Biomechanics of the Corneoscleral Shell in Hyperopia and Myopia According to Ultrasound Examination Results and Ocular Response Analyzer Data

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Introduction. To assess the role of supporting (biomechanical) properties of the sclera in postnatal period of refractogenesis and myopia development, we need to study these properties in children with various clinical refractions.

Purpose: To study the biomechanical features of the corneoscleral shell of hyperopic and myopic eyes in children.

Material:

58 children (116 eyes), including:
- 33 children (66 eyes) aged 7–16 with myopia from –0.5 to –10.75 D;
- 25 children (50 eyes) aged 6–13 with hyperopia from +1.5 to +11.0 D.

Methods:

- Ophthalmologic examination, including autorefractometry.
- Pachimetry: central corneal thickness (CCT) measurement.
- Ultrasound biometry: axial length (AL) measurement.
- Acoustic density of the equatorial and posterior sclera (ASD) measurement. This was done using a multifunctional ultrasound diagnostic machine Voluson 730 Pro (with a linear frequency sensor ranging from 10 to 16 mHz), which performs digital analysis of ultrasound tissue histograms (Fig. 1). In the grey scale B-scan, a horizontal section of the posterior segment of the eyeball was passing through the optic nerve. The sclera was visualized as hyperechogenic lines. All images were analyzed at the same distance from the optic disc: for any area of interest, numerical parameters and densitometric indices were registered with diverse magnifications as conventional units of ultrasound digital image analysis.
- Biomechanical parameters - Corneal Hysteresis (CH) and Factor of Corneal Resistivity (FCR) measurement using Ocular Response Analyzer (ORA, Reichert, USA) (Fig. 2).

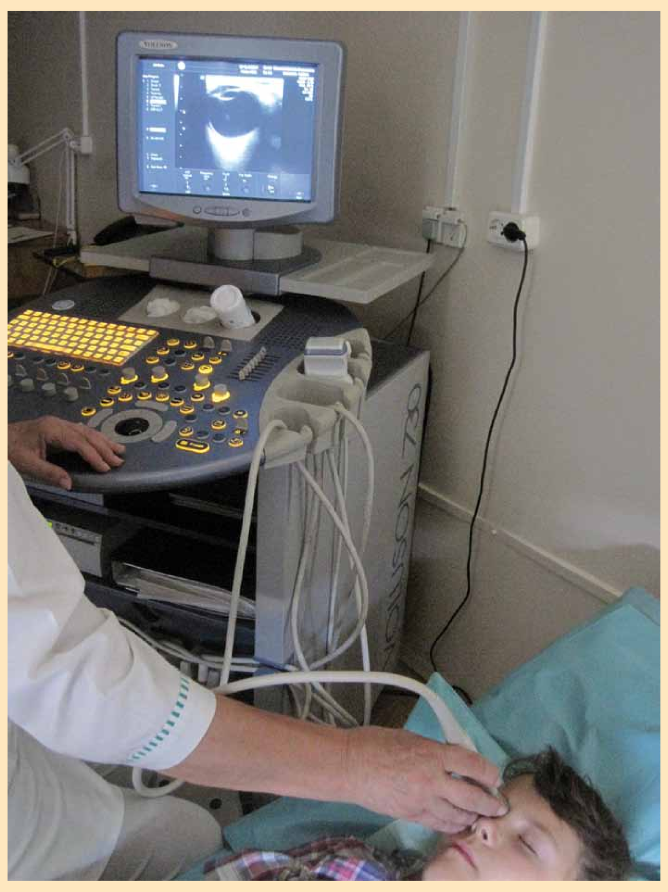


Fig. 1. Acoustic density of the sclera (ASD) measurement.

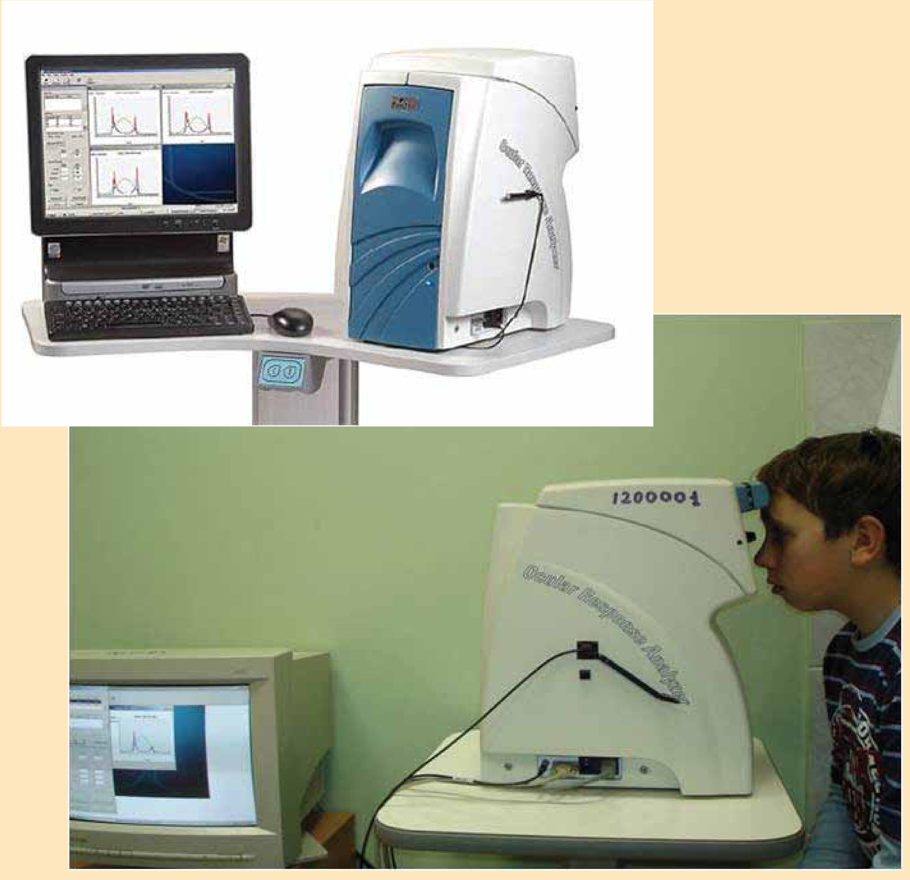
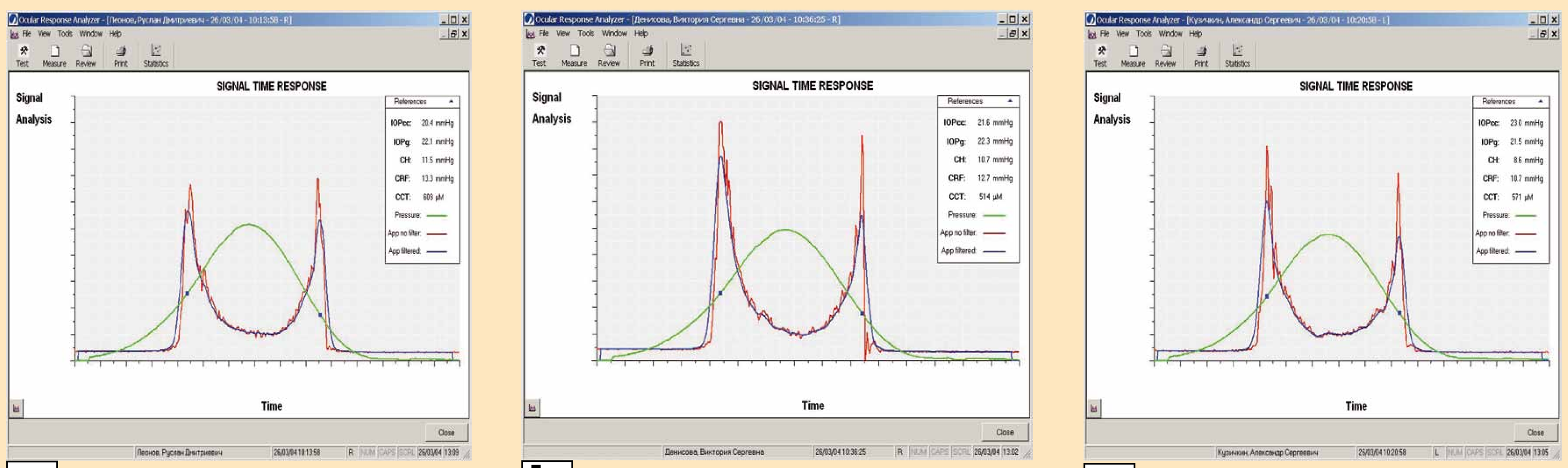


Fig. 2. Patient examination using Ocular Response Analyzer (ORA).

Results

Ocular Response Analyzer Data

ORA corneograms of children with various refractions are presented in Fig. 3 (a, b, c)



a – Hyperopia **b** – Moderate myopia **c** – High myopia

Fig. 3 (a, b, c). ORA corneograms of children with various refractions.

Table 1. CCT, AL and biomechanical parameters of the corneoscleral shell in children with hyperopia and myopia

Parameters	Refraction	
	Hyperopia	Myopia
CCT, mkm	553.6±6.2	551±5.8
AL, mm	21.05±0.95*	25.27±0.87*
CH, mmHg	13.45±1.1*	11.2±0.3*
FCR, mmHg	12.95±0.78	11.8±0.97

* – P<0.05: difference with hyperopia and myopia is statistically significant

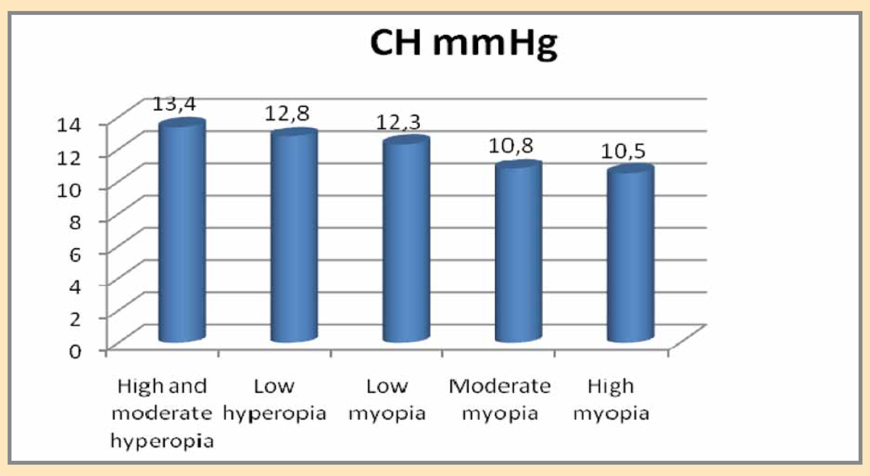


Fig. 4. CH values in various clinical refraction of the children and adolescents.

Although central corneal thickness (CCT) is practically the same in both groups, biomechanical parameters of the eyes with hyperopia and myopia are different (Table 1).

We found CH to be reliably lower (P<0.05) in moderate and high myopia (respectively 10.8±0.4 mm Hg and 10.5±0.3 mm Hg) than in low myopia (12.3±0.2 mm Hg) as well as in low (12.8±1.0 mm Hg), moderate and high (13.4±0.9 mm Hg) hyperopia (Table 2, Fig. 4).

In contrast to that, FCR shows no reliable correlation with the clinical refraction of children and adolescents, even though it tends to subside in myopia (11.8±0.97 mm Hg) as compared to hyperopia (12.95±0.78 mm Hg) (Table 2).

Table 2. CCT, AL and biomechanical parameters of corneoscleral shell in children with various clinical refraction

Parameters	Refraction				
	High and moderate hyperopia N=8	Low hyperopia N=10	Low myopia N=11	Moderate myopia N=11	High myopia N=16
	M±m	M±m	M±m	M±m	M±m
CCT, mkm	562.25 ±8.48	541.0±9.5*	553.5±6.0*	556.5±5.5*	544.6±5.9*
AL, mm	20.0±0.9**	22.1±1.0	23.9±0.9*	25.2±0.8*	26.7±0.9*
CH, mmHg	13.38±0.87**	12.8±1.0	12.3±0.2*	10.8±0.4*,**	10.5±0.3*,**
FCR, mmHg	13.79±0.58	13.0	12.2±0.2*	11.6±0.5*	11.6±0.4*

* – Difference with high hyperopia and moderate hyperopia is significant
** – Difference with low myopia is significant, P<0.05

Ultrasound Examination Results

Ultrasound sclera histograms are presented in Fig. 5 (a, b).

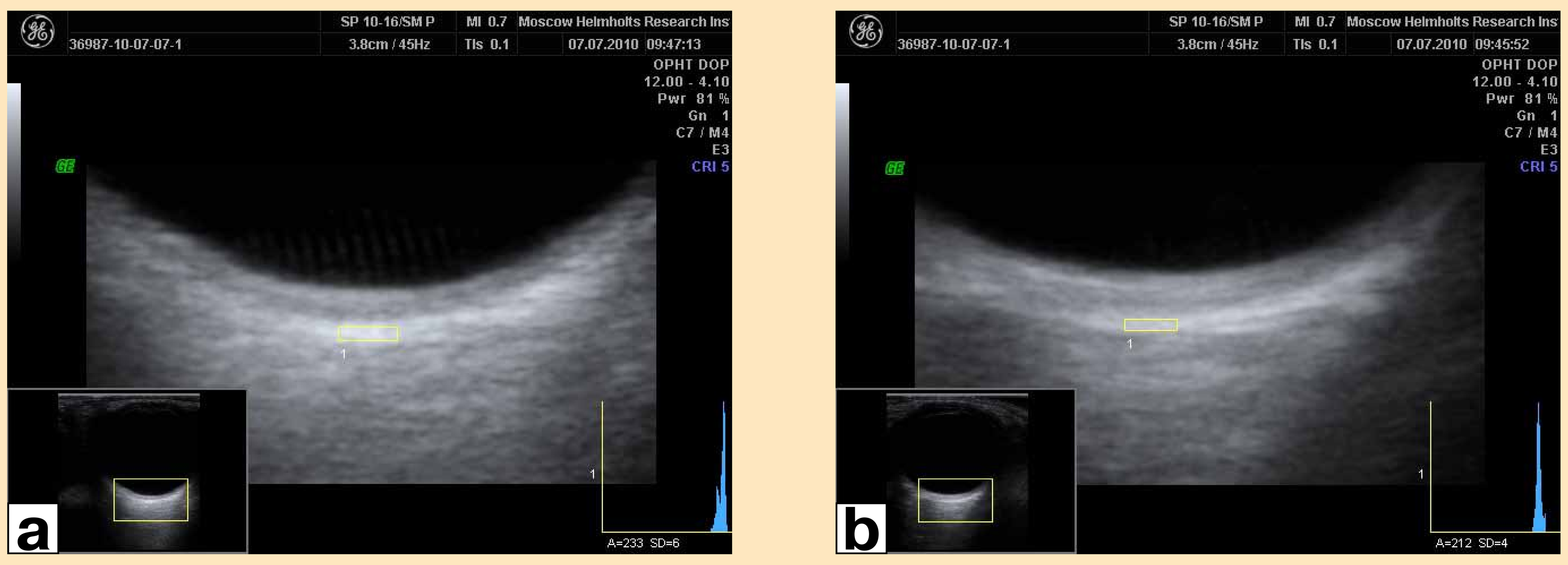


Fig. 5. ASD data corresponding to children eyes:
a) highly hyperopic ASD=233 units and b) highly myopic ASD=212 units

Table 3. Acoustic sclera density (ASD, units) in children with various degrees of myopia and hyperopia

Refraction	ASD in posterior pole	ASD in equatorial area
High hyperopia	233±1.76*	230±1.23*
Moderate hyperopia	228±1.21**	226±1.13**
Low hyperopia	225±1.01***	222±1.18***
Low myopia	223±1.35	219±1.17
Moderate myopia	219±1.34	214±1.21
High myopia	215±1.13	209 ±1.15

* – Difference between high hyperopia, on the one hand, and moderate and low hyperopia as well as myopia of all degrees, on the other hand, is significant
** – Difference between moderate hyperopia and myopia of all degrees is significant
*** – Difference between low hyperopia and moderate and high myopia is significant P<0.05

Table 4. Decrease of ASD (%) with the refraction increase

Refraction	Posterior pole %	Equatorial area %
High hyperopia	Initial level	
Moderate hyperopia	2,14	2,74
Low hyperopia	3,43	3,48
Low myopia	4,29	4,78
Moderate myopia	6,00	6,96
High myopia	8,72	9,13

As the refraction grows, the acoustic density of the sclera is significantly subsiding, especially in the equatorial area: from 233±1.76 units in the posterior pole and 230±1.23 units in the equatorial area for high hyperopia to 215±1.13 units and 209±1.15 units, respectively, in high myopia (Table 3, 4).

It is worth noting a more expressed ASD reduction in the equatorial zone as compared to the posterior pole of the eye, which agrees well with the view that the extension of the equatorial zone of the sclera plays a leading role in the course of eye growth and refraction increase in children.

Conclusions. The significant reduction of CH and ASD that takes place with the increase of myopic refraction is primarily accounted for by damaged biomechanical properties of the sclera. The results enable us to state that moderate and high hyperopia is a specific condition that has distinctive biophysical features of the corneoscleral eye shell. The disturbance in sclera biomechanics is a triggering factor of eye growth and refraction increase in children.

Combined Treatment of Rapidly Progressing Myopia in Children Using Scleroplasty and Orthokeratology

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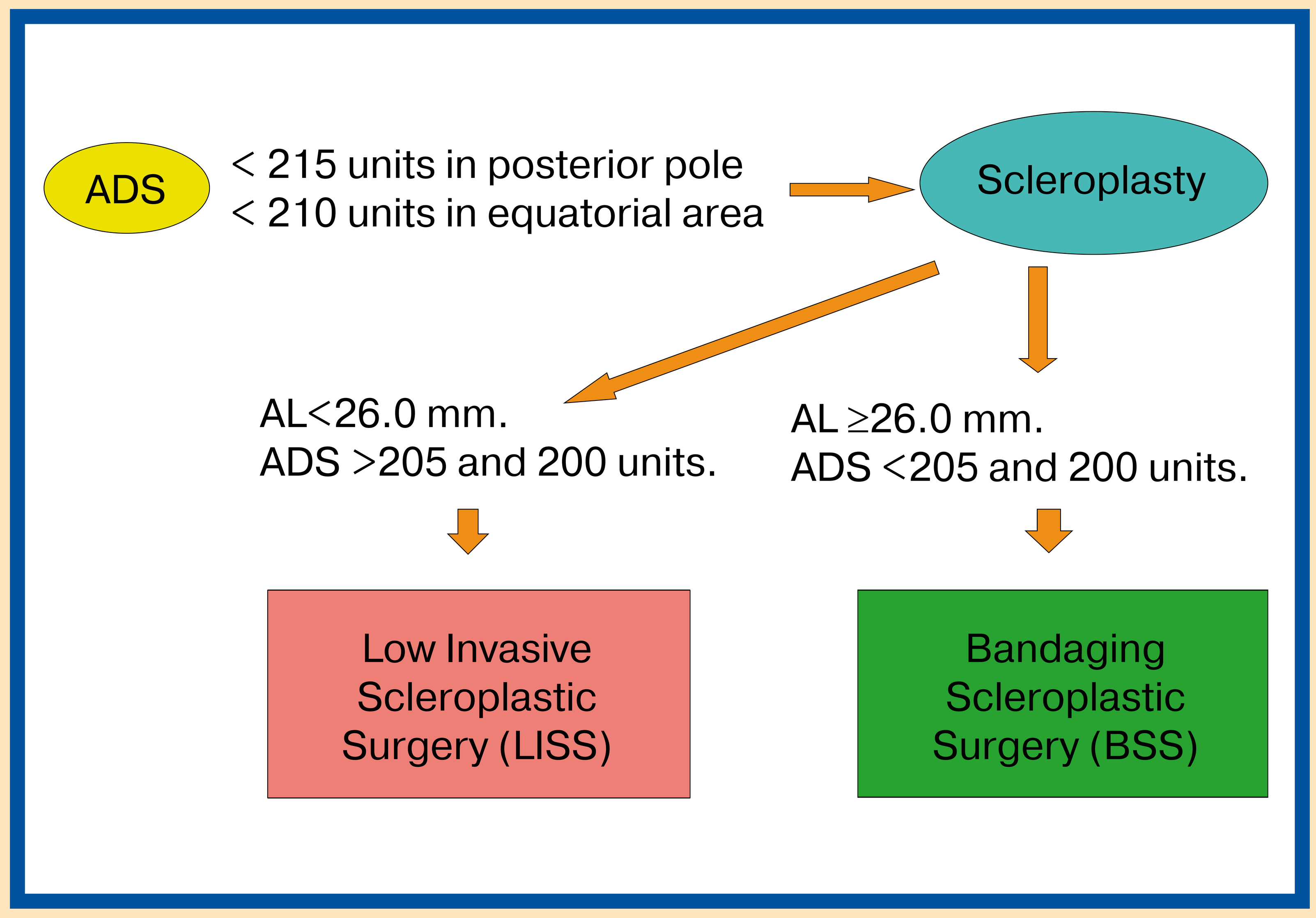
Introduction. In recent years, orthokeratology has established itself as a method of correction and control of myopia progression in children. However, according to our data, 19.6% of patients showed such progression over an average of 4.2 years of observation , while axial length increased by more than 0.3 mm.

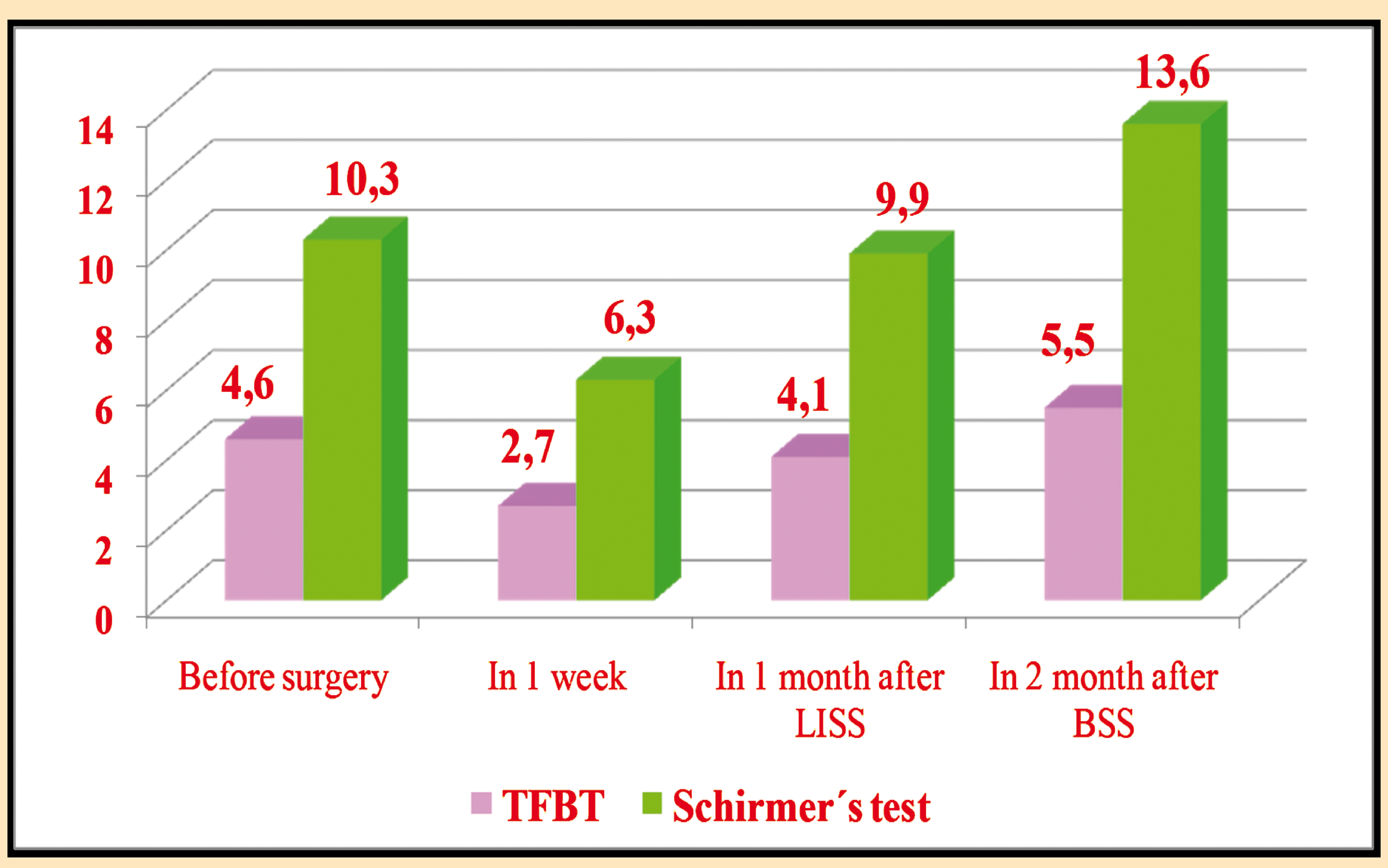
Purpose: To develop a pattern of combined sclera-strengthening treatment and OK correction of rapidly progressing myopia in children.

Material and Methods. 25 children (33 eyes) aged 9–12 (averagely, 10±1.3 years) with myopia from -2.5 to -6.5 D (averagely, -5.0±0.9 D) received combined treatment. Before starting the treatment, all children were examined for acoustic density of the sclera (ADS), which was determined from scleral histograms obtained using an ultrasound device, Voluson 730 Pro. If ADS values were lower than 215 units in the posterior pole and lower than 210 units in the equatorial area the first phase of treatment was scleroplasty. In the case of axial length (AL) < 26.0 mm and ADS > 205 units, low invasive scleroplastic surgery (LISS) was performed. If AL≥ 26.0 mm and ADS<205 units, bandaging scleroplastic surgery (BSS) according to Snyder-Tompson technique was performed (Table 1). To determine when the patient could start wearing OK- lenses, the patients were tested for the condition of tear production and tear film using Schirmer and Norn tests before and 1 week, 1 month and 2 months after the surgery. Myopia progression was controlled according to the dynamic of AL.



Number of patients	Number of treated eyes				
	BSS	LISS	BSS in fellow eye	LISS in fellow eye	Total
25	7	18	1	7	33

Table 1. Patients (eyes) received various types of scleroplastic treatment



LISS – Low Invasive Scleroplastic Surgery
BSS – Bandaging Scleroplastic Surgery

Fig. 1. The dynamics of Schirmer's test values and tear film breakup time (TFBT) before and after sclera reinforcement surgery

Results. Tear film breakup time (TFBT) and Schirmer test values changed after the surgery and gradually recovered, which required 1 month after LISS and 2 months after BSS. Thus, wearing of contact lenses, including OK lenses, may be recommenced 1-2 months after extrascleral surgery, including scleroplasty.
Over the period of 1-3 years after the surgery, no myopia progression or AL elongation were noted (Table 2).
In the fellow eyes of 7 patients ,1-2 years after the surgery, axial length grew by 0.3 mm or more, in which case scleroplasty was administered. For this purpose, wearing of OK lenses was suspended; after the anatomical and optical parameters of the cornea stabilized (in 1-2 weeks as a rule), scleroplastic surgery was given, whereupon, 1.5 months later, wearing of OK lenses was resumed.

Number of eyes	AL before combined treatment	AL 1-3 years after combined treatment
25 treated eyes	24,59±0,1	24,47±0,06
25 fellow eyes	24,52±0,1	24,64±0,08
Including 8 eyes	24,53±0,1	24,79±0,1
8 Eyes after surgery	24,79±0,1	24,67±0,2

Table 2. The results of combined treatment (according to the dynamic of the axial length)

Conclusions. For patients with rapidly progressing myopia and low acoustic density of the sclera, the combined treatment pattern consisting of scleroplasty followed by OK lens wearing could be recommended. Scleroplastic surgery does not impede the use of OK lenses after that.

Prevalence of Myopia Among Hong Kong Chinese Schoolchildren

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Introduction

Studies have documented increasing prevalence of myopia among Asian countries within the past two decades especially in urbanized areas such as Taiwan[1], Japan[2] and Malaysia[3]. This study aims to determine the prevalence of myopia and its current trends among the Chinese schoolchildren in Hong Kong.

Methods

Six local primary schools were selected in a multi-disciplinary health screening program during the period of 2005 to 2010. LogMAR visual acuities and binocular status were assessed under our participants' habitual refractive condition. Refractive error and ocular biometry were measured under non-cycloplegic conditions with an open-field auto-refractor (Shin-Nippon NVision-K 5001, Ryusyo Industrial Co. Ltd, Osaka, Japan) and IOLMaster (Zeiss Inc. Meditec-AG, Jena, Germany) respectively. Hyperopia was defined as a spherical equivalent refraction (SER) >+0.50D, emmetropia as SER between -0.50D and +0.50D (inclusive) and myopia as SER< -0.50D as a definitive comparison of SER with our previous study.

Results

Data of refractive error, axial length and keratometry from 2725 schoolchildren, 5 to 15 years of age (mean age=9.03±1.89, 53% boys, 47% girls) were analyzed after exclusion of subjects with strabismus (n=104), of non-Chinese ethnicity (n=11), incomplete dataset (n=30) and presence of ocular or systemic conditions (n=13). Only data from the right eye was presented as data between left and right eyes were highly correlated (Pearson r=0.930 for SER, p<0.001). The mean SER for this population was -1.02±1.71D, ranging from +6.94 to -10.00D. Data from schoolchildren of age 5 and 13 or above were further excluded as the sample size (n=75) was of weak statistical value. The mean age of the stratified sample (age 6-12 years, n=2651) was 8.92±1.77 with a mean SER of -1.02 ±1.70D. Figure 1 shows the frequency distribution of age and gender of our sample population.

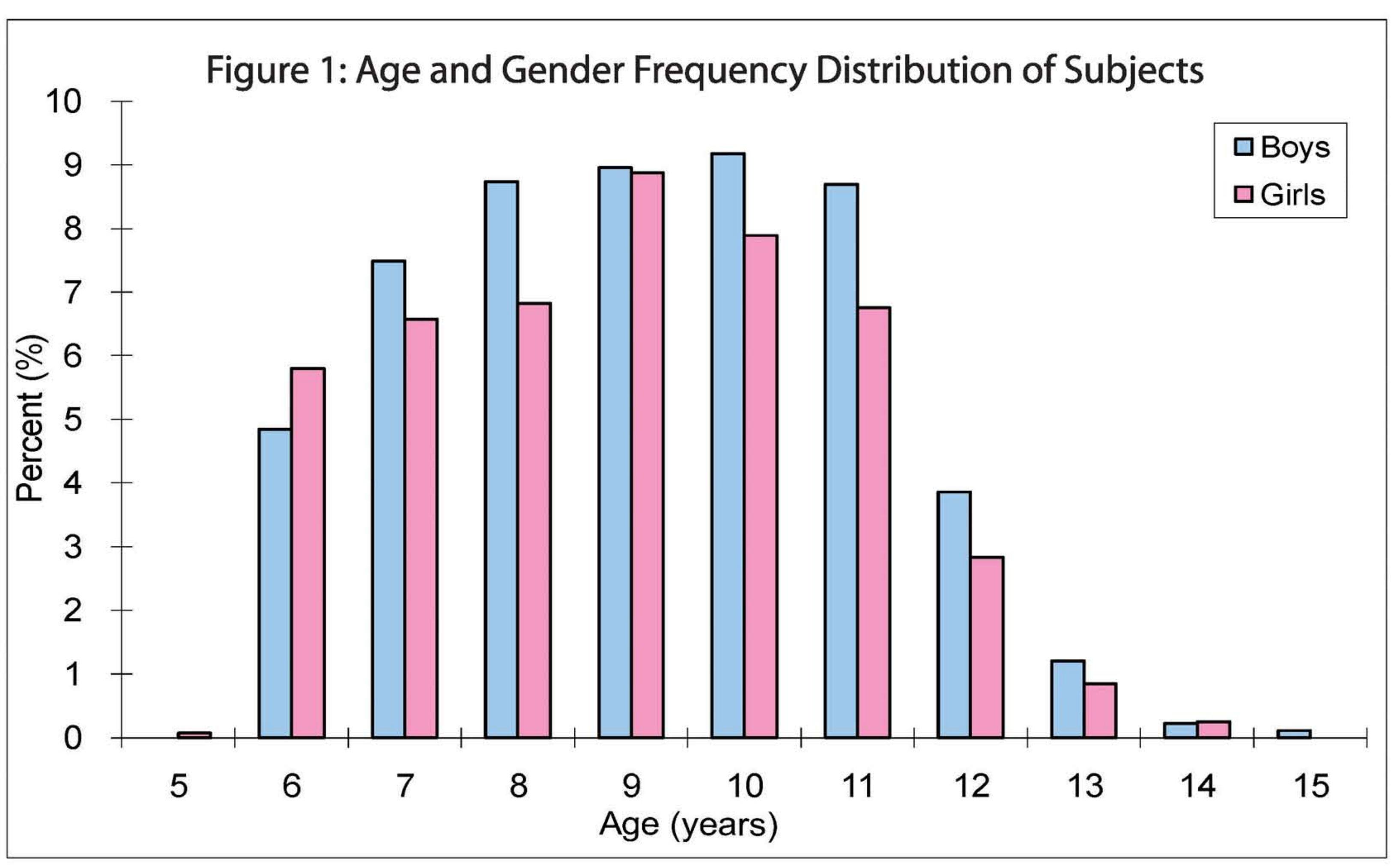

Figure 1: Age and Gender Frequency Distribution of Subjects

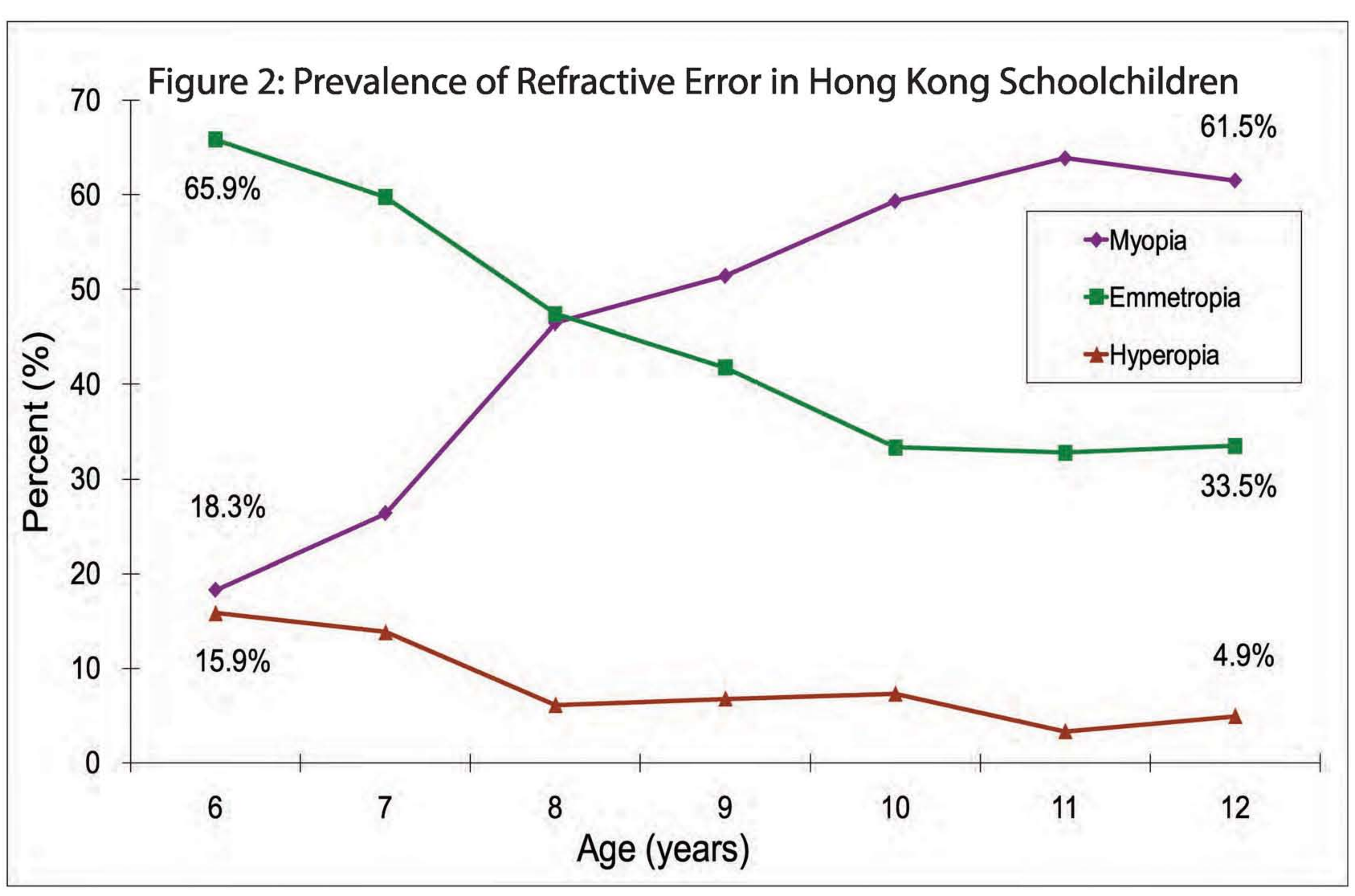

Figure 2: Prevalence of Refractive Error in Hong Kong Schoolchildren

Figure 2 illustrates prevalence of refractive errors among the six-year old as compared to the twelve-year old age categories. Mean SER rose from -0.06±1.03D at age six to -1.67±1.99D by the age of twelve years.

No gender differences were found in SER (Mann-Whitney test, U=886300, p=0.064) but boys (49.5%) had a slightly higher prevalence in myopia than girls (46.2%) (χ^2=8.727, df=2, p=0.013). Both prevalence of myopia (χ^2 =272.217, df=12, p<0.001) and SER (Pearson r= -0.317, p<0.001) were associated with age.

Prevalence of high myopia (SER of more than -6.00D) in this population group was 1.8% with an increase from 0.7% at age six to 3.8% by the age of twelve years.

Discussion and Conclusions

1. The prevalence of myopia among the Chinese schoolchildren population in Hong Kong are similar to our previously reported values from 19 years ago[4] with as high of a prevalence value as those reported by other Asian countries during the early 1990s[1-3] (Fig.3).
2. The prevalence of myopia increases with increasing age (Pearson r=-0.3000, p<0.001). This trend is similar to our previously reported findings[4] (Pearson r=-0.3302, p<0.001) despite differences in the sampled population.
3. Our findings do not support the concurrent trends as observed in other Asian countries where there is a reported increase in myopia prevalence. It is postulated that myopia prevalence among Hong Kong schoolchildren may have reached a "saturated" level as observed in Taiwan where prevalence of myopia was reported to have stabilized in 2005[5] (Fig. 3).

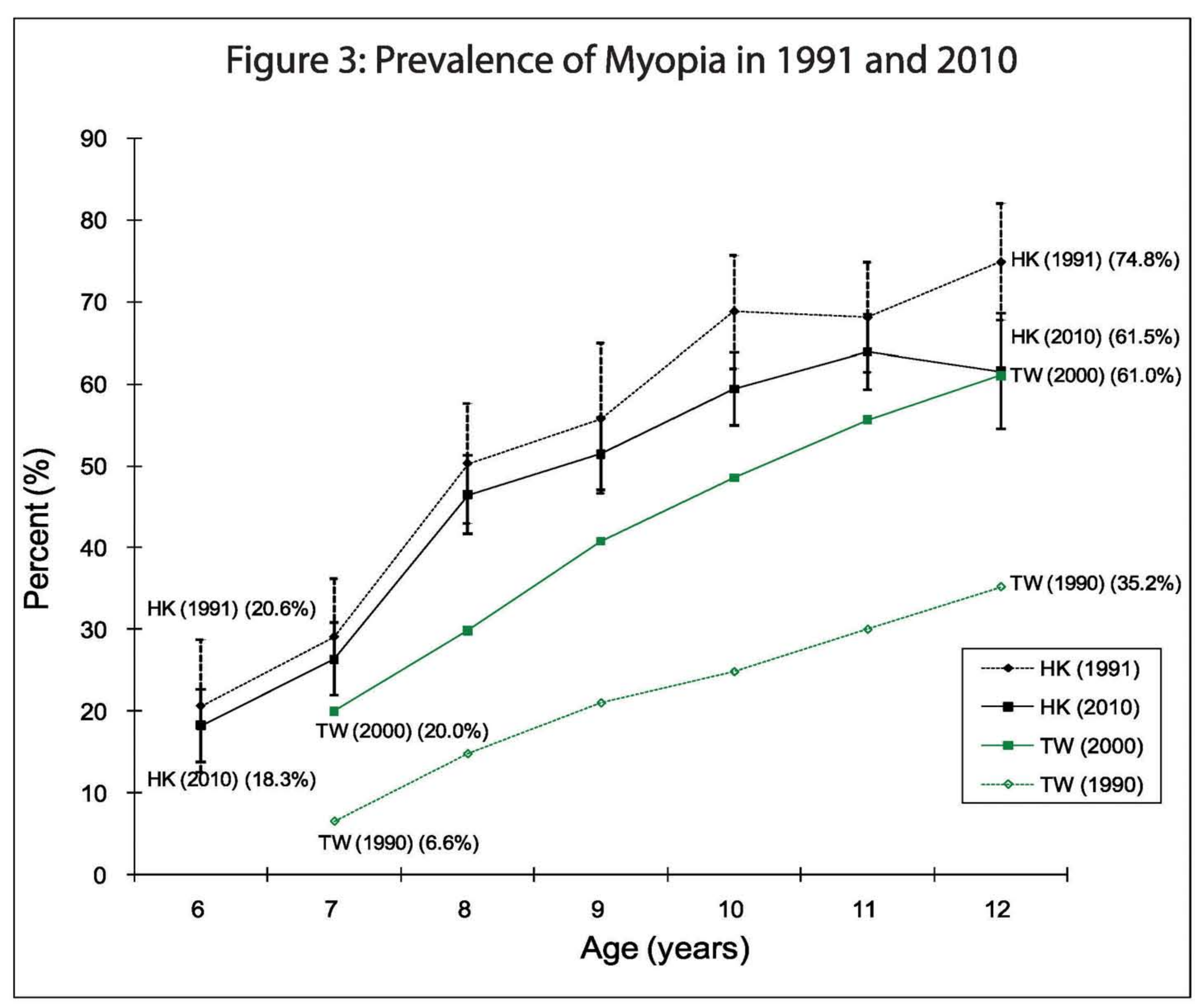

Figure 3: Prevalence of Myopia in 1991 and 2010

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Twelve Years Later: Has the Rate of Myopia in Singapore Deteriorated?

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INTRODUCTION

A myopia cohort study was conducted on military conscripts from April 2009 to April 2010. The aim was to compare the current trend of myopia with that of 12 years ago (Wu et al., 1998).

POPULATION DEMOGRAPHICS

	All Subjects		Chinese		Malay		Indian		Other	
	No.	%	No.	%	No.	%	No.	%	No.	%
No. of subjects	29004	100	20088	69.3	6127	21.1	2232	7.7	557	1.9
Age (yr)										
16-19	22576	77.8	15655	77.9	4825	78.7	1684	75.4	412	74.0
20-25	6268	21.6	4315	21.5	1277	20.8	535	24.0	141	25.3
<=15	114	0.4	92	0.5	14	0.2	5	0.2	3	0.5
>=26	46	0.2	26	0.1	11	0.2	8	0.4	1	0.2
Education Level										
Primary	754	2.6	441	2.2	245	4.1	58	2.6	10	1.8
Secondary	21594	75.7	14465	72.9	5025	84.2	1694	77.4	410	75.2
Tertiary	6186	21.7	4923	24.8	701	11.7	437	20.0	125	22.9

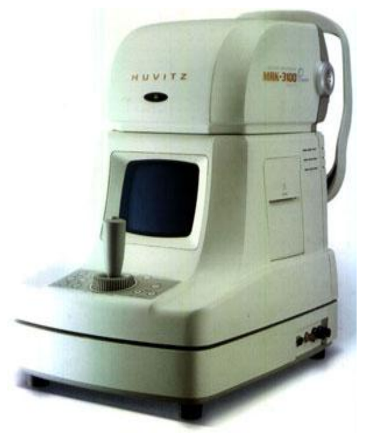
METHODS

Participants

Participants were recruited from the pre-enlistee and enlistee population of the Singapore Armed Forces.

Data Collected

1) Habitual VA (LogMAR Chart)
2) Auto-Refraction (Huvitz NRK-3100 auto-refractor)
3) Auto-Keratometry (Huvitz NRK-3100 auto-refractor)
4) Ocular History
5) Demographic Data



Huvitz NRK-3100 auto-refractor

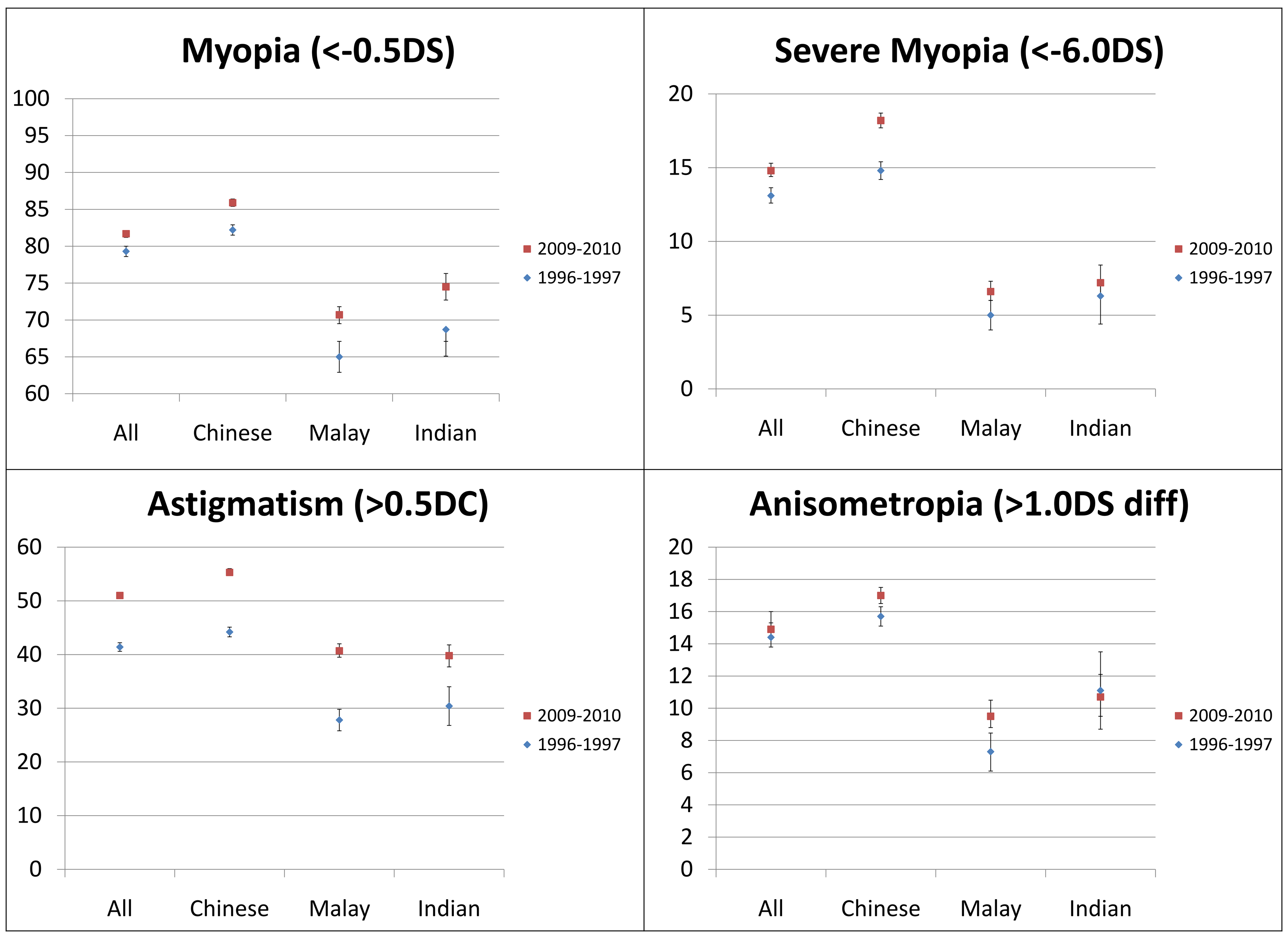
Analysis

Statistical Package for the Social Sciences (SPSS Version 15.0).

RESULTS (1):

The prevalence of myopia, severe myopia, and astigmatism has generally increased across all races over the last 12 years (P<0.01 for all except severe myopia in Indians). Anisometropia has increased for Chinese and Malays only (P<0.01).

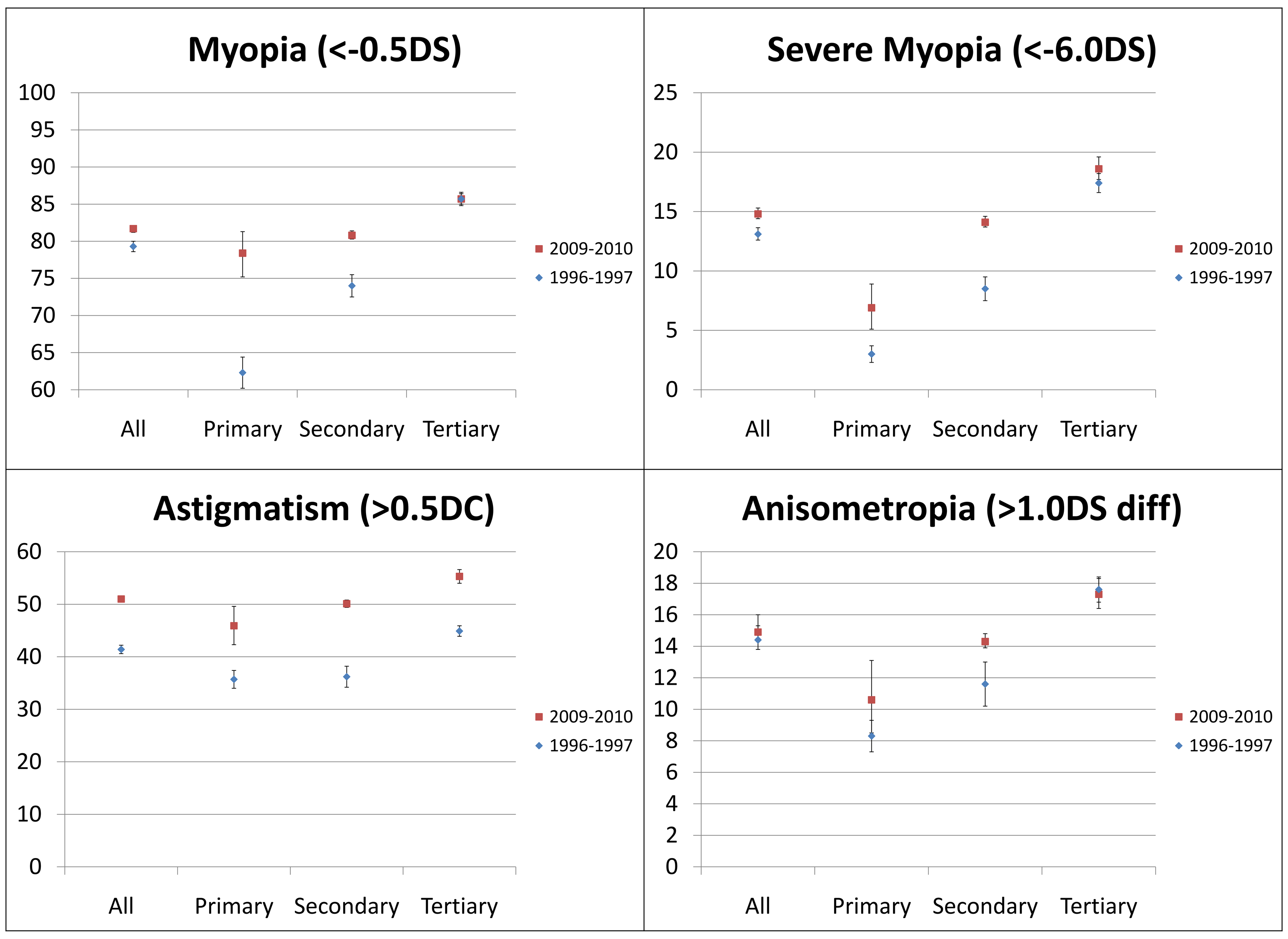
		Wu et al., 1998				Current Study, 2009-2010			
		All	Chinese	Malay	Indian	All	Chinese	Malay	Indian
Hyperopia	N	106	74	19	7	245	152	74	19
(>+0.5DS)	%	0.7	0.6	1.0	1.1	0.9	0.8	1.2	0.8
Myopia	N	11,963	10,168	1,258	447	23373	17336	4363	1674
(>-0.5DS)	%	79.3	82.2	65.0	68.7	81.7	85.9	70.7	74.5
Severe	N	1,976	1,831	97	41	4246	3675	409	162
Myopia	%	13.1	14.8	5.0	6.3	14.8	18.2	6.6	7.2
(>-6.0DS)									
Astig	N	6,247	5,468	538	198	14576	11170	2513	893
(>0.5DC)	%	41.4	44.2	27.8	30.4	51.0	55.3	40.7	39.8
Anisome-	N	2,172	1,942	141	72	4256	3430	585	241
tropia	%	14.4	15.7	7.3	11.1	14.9	17.0	9.5	10.7
(>1.0DS)									



RESULTS (2):

The prevalence of myopia, severe myopia, and astigmatism has generally increased across all education levels over the last 12 years (P<0.01 for all except myopia and severe myopia for tertiary education). Anisometropia has increased for secondary education only (P<0.01)

		Wu et al., 1998			Current Study, 2009-2010		
		Pri	Sec	Tert	Pri	Sec	Tert
Hyperopia	N	24	29	36	7	190	40
(>+0.5DS)	%	1.2	0.9	0.4	0.9	0.9	0.7
Myopia	N	1,257	2,344	7,766	583	17124	5197
(>-0.5DS)	%	62.3	74.0	85.7	78.4	80.8	85.7
Severe	N	61	269	1,577	51	2994	1129
Myopia	%	3.0	8.5	17.4	6.9	14.1	18.6
(>-6.0DS)							
Astig	N	720	1,146	4,069	341	10604	3351
(>0.5DC)	%	35.7	36.2	44.9	45.9	50.1	55.3
Anisome-	N	167	367	1,595	79	3038	1049
tropia	%	8.3	11.6	17.6	10.6	14.3	17.3
(>1.0DS)							



RESULTS (3):

As reported by Wu and colleagues (1998), ethnic differences persisted even after adjusting for education. The PRR remained highest in Chinese, although there was significance observed for severe myopia in Indians.

	Wu et al., 1998				Current Study, 2009-2010			
	Myopia		Severe Myopia		Myopia		Severe Myopia	
	Crude PRR	Adjusted PRR	Crude PRR	Adjusted PRR	Crude PRR	Adjusted PRR	Crude PRR	Adjusted PRR
Chinese	1.3*	1.1*	3.0*	1.5*	1.2*	1.4*	2.7*	6.3*
Malay	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Indian	1.1*	1.0	1.3*	1.2*	1.1	1.2	1.1	3.1*

CONCLUSIONS

1) The prevalence of myopia and astigmatism in Singapore has generally increased over the last 12 years.
2) The effects of ethnicity are still very strong, even after controlling for confounding factors such as education.

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A Cohort Study of Myopic Refractive error progression in Korean children myopes

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Purpose

- Myopic refractive error and prevalence of myopia increase with age increase in school children specially in Asia [1-2].
- The increasing rate of the myopic refractive error and myopia prevalence among the Korean children students were 0.2D and 5.3% respectively [3]
- To determine myopic refractive error in an optometric clinic-based cohort study in Korean children

Subjects and methods

Subjects

- Data were available for 99 Korean children (male : 55, female : 44) who had myopic refractive error in Korean cohort study of myopic refractive error change.
- A mean 33 ± 8 months cohort study was conducted in Korean children aged 4 years 11months to 16 years 2 months at first visit.

Methods

- Refractive errors were measured using Shinnipon N-vision 5500 under non-cycloplegia every mean 6 months.
- Spherical refractive error and astigmatism data were used separately for this study
- Refractive error results are presented for the right eye of each subject

Results

Spherical Myopic Refractive error Change

- Mean myopic refractive error increase -1.80D to -3.43D(paired t-test: $p < 0.001$) for 33 months and the rate of increase was 0.063 D per month(0.76D/year)(Fig.1).

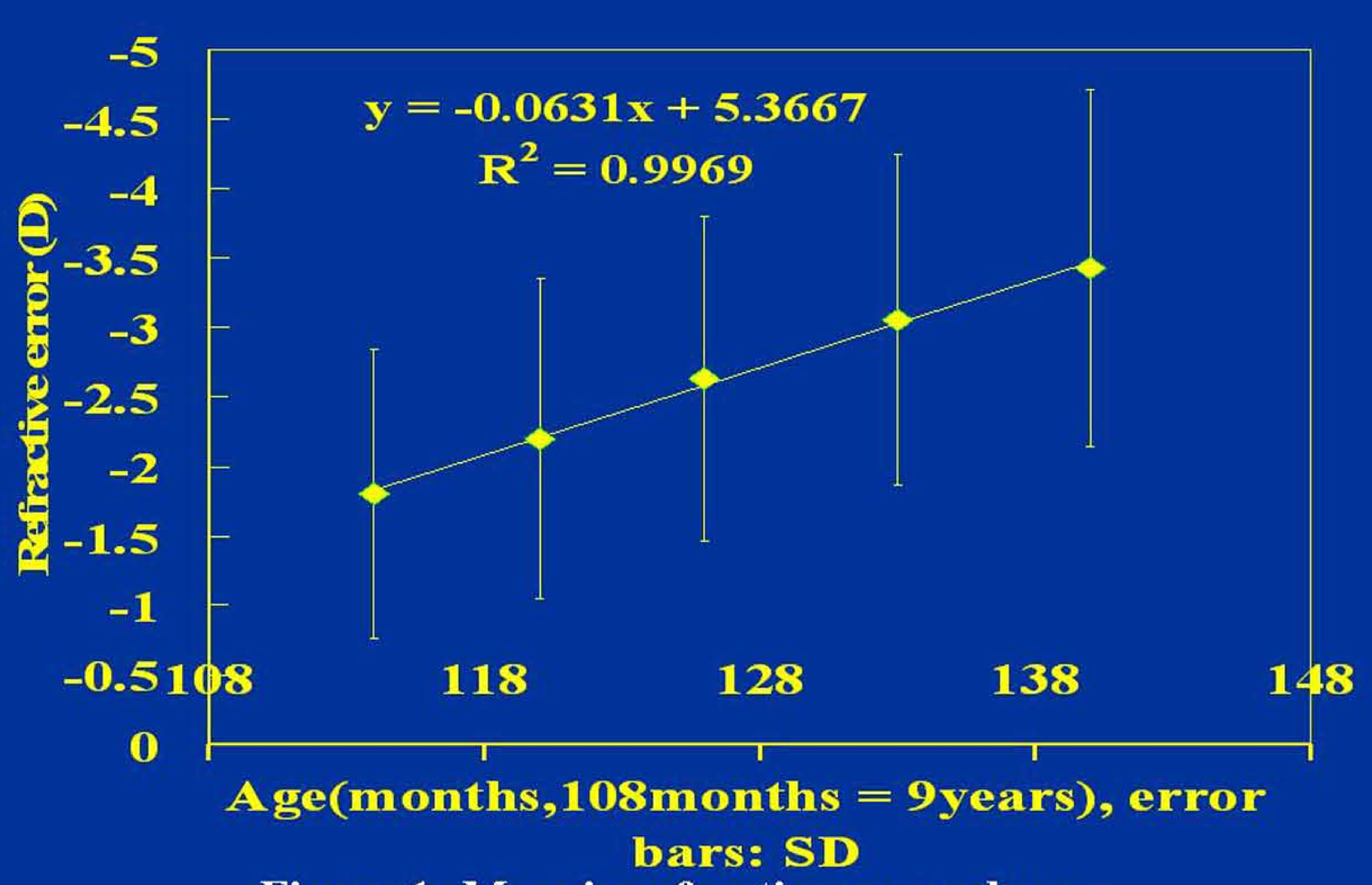

Figure 1: Myopic refractive error change

Astigmatism Change

- Astigmatism increased -0.43 D to -0.71D for 33 months (paired t-test: $p < 0.001$)(Fig.2).

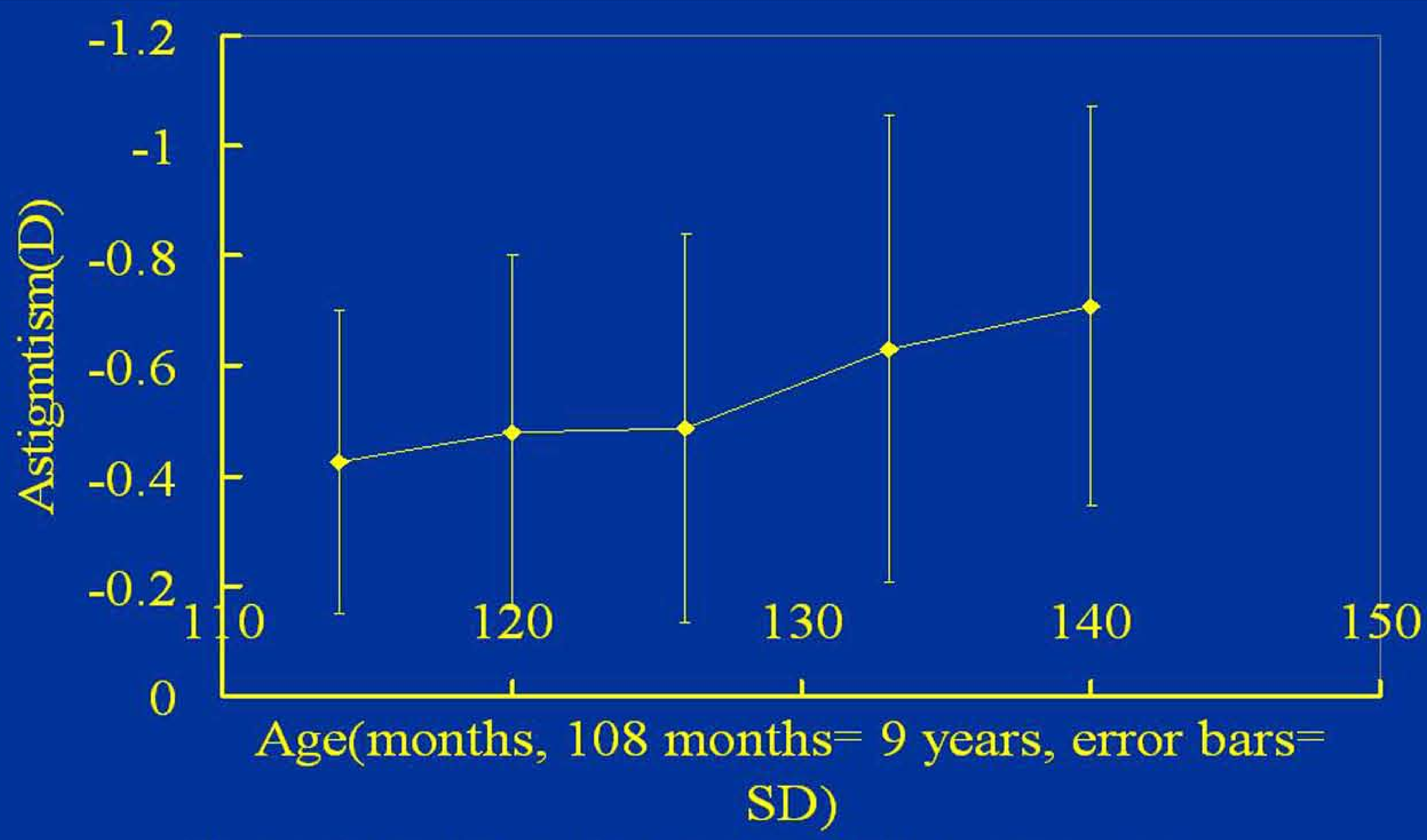

Figure 2: Astigmatism change with age increase.

Refractive error increase with onset age of myopia

- Refractive error is the more increase the earlier onset
- Refractive error increase was
  - 0.085D per month for 6 years old of onset
  - 0.068D per month for 9 years old of onset
  - 0.056D per month for 11 years

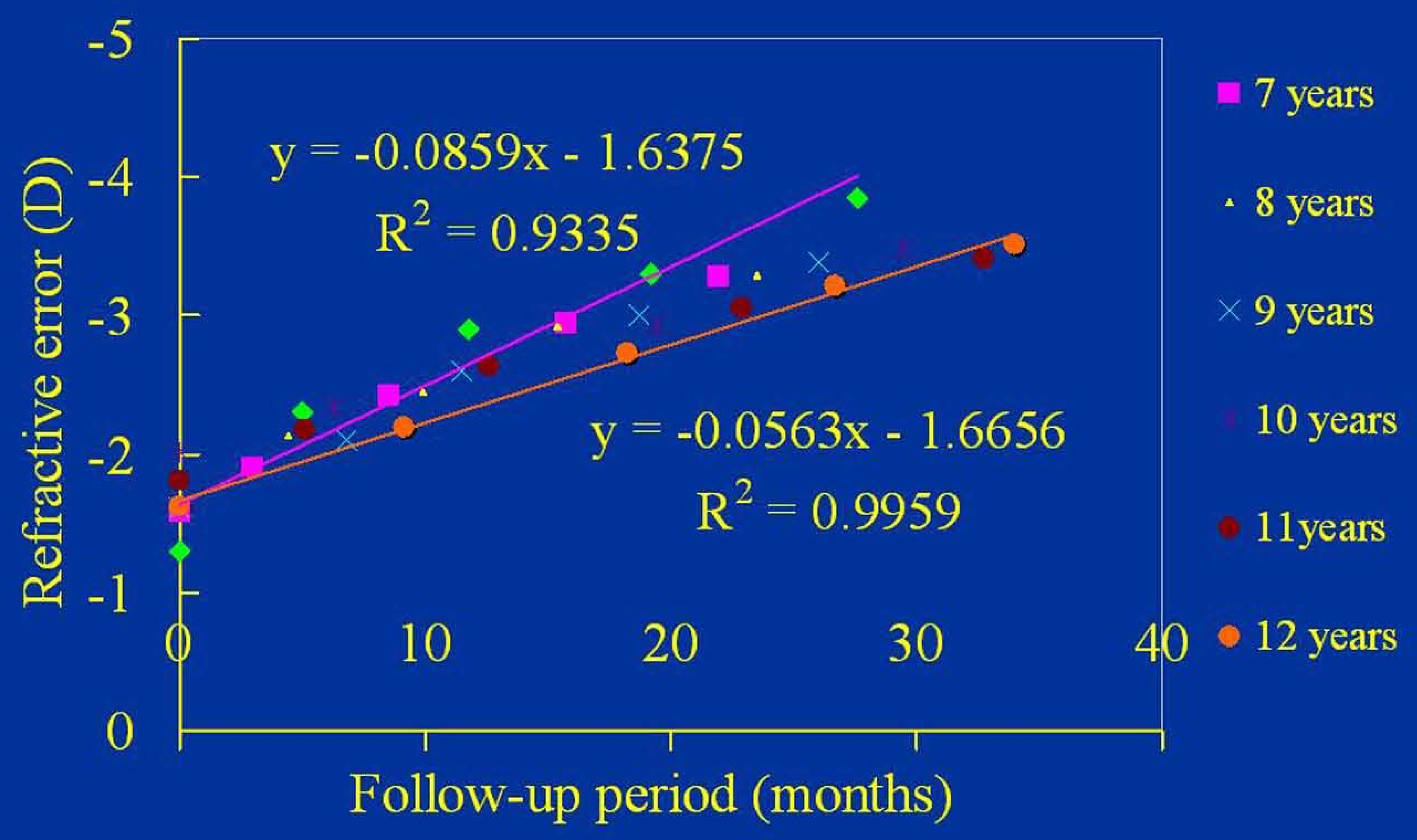

Figure 3: Myopic Refractive error change with onset age of myopia .

Discussion and conclusion

The average annual myopic refractive error change for children with myopia was very high1-2 in Asia. This results also show that the rate of myopic refractive error progression for myopic children in Korea is higher than for myopic school children in other Asian countries. And this cohort study results show higher average annual myopic refractive error change with myopia than non-cohort study in children in Korea3.

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Conjunctival and corneal conditions among myopic schoolchildren in Hong Kong

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Background

Allergies such as rhinitis and eczema are common among Hong Kong children[1]. Sometimes severe allergic conditions may cause problems in ocular tissues such as papillae and corneal staining that may affect contact lens wear. Clinical trials of myopia control using contact lenses have become more popular (e.g. Ortho-K lenses[2] and bifocal soft lenses[3]) in recent years. External ocular health (EOH) is one of the concerned issues in prescribing contact lenses for young children in myopia control studies.

Purpose

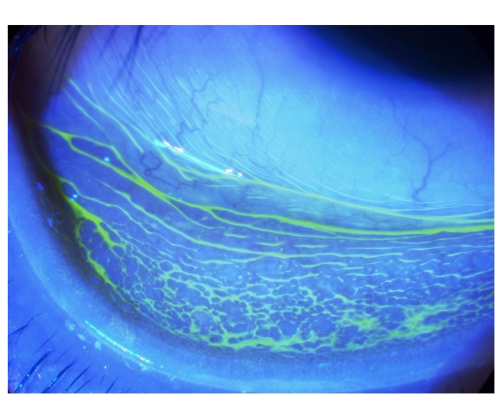
To evaluate the presence and severity of papillae and corneal staining among Hong Kong myopic schoolchildren in order to provide a reference for fitting contact lenses to young children in myopia control clinical trials.

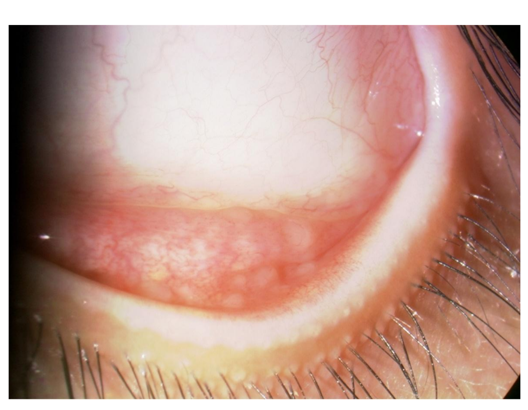
Methods

Myopic children aged between 8 and 13 year-old were recruited for a 2-year myopia control study with soft contact lens since November 2007. Those children had not worn contact lenses before. Slit-lamp biomicroscopy was performed on each subject to examine their EOH in order to provide a reference for selecting suitable candidates for myopia control study using contact lenses. Cornea and Contact Lens Research Unit (CCLRU) grading scales[4] were used for grading the severity of corneal and palpebral conditions, i.e. central and peripheral corneal staining; papillae at upper and lower palpebral conjunctivae. The parents were also surveyed to assess the prevalence of allergic problems (eczema, asthma and rhinitis) among children.

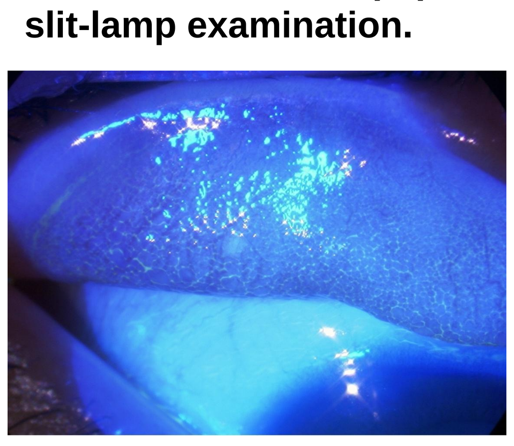
Results

A total of 781 schoolchildren were evaluated. Peripheral corneal staining (45.6%) were more common than central staining (7.6%). Among the children with corneal staining, 13.8% and 25.4% of them showed moderate to severe (grade 2 or above) peripheral and central staining respectively. About one-tenth of the subjects had trichiasis. 37.3% and 17.4 % of them also had accompanied peripheral and central corneal staining respectively. Papillae were found to be very common in both upper (84.0%) and lower (94.4%) palpebral conjunctivae. About two-third of the subjects (67.5%) had papillae with grade 2 or above at lower palpebral conjunctivae whereas about 39.1% at upper palpebral conjunctivae. **Figure 1.** shows the typical features observed among the schoolchildren, including papillae and central corneal staining. **Figure 2-5.** show the percentage of different grades of corneal staining and papillae. 40% of children had allergic rhinitis as reported by their parents; 11.5% of those children required medications to relieve the symptoms and about 20% of them complained about itching eyes.

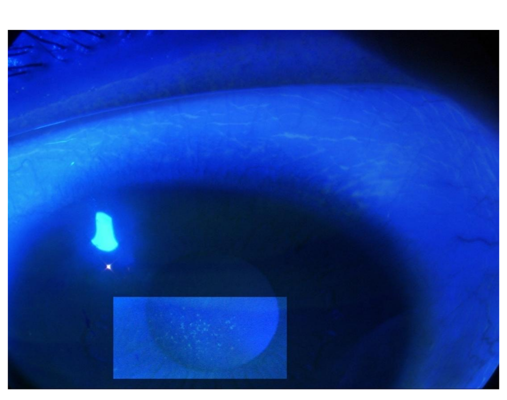




Moderate to severe papillae at lower palpebral conjunctivae under slit-lamp examination.



Papillae at upper palpebral conjunctiva



Central corneal staining

Figure 1. Common features observed in young children

Eczema (10.6%) and asthma (3.2%) were found to be less common (**Figure 6**). Papillae (grade 2 or above) were significantly associated with allergic rhinitis ($p<0.001$) and eczema ($p = 0.008$), but not with asthma. Only one-third ($n = 221$) of the children were eventually selected to have contact lens trial fit for the myopia control study according to their EOH conditions.

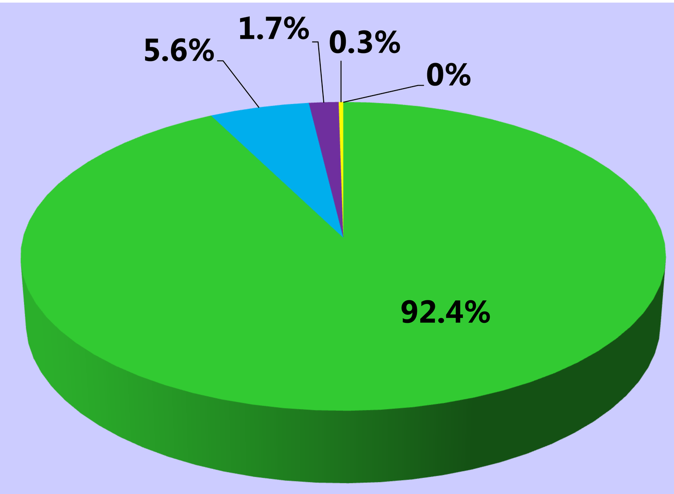


Figure 2. Central corneal staining

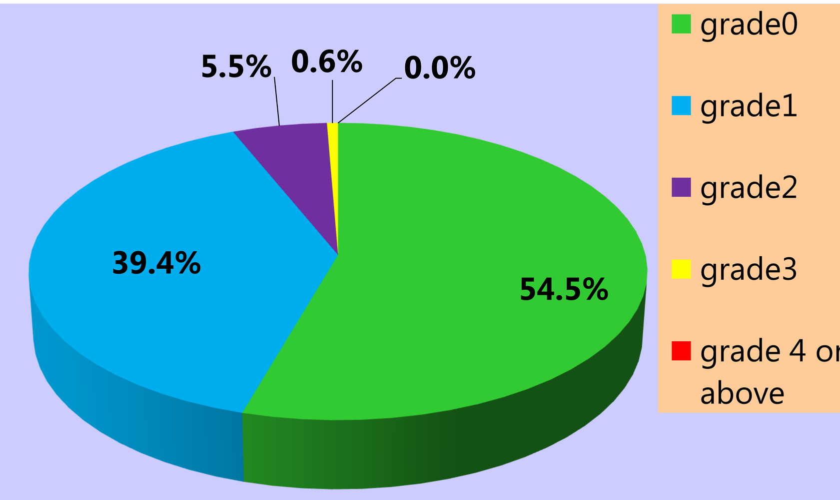


Figure 3. Peripheral corneal staining

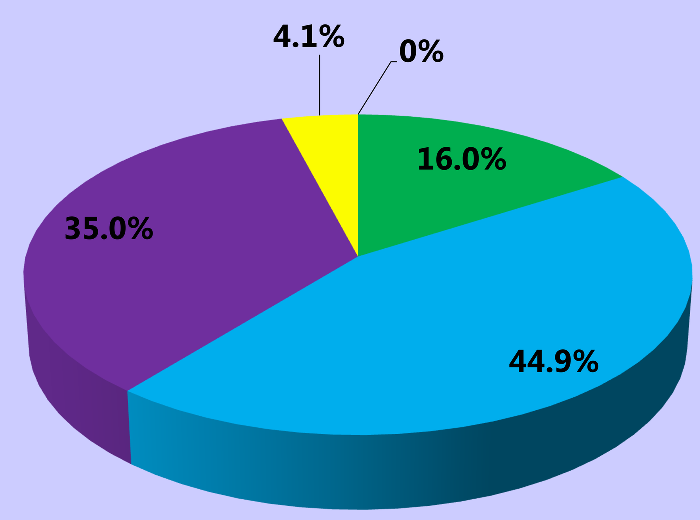


Figure 4. Papillae at upper palpebral conjunctivae

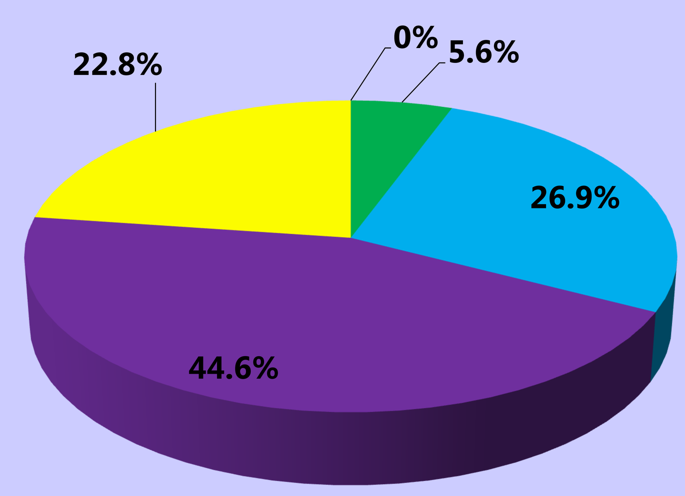


Figure 5. Papillae at lower palpebral conjunctivae

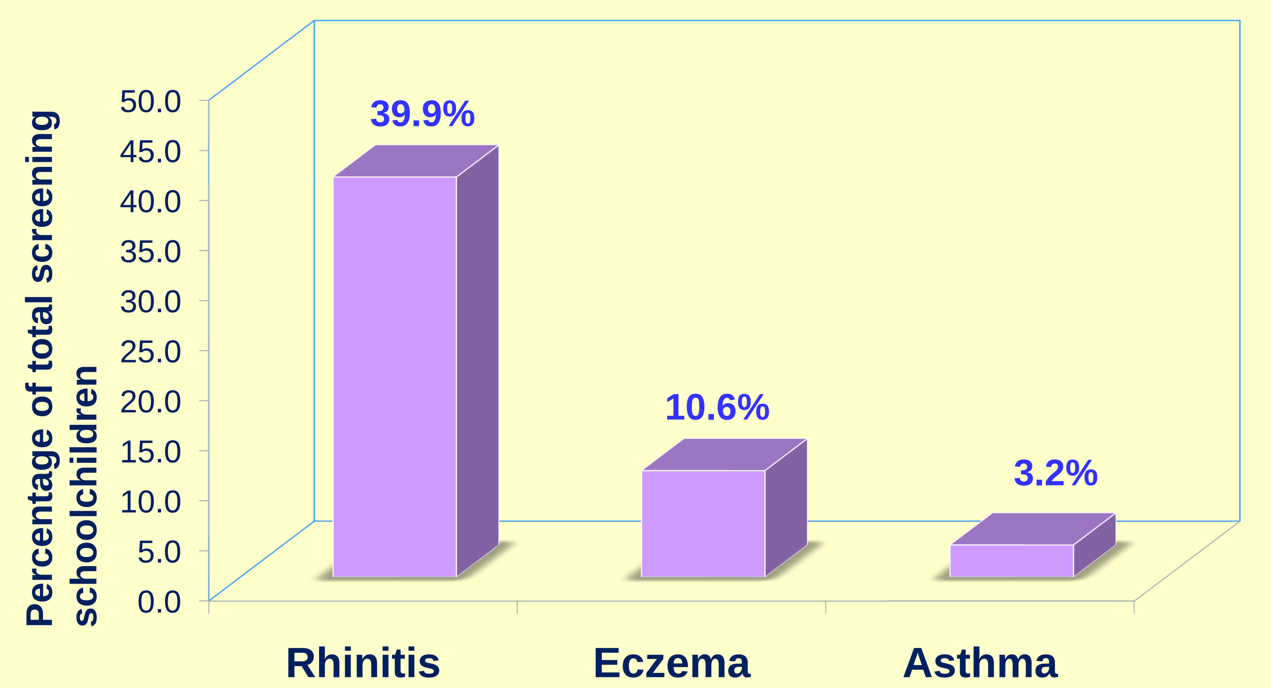


Figure 6. Common allergic problems in schoolchildren (8-13 years old)

Conclusions

Papillae are common ocular allergic problems in Hong Kong schoolchildren, and are highly associated with allergic rhinitis. Contact lenses wear in young children needs to be cautious in particular if they already present signs of ocular allergy.

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Suggestions for a new classification of myopia

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Purpose

To propose a new classification of myopia in order to facilitate the clinical management for myopia.

Background and Methods

A variety of systems, based on different methods, have been applied for the classification of myopia in the past literature, such as congenital vs. youth-onset, physiological vs. pathological, hereditary vs. environmentally induced, stationary vs. progressive, axial vs. refractive. However, there is a lack of system which facilitates the clinical management of the disorder in the daily practice.

A systematic literature review on the myopia classification used in the last 50 years was performed and a new classification, from the clinical management' s point of view, is proposed accordingly,.

Results

Myopia is proposed to be classified into Congenital Myopia, Symptomatic Myopia and Induced Myopia.

Congenital Myopia is an myopia that presents at the birth or at the early age, which is hereditary (solely gene-related) and incurable at present.

Symptomatic Myopia is the myopia that presents as one symptom of some primary diseases, such as diabetes, Mafan' Syndrome and cataract. The refractive error of this kind of myopia can be obviously eliminated or fully reversed when the primary disease is treated properly.

Induced Myopia refers to the one that is related with external factors, mainly environmental ones. This myopia usually appears in school-age children or in young adults. It is worth paying the most attention to and urgently needs solutions to be cured.

Conclusion

Myopia is proposed to be classified into three categories: congenital myopia, symptomatic myopia and induced myopia. Such a classification system may help better management for patients clinically.

Statement of proprietary interests: None

Manipulation of Retinal Defocus to Stimulate Axial Elongation in Axial Hyperopia

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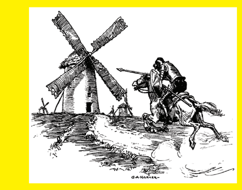

STUDY OBJECTIVE

This case explores whether bifocal contact lenses can be used to stimulate axial elongation in a child with axial hyperopia by altering the prescribed powers to impose hyperopic defocus.

BACKGROUND

Myopia has become the focus of growing attention and concern because the prevalence of myopia appears to be increasing in some populations (reaching 90% for some university student populations in Asia).[1,2] A dominant theory on the environmental causes of myopia that attempts to explain both emmetropization and myopic progression is that retinal blur influences ocular growth.[3,4] Emerging optical treatments are starting to show varying levels of success in inhibiting myopia progression. While these treatments include such varied approaches as progressive addition lenses, bifocal eyeglasses, bifocal contact lenses, corneal reshaping, and anti-myopia contact lenses and spectacles, they all presumably alter axial or peripheral hyperopic defocus.

Simultaneous vision bifocal contact lenses have been shown to be quite effective in controlling myopia progression through slowing of axial growth.[5,6] Because such contacts can simultaneously focus images both on and in front of the retina (imposed myopic defocus), it may be possible to utilize them to expose the retina to both in focus images along with images behind the retina (imposed hyperopic defocus). An axially hyperopic eye exposed to hyperopic defocus from an optical zone with less plus power than another optical zone, might be stimulated to grow.

A treatment for axial hyperopia is proposed whereby a simultaneous vision soft contact lens bifocal is prescribed with the distance power reduced from the distance prescription by approximately the power of the near add. The intent of this prescribing strategy is to cause the eyes to preferentially utilize the near zone for both distance and near viewing. If the eyes primarily use the near zone, the distance zone will act like a negative add zone, thus exposing the retina to hyperopic defocus, a presumed trigger to axial elongation in myopia progression.

In this case, a ten year old girl with axial hyperopia was prescribed near center simultaneous vision bifocal contact lenses to test the possibility that axial elongation could be stimulated with an "anti-hyperopia" prescribing strategy.

METHODS

C.R. was ten years old upon presentation for her eye examination. She had a history of high levels of hyperopia and had undergone brief periods of occlusion therapy of the left eye at age 4 and atropine penalization for one year at the age of five. Her habitual prescription was single vision spectacle lenses. Parent and child expressed an interest in contact lenses and after undergoing an informed consent process, they opted to try bifocal soft lenses with an anti-hyperopia prescribing approach.

In addition to standard comprehensive examination procedures including cycloplegic subjective and automated refraction with the Nidek ARK 700, axial lengths were measured with the Zeiss IOL Master. Annual examination have been performed for four years, the first two years of which included two six month periods of bifocal contact lens wear. The final two years were periods during which C.R. only rarely wore single vision reading glasses.

INITIAL REFRACTIVE DATA

Initial Exam

- Presenting UCVA OD 20/25; OS 20/20
- Cover Test @ 6M: +6 (Micro RET); @ .40M +6 (Micro RET) (Habitual Rx)
- Stereopsis: 800″ (Habitual SV Lens); 50″ (+2.00 Add)
- Associated Phoria @ .40M +2.00 Add
- Autorefraction: OD +2.25 - 0.25 X 149
  OS +2.50 - 0.25 X 174
- Cycloplegic AR: OD +3.00 - 0.25 X 160
  (1% Myd X 2): OS +3.00
- Manifest Ref.: OD +2.00 - 0.25 X 85 = 20/25
  OS +2.00 = 20/20
- Cycloplegic Ref. :OD +2.75 - 0.25 X 85 = 20/25
  OS +2.75 = 20/20
- Average Keratometry: OD 43.95; OS 43.95
- Axial Length: OD 22.36; OS 22.26
- Anterior Chamber Depth: OD 3.50; OS 3.54

BCL Prescription

- VA OD: 20/25; OS 20/20; Near OD: 4pt; OS 4pt
- Corrected Near Cover Test +4; Associated Phoria +1.00
- Stereopsis: 60′

End of BCL Wear

- Wore CL 6 mo. , off 6 mo., wore 6 mo., off 6 mo.
- VA w/o OD 20/25; OS 20/20
- Cover Test @ 6M: 6+6 (Micro RET; @ .40M: +4 (M. RET)
- Associated Phoria @ .40M +2.00
- Autorefraction: OD +0.25 - 0.25 X 81
  OS +0.50 - 0.25 X 141
- Manifest Ref.: OD +0.75 - 0.25 X 90 = 20/20-2
  OS +0.75 = 20/20
- Average Keratometry: OD 43.72; OS 43.89
- Axial Length: OD 23.10; OS 23.03
- Axial Length Change: OD 0.74mm; OS 0.77

FINAL REFRACTIVE DATA

- 4 yrs elapsed, first two with 2 six mo periods CL wear, then 2 years no correction
- VA w/o OD 20/25; OS 20/20
- Cover Test @ 6M: +8 (Micro RET); @ .40M +6 (Micro RET)
- Stereopsis: 50″ (Uncorrected);
- Associated Phoria @ .40M +1.00
- Autorefraction: OD +1.00 = 20/20-2
  OS +0.75 - 0.25 X 180 = 20/20
- Cycloplegic AR: OD +1.25 - 0.25 X 163
  (1% Myd X 2): OS +1.25
- Manifest Refraction: OD +0.75 = 20/20-2
  OS +0.75 = 20/20
- Cycloplegic Refraction: OD +0.75 = 20/25
  OS +0.75 = 20/20
- Average Keratometry: OD 43.32; OS 44.09
- Axial Length: OD 23.12; OS 22.98
- Anterior Chamber Depth: OD 3.55; OS 3.56

RESULTS

Changes in refraction

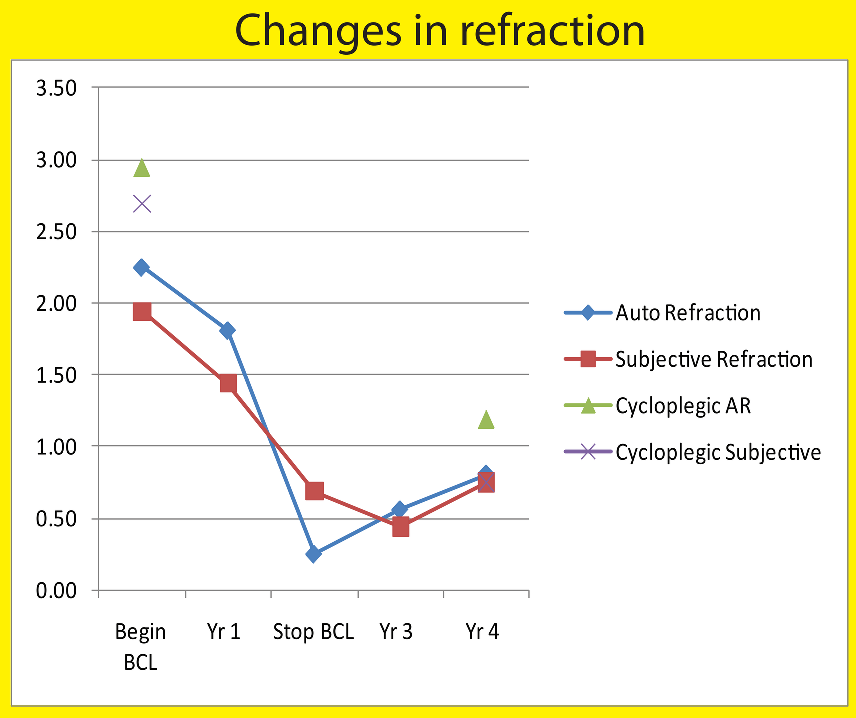

Chart shows changes in manifest and cycloplegic auto and subjective refraction, expressed in spherical equivalent and averaged between the eyes during two years of bifocal contact lens wear and then two years of mainly uncorrected vision.

Changes in Axial Length

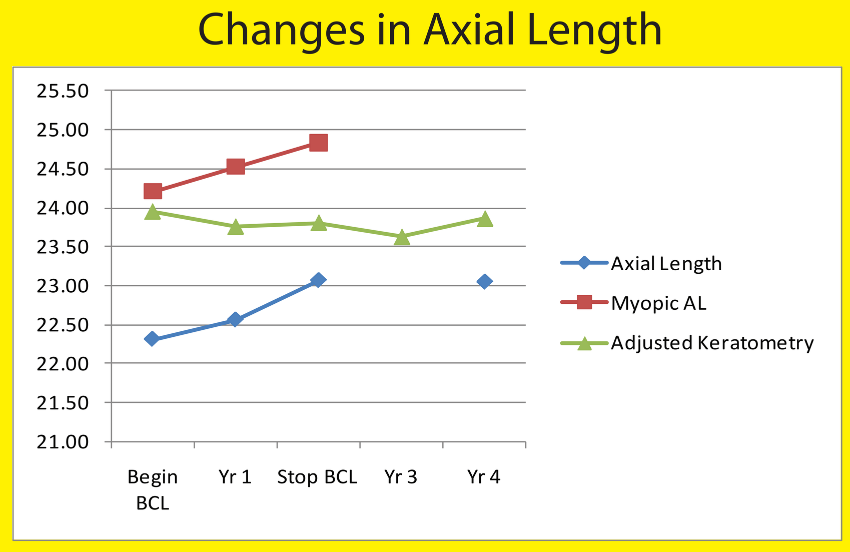

Chart shows changes in axial length from onset of bifocal contact lenses until discontinuation, and then at the end of the study period. Also shown for comparison is two year progression of axial length in single vision wearing children in a myopia progression clinical trial (2nd year extrapolated). Keratometric changes are shown over the four year period on an adjusted scale (-20D).

Change in Hyperopia with and after BCL

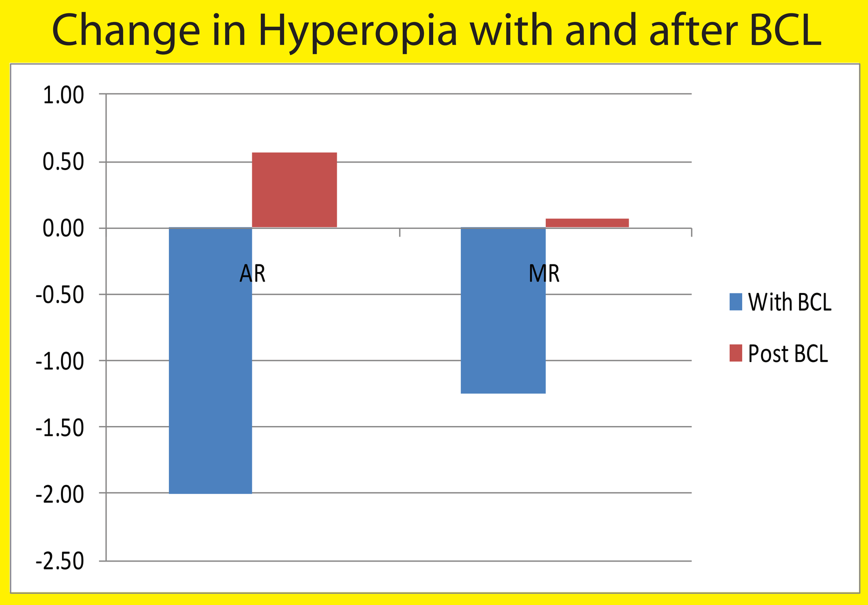

Chart shows change in hyperopia during bifocal contact lens wear and during two years of largely uncorrected vision after discontinuation.

DISCUSSION

This case explores the refractive, keratometric and axial length changes in a 10 year old hyperopic girl wearing bifocal contact lenses prescribed in a manner intended to stimulate axial elongation. As measured by manifest subjective refraction, her reduction in hyperopia was about equivalent in magnitude to the type of refractive changes in progressing myopes of a similar age. Similarly, her axial elongation over two years was quite comparable to the axial elongation reported over two years in children aged 8-13 with high rates of progression in the control group of a recent bifocal eyeglass clinical trial.[7]

While it cannot be said that her refractive changes and axial elongation occurred as a result of the bifocal contact lens, these changes suggest that further research may be warranted. Indeed, a more formal one year double masked randomized trial comparing "anti-hyperopia" bifocal contacts vs standard soft lenses is underway in an identical twin pair. Such a study design should provide a little more evidence pro or con as to the effectiveness of this technique.

The goal of this treatment is to encourage axial elongation to cause a reduction in hyperopia to preferably low levels of hyperopia in the range of +1.00 to Plano. The treatment goals may vary depending on the age of the patient and whether there may be an advantage to avoid approaching too close to myopia.

The method involves starting with a comprehensive eye examination to include a manifest subjective refraction, a cycloplegic refraction, distance and near phorias, fixation disparity measures, axial length, and other biometric measures. A simultaneous vision bifocal contact lens is then prescribed with an initial prescription equal to the manifest spherical equivalent refraction minus the maximum add power that still provides adequate distance and near vision. Yet to be determined is whether there are advantages or disadvantages to distance center or near center lens designs. The patient may use the near add to read, thus easing the accommodative demand. If this is the response, then while reading, the retina would be exposed to peripheral or axial hyperopic defocus from the less plus or more minus distance zone, a presumed trigger to axial elongation. For distance viewing, the patient may choose to use the under-corrected distance portion, thus exposing the eye to myopic defocus from the near zone, though this would require more focusing effort than would be desirable. In this case the myopigenic stimulus present for near work would be counter balanced by the hyperogenic stimulus during distance viewing.

It can be argued that human systems conserve energy, thus to lessen accommodative effort at distance the near add may be utilized and a myopigenic stimulus may be present during distance viewing as well. To encourage this double stimulus to growth, it may be advantageous to prescribe the distance power low enough to encourage use of the near portion for distance and near vision. The method could also include accommodative testing of the individual patient to see which portion is being used, depending on the various powers or with different designs, i.e. distance center vs near center, and thereby the optimal lens design and prescription can be determined to maximize the hyperopia treatment effect. It is worth noting once again that intentional stimulation of axial elongation may not be without some risks, particularly with eyes of normal or longer than average axial length.

This method, should it prove to have the intended effect, could be used selectively at various ages to reduce unwanted hyperopia with the goal of low hyperopia or emmetropia. With the onset of presbyopia, should the patient still be close to emmetropia, monovision could be induced with a contact lens providing myopigenic stimulus. Similarly, should an otherwise progressing myope be adequately stabilized at a low level of myopia using antimyopia contact lenses until the onset of presbyopia, anti-hyperopia or perhaps "pro-nearsightedness" contacts could be prescribed to create the ideal amount of myopia for better reading.. It may one day be possible to think about refractive error modulation with lenses, rather than only using lenses to temporarily correct refractive errors.

To further investigate the principles behind this potential treatment approach, a laboratory research study should be conducted to study the accommodative responses of hyperopic subjects to such lenses prescribed in various manners. Such a study is in the planning stages. Larger scale clinical trials are also being planned, pending the results of the preliminary case studies and the upcoming accommodative response study.

CONCLUSIONS

While it would be inappropriate to conclude anything from a single case report, the refractive and axial length changes in this 10 year old hyperope are consistent with the intended effect of the proposed method. Myopia research in animal models, bifocal contact and ortho-k, and emerging findings from anti-myopia lens studies, suggest that it may be worth continuing to explore the effects of manipulating axial and peripheral defocus to purposely modulate refractive error.

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ACKNOWLEDGEMENTS

Author acknowledges Earl Smith's research as inspiration and the proposed clinical method described here is consistent with principles embodied in his patent US 7,025,460., though he might argue that bifocal contact lenses are not the ideal way to manipulate retinal defocus. Christine Wildsoet has as always offered invaluable advice, and future cool refractive studies may be forthcoming with her. Kimberly Mei Aller helped jazz up the poster for her non-artistic Dad.

Three year longitudinal follow-up data on a clinical trial of the efficacy of multifocal contact lenses for myopia control

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UNSW THE UNIVERSITY OF NEW SOUTH WALES

Purpose

To follow the progress of a clinical trial of the efficacy of multifocal soft contact lenses compared to multifocal spectacle lenses for myopia control.

Introduction

The peripheral blur model of myopia progression suggests that the peripheral retina should be maintained in clear focus or slightly myopic compared to the fovea. As myopic eyes tend to be more prolate in shape, the relatively hyperopic trend in the periphery would require over-plus 'correction' to stabilise the refraction while a minus correction is required for the central myopia.

Multi-focal spectacle lenses have been shown to slightly reduce the progression of myopia, (Leung & Brown 1999, Gwiazda et al 2003). In multifocal spectacle lenses, the plus add is in the lower field only.

Multi-focal contact lenses offer the possibility of a plus add in the whole visual field. Bifocal concentric multizone contact lenses have been shown to reduce the progression of myopia, (Aller 2000, 2008).
A preliminary report of this trial was presented at the previous IMC conference in Cairns (Howell 2008).

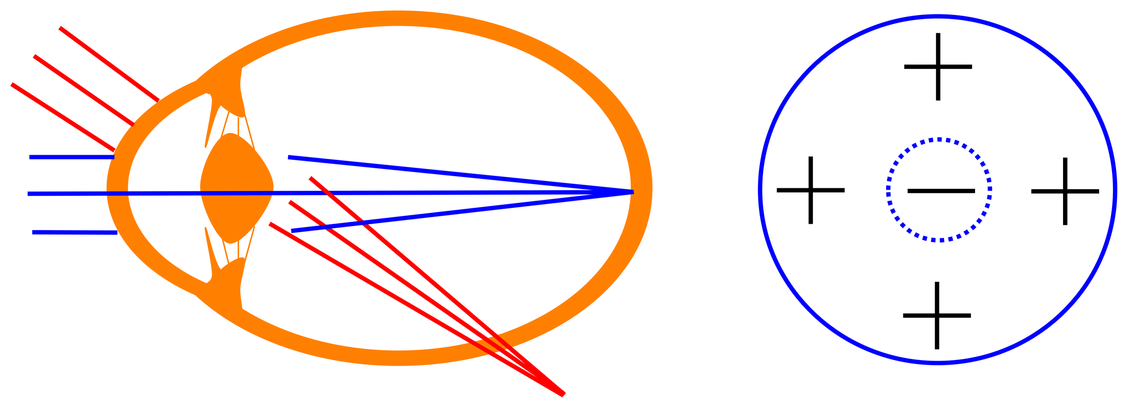


Figure 1. Prolate myopic eye is relatively "hyperopic" in the periphery and requires relative plus in the periphery of a correcting lens

Methods

Progressing myopic children less than 16 years of age wore +1.50 add multifocal spectacle lenses for at least 1 year and then were fitted with distance centre +1.50 add multifocal soft contact lenses. Some of these children have now been followed for greater than 3 years of contact lens wear.

All subjects were private optometric clinic patients.
Refraction was assessed using a free-space autorefractor (Shin-Nippon NVision-K 5001) & subjective minimum minus to optimum acuity.

All subjects were prescribed multi-focal spectacle lenses (+1.50 D add) . All were followed regularly for at least 12 months
Some children showed a decrease in the progression of myopia while wearing multi-focal spectacles & have NOT been included in this study.

Those that were still progressing significantly after at least 12 months were offered contact lenses as an alternative to the spectacles & form the subjects for this study. Each subject acts as their own control for the CL efficacy compared to spectacles.

Multi-focal Spectacles Zeiss/SOLA MC Myopia Control lenses. Short corridor progressive lens +1.50 add

Multi-focal contact lenses. Cooper Proclear 'D' Multifocal disposable daily wear contact lenses. Minus centre / Plus surround +1.50 D

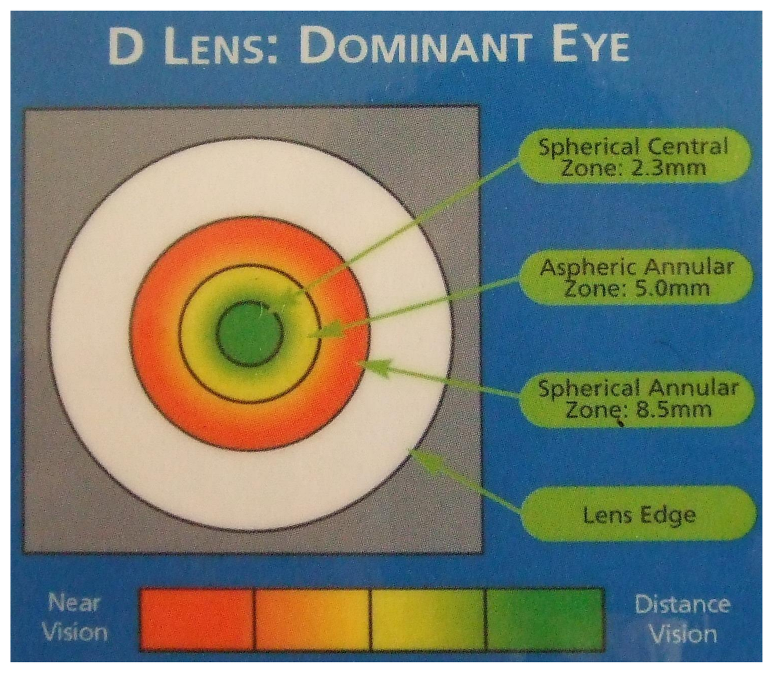
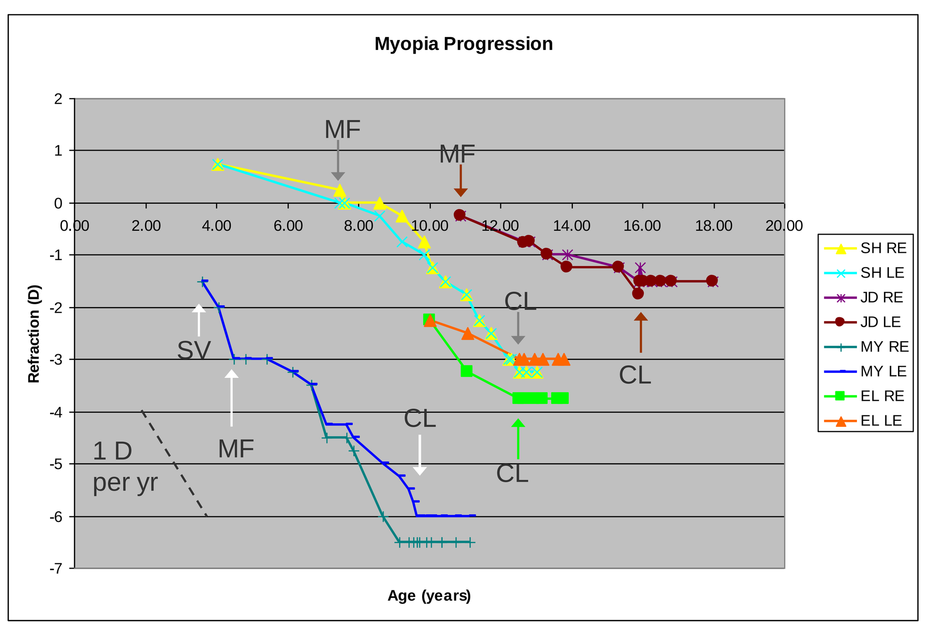


Figure 2. Cooper Proclear "D" Multifocal C/L design.

Results



	Previous 12 months wearing multi-focal glasses +1.50 add	Following 12 months wearing multi-focal C/L +1.50 add	Second 12 months wearing multi-focal C/L	Third 12 months wearing multi-focal C/L
Progression of myopia D / Annum	-0.54 ±0.17 D n=21	-0.18 ±0.2 D n=21	-0.14 ±0.15 D n=16	-0.14 ±0.12 D n=10

$p<0.001$

Conclusions

Distance centre (plus add surround) multifocal soft contact lenses (-0.18 D/annum) would appear to significantly reduce the myopia progression compared to multifocal spectacle lenses (-0.54 D/annum). This contact lens efficacy was maintained over the three years of the current clinical trial. No 'rebound' increase in myopia progression has been observed.

Significantly less progression of myopia with multi-focal contact lenses compared to multi-focal spectacles in the same subject.
(Note: The progression rate of -0.54 D/Annum for MF glasses does not necessarily reflect the 'typical' glasses efficacy as stabilised "successful" MF glasses patients were excluded from this study).

The data is consistent with a model that 'myopic blur' on the whole peripheral retina relative to the fovea is more likely to be refractively stable.

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Commercial Interest

None
No sponsorship.
Respective lens suppliers were not aware of the nature of the clinical trial

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Clinical Performance of Defocus Incorporated Soft Contact (DISC) Lenses for Myopia Control

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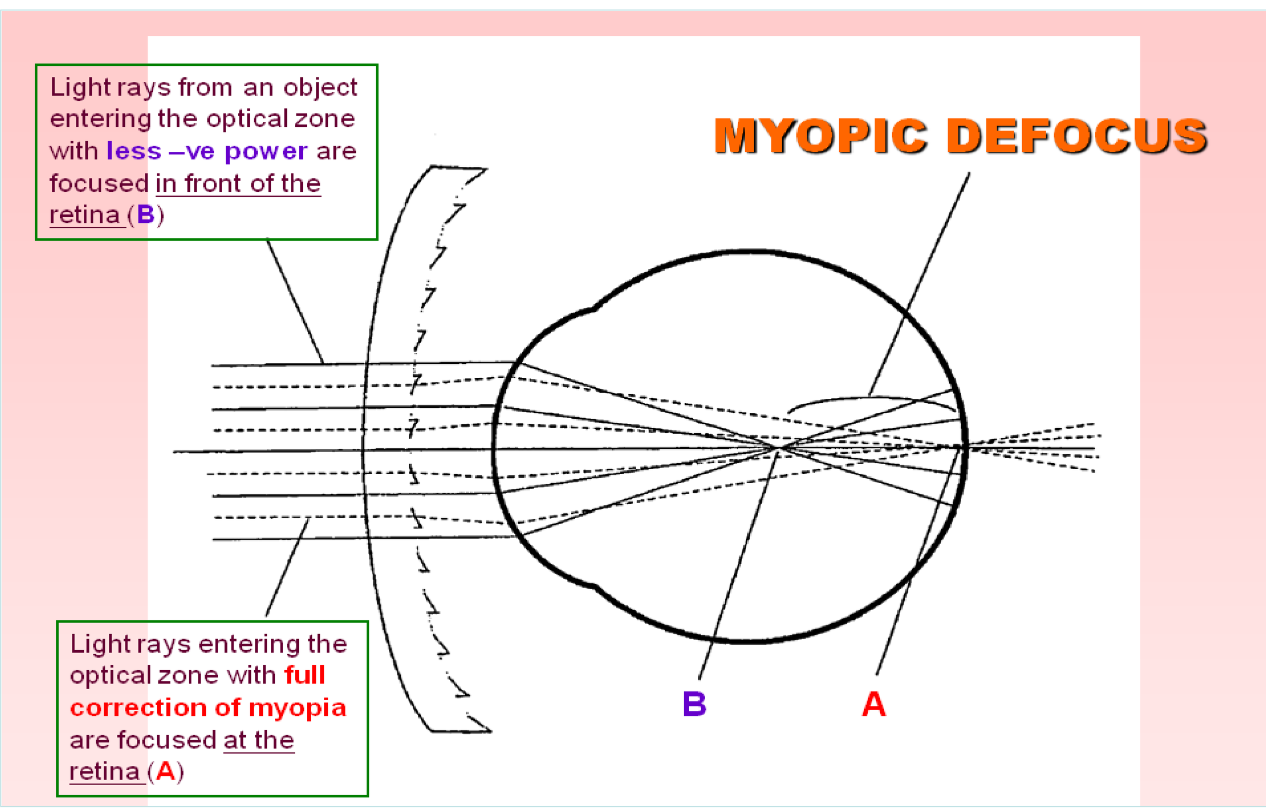
Background

The Defocus Incorporated Soft Contact (DISC) lens is a custom-made multi-zone bifocal (interzone power difference: 2.5D) soft contact lens which simultaneously provides clear vision and defocus at all viewing distances. It comprises of correcting zones for correcting the distant refractive error, and defocusing zones to incorporate constant myopic defocus in order to slow down eye growth and myopia progression.



Purpose

To compare the clinical performance of a specially designed DISC lens with traditional contact lenses.

Methods

Thirty-two myopic (-1 to -5D, with astigmatism less than 1D) Hong Kong Chinese schoolchildren aged between 9 to 15 years were recruited. They were randomly selected from the subject pool of our on-going 'myopia control study' using the DISC lenses. Half of the subjects wore the DISC lenses and the other half wore single vision (SV) contact lenses of the same material. Lens evaluation was performed for each subject after 30 minutes of lens wear. Clinical performance of the lenese was assessed for their right eyes in terms of lens fitting (centration, primary gaze movement, movement with blink, lens tightness)[1,2], physiology parameters (limbal and bulbar redness, corneal and conjunctival staining)[3]. Subjective perception of comfort and vision quality (ratings of grade 1-5) of each subject were also collected. Assessments on visual performance included: distance visual acuities (VA) under different contrasts (100%, 25%, 10% and 5%) in photopic and scotopic conditions, near VA at high contrast and low contrast. Each subject was given a break and then switched to wear the other lens type on the same eye. Measurements were repeated after 30 minutes of lens adaptation. Paired t-test was used for statistical analysis.

Results

Lens fitting performance, physiology parameters and subjective perception of lens comfort were very similar for both lens types (p>0.05). Overall satisfaction of vision with lenses was graded by the subjects on a scale from 1-5 (1-very poor, 2-poor 3- fair; 4-good, 5-excellent). The mean grades for both lens types were good (DISC lens = 4.13, SV lens = 4.81) although some of the subjects reported slightly better vision with SV lenses than the DISC lenses. There was no statistical significant difference between two lens types in high contrast near VA (p = 0.325), but a significant difference was showed in low contrast near VA (p<0.0001) (**Figure 1**). The mean differences of low contrast near VA were 0.07 and 0.1 logMAR units (3 letters to 1 line) under photopic and scotopic conditions respectively. The distance VA of various contrast levels was significantly better for SV lens than the DISC lens under both photopic and scotopic conditions (**Figure 2**).

The mean differences of 10 % and 5% (p <0.0001) low contrast distance VA were 0.09 and 0.16 logMAR units (about 1 to 1.5 lines). However, the mean differences of 100% (p = 0.001 for photopic, p= 0.0002 for scotopic conditions) contrast and 25% (p<0.0001) contrast levels were only 0.03 and 0.04 logMAR units (1.5 to 2 letters) respectively, and this was not likely to be clinically significant.

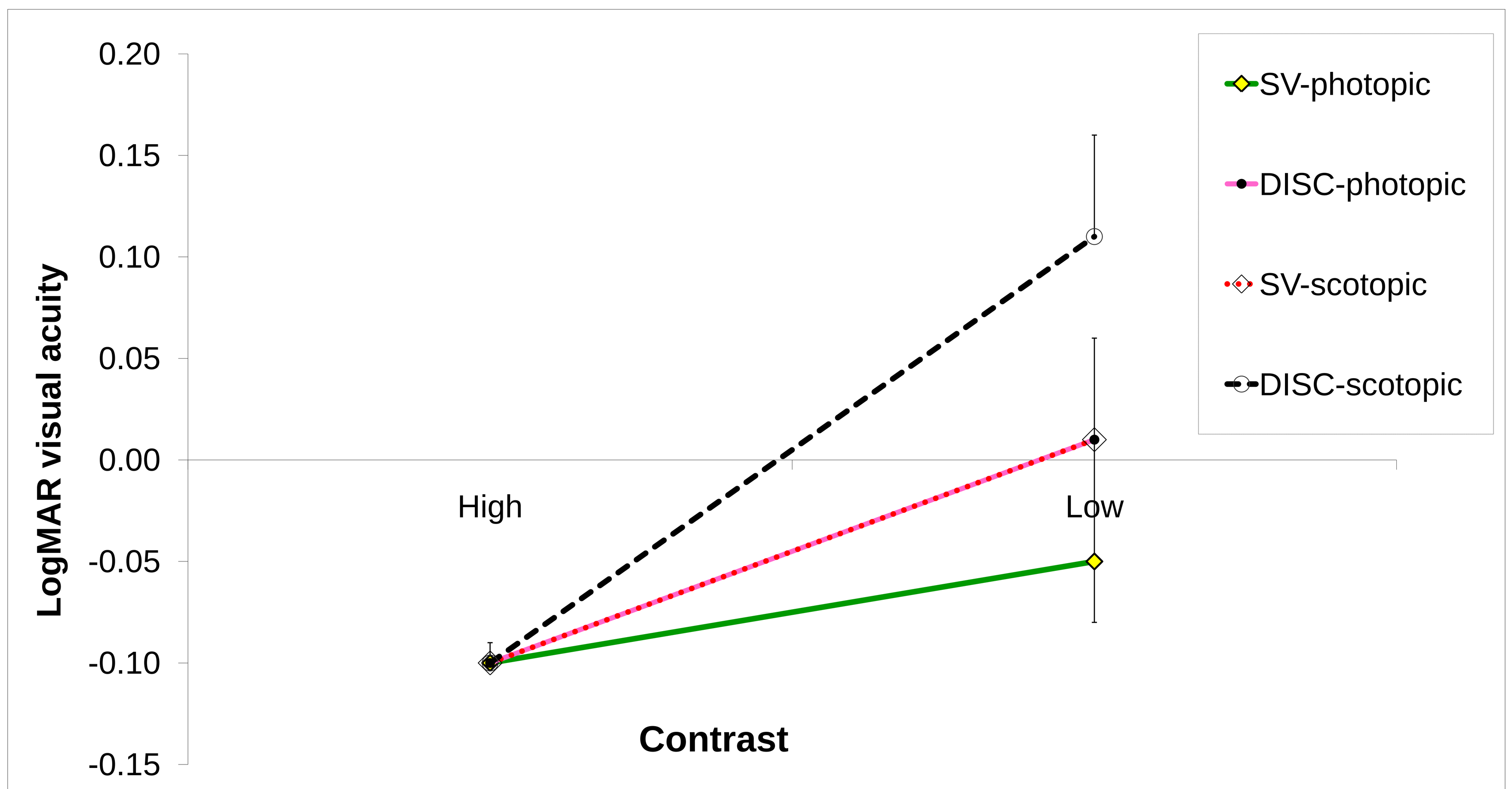


Figure 1. High contrast and low contrast near VA with the SV and the DISC lenses

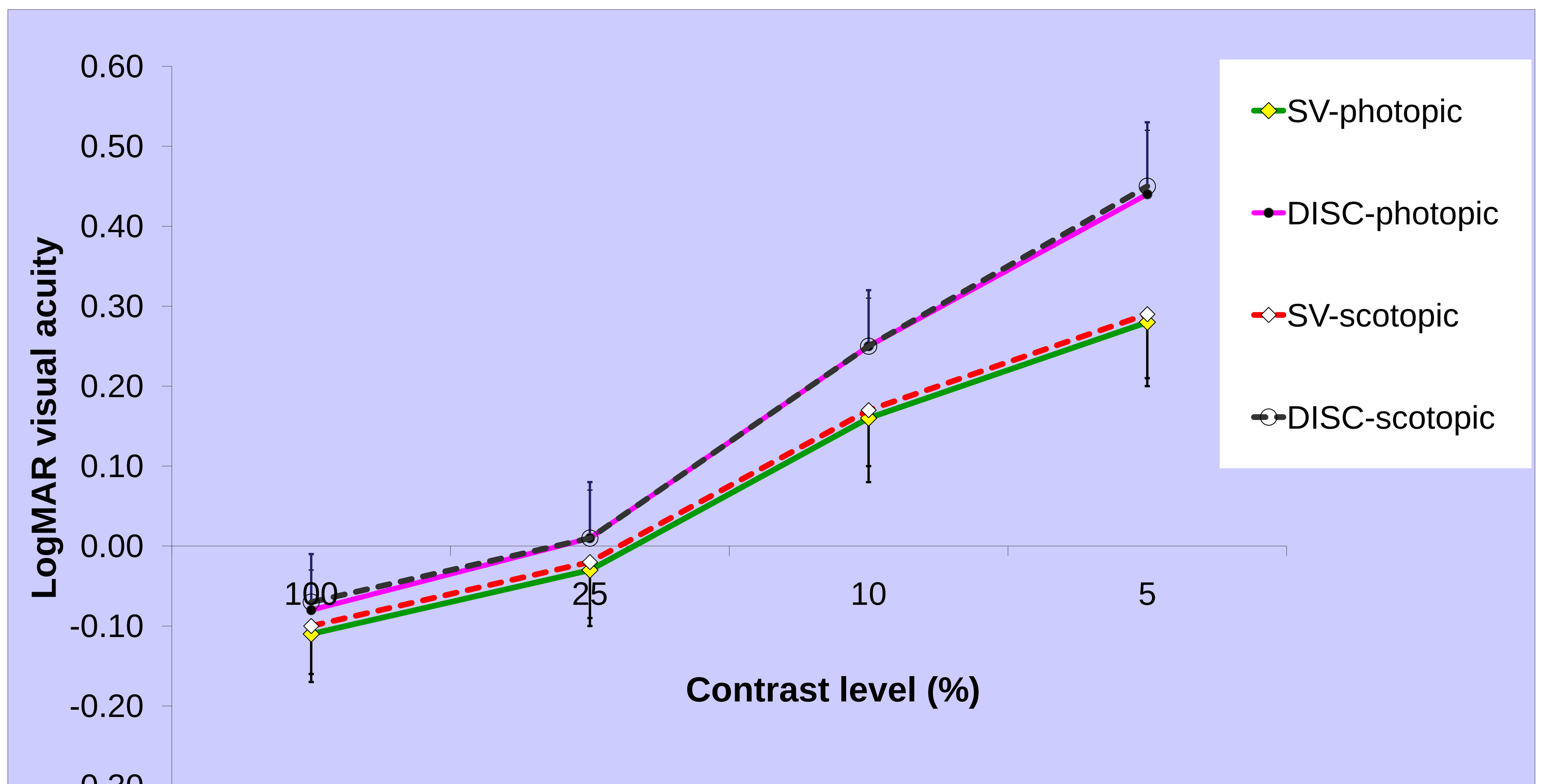


Figure 2. Distance VA with the SV and the DISC lenses under different contrasts

Conclusions

The DISC lens shows similar clinical performance as single vision lens in most aspects except low contrast VA. Overall performance indicates that the DISC lens can be prescribed for schoolchildren.

References

1. Brennan NA, Coles MLC, Ang JHB. An evaluation of silicone-hydrogel lenses worn on a daily wear basis. *Clin Exp Optom*. 2006;89:18-25.
2. Young G. Evaluation of soft contact lens fitting characteristics. *Optom Vis Sci.* 1996;73(4):247-254.
3. Young G, Hunt C, Convey M. Clinical evaluation of factors influencing toric soft contact lens fit. *Optom Vis Sci*. 2002;79(1):11-19.

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A patent 'Method of Optical Treatment' (US patent no. 7506983) was issued on 24 Mar 2009.