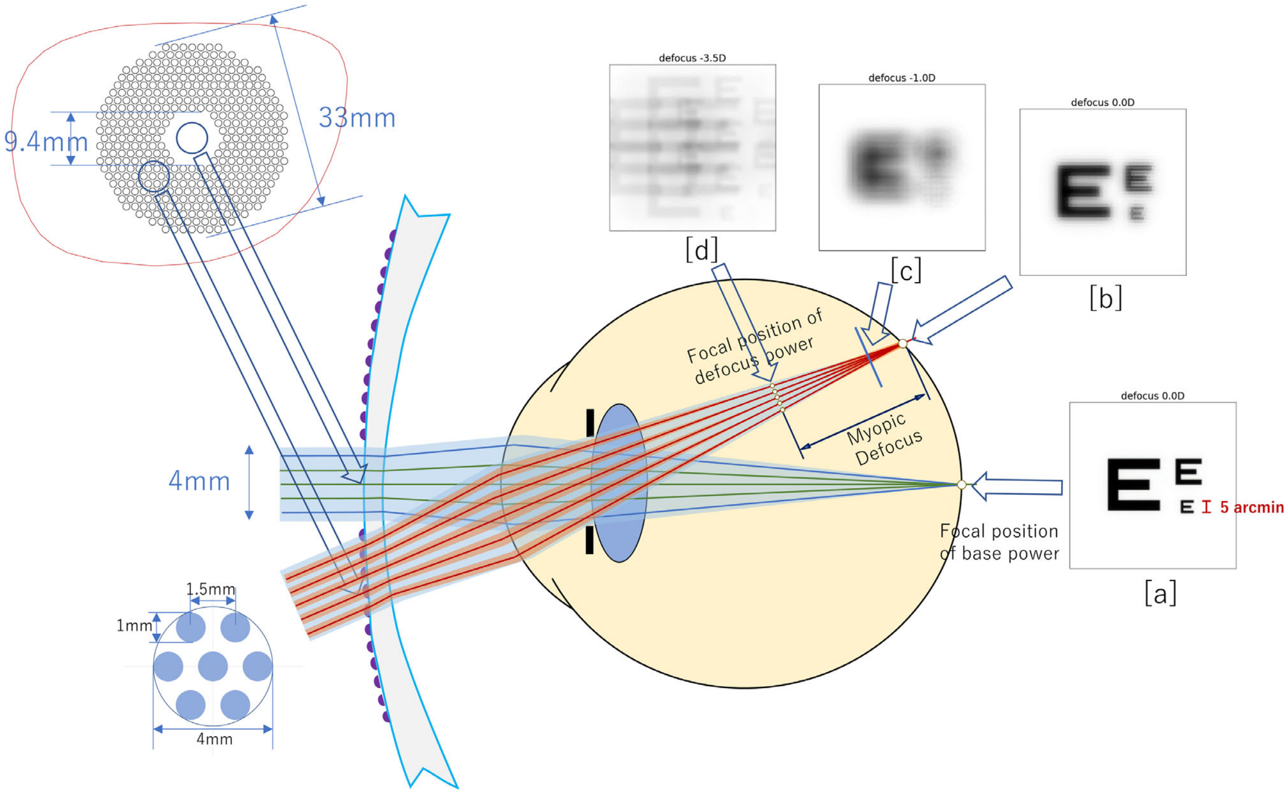

Figure. Basic structure and design of the DIMS lens. Blue rays represent ray traces from the central (carrier) part of the lens and forming a clear image on retina [a] and the red rays show ray traces from the peripheral part of the lens, which contains the lenslets, forming an image that is simultaneously refracted by both the base part and lenslets [b]. If the target is at near and the eye does not accommodate, the image [c] or [d] will be formed on retina. The smallest Snellen chart in each image in the figure has the size of 5 arcmin which indicates VA 0.0 logMAR (20/20). Other two charts indicate VA +0.30 logMAR (20/40) and +0.50 logMAR (20/80), respectively. All images were generated using real ray tracing and wave optics calculations. Viewing an object through the central part of the lens produces a clear image with no ghosting. Viewing a target through the peripheral part of the lens leads to ghosting depending on the relative refractive error at the retina as described in [c] or [d].

University and all procedures of the study met the tenets of the Declaration of Helsinki. Written assent and informed consent were obtained from the children and their parents before joining the study. The children, their parents, and the investigator who performed the measurements did not know the group allocation of spectacle lenses. Masking procedures are described elsewhere in the literature.

Participants

One hundred eighty Chinese myopic children participated in the randomized controlled clinical trial of DIMS lenses.[41] In the present article, only results for the children ($n = 160$) who completed the full 2-year trial are included. The participant inclusion criteria at enrolment were between 8 and 13 years of age, with myopia (spherical equivalent refraction from −1.00 to −5.00 D, astigmatism and anisometropia up to 1.5 D, and monocular best-corrected VA of 6/6 or better. The participating children did not have any ocular or systemic abnormalities, binocular vision problems, or any prior history of myopia control inventions. They were required to accept masking from the types of the lenses that they wore in the clinical trial. The children were randomly assigned to wear either the DIMS lenses or SV spectacle lenses full time for at least 10 hours per day throughout the trial. Their spectacle prescription was updated if more than 0.5 D of change in spherical equivalent refraction was found in any of the follow-up visits. The final distance prescription was based on the cycloplegic subjective refraction determined by the masked optometrist.

Participants' best-corrected VA at distance and near, binocular visual function, and accommodation were measured at baseline before prescribing the experimental spectacles. Two-year changes in visual function were compared between DIMS lens wearers and SV controls, and comparisons between groups were conducted every 6 months.

Visual Function Measurements

Each participant (for both the treatment and control groups) wore a full distance correction in a trial frame using full aperture trial lenses for all following measurements: distance and near VA, horizontal phoria, amplitude of accommodation (AA), lag of accommodation, and stereopsis. The distance correction was based on noncycloplegic subjective refraction determined by the masked optometrist. For monocular measurements, a full aperture occluder was inserted in front of the nonviewing eye. Participants wore SV correction for these tests because we wanted to determine whether long-term wear of DIMS lenses affected visual function, not whether current wear of the DIMS lenses altered visual function. Thus, all participants wore SV correction to eliminate the influence of DIMS lenses on the current measurements.

Visual Acuities

Both distance and near best-corrected VA were measured monocularly under photopic conditions (85 cd/m^2). The right eye was tested first and then the left eye. High-contrast VA (HCVA; 100%) and low-contrast (LCVA; 10%) at distance were assessed using Logarithmic 2000 series Early Treatment Diabetic Retinopathy Charts and Low Contrast Early Treatment Diabetic Retinopathy Charts at 4 m (Precision Vision Inc., Woodstock IL, USA) with an illuminator cabinet. The children were asked to read to the smallest row that they could read. The testing was stopped when three or more of the five letters per row were read incorrectly. VA was recorded in letter-by-letter logarithm of the minimum angle of resolution (logMAR) notation, each letter in the chart representing 0.02 score. HCVA and LCVA at near were measured at 40 cm using Mixed Contrast European-Wide Near Vision Card (Precision Vision Inc.). The near VA chart also had five letters per line. Therefore, the starting and stopping rules and recording of near VA test were same as those of distance VA test.

Binocularity and Accommodation

Distance and near phoria were measured in real space using Howell Phoria Distance and Near cards placed at 3 m and 33 cm. The magnitude (to the nearest 0.5 Δ) and the direction of phoria were recorded. Esophoria and exophoria are represented by positive and negative values, respectively. Monocular and binocular AA were measured by the push-up method using a Royal Air Force rule. The examiner slowly moved the chart toward the participant, who was instructed to try to keep the words being viewed clear and report when blur was first seen. The average values of the three measurements (in diopters) were used for data analysis. Accommodation responses were evaluated using an open-field autorefractor (Shin-Nippon NVision-K5001, Ajinomoto Trading Inc., Tokyo, Japan) while the children were viewing a letter target at 33 cm with a print size of 20/30 binocularly. Lag of accommodation was calculated as the difference between the measured accommodative response and the actual accommodative demand (3 D). Stereoacuity (seconds of arc) was assessed at 40 cm using Randot Stereotest with Polaroid goggles and the test was stopped after the first miss in the row.

Statistical Analysis

All statistical analyses were conducted using SPSS version 20 (SPSS Inc, Chicago, IL). Data are presented as mean and standard deviation for each experimental group. Monocular data for the two eyes showed no statistically significant differences ($P > 0.05$) and the data were highly correlated ($P > 0.85$); therefore, data from only the right eyes were used for statistical analysis. Unpaired *t*-tests were used to compare visual function between DIMS and SV groups. The Mann–Whitney *U* test was used if the data were not normally distributed.

The changes in visual function at different visits (6, 12, 18, and 24 months) between two lens groups were compared using repeated measures analysis of variance (ANOVA) with treatment group (DIMS vs SV) as the independent factor (multivariate tests). For significant outcomes, post hoc comparisons for each pair of visits were conducted subsequently. Analyses were also performed separately for the two groups. Repeated measures ANOVA was conducted to compare visual function at different visits within a group. A *P* value of less than 0.05 was considered to be statistically significant.

Results

Baseline Demographic Data

A total of 160 children completed the study ($n = 79$ in the DIMS group and $n = 81$ in the SV group). There was no significant difference between the two groups in the baseline demographic data, including age, gender, refractions, axial length, and corneal parameters (Table 1). Both groups showed overall good compliance and could wear the spectacles full time. The mean daily lens-wearing times in the DIMS and SV groups were 15.5 ± 2.6 and 15.3 ± 2.1 hours, respectively, and were not significantly different. There were no

Table 1. Baseline Demographics Data of the Children Who Completed the 2-Year Trial of DIMS Lenses

	DIMS ($n = 79$)	SV ($n = 81$)	*t*-Test or χ^2 Test, *P* Value
Age at enrolment, years	10.20 ± 1.47	10.00 ± 1.45	0.508
Gender, % (number)			
Male	58.2% (46)	54.3% (44)	0.118
Female	41.8% (33)	45.7% (37)	
Cycloplegic autorefraction in SER, D	−2.97 ± 0.97	−2.76 ± 0.96	0.174
Axial length, mm	24.70 ± 0.82	24.60 ± 0.83	0.515
Corneal power at steep meridian, D	44.5 ± 1.6	44.5 ± 1.7	0.855
Corneal power at flat meridian, D	43.2 ± 1.4	43.2 ± 1.4	0.955

SER, spherical equivalent refraction; Δ, prism diopters.
Parameters are given as means ± standard deviations.

statistically significant differences in baseline visual function between two lens groups ($P > 0.05$).

Visual Function

Table 2 shows the mean and standard deviation of visual function before (baseline) and after DIMS and SV lens wear (6-, 12-, 18-, and 24-month visits), respectively. In the comparison of the changes in visual function from baseline across 6-month visits between groups (Table 2), no statistically significant differences were found between the DIMS and SV groups (repeated measures ANOVA, time and treatment group as factors; $P > 0.05$). However, there were statistically significant effects of time on some visual function changes (time; $P < 0.05$), namely, distance HCVA, AA, accommodative lag, and stereoacuity. Significant changes in those visual function over time were found within individual groups.

Visual Acuities

For visual acuities, there were statistically significant time effects for distance HCVA in both the DIMS (repeat measures ANOVA; $P < 0.001$) and SV ($P < 0.001$) groups. For the DIMS group, significant differences were observed at all 6-month visits as compared with the baseline visit (post hoc Bonferroni adjustment; $P < 0.001$). Improvement in distance HCVA was shown in the first 6 months (−0.04 ± 0.06 LogMAR). This gradually increased over 24 months (−0.09 ± 0.07 logMAR). Similar findings were obtained in the SV group for whom equivalent improvements in distance HCVA occurred over the 2 years (from −0.03 ± 0.06 to −0.07 ± 0.06 logMAR).

Binocularity and Accommodation

The results revealed statistically significant differences over time for monocular and binocular AA, accommodative lag (for a 3D stimulus), and stereoacuity in both the DIMS and SV groups (repeated measures ANOVA; $P < 0.01$) (Table 2). For both lens groups, there were no statistically significant changes in distance and near phoria over 2 years as compared with the baseline values.

For both lens groups, statistically significant changes in monocular and binocular AA were observed at all 6-month visits over 2 years (post hoc Bonferroni adjustment; $P < 0.001$). Decreases in AA were observed in the first 6 months and within 18 to 24 months. The decreases in binocular AA (DIMS vs SV: −1.90 D vs −2.06 D) were greater than those in monocular AA (−1.68 D vs −1.56 D) after 2 years of lens wear. After DIMS lens wear, the accommodative lag was significantly reduced ($P = 0.001$) throughout the clinical trial. The significant reduction in accommodative lag (3 D stimulus) was found in the first 6 months, and the amount of reduction slightly increased over 2 years. Similar findings were noted in the SV group ($P = 0.002$).

Improvements in stereoacuity were shown in both groups after 2 years. Statistically significant changes mainly occurred after 12 months and these changes were maintained in the second year. However, the changes in stereoacuity (DIMS vs SV, −5.9 sec of arc vs −7.4 sec of arc) over 2 years were not clinically significant.

Discussion

The current study aimed to determine whether, after a period of continuous wear of DIMS lenses, the visual

Table 2. Visual Function at Baseline and 6-Month Intervals Over 2 Years of Spectacle Wear in the DIMS Group ($n = 79$) and SV Group ($n = 81$) and Their Comparison

						Multivariate Tests, *P* Value		Repeat measures ANOVA, *P* Value
Group	Baseline	6 Months	12 Months	18 Months	24 Months	Time	Time × Group	Within Group
Monocular VA, OD (logMAR)								
Distance HCVA								
DIMS	−0.02 ± 0.05	−0.06 ± 0.06	−0.09 ± 0.05	−0.09 ± 0.07	−0.11 ± 0.06	<0.001*	0.540	<0.001*
SV	−0.02 ± 0.06	−0.05 ± 0.05	−0.07 ± 0.06	−0.08 ± 0.07	−0.09 ± 0.07			<0.001*
Distance LCVA								
DIMS	0.14 ± 0.07	0.14 ± 0.06	0.14 ± 0.06	0.13 ± 0.05	0.12 ± 0.04	0.285	0.657	0.237
SV	0.14 ± 0.07	0.14 ± 0.05	0.14 ± 0.04	0.14 ± 0.04	0.13 ± 0.05			0.433
Near HCVA								
DIMS	0.02 ± 0.03	0.01 ± 0.03	0.01 ± 0.02	0.01 ± 0.03	0.01 ± 0.03	0.058	0.573	0.070
SV	0.02 ± 0.05	0.01 ± 0.03	0.00 ± 0.02	0.00 ± 0.02	0.01 ± 0.03			0.246
Near LCVA								
DIMS	0.13 ± 0.08	0.12 ± 0.06	0.12 ± 0.05	0.11 ± 0.05	0.11 ± 0.05	0.222	0.253	0.051
SV	0.12 ± 0.08	0.11 ± 0.06	0.11 ± 0.06	0.11 ± 0.06	0.11 ± 0.06			0.054
Binocularity and accommodative response								
Distance phoria (Δ)								
DIMS	−1.0 ± 1.9	−1.1 ± 1.9	−0.9 ± 1.6	−1.0 ± 1.7	−1.0 ± 1.8	0.440	0.063	0.072
SV	−0.6 ± 1.3	−0.6 ± 1.6	−0.4 ± 1.6	−0.4 ± 1.3	−0.4 ± 1.4			0.069
Near phoria (Δ)								
DIMS	−2.0 ± 3.8	−2.5 ± 4.1	−2.2 ± 3.7	−2.5 ± 4.1	−2.7 ± 3.9	0.062	0.759	0.058
SV	−0.8 ± 3.3	−1.0 ± 3.2	−0.7 ± 3.6	−0.9 ± 3.8	−1.3 ± 3.3			0.057
Monocular AA, OD (D)								
DIMS	12.6 ± 2.4	11.6 ± 2.7	12.1 ± 2.2	12.0 ± 2.5	11.0 ± 2.6	<0.001*	0.090	<0.001*
SV	13.2 ± 2.2	12.1 ± 2.5	11.9 ± 2.7	12.8 ± 2.7	11.6 ± 2.7			<0.001*
Binocular AA (D)								
DIMS	15.6 ± 2.9	15.0 ± 3.4	15.1 ± 3.0	14.3 ± 3.3	13.7 ± 3.5	<0.001*	0.232	<0.001*
SV	16.5 ± 3.1	15.4 ± 3.4	15.2 ± 3.3	15.3 ± 3.3	14.4 ± 3.3			<0.001*
Accommodative lag at 3D stimulus, OD (D)								
DIMS	1.0 ± 0.4	0.9 ± 0.4	0.8 ± 0.5	0.7 ± 0.5	0.8 ± 0.4	0.005*	0.543	0.001*
SV	1.0 ± 0.4	0.9 ± 0.4	0.9 ± 0.4	0.8 ± 0.4	0.9 ± 0.4			0.002*
Stereoacuity (sec of arc)								
DIMS	35.1 ± 17.0	35.1 ± 12.6	−33.5 ± 16.1	28.6 ± 12.4	29.2 ± 13.1	<0.001*	0.320	<0.001*
SV	35.3 ± 14.7	3.3 ± 14.7	34.7 ± 15.3	30.2 ± 13.1	27.9 ± 13.0			0.005*

Δ, prism diopter; OD, right eye.

*$P < 0.05$ (repeated measures ANOVA).

function of myopic children who were then corrected with SV lenses differed from those of similar children who had been continuously corrected by SV lenses. Our results showed that there were no significant differences in the visual function changes after 2 years between the DIMS and SV groups (Table 2). Any adaptation to DIMS lens wear did not lead to adverse effects on visual function when compared with SV spectacle lenses. Changes in some visual function over time were found only within individual lens groups.

Children in both lens groups showed statistically significant improvements in best-corrected distance HCVA and stereoacuity after 2 years. The changes in stereopsis performance were not clinically significant. Surprisingly, distance HCVA was improved by nearly one line of letters (mean differences of -0.09 ± 0.06 LogMAR) after 2 years of DIMS lens wear; such a change is clinically meaningful. The mean distance HCVA after DIMS wear was better than logMAR 0.00 (Table 2). For the SV group (Table 2), similar findings were obtained. The improvement in distance VA in both lens groups might occur because the children became older and more experienced with the data collection process. Such VA improvement also might be due to a practice or learning effect. However, no significant improvements were observed in distance LCVA, near HCVA, or LCVA in either group of children. Each participant had the distance HCVA test first and then underwent the other VA tests. It is possible that some children may have become bored or tired when they were repeatedly tested with similar procedures. This factor might limit the possible improvements in the forms of VA that were tested later in each measurement session. Differences in the difficulties presented by HCVA and LCVA tests might also influence the amount of VA improvement observed.

Children in the DIMS group have experienced decrease in monocular and binocular AA and accommodative lag with time over the study period. The children in the SV group exhibited a similar trend of AA decreases. Such changes in accommodation might simply be due to increases in age. Most studies in the literature have found that AA decreased significantly with age in young children,[42–46] although some authors have indicated that the effects of age on AA in children aged less than 10 years could be uncertain.[43–46] AA was found to decrease by 0.35 D to 0.5 D annually among schoolchildren using the push-up method,[46] whereas our study showed a greater decrease in AA in the range of 0.75 D annually. It could be related to the ethnicity or age of the study samples.

Our results showed that differences in accommodative lag over time did not depend on the child's treatment group (time by group interaction; $P = 0.543$). Children in both groups exhibited decreases in mean lag by about 0.15 D over 2 years. Therefore, the decrease in mean lag in the DIMS group was unlikely to be accounted for by the influence of the myopic defocus. Anderson et al.[47] reported that accommodative lag exhibited a significant linear decrease with age from 3 to 20 years at a rate of about 0.034D per year with a 3D stimulus. This rate was much less when compared with 0.15D over two years in our study. The study design, refractive status and ethnicity of the participants might be possible factors contributing to such differences. First, this study was not a cross-sectional study: we followed the longitudinal changes in lag. Second, the study by Anderson et al.[47] included both myopes and emmetropes, but our study only included myopic children. Myopes have been generally found to have greater accommodative lag than nonmyopes.[48–50] In the present study, the children in both DIMS (lag at baseline of 0.97 D) and SV groups (1.03 D) had a larger mean lag. A recent investigation also reported similar values in Chinese myopic children (mean, 0.97D), but it included a wider range of age groups (5–13 years).[50] These findings indicate that Chinese myopic children tend to have larger accommodative lag than Caucasians (0.43 D).[51,52] However, whether Chinese myopic children exhibit greater annual reduction rate in lag is not known: further investigation is needed.

For other myopic control spectacles, such as bifocals and PALs, most studies only reported the findings of visual performance when wearing the lenses or the initial visual data at the start of lens wear. The near additions in bifocal spectacles and PALs were supposed to correct or decrease accommodative lag at near, with the intended result of slowing myopia progression. Berntsen et al.[34] found that the children with high accommodative lag had a moderate reduction in accommodative lag when wearing PAL spectacles of 2 D addition. They suggested that a 2.00-D bifocal addition did not get rid of accommodative lag and reduced lag by less than 25% of the bifocal power, indicating that children mainly responded to a bifocal by decreasing accommodation. It was proposed that bifocals might not benefit exophoric myopic children because positive add induces extra exophoria and creates a greater demand on positive fusional vergence.[53] Cheng et al.[28] found that incorporating near base-in prism when prescribing bifocal lenses for progressing myopes with exophoria could decrease the positive lens-induced excess exophoria and slow myopia progression over 3 years. However, the effects on binocularity and accommodative functions after the treatment were not reported, and we could not make comparison with our findings in the current study.

Overall, no evidence was found for the existence of any adaptive process, which might have occurred during long-term DIMS lens wear and affected visual performance after DIMS lens removal. In the DIMS-treated children, removal of the DIMS corrections and their replacement by SV lenses gave visual performance results that were the same as those for the control group who had been continuously wearing SV corrections. Adaptation effects may be absent because foveal vision was usually through the clear center of the DIMS lens, which gave the same retinal image as the corresponding SV lens. Additionally, although imagery through the periphery of a DIMS lens included both lenslet and carrier contributions, the lenslet image was continuously changing with small changes in pupil diameter and fixation direction, making neuroadaptation to its characteristics impossible.

One limitation of this study is that we only determine accommodative lag using a target of a 3-D stimulus. Measurement with different accommodative stimuli (e.g., 2 D to 4 D target stimuli) could provide more information for the accommodation response in different viewing distances during reading.

Conclusions

There were no significant differences between the visual function of the DIMS and SV groups over 2 years. Although some changes in visual function, such as distance VA and accommodation, were observed in myopic children after 2 years of DIMS lens wear, similar changes occurred in those who wore regular SV spectacles. Children in both lens groups showed better distance HCVA, but decreased AA and accommodative lag after 2 years. In conclusion, DIMS lens wear had no adverse effect on the measured visual function. Further studies are needed to determine any effects occurring over longer periods of time.

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