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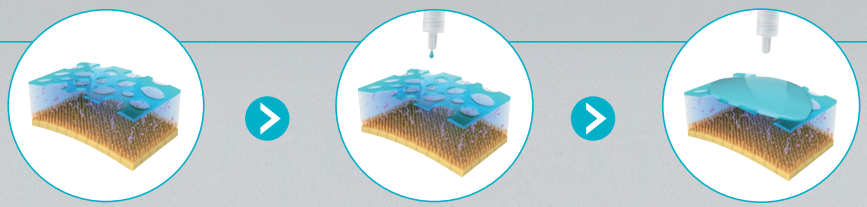

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September 2019 Paediatric eye care and myopia

From the Editors

It would be impossible to produce an issue of *Pharma* with a focus on paediatric optometry without addressing the global epidemic of myopia. Today, childhood myopia is happening more frequently, and earlier, than ever before.

As Ian Morgan explains in this issue, the sudden rise in myopia has led to a deeper understanding of the condition. While genetics likely play a role, the evidence points to environmental factors—low levels of outdoor activities and prolonged engagement in near tasks—as the most likely explanation for the sudden rise in myopia world-wide.

At the same time, excessive screen time has become a pervasive problem among children. As Nicola Anstice and Andrew Collins point out in this issue, approximately 70 per cent of three-to-five-year-olds spend up to 2.5 hours per day viewing electronic devices. The mounting body of evidence is leading more and more people to the conclusion that this is plainly an unhealthy state of affairs.

It's clear that there is a need for a united global commitment to managing child myopia and reducing the growing frequency of high myopia. It is also clear that optometrists are uniquely situated to take the lead in this regard.

Optometrists are best-placed to not only assess, diagnose and treat a variety of paediatric eye health conditions, but are also critical in managing the progression of childhood myopia and minimising its impact on long-term ocular health.

In this issue, a variety of intervention strategies are discussed to help each practising optometrist establish their own approach to paediatric care and to address the growing threat of myopia.

Every paediatric eye exam offers an opportunity to start a conversation with a parent or guardian about these important issues and to develop a partnership with them to mitigate the threats to their children's ocular health.

This issue of Pharma offers 6 (1T) CPD points.

Editor JEFF MEGAHAN
j.megahan@optometry.org.au

Clinical Editor KERRYN HART
BOptom GCertOcTher MPH
Teaching Scholar, Deakin University

Publications Manager JESSICA DONALD

Cover 'Youth optometry' by Lachlan Hessing. Image by Karen Wilson Photography.

Optometry Australia ABN 17 004 622 431
Level 1, 201 Clarendon Street
South Melbourne VIC 3205
Ph 03 9668 8500
www.optometry.org.au

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Digital devices and children's vision

Managing digital eye strain

Dr Nicola S Anstice
PhD BOptom (Hons) Cert Oc Pharm Cert E-learning

Discipline of Optometry and Vision Science, the University of Canberra

School of Optometry and Vision Science, the University of Auckland, New Zealand

Dr Andrew V Collins
BOptom MSc PhD CertOcPharm

School of Optometry and Vision Science, the University of Auckland, New Zealand

Digital eye strain (DES), a condition characterised by ocular and visual discomfort associated with computer and other digital device use, is a growing problem in modern society.[1] While most research has focused on DES in adults, understanding the effects of digital devices on vision in paediatric patients is essential as approximately 70 per cent of three-to-five year-olds regularly use devices and may spend up to 2.5 hours per day viewing electronic screens.[2]

Clinical assessment

Up to 80 per cent of teenagers experience asthenopia associated with electronic displays.[3] Identifying patients with DES begins with taking a thorough history specifically inquiring about the number and type of devices used, as patients who use two or more devices simultaneously are 25 per cent more likely to report symptoms of DES than single-device users.[4] Following the case history, clinicians should employ both subjective and objective measures to diagnose paediatric patients with DES. Appropriate testing protocols are summarised in Table 1.

Ohio State University developed a 10-item questionnaire which has been used in several studies to calculate a total symptom score associated with computer use.[9] The simplified 6-item visual fatigue scale[10] may also be appropriate, particularly when illustrative cartoons are added to help children grade their symptoms more accurately. Clinical assessment should include standard techniques investigating uncorrected refractive error, accommodation and vergence function.

As DES is also associated with external ocular discomfort, a complete dry eye assessment should be undertaken. In a cohort of 288 10–12-year-olds, 10 per cent were classified as having dry eye disease based on questionnaire responses and the presence of at least one objective sign.[11] In this study, smartphone use and increased time on computers were both strongly correlated with dry eye disease. In adults, digital device use reduces blink rate by two-to-five-fold as well as increasing the number of incomplete blinks[1] which may be why there was an increased prevalence of dry eye disease in children using digital devices. Conversely, a follow-up case-control study found that outdoor activity had a protective effect in children at risk of dry eye.[12]

Managing patients suffering from digital eye strain

Management plans should be individually tailored depending on results of refractive, oculomotor and ocular surface examination. Mild to moderate astigmatism (> 0.50-1.00 DC) should be corrected, and large lags of accommodation should be treated.* Prescribing progressive addition lenses to pre-presbyopic adults increased the distance at which digital devices were held but did not improve subjective ratings of visual symptoms after one month of wear.[13] Indiscriminate prescribing of low plus lenses to all digital device users is not appropriate. In a large study of over 1,000 computer users, low hyperopes were over-represented in the asymptomatic cohort, while emmetropes were over-represented in the symptomatic group.[14] Micro-fluctuations in accommodation, caused by respiration and pulse, may be associated with DES and some studies have reported that prescribing coloured or blue light-blocking filters may improve symptomatology by reducing these microfluctuations.[1]

Dry eye disease should be treated with appropriate medical and environmental interventions.[15] As reduced blink rate

Ocular condition	Clinical assessment method	Findings of interest
Symptoms	Validated questionnaire[9,10]	Asthenopia, blurred vision, headaches
Refractive error	Subjective/objective refraction or cyclo-plegic retinoscopy where needed	Small amounts of uncorrected oblique astigmatism[5]
Accommodative response	Push-up method	Insufficient or ill-sustained accommoda-tion.*
Accommodative lag	Dynamic retinoscopy	Higher lags[4]*
Convergence	Near point of convergence and hetero-phoria at required working distance(s)	Eso-deviations[6]*
Associated heterophoria	Mallett unit	Small associated phorias protective[7]
Dry eye	DEWS II diagnostic assessment protocol[8]	Incomplete blinking

Table 1. Tests that should be included in optometric assessments for children using digital devices
*See 'Paediatric Guidelines' tables on pages 14 and 15 of this issue of *Pharma*.

and partial blinks are particularly problematic in digital device users,[16] computer applications which encourage more frequent blinking through visual and auditory prompts have been investigated. Although these increase blink rate, they do not reduce the DES symptom score.[1] This may be because a significant number of partial blinks were still occurring. Therefore, blink efficiency exercises, whereby patients practice 24 full and complete 'light' blinks in a 30 second period several times a day, may be more useful.

Digital devices and the development of myopia in children

Two recent studies have investigated links between device use and myopiagenic risk factors with contrasting findings. The Ireland Eye Study (IES) found myopia prevalence increased with increased screen time (more than three hours) particularly in 6–7-year-old children.[17] Overall, using digital devices for more than three hours per day was associated with a nearly four-fold increased prevalence of myopia. Conversely, the large Rotterdam Generation R Study found that while increased time watching television was associated with a slightly increased risk of developing myopia, computer use was not.[18]

One potential mechanism by which device use might be myopiagenic is that screen light produced by digital devices may alter both ocular and systemic circadian rhythms, which has been shown to be important in the control of refractive development and eye growth in animal models.[19,20] Additionally, increased screen time may result in more time spent on near work, a more sedentary lifestyle and reduced participation in sports and other outdoor activities, contributing to myopia development.

Digital devices, sleep patterns and blue light

Nearly three-quarters of Australian teenagers are using digital devices from 5:00pm to 10:00pm and 28 per cent between 10:00pm and midnight.[21] Recent systematic reviews have found strong associations between increased screen time and delayed bedtimes, shorter sleep duration and reduced sleep quality among children and adolescents.[22,23] The spectral composition of light emitted from many digital devices is enriched for short-wavelengths which can suppress overnight melatonin levels,[24] altering the circadian rhythm and contributing to hyper-arousal and decreased sleepiness at bedtime.[25]

There has been limited scientific attention paid to short wavelength blocking spectacle lenses, although some studies have claimed that these lenses improve sleep quality for night-time digital device users who suffer from insomnia and reduce visual fatigue while using computers.[26] There was no clear evidence supporting the use of blue blocking spectacle lenses for treating patients with DES.[27]

In summary, digital eye strain is common in children, and optometrists should evaluate children, even as young as three years old, for signs and symptoms of DES. There is currently a lack of high-quality evidence for prescribing progressive addition or low plus lenses in children using digital device. However appropriate correction of even small amounts of ametropia, management of accommodative and binocular vision problems, and treatment of dry eye disease are crucial. It is currently unclear whether digital device use is associated with increased myopia prevalence and, if it is, whether this is due to altered circadian rhythms or the adoption of a more sedentary lifestyle. Finally, as exposure to blue wavelength light at night disrupts sleep patterns, there is some data to support prescribing blue wavelength filtering lenses to paediatric patients who use digital devices at night.

* See 'Paediatric Guidelines' tables on pages 14 and 15 of this issue of *Pharma*.

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CLINICAL AND EXPERIMENTAL OPTOMETRY

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Lisa Donaldson
BSc (Hons) MCOptom

Dr Ahalya Subramanian
PhD BSc MCOptom

Dr Miriam L Conway
PhD BSc (Hons) Orthoptics

University of London, London, UK

Eye care in young children: a parent survey exploring access and barriers

Summary and comment provided by Maria Markoulli
PhD MOptom GradCertOcTher FBCLA FAAO
Deputy Editor, *Clinical and Experimental Optometry*

Senior Lecturer Postgraduate Research Coordinator
School of Optometry and Vision Science, UNSW Sydney

Most optometrists in clinical practice will spend some of their day examining the eyes of young children and educating both the children and their parents as to the importance of a regular eye examination. According to the Optometry Australia website, one in five Australian children either suffer from an undetected vision problem or require ongoing assessment. With that in mind, it is recommended that children have a full eye examination before starting school and 'regularly' as they proceed through the education system. Excellent guidelines are provided on Optometry Australia's webpage for optometrists[1] and for parents.

One of the challenges to ensuring that all children are examined early to prevent the consequences of undiagnosed hyperopia, strabismus and ocular disease, is the necessary reliance on their parents or guardians to seek out eye care. Some barriers to this have been reported cost, lack of time and lack of cooperation from family members in arranging appointments.[2]

In order to provide a greater understanding of the barriers that prevent parents from seeking eye care for their children, Donaldson et al designed a questionnaire that aimed to explore parental knowledge and attitude with regards to eye care for their young children.

The authors distributed 1,317 hard-copy questionnaires and 90 online questionnaires to the parents of children aged four to six years; 384 questionnaires were returned. All questionnaires were completed anonymously. The questionnaires sought to understand parental attitudes to accessing eye care and whether these beliefs and barriers were influenced by demographic factors such as ethnicity, parental income, parental education, confidence in speaking English and a family history of eye problems.

Of all the responses received by the authors, 65 per cent were from parents whose children attended a school where vision screening already took place. Interestingly, of these, only 15 per cent were aware that their children had their vision screened within the school. Barriers were identified by 38 per cent of respondents and included not knowing how to access an eye exam, a fear of their child being prescribed glasses unnecessarily or that any glasses prescribed would 'weaken' the child's eyes and a belief that the child was too young to have an eye test. The most significant demographic factor that played a role in being likely to report barriers to eye care was ethnicity. When compared to parents from white ethnic groups, parents from African/Afro-Caribbean ethnic groups were more likely to report not knowing how to access an age-appropriate eye test for their child. Parents of African/Afro-Caribbean ethnic origins were also statistically more likely to report barriers to eye care.

Identified reasons to consider seeking an eye test included having concerns about poor vision, being advised by a health care provider or a teacher to seek eye care and vision complaints from the child. Family history also played a role.

The authors of this study suggest that improved communication with parents regarding the need for eye care is clearly needed, as well as improved communication of the results of vision screening exams at school.

While this study was conducted in the UK, the results are applicable to Australia. The findings that certain ethnicities are less likely to access eye care is supported by other studies that show a similar result in health care.[2] Donaldson et al. suggest that these barriers need to be addressed by improving accessibility to services, particularly to minority ethnic groups.

In general, the outcomes of this study indicate the need for better parental education regarding the timely detection and intervention of childhood eye conditions.

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Moving away from single-vision glasses

Better ways of correcting childhood myopia

Philip Cheng
BOptom, Ocular Therapeutics (GCOT)

Optometrist
Eyecare Concepts Melbourne

As single-vision lenses image light along a relatively uniform plane, focused at the fovea for best central vision, peripheral light is focused behind the retina, particularly as the eye becomes increasingly oblong-shaped with higher levels of myopia and axial elongation. This phenomenon is known as relative peripheral hyperopic defocus.

It has emerged through scientific research that one of the driving forces of eye elongation in myopia may be signals originating from the peripheral areas of the retina, and that relative peripheral hyperopic defocus plays an important role in influencing the growth of the eye.[1]

We now know that every dioptre of myopia progression increases the lifelong risks of developing serious sight-threatening complications,[2] such as myopic maculopathy, retinal detachment and glaucoma. The risk of visual impairment with myopia increases exponentially with increase in axial length. An axial length of 26 mm corresponds to a lifetime risk of vision loss of 25 per cent, increasing to 90 per cent for axial length of greater than 30 mm.[3]

Practitioners should consider myopia as a progressive condition rather than a simple refractive error. Just as we manage other ocular conditions with potential for progression and visual impairment—such as ocular hypertension, glaucoma and macular degeneration—we have a duty of care to our paediatric patients to inform them, and their parents, of the potential progression of their myopia, the ocular health risks associated with higher levels of myopia, and the options available to treat and slow the progression of this condition.

Optometrists now have the tools to manage our young progressive myopes in an evidence-based manner. Orthokeratology (OK), multifocal soft contact lenses (MFSCLs), multifocal or bifocal spectacle lenses and atropine treatment have all been shown to reduce myopia progression by varying degrees.[4]

OK and MFSCLs are beneficial in reducing myopia progression in terms of refractive error change as well as axial elongation.[5-6] 0.01% atropine showed promise in slowing progression in the ATOM2 study,[7] but the recent Low-Dose Atropine for Myopia Progression Study (LAMP) demonstrated a lesser effect in slowing axial elongation.[8] While the therapeutic effect of atropine is dosage-dependent,[8] higher doses are associated with greater side-effects[9] and rebound effect when treatment is ceased.[10] Multifocal and bifocal glasses can be effective in a sub-group of myopes with binocular vision issues at near.[11-12]

In Australia, we now have several options of MFSCLs for myopia management, including CooperVision MiSight 1 Day, Visioneering Technologies NaturalVue Multifocal 1 Day and mark'ennovy Mylo monthly disposable lenses.

Each of these lenses feature different optical designs but the general principle is to provide clear distance vision in the form of a centre-distance multifocal design and relative plus in the mid-periphery to reduce hyperopic defocus in the peripheral retina, thereby modulating eye growth. In the literature, MFSCLs have shown greater control of myopia progression and axial elongation compared with single-vision spectacle lenses.[6,13-14]

CASE REPORT

EN, a seven-year-old Asian female, was referred for myopia management in October 2018. One year prior she had 6/6 unaided vision in both eyes. She was first diagnosed with myopia in June 2018, with a refraction of -0.50 D in each eye. A three-month review revealed her myopia had progressed to RE -1.00 D LE -1.25 D. She had a strong family history of myopia; her mother a high myope of -9.00 D and her father at -2.00 D.

EN's refractive error was confirmed with cycloplegic refraction. She had a mild accommodative lag (MEM +1.25) and a normal near exophoria of 2 PD. Her axial lengths measured RE 23.97 mm LE 23.93 mm with optical biometry using the Zeiss IOL Master.

At just seven years of age, with rapid progression and a strong family history, EN fits the profile of high-risk, fast progressor. Her mother was keen to slow the progression of her daughter's myopia and had heard about orthokeratology. However, EN was a little scared about the prospect of wearing contact lenses.

A decision was made with EN and her mother to start on MFSCLs, for several reasons. Soft lenses are more comfortable to wear than OK, at least in the beginning for a sensitive child. With her relatively low myopia, MFSCLs provide a more precise and consistent correction than OK, without the inherent over-correction factor involved in OK lens fitting.

EN agreed to trial MFSCLs. Her mother, an experienced contact lens wearer, took the daily responsibility of lens insertion and removal. A trial of both MiSight 1 Day and NaturalVue

Multifocal 1 Day was completed, with the patient favouring the NaturalVue for visual clarity at her review. Assessment of both lenses on eye showed better lens centration with the NaturalVue lens in this particular case (Figure 1).

EN returned for her myopia review in March 2019, very happy about wearing her contact lenses. Cycloplegic refraction was RE -1.50 D LE -1.75 D, and axial length measurements RE 24.07 mm LE 24.05 mm. While still early in the treatment process, her current results suggest a slowing of her progression from greater than -2.00 D per year to -1.25 D per year.

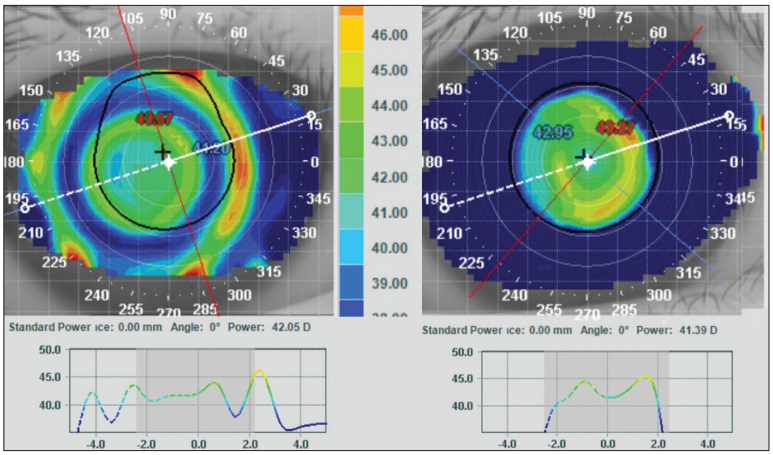

Figure 1. Corneal topography of lens-on-eye is helpful for assessing the fitting and centration of MFSCLs. For patient EN, MiSight 1 Day (left) demonstrated a slight lateral decentration compared to NaturalVue Multifocal 1 Day (right).

Discussion

The arrival of new contact lens technologies that effectively reduce the progression of childhood myopia means practitioners now should ask the question of whether the traditional method of correcting myopia, with single-vision distance glasses, is still an appropriate way of managing a child with progressive myopia.

OK and MFSCLs are both excellent options for progressive myopes. With diligent lens care, hygiene compliance, proper lens fitting and regular reviews, OK is a safe option for children,[15] although daily-disposable soft lenses remain the lowest-risk contact lens modality.[16]

As younger myopic children are at higher risk of progression,[17] a discussion about myopia management should take place at the earliest opportunity. Even young children, with assistance and supervision from their parents, can wear OK and MFSCLs safely and successfully.

Aside from the benefit of slowing progression, children who wear contact lenses can enjoy the freedom of participating in sports and physical activities without the inconvenience of wearing glasses. Indeed, there are intangible benefits of increased self-esteem and confidence that come from contact lens wear.[18]

MFSCLs for myopia management are relatively easy to fit, provide instant clear distance vision, do not require additional diagnostic equipment, take less chair time than OK, and now more lens designs are available to fit a wider range of eyes and prescriptions.

Assessment of lens centration with a corneal topographer is helpful, but not essential. Lens decentration, which affects visual performance, can also be assessed with careful retinoscopy.

Patient selection is an important part of achieving satisfactory results with MFSCLs – low amounts of astigmatism for good vision and a stable tear film for comfortable day-time lens wear are ideal characteristics. Children are generally more tolerant than adults of the different quality of vision experienced through the optics of MFSCLs.

For OK practitioners, MFSCLs provide an alternative for cases where OK might not be the best option. This may be a patient who is intolerant to wearing a rigid lens, or a patient whose corneal topography is not suitable for OK; those with flat corneas and/or high myopia where OK is unable to provide full myopic correction to be glasses-free may prefer MFSCLs from a vision and convenience point-of-view. MFSCLs can also serve as a preparatory step towards OK wear for some children.

Axial length measurement is a valid and convenient method of monitoring myopia progression, and helpful for evaluating risk of myopia pathology.[19] But for the majority of practices without access to optical biometry, it is easier to assess refractive change for patients wearing MFSCLs than for OK wearers who require a two to three-week washout period before their refraction can be accurately remeasured.

As eye-care practitioners, we have a professional and ethical responsibility to our patients to do our best for their long-term eye health. Although there is still much to learn about myopia, and there is not one treatment that guarantees success for every child, we are fortunate to have a range of evidence-based options to offer to our patients. By slowing myopia progression by just one dioptre we can reduce the lifetime risk of a patient developing myopic maculopathy by 40 per cent.[2]

It is time to consider myopia management in a similar way to how we view glaucoma management. As with today's glaucoma treatment options that include eye drops, laser treatment and surgical procedures, each with benefits and risks and treatment effectiveness that vary between patients, so are treatments for myopia management. A myopia management plan should be tailored to the individual needs and progression risk profile of the child, and adaptive to change as needed to achieve optimal myopia progression control.

Let's start by moving away from the outdated band-aid solution of correcting childhood myopia with single-vision glasses. The young patient in your chair deserves better.

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Moving away

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Myopia control with dual

David Foresto
BApSc(Optom) Grad Cert Ocular Therapeutics

Principal Optometrist
Foresto EyeQ Optometrists

Lecturer and Clinical Supervisor
Queensland University of Technology

The practice of myopia control is a growing element of optometry and an important public health measure. If there is no alteration in current trajectory, it is estimated that by 2050 more than 50 per cent of the world's population will have myopia and 10 per cent will have high myopia (5 dioptres or more).[1]

High myopia is associated with pathologies including retinal detachment, glaucoma, cataracts and myopic macular degeneration.[1,2] For these reasons, the clinical care of myopia must not be limited to correction of refractive error, but also to employing known strategies to reduce myopic progression.

Therapies which are known to have an impact on reducing myopic progression include orthokeratology, dual focus soft contact lenses, multifocal soft contact lenses, atropine, pirenzepine and multifocal spectacle lenses.[3,4,5,6]

CooperVision's MiSight 1 day product is a dual focus, daily disposable hydrogel contact lens, which incorporates four alternating distance and near zones in a concentric ring design. Dual focus soft contact lenses have been reported to reduce myopic progression by 25–79 per cent.[4]

CASE REPORT

A 9-year-old girl of Asian ethnicity presented for assessment with concerns that her distance vision had deteriorated substantially in the six months since having her spectacles updated with her previous optometrist. She had a history of three years of spectacle wear and a family history of high myopia, including her mother being approximately 10.00 D myopic. She had no previous history of other ocular pathology and her general health was good.

Presenting spectacle correction was R -4.25/-0.50x55 and L -4.00/-0.75x154 and her cycloplegic refraction and acuities were: R -5.00/-0.25x55 (6/6) and L -5.00DS (6/6).

Binocular vision assessment showed results within normal limits and ocular health assessment showed no other pathology.

The available myopia control options were discussed with the patient and her mother. A recommendation was made to proceed with soft dual focus contact lenses. The reasons for this recommendation included

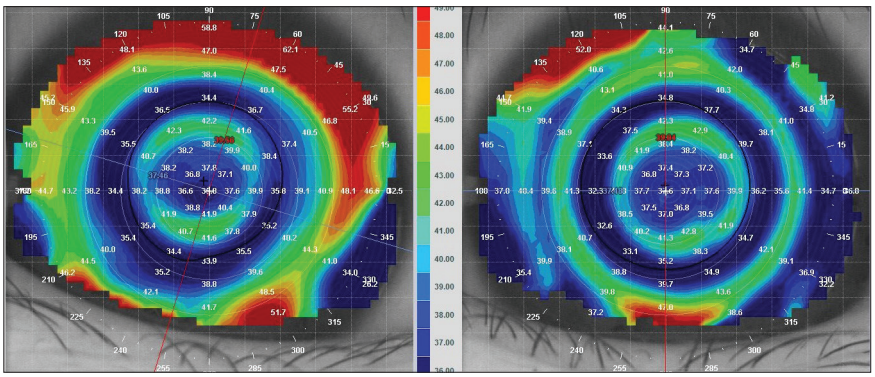

Figure 1. Topography scans of the lenses on eye showing appropriate centration

focus soft contact lenses

A new, effective and repeatable approach

the patient's parents feeling more comfortable with daily wear soft lenses than overnight orthokeratology lenses, given their own use of soft lenses. The patient was fitted with CooperVision MiSight 1 day contact lenses.

Slitlamp assessment showed that the lenses were fitting suitably and corneal topography over the contact lenses verified appropriate centration of the annular optic zones in the primary gaze position (Figure 1).

Three monthly follow-up appointments were maintained for the next three years (Figure 2). The patient demonstrated 0.75 D of progression in her right eye and 1.00 D in the left eye throughout the duration of the follow-up period. This progression was equivalent to that exhibited in the six months immediately prior to the commencement of myopia control therapy. The final 20 months of the follow-up period showed nil change in refractive error.

Discussion

With the currently available body of literature supporting the efficacy of various myopia control therapies, as well as with the understanding of the relationship between high myopia and serious ocular pathology, eye-care practitioners should feel compelled to offer myopia control treatment as a routine part of the care of myopic patients.

It is hoped that cases such as this one will become rarer as myopia control is practised more widely. In order to limit the progression and associated lifetime ocular pathology risks as much as possible, effective intervention should begin early.

In the process of deciding whether to implement myopia control, the practitioner should assess not just the level of myopia but also that patient's risk of further progression. It should also be noted that some level of progression even with treatment is to be expected and parents and children should be educated about this accordingly.

Appropriate centration

It is currently hypothesised that the reduction in myopic progression seen with dual focus soft contact lenses is a result of inducing peripheral myopic defocus. For this reason, as well as for reasons of visual quality, optometrists should take efforts to ensure these lenses are fitted with appropriate centration.

In this case a topographer was used over the lenses on the eyes, however it should also be noted that the annular zones are generally distinguishable with retinoscopy in very low room illumination. If a topographer is used, the optometrist should avoid physically retracting the patient's lids, or asking the patient to do likewise, as this may not give a realistic assessment of the lens centration with the eyelids in their habitual state.

In the author's experience, fitting children with soft dual focus contact lenses for myopia control requires very little additional chair time compared to fitting soft disposable contact lenses to an adult. Most children are able to safely insert and remove their own lenses with appropriate training. It is also worth noting that the child in this case study has found wearing contact lenses to be a positive experience, as is often the case.

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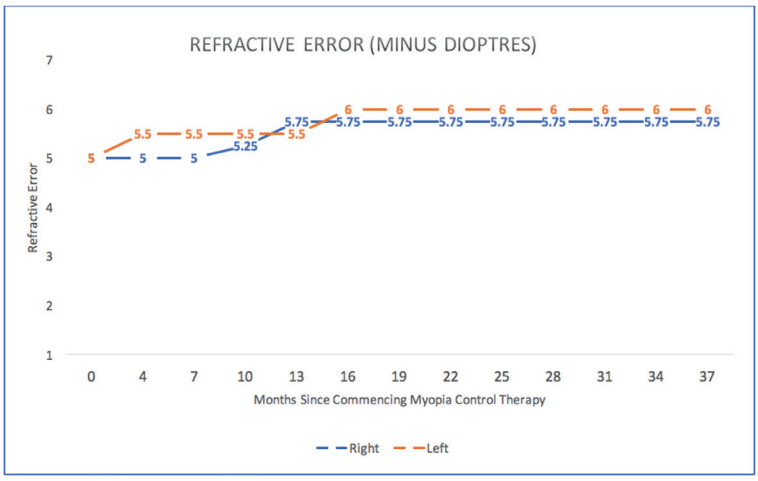

Figure 2. Level of refractive error versus time since commencing myopia control treatment

The changing landscape of

Optometry's role in

Professor Padmaja Sankaridurg
BOptom MIP PhD

Conjoint Professor, School of Optometry and Vision Science, UNSW

Head of Myopia
Brien Holden Vision Institute

As almost all practising optometrists know, we are in the grips of a global myopia epidemic. The number of children affected by myopia is increasing around the world; these climbing numbers mean that cases of high myopia are also increasing and that we will soon face the consequences of the numerous ocular complications associated with it.

Pharma's Clinical Editor Kerryn Hart recently conducted an interview with Professor Padmaja Sankaridurg, the Head of Myopia at the Brien Holden Vision Institute. As one of the world's leading myopia researchers, Professor Sankaridurg has been on the forefront of the rapidly-changing landscape of myopia management. As she points out, there are a range of strategies to manage myopia, and optometrists are uniquely positioned to treat and detect the condition.

KH: Why is myopia the 'big topic' right now? Phrases like 'myopia epidemic' are frequently used – are things genuinely that dire? And if so, what should optometrists do to prepare?

PS: The evidence is clear on the rising prevalence of myopia. In many urban cities of East and South East Asian countries such as Singapore, Hong Kong, Taiwan and China, approximately 50 per cent or more of 10-year-old children are myopic.[1] Although the prevalence elsewhere in the world is not as high, the evidence indicates rising prevalence. Overall, the condition is widespread affecting approximately one in three to four people, and is expected to rise to affect one in two people by the year 2050; therefore references to 'epidemic' or 'myopia epidemic' are probably justified.[2]

If these estimates for the future eventuate, and if we do not implement appropriate measures now, the situation can get dire. As the current population ages, and more of the younger generation present with myopia, optometrists are not only likely to see more myopes than before in their practice, but they will also need to deal with an increasing number of complications associated with high myopia such as retinal detachment, myopic maculopathy and glaucoma.

Also, myopia management has evolved significantly in the past decade with many strategies available in clinical practice. Being aware of the problem and keeping themselves abreast of the evidence with respect to myopia management will help optometrists choose and employ the appropriate strategy to cater to the individual.

KH: Myopia control is a relatively new field of research. Is there reliable evidence to suggest all optometrists should be doing this?

PS: Although mechanisms to slow progression of myopia have been studied for years, especially over the last decade, there has been a tremendous surge in research and interest from all quarters—researchers, practitioners and community—for ways and methods to slow myopia. Already, this activity has translated to a number of products (spectacles, contact lenses and pharmaceuticals) specifically designed to slow myopia. Although there is room to improve on the efficacy obtained with certain myopia control strategies, and in determining which strategy is appropriate for a given individual, the evidence is irrefutable: it is possible to delay and slow the progression of myopia.

KH: Is there a 'golden' age where all children should be tested for myopia and other eye conditions?

PS: Myopia typically onsets anywhere from six years onwards and is generally observed anywhere from six to 13 years of age. Having said that, in many Asian countries, myopia is increasingly seen in younger ages with some presenting at four years of age.[1] Although not entirely clear, there is some evidence linking the onset to an early start of education.[3] Considering the above, it is preferable that children are assessed prior to starting school at approximately four to five years of age to ensure that there is no vision impairment, the child is not at an increased risk for certain eye conditions, including myopia, and that the eye health is normal. This will also provide an opportunity to engage and educate the family unit on appropriate visual practices (screen time, outdoor time) for maintaining good visual health and to impress on the need for regular visits to ensure normal eye health.

KH: Are there any barriers to optometrists undertaking myopia control (for example: some don't fit orthokeratology and others aren't therapeutically qualified), and how can they overcome these barriers?

PS: As stated previously, and as outlined in the report on Interventions for Controlling Myopia Onset and Progression,[4] multiple avenues and strategies are available and could be adopted by all optometrists to better manage myopia. For example, the report outlined evidence that indicated undercorrection is not effective. Although environmental strategies such as improved time outdoors showed efficacy in reducing onset but not progression, adoption of the strategy has positive benefits to both visual and general health and can be advocated by all optometrists. Furthermore, there are a number of spectacle lens based strategies (and more added since the publication of the report[5]) that are available. And

myopia management

reversing the alarming trends

depending on the motivation of the user and the requirements, other select treatments such as contact lenses and pharmacological treatments can be applied when needed.

Given the range of options available, it is possible for the optometrist to choose options that suit the circumstance—for example, parents may be interested in starting their child in a spectacle lens and may progress to contact lenses or orthokeratology when the child is older.

KH: What are some of the important considerations when deciding between intervention or non-intervention for our young patients?

PS: As the evidence grows for controlling myopia, non-intervention is likely to be less of an option for managing myopia. At a minimum, optimum correction of refractive error is a must. Lack of sharp and clear vision in children may have behavioural and social implications and is not recommended.

With respect to deciding interventions, although there are a number of strategies that are effective, deciding on a particular strategy is based on a number of factors such as availability of the intervention, experience of the practitioner, motivation of the individual and/or their carers, as well as age, cost, care, the ability of the patient to attend required after-care visits and so on. For example, if a child is suitable for wearing contact lens but they have busy parents who are unable to monitor the child closely and are not able to attend the necessary visits, then one would need to evaluate the situation and decide if contact lenses should be prescribed.

KH: Is there any added benefit to using two of the more successful myopia control strategies, that is: orthokeratology and low-dose atropine?

PS: Recently there have been a few studies that have considered combination strategy to improve efficacy with some initial results but further evidence is needed to determine if the solutions are effective.[6,7] The rationale underlying these strategies are manifold: the combination could work synergistically (for example, pharmaceutical combinations); they may effect eye growth utilising different pathways (for example, optical defocus combined with atropine which possibly affects the ocular tissues) and thus providing for a greater effect; or the compliance and/or dosing may be more effective in a combination (for example, atropine through contact lenses) resulting in a greater benefit. As with all strategies, the risks versus benefits should be given due consideration prior to application in practice.

KH: Can you think of any examples of where myopia control has made a huge difference to a patient?

PS: Remember that the goal of myopia control is benefit in the long run. The strategy is somewhat similar to obesity or diabetes management. Preventing the onset of myopia—or in eyes that are already myopic—keeping it in check at low levels will reduce the burden, life time costs, risks of complications and vision impairment in adult life.

Interestingly, in my recent conversation with an ophthalmologist in Vietnam who specialises in refractive surgery, they mentioned that they are increasingly having to refuse surgery for cases that present with high myopia where the outcome is uncertain and the eyes are at a higher risk of additional complications. Similarly, orthokeratology cannot be performed for myopia over a certain magnitude. Appropriate myopia control at a young age would keep the progression at check and not only provide the young adult with suitable alternatives but will help reduce the risk of complications in adult life.

KH: If you could give one piece of advice to an optometrist thinking about introducing myopia control to their practice, what would it be?

PS: Managing a child with myopia is the best place to start being an advocate for eye health. The relationship is rewarding for both practitioner and patient, the evidence predicts a fairly successful outcome with the strategies and is often long term. All in all, it's a beneficial relationship and there is no reason to hesitate.

Kerryn Hart
BOptom GCertOcTher MPH

Clinical Skills Teacher In Optometry, Deakin University

Optometry Australia Policy and Standards Advisor

Clinical Editor of *Pharma*

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GUIDE

OPTOMETRY AUSTRALIA'S PAEDIATRIC EYE CARE REFERENCE GUIDE PAGES 14-15

Accommodative-vergence dysfunction and learning difficulties in paediatric patients

Andrew Tan Nguyen
MC-DOptom Melb

Optometrist
VisionWest, Perth

CASE REPORT

As an optometrist who suffers from an accommodative-vergence dysfunction, I empathise with patients who encounter blurred vision, headaches, fatigue, and diplopia when performing near tasks. Growing up, my accommodative-vergence issues were unfortunately misdiagnosed by multiple optometrists, resulting in delayed academic development. My avoidance of near work and apparent lack of attention in class was thought of simply as laziness.

It was not until first-year optometry school that I discovered having a 22 prism-dioptre base-in decompensated exophoria at near was abnormal; the normal near phoria range is 0–6 base-in exophoria.[1]* With additional testing, I was finally able to classify my two issues, accommodative insufficiency and convergence insufficiency, and take appropriate measures to correct the problem. Prior to this I assumed that my issues were a normal part of life.

As a result of my personal experience, I have come to develop an appreciation for those suffering from accommodative-vergence dysfunctions. This case study involves a typical patient I would encounter with undiagnosed accommodative insufficiency while locuming across Australia.

Master AN was first seen by another optometrist at the age of 10. He had presented with no complaints and was healthy. At this time, although he was a high achieving student, his mother had remarked that he held books oddly close to his face and was readily fatigued. Unaided distance vision was OD 6/4.8 OS 6/4.8 OU 6/4.8. Unaided near vision was N5. Alarmingly, no other screening tests were conducted. Subjective refraction was OD +0.50 and OS +0.50. Anterior and posterior eye examination was unremarkable. The patient was discharged without any intervention.

Master AN presented to me a year later with complaints of intermittent frontal headaches and near vision blur after short periods of reading. His problems began three months prior to this visit and had peaked within the last week. His mother informed me that his performance in school had been affected in the past few months. The patient remained otherwise healthy.

Unaided distance vision was OD 6/7.5- OS 6/7.5- OU 6/6. Unaided near vision was N5. Dry retinoscopy was: OD +0.50/-0.25x90 6/6 OS +0.50/-0.50x90 6/6. Subjective refraction was OD +0.50 6/6 OS +0.50 6/6 OU 6/4.8.

Cover test was orthophoric in the distance and esophoric at near. The near point of convergence (NPC) was 10 cm/12 cm (break/recovery); mild pain was experienced during testing. Near horizontal phoria measured with a Howell phoria card was 3 Δ esophoria. Convergence facility using 12BOΔ/4BIΔ yielded 15-cycles-per-minute.

Near point accommodation (NPA) was 7D in both eyes. Monocular estimation method (MEM) retinoscopy was initially measured to be +1.50 lag in both eyes and remained stable when re-tested after 30 minutes. Binocular accommodative facility showed the patient was unable to resolve -2.00 flippers and resolved -1.00 flippers with difficulty. He had no trouble resolving the +1.00 or +2.00 flippers. Accommodative-convergence/accommodative (AC/A) ratio was 3.25Δ:1.

Stereopsis testing was normal at 40" (titmus fly). 24-plate Ishihara testing revealed normal colour function. Pupillary functions were normal. All external and internal health tests were normal.

Analysis of the consultation

From the history, the patient's symptoms appear to be ocular related. Some of the general symptoms related to accommodative-vergence dysfunctions include frontal headaches, blurred vision, eye strain, reading issues, fatigue, sleepiness, reduced reading comprehension over time, poor attention and concentration when reading, and an avoidance of near work.[2] Identifying the correct signs and symptoms during history-taking can make all the difference in efficiently diagnosing binocular vision issues. Any combination of these symptoms should prompt further investigation.

The important values to consider in this case are the reduced NPA, high lag on MEM retinoscopy, and the inability to resolve negative lenses during accommodative facility testing, as they are characteristic of accommodative insufficiency.[2]

Accommodative insufficiency occurs when the amplitude of accommodation is reduced relative to the patient's age. This is in contrast to accommodative excess where the patient has difficulty with relaxing accommodation and accommodative infacility where they have a difficulty with changing the posture of their accommodation.[1]

Continued page 16

Paediatric eye care reference guide

From the Optometry Australia Clinical Practice Guide for Paediatric Optometry

Table 1 outlines the potential components of a comprehensive vision and eye health examination for different age categories. It is recommended that each consultation is tailored to suit the needs of the individual child. Factors to consider include their ability to comprehend and undertake tests as well as clinical need based on presentation and symptoms.

Table 1: Standard Testing Protocol by Age

Test/Procedure	Birth - 2 years, 11 months	3 years - 6 years, 11 months	7-14 years
Patient History	Parent	Parent/Child	Parent/Child
Visual Acuity	• Fixation Preference • Preferential Looking Test: - Teller Acuity Cards - Lea Paddles • Patti Pics • Lea Chart • Cardiff Cards • OKN Drum	• Lea Chart at 3m • Patti Pics at 3m • Snellen Chart at 6m • Broken Wheel Test	• Snellen Chart at 6m
Refraction	• Static (Dry) Retinoscopy • Cycloplegic Retinoscopy • Mohindra Retinoscopy	• Static (Dry) Retinoscopy • Cycloplegic Retinoscopy • Mohindra Retinoscopy • Topography	• Static (Dry) Retinoscopy • Cycloplegic Retinoscopy • Subjective Refraction • Blur Function • Topography
Binocular Vision Testing	• Cover Test • Hirschberg Test • Krimsky Test • Bruckner Test • Ocular Excursions • Near Point of Convergence • Dolls eye reflex • Vestibulo-ocular reflex (VOR) • Worth 4 Dot	• Cover test • Hirschberg/Bruckner • Ocular Excursions • Near Point of Convergence • Monocular estimation method (MEM) retinoscopy • Objective fusional vergence • Distance and Near Phoria Measurement • Near Point of Accommodation • Worth 4 Dot	• Cover test at distance and near • Ocular Excursions • Near Point of Convergence • Monocular estimate method (MEM) retinoscopy • Near Point of Accommodation – monocularly • Positive and negative fusional vergences • Positive and negative relative accommodation • Accommodative convergence/ accommodation (AC/A) ratio • Accommodative facility • Vergence Facility • Distance and Near Phoria Measurement • Worth 4 Dot
Stereopsis	• Lang I & II • Titmus Fly • Randot Stereo Test • Frisby Test • TNO Stereo Test • Stereo Smile Stereoacuity II Test • Randot Preschool Stereoacuity Test	• Lang I & II • Titmus Fly • Randot Stereo Test • Frisby Test • TNO Stereo Test • Stereo Smile Stereoacuity II Test • Randot Preschool Stereoacuity Test	• Lang I & II • Titmus Fly • Random Dot Stereogram • Frisby Test • TNO Stereo Test • Stereo Smile Stereoacuity II Test
Colour Vision Assessment	• Ishihara • Colour Vision Testing Made Easy • City University Colour Vision		
Ocular Health Assessment	• Gross inspection of the external features, including lid anatomy • Assessment of Pupillary Responses • Assessment of the Anterior Segment • Assessment of the Posterior Segment • IOP where clinically indicated • Topography where clinically indicated		

Table 2 (taken from Fricke T, Dinardo C. *Vision Therapy Guidelines for Visual Efficiency 2014*) provides standard testing protocols and a guide to clinical normative values for accomodation and vergence parameters.

Table 2. Guide to Clinical Normative Values for Accommodation and Vergence Parameters

Parameter	Vergence Test	Normative Value	Accommodation Test	Normative Value
Posture	Near Phoria Distance Phoria	3 pd exo ± 4[1] 1 pd exo ± 1[2]	Near Retinoscopy	+0.50DS ± 0.25
Amplitude	Near point of convergence (NPC): Break Recovery	≤ 5cm ≤ 7cm[4]	Near Point of Accommodation	≥ 15D – 0.25 (age)[5]
Range	Near Base In Near Base Out Distance Base In Distance Base Out	≥ 10/16/10 ≥ 12/18/11 ≥ 7/4 ≥ 14/7[6]	Relative Accommodation	±2.00 D at near -2.00 D at distance[5]
Facility	3pd BI/12pd BO flipper[7]	15 cycles per minute at near	± 1.00 D Flipper ± 2.00 D Flipper	8 cycles per minute at near with ±2.00 D flipper[8]
Interaction	AC/C Ratio 2.2pd/D ± 0.8 (consider ratio to + and – lenses separately)[9]			

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Table 3. Normative visual acuity by age (Taken from Pan Y, Tarczy-Hornoch K, Cotter S, Wen G, Borchert M, Azen S, Varma R. Visual Acuity Norms in Pre-School Children: The Multi-Ethnic Pediatric Eye Disease Study. Optometry and Vision Science. Vol 86. No 6. June 2009.

Table 3: Mean visual acuity by age

Age (months)	Age (years)	Snellen Visual Acuity
30-35 months	2.5 - 3	6/19
36-47 months	3 – 4	6/15
48-59 months	4 – 5	6/12
60-72 months	5 – 6	6/9.5

Clinical Pearls for cycloplegia

- For children less than 6 months of age a concentration of 0.5% Cyclopentolate Hydrochloride is recommended while 1% is recommended for children older than 6 months.[9]
- It is particularly important that over-dosage is avoided in children with Down syndrome, cerebral palsy and other CNS disorders in whom there may be an increased reaction to cycloplegic agents.[10] In these cases, Tropicamide (1%) may be used as the dilating agent
- Retinoscopy should be performed 30-45 minutes after administration of eye drops.[9] An appropriate distance target should be used to control fixation and any remaining accommodation

Accommodative-vergence

From page 13

Patients with accommodative insufficiency exhibit difficulty with stimulating accommodation. Diagnostic signs of accommodative insufficiency include a low accommodative amplitude, low positive relative accommodation (PRA), failure to pass accommodative facility with minus lenses and a lag ≥ +1.00D on MEM retinoscopy.[2]

Due to the relationship between the accommodative-vergence system, accommodative insufficiency may also be linked with other binocular vision problems. This patient was found to have a mild esophoria at near. It is not uncommon to find an esophoria or exophoria at near which can cause a secondary or pseudo vergence issue. These vergence issues generally resolve with the correction of the accommodative issue.[2]

Treatment

The first step to managing accommodative insufficiency is treating refractive errors.[2] This is important because even small uncorrected refractive errors can cause accommodative fatigue. Correcting for refractive differences between the two eyes has been shown to sufficiently recover normal accommodative-vergence functions in 63 per cent of cases.[3]

The second step is to use near addition plus lenses. Plus lens additions are the most commonly prescribed treatment for accommodative insufficiency.[2] Added plus lenses have been shown to improve posture during near visual tasks, normalise near working distance and reduce physiological activation of the accommodative-vergence system.[2]

The patient was prescribed a pair of multifocal glasses to correct his refractive error (OD +0.50 DS OS +0.50 DS) with a near addition of +1.00 DS. A +1.00 DS addition was selected because MEM retinoscopy was approximately +1.00 higher than expected. Using the AC/A ratio, the patient's esophoria was also positively shifted to an exophoria, placing him in the normal phoria range at near.* The patient was able to comfortably accept the +1.00 addition.

Referring the patient for vision therapy was discussed but not considered during the consultation. While vision therapy is effective for treating accommodative insufficiency,[4] it was decided to trial spectacles first to see if they improved the patient's symptoms. The time commitment, costs involved, and lack of motivation to undertake a vision therapy program were factors taken into consideration. A review appointment was scheduled in six months to deliberate the need for vision therapy.

Discussion

The ability to clearly and comfortably interpret what we see is dependent on three components: visual integrity, visual efficiency and visual information processing.[5] Visual integrity involves factors that impact visual acuity, refractive status and eye health. Visual efficiency examines how well the eyes move and interact together and includes the evaluation of accommodation, binocular vision and oculomotor skills. Visual information processing provides the ability for our eyes to understand and analyse what we see; it incorporates various aspects of perception and motor integration of visual information.

All optometrists understand the importance of visual integrity; refraction is the crux of the job. Problems arise however, when clinicians only consider visual integrity when examining children and forget the other two aspects of vision, thereby declining to conduct the appropriate screening tests, as seen with the first optometrist who should have noted the patient's fatigue and abnormal reading distance as red flags. This is important because poor visual efficiency can have negative consequences on visual information processing and reduce a child's school performance and potentially cause developmental delays.[6] Children who suffer from visual efficiency problems scored lower in every academic area: reading, mathematics and science, when compared to their peers.[7] Improving visual efficiency can enable children to perform to their maximal learning potential. Accommodative-vergence dysfunctions are better predictors of academic success than race and socio-economic factors.[8]

Undiagnosed accommodative-vergence dysfunctions can also have serious long-lasting consequences on childhood development. Children who suffered from undiagnosed vision-related learning problems are more prone to having co-existing emotional problems, are more likely to be charged with juvenile delinquency, and grow up to be functionally illiterate adults.[9] As many as 1 in 5 children suffer from vision problems[1] and with the prevalence of electronic devices today, this number is increasing.[10]

Conclusion

As optometrists we must do our best to ensure that children are not disadvantaged at school or in life by vision problems. Most accommodative-vergence dysfunctions can be managed or treated, but only if children are correctly examined and their issues correctly diagnosed. It is essential to test accommodative-vergence function in all children, as not all children with problems will complain about their issues.

* See 'Paediatric Guidelines' tables on pages 14 and 15 of this issue of *Pharma*.

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Paediatric optic nerve anomalies

Associate Professor Ann Webber
PhD MS BAppSc(Optom)(Hons) Grad Cert Oc Ther FAAO (Diplomate BVPPO)

School of Optometry and Vision Science, Queensland University of Technology

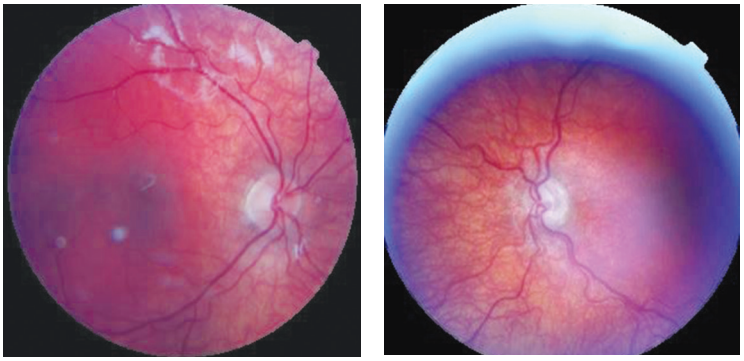

Figure 1. Retinal photographs of a two years, 11-month-old male. A: RE normal ONH and B: LE hypoplastic ONH.

The optic disc or optic nerve head is the portion of the visual pathway where the axons of the retinal ganglion cells collect together to form the optic nerve to exit the eyeball. Optometrists routinely employ direct and indirect ophthalmoscopy, slitlamp biomicroscopy, retinal photography and optical coherence tomography (OCT) to assess and evaluate the optic disc and neuro-retinal rim for the purpose of screening for health, disease and ability to function.[1]

In paediatric optometry practice, careful inspection of the optic nerve head is essential to identify congenital anomalies that might explain or predict findings of vision loss in children and, importantly, to identify children who may be at risk of accompanying neurological pathology.

Gathering sound clinical information in young children is particularly important as these patients have a vulnerable developing visual system, with any structural ocular abnormality that reduces visual acuity in infancy likely to lead to amblyopia. Further, an abnormal optic disc appearance may herald sight or life-threatening pathology that needs referral for further neuro-ophthalmic investigation.

A paediatric eye examination can be challenging, especially if the child is incapable of providing reliable responses for a measure of visual acuity. The clinician may need to rely on objective assessments to examine and record vision and ocular structures, with retinal photography and OCT highly beneficial to the ophthalmic exam, and particularly valuable to record for change in nerve head characteristics over time.

The two cases presented here are examples of when ocular photography and OCT scanning in the primary care optometry practice, both at baseline and at time of onset of new signs or symptoms, proved highly useful to diagnosis and monitoring of structural optic nerve head anomalies.

CASE REPORT 1

Optic nerve head hypoplasia

A Caucasian male aged two years and 11 months was referred for paediatric optometry assessment and amblyopia management advice. He was reported to have a recent onset left esotropia and reduced acuity in the left eye. He was born at full gestational term, of normal birth weight and had met developmental milestones at expected ages. General health was unremarkable with no prescribed medications or allergies.

Entering unaided acuities were RE 6/6 and LE 6/120 (tested with isolated LEA optotypes employing a matching card). Cover test showed 30 prism dioptre LE constant esotropia at both distance and near fixation. His parent reported that the strabismus was first noted approximately six months prior as an intermittent turn, but had become more frequent over the intervening period. Pupil reactions and extra ocular muscle motility were normal. Cycloplegic refraction determined refractive error of R +1.00 DS L +1.00/-2.00 x 180. Anterior segment examination was unremarkable. Posterior segment examination by binocular indirect ophthalmoscopy through dilated pupils indicated an anomalous disc appearance, with careful inspection limited by diminishing child cooperation.

Fundus photography was attempted. The child was asked to kneel on the examination chair so that the positioning of chin on retinal camera support was not limited by his small stature. The goal of obtaining a photo of the eye was explained to the child, with instructions that positioning onto the instrument 'was just like riding a motor-bike,' he was to hold onto the side of the chin support like holding bike handles and to rest against the forehead support as if that were his helmet. He was asked to 'look at the green GO light' as the photo was taken. While the resultant photos are unlikely to win recognition for their quality, they clearly document the normal optic disc appearance of the right eye, and the optic nerve head hypoplasia of the left eye (Figures 1A–B).

Optic nerve head hypoplasia is the most common optic disc anomaly reported in ophthalmic practice.[2] The disc appears as an abnormally small optic nerve head – pink, grey or pale in colour – and is surrounded by a yellowing, mottled peripapillary halo, bordered by a ring of increased or decreased pigmentation (the 'double

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Optic nerve

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ring' sign). The major retinal veins are often tortuous, with this finding helpful to establish diagnosis.

Visual acuity (VA) in optic nerve head hypoplasia is reported to range from 6/6 to no light perception, and can have accompanying visual field defects. Since VA depends on the integrity of papillo-macular nerve fibre bundle, VA loss does not always correlate with the size of the disc. There is a strong association between optic nerve head hypoplasia and astigmatism,[3] a finding that was present in this case. Optic nerve head hypoplasia is often associated with central nervous system (CNS) abnormalities and endocrine disorders, including isolated growth hormone, thyrotropin, corticotropin, or antidiuretic hormone deficiency.[3] Magnetic resonance imaging (MRI) is considered the optimal non-invasive neuro-imaging modality for delineating associated CNS malformations in patients with optic nerve hypoplasia.[2]

This patient was referred for neuro-ophthalmic MRI and endocrine function investigation, which fortunately returned findings that were unremarkable. Specific amblyopia treatment, such as correction of refractive error or patch penalisation, was not prescribed as significant vision recovery was considered unlikely with the evidence of substantial visual pathway structural anomaly. The esotropia was likely a sensory secondary strabismus and not the primary cause of reduced vision development, with little functional improvement deemed likely with strabismus surgery. The severe vision loss in the affected eye of this patient renders him essentially monocular, so his parent was counselled regarding the importance of eye protection for the fellow eye and periodic review of the fellow eye.

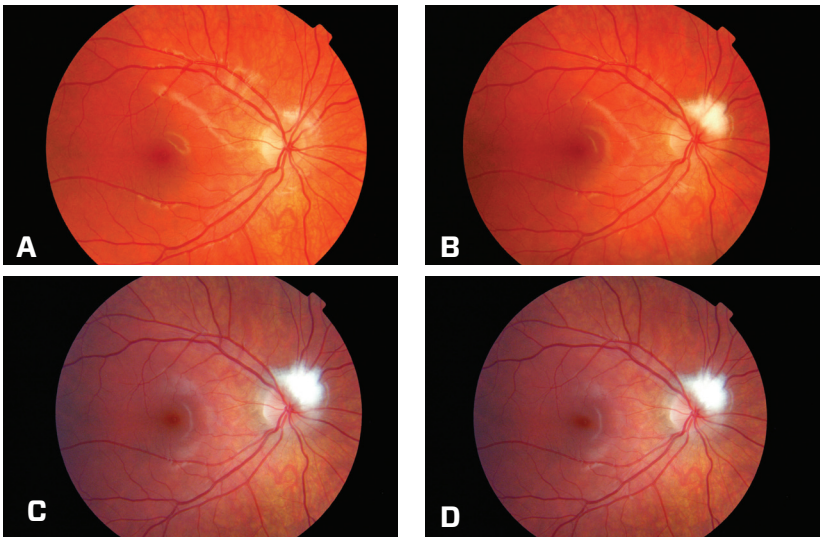

Figure 2. A: September 2012, age six years. B: March 2016, age 10 years. C: May 2017, age 11 years. D: May 2019 age 13 years.

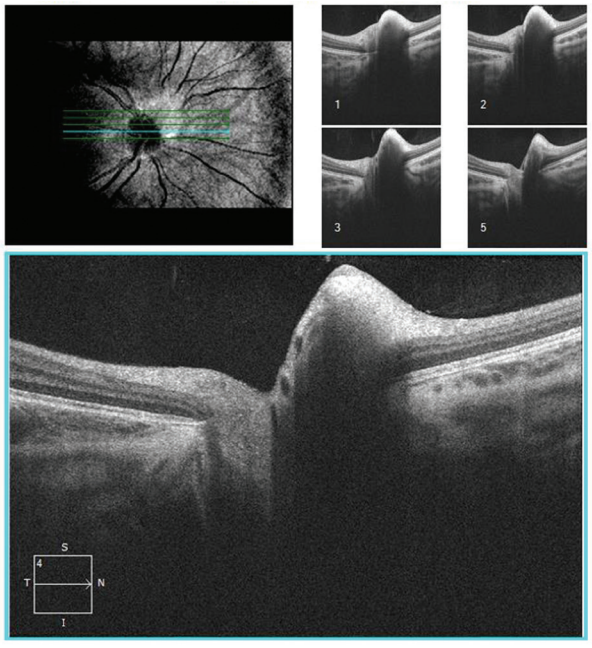

Figure 3. OCT scan May 2017, age 11 years

CASE REPORT 2

Acquired and progressive medullation of optic nerve head retinal nerve fibre

A Caucasian female aged six years presented in September 2012 for investigation of intermittent blurred vision. Entering unaided acuities were: RE 6/6+ LE 6/6++. High AC/A convergence excess esophoria at near was identified and managed conservatively with vision therapy. Baseline retinal images were taken (Figure 2A). The patient re-presented in March 2016, aged 10 years, with low myopic refractive error (RE -1.00 DS LE -1.00 DS) and high AC/A convergence excess esophoria, with VA correcting to RE 6/4.5 LE 6/4.5. Inspection of the optic nerve head showed white striations emanating from the superior temporal rim of the right optic nerve head (Figure 2B). While the appearance was consistent with the focal benign malformation myelination of retinal nerve fibre layer, this was not present in the prior photos, therefore the patient was referred for ophthalmological opinion to differentiate from juxtapapillary inflammation. Ophthalmic ultrasound and OCT scans were performed to rule out the presence of optic nerve oedema, which found no fluid distension of the optic nerve sheath. Continued monitoring with retinal photography and OCT shows increased thickening of the myelination (Figure 2C–D).

Mild thickening of myelination was seen in May 2017 at age 11, with high definition OCT imaging able to document the elevated dense RNFL (Figure 3). Review in May 2019 showed no further change.

Discussion

The prevalence of retinal nerve fibre myelination is nearly one per cent. Acquired and progressive myelination of nerve fibre is rare, however a number of cases are reported in the literature with associations with optic nerve head drusen or other optic nerve head trauma, suggesting that the oligodendrocyte-like cells are able to infiltrate the retina due to an acquired insult.[4]

Medullated nerve fibres are usually seen as white striated patches emanating from the superior and inferior aspects of the disc. Because they can elevate portions of the disc and obscurate blood vessels, mild presentations can be mistaken for papilloedema. The myelination of the afferent visual pathways commences at approximately five months gestation at the lateral geniculate body and terminates at the lamina cribrosa at about term. Oligodendrocytes, which are responsible for myelination of the CNS, are not usually present in the human retina, however they are found in areas of medullated nerve fibres while absent in other areas. Speculative pathogenic theories for how both congenital and acquired cases occur include a defect in the lamina cribrosa or late development of the lamina cribrosa that may allow oligodendrocytes to allow access and migration of these cells into the visible retina.

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The IMI Reports and Clinical Management Guidelines

The International Myopia Institute's clinical strategies for myopia

Dr Kate Gifford
PhD BAppSc (Optom) Hons GCOT FBCLA FIACLE FCCLSA FAAO

Clinical Optometrist, Gerry & Johnson Optometrists, Brisbane

Visiting Research Fellow, Queensland University of Technology

INTERNATIONAL MYOPIA INSTITUTE

The International Myopia Institute (IMI) White Paper Reports were published in the high-ranking journal *Investigative Ophthalmology and Visual Science* in February 2019. In a similar spirit to the Tear Film and Ocular Surface Society Dry Eye Workshop (TFOS DEWS and DEWS II) reports, the IMI Reports present a comprehensive peer consensus from over 85 participant authors on a wide scope of topics relating to research of myopia mechanisms, product research and development, clinical and industry best practice and the public health message. The IMI Reports are open-access and freely available, creating a clear picture of the current landscape of myopia research and practice, with an eye to the future.

The IMI Reports have come at exactly the right time. Over the past few years there has been a dramatic increase in clinician awareness and product innovations by industry to match the research findings of a global increase in the prevalence of myopia, forecast to affect 50 per cent of the world's population by 2050.[1] The well-informed optometrist would benefit from reading any and all of the IMI Reports, however, if pressed for time, the place to start is the Myopia Control Reports Overview and Introduction, which details the background of risk factors for myopia onset and progression, along with providing an overview of each report to direct further learning. From there, essential practitioner reading includes the following Reports:

Defining and Classifying Myopia – Get clear on the definitions of pre-myopia, myopia, high myopia, and myopia complication with key references.[2]

Interventions for Myopia Onset and Progression – Understand the research behind optical, pharmacological, environmental (behavioural) and surgical interventions for myopia.[3]

Clinical Management Guidelines – Appreciate the scope of risk identification, parent and patient communication, informed consent, basic examination procedures, follow-up schedules, when to change and stop treatment, future treatments and additional resources for clinical practice.[4]

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IMI report

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Industry Guidelines and Ethical Considerations for Myopia Control – Consider factors in the ethical development, registration, marketing, on- and off-label prescribing and patient use of myopia control treatments, including risk versus benefit and quality of life considerations.[5]

The Clinical Management Guidelines (CMG) Report[4] provides a framework for putting research into practice. Best practice myopia management involves an understanding of the causes and risk factors for myopia; the long-term eye health risks; the efficacy and safety of the available optical, pharmacological and visual environment interventions; and the skills to translate this into lay language for both the patient and parent. The CMG Report commences with an outline of myopia development causes—identifying the pre-myope—through the risk factors of family history (one or two myopic parents), less time spent outdoors and specific binocular vision disorders (esophoria and accommodative lag). The key identifier of the pre-myope, though, is the child who is less hyperopic than age normal; specifically: a child who is +0.75 or less at age 6–7 years.

Evidence-based interventions for this child are currently limited to education on achieving around 90+ minutes of time outdoors per day. Managing binocular vision disorders associated with myopia onset may also be beneficial, although specific studies on delaying myopia with this sort of intervention have not been undertaken.

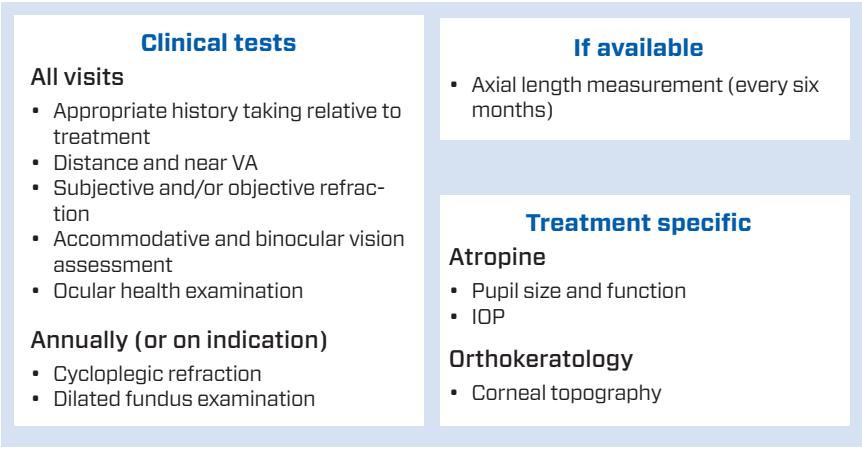

Figure 1. Clinical tests in myopia management, published from the IMI Clinical Management Guidelines

Management

Once a child becomes myopic, a management strategy should be instigated which not just corrects myopia but also aims to slow its progression. Based on the available evidence, this can be implemented for children as young as six years of age and should continue until the mid-to-late teens, although rebound effects on treatment cessation and young adult myopia progression are both yet to be fully understood.

The CMG Report provides guidance firstly on discussing myopia and its treatments—options, efficacy, safety, additional corrections and informed consent—while emphasising the importance of establishing reasonable expectations and informed consent (Chapters two and three). The report then proceeds to the key elements of the baseline exam for myopia control (Chapter four; see Figure 1 of the CMG Report, and Figure 2). The standard procedure for examination includes appropriate history taking relative to the treatment, distance and near acuity, subjective and/or objective refraction, accommodative and binocular vision assessment and ocular health examination. Cycloplegic refraction is considered useful annually, or as indicated. Fundus examination through dilated pupils is also suggested as an annual exam component, especially for high myopes (> 5 D) and/or if axial length is 26 mm or greater.

While axial length measurement is considered a necessity for a research study, for clinical practice it is currently considered preferable, but not a necessity, every six months. This is a particular issue with orthokeratology (OK) treatment where refractive change is more difficult to measure; and with atropine therapy where a mismatch between axial length and refractive control has been repeatedly noted. These two treatments also carry their own specific recommendations for follow-up examination—OK monitoring requires corneal topography, and atropine monitoring requires assessment of pupil size and function and intraocular pressure.

The bulk of the CMG Report is then dedicated to selecting a treatment strategy and management guidelines. Considering a child's baseline refractive error (for example, astigmatism limits certain contact lens treatments) and capacity is important alongside treatment consideration such as advice on add powers in multifocal

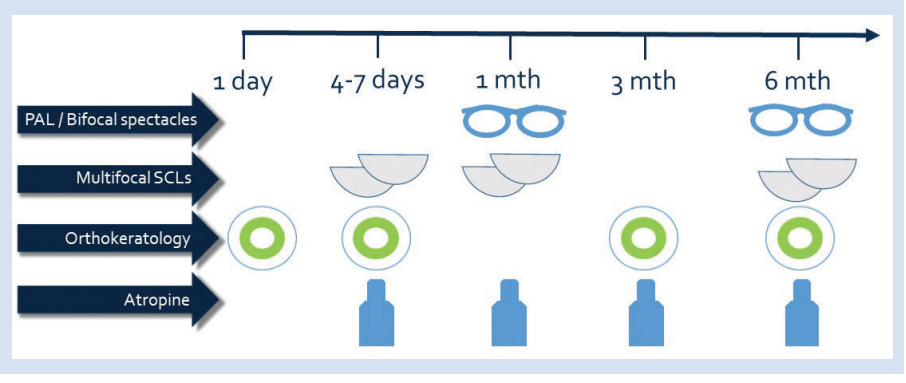

Figure 2. Clinical review schedules based on treatment type, adapted from the IMI Clinical Management Guidelines.

soft contact lenses and detail on spectacle lens options (Chapter 5).

Guidelines for clinical care (Chapter 6) detail all aspects of treatment and advice from ideal wearing time (at least five to six days a week, dependent on the treatment), back up corrections, advice on visual environment, when to change or end treatment and special considerations such as late onset and high myopia. A summary of follow-up schedules by treatment is provided in Figure 2. The CMG Report concludes with information on clinical references – key research papers, websites, courses and communication tools – where much is provided as weblinks in the supplementary digital content.

Looking to the future

The report holds more promise for the influence that current research may have on future clinical practice. The myopia managing clinician of the future may be measuring parameters such as relative peripheral refraction, aberrometry, pupillometry, sub-foveal choroidal thickness and utilising light exposure and visual activity data from wearable devices (Chapter 4). Each of these is an arena for current research and as their role in predicting myopia progression or treatment response is understood, these may translate into clinical practice. The hot topics of OK and multifocal soft contact lens optimisation are detailed in Chapter 7, along with emerging treatments such as the 7-methylxanthine nutritional supplement in Denmark and scleral reinforcement in Russia.

Conclusion

The publication of the IMI White Paper Reports is a landmark moment for the eye-care profession and industry. By providing a full-scope, critically-evaluated and robustly synthesised expedition through the world of myopia research and practice, these reports clearly draw a line in the sand for future coordinated efforts for the ultimate benefit of our young myopic patients.

The clear message for eye-care professionals right across the world is that it's no longer best practice to simply prescribe single vision spectacles for progressing myopes when better options to control myopia are available. Myopia management, at minimum, starts with a discussion on the consequences of myopia, risk factors and treatments—allowing parents and patients to make informed decisions which could influence lifelong eye health outcomes. While there is no way to predict the level of progression or perfect treatment for the individual myope—and there may never be—there are many tools and treatments available.

Improving the access of our young myopic patients and their parents to the right information and treatments is built on a foundation of practitioner education and confidence in implementation. The IMI White Papers, and particularly the Clinical Management Guidelines, are designed to support practitioners through this imperative evolution of clinical practice.

Dr Gifford (PhD BAppSc (Optom) Hons GCOT FBCLA FIACLE FCCLSA FAAO) is a clinician-scientist in Brisbane private practice, a peer educator, and a Visiting Research Fellow at the Queensland University of Technology. She is the Chair of the Clinical Management Guidelines Committee of the International Myopia Institute and lead author on their report.

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Key resources*

Blog
To read more on axial length in clinical practice, the author has written a blog entitled 'Axial length measurement – a clinical necessity?' (myopiaprofile.com)

Journal
The International Myopia Institute White Paper Reports – special issue of Investigative Ophthalmology & Visual Science, Volume 60 Issue 3. (iovs.arvojournals.org)

Websites
The International Myopia Institute – a summary of prevalence, impact and solutions for the global myopia problem, with information on the Committees and links to the White Paper Reports. (myopiainstitute.org)

The website Myopia includes easy access to the CMG Supplementary Digital Content and a new podcast series with IMI Report lead authors, along with numerous educational blogs and resources for putting myopia management into practice (myopiaprofile.com)

The BHVI Global Myopia Centre, a portal to online courses, calculators and resources (globalmyopiacentre.org)

Online magazine
Issue 47 of ContactLensUpdate.com, entitled 'Myopia Matters: Summarising the IMI Reports'. This free-to-access resource includes an editorial written by this author, a summary of each of the white papers by the researchers of the Centre for Ocular Research and Education (CORE – University of Waterloo, Canada) and a practitioner reference factsheet download on the Clinical Management Guidelines. (contactlensupdate.com)

Facebook group
The companion Facebook Group 'Myopia Profile', administered by the author – a closed, industry-only group which includes more than 5,000 eye care practitioners from over 50 countries discussing the latest research, industry developments and clinical cases (facebook.com)

Electronic newsletter
Review of Myopia Management, a new electronic newsletter and website with a variety of clinical and practice management blogs and resources.
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*Full links appear with the online version of this article on the Optometry Australia website.

Low dose atropine

Therapeutic treatment for myopia progression

Elisse Higginbotham
MOptom

Clinical supervisor
Australian College of Optometry

Croucher Rateau Chew
Optometrists, Melbourne VIC

Myopia is becoming an epidemic. It is a statement that bears repeating. The Brien Holden Vision Institute (BHVI) predicts that myopia will reach a prevalence of up to 50 per cent globally by 2050.[1] Further, the increase in the number of myopic patients is also associated with an increase in the number of high myopes. In the same study, the BHVI predicted that 10 per cent of the global population will have high myopia by 2050.[1] As practising optometrists, we are already aware of the dangers of high myopia: it significantly increases the risks of retinal detachment, myopic maculopathy, cataract and glaucoma (see Table 1).[2]

What we are perhaps less aware of is the fact that *any* degree of myopia significantly increases the risk of eye disease. While being -6.00 is indeed a risky scenario, being -4.00 is riskier than -2.00, and even being -1.00 carries more risk than being emmetropic or hyperopic (see Table 1).[2]

It is becoming increasingly clear that doing something to prevent the development of myopia (not just high myopia) is important, both from a global epidemic perspective, and the more personal perspective of the young patient sitting expectantly in your chair.

There are a number of studies published in the last 20 years that demonstrate that myopia progression can be modified, probably for most young people. Almost always, these studies investigate an intervention. For example: the impact of atropine eye drops, orthokeratology contact lenses or multifocal soft contact lenses on the progression of myopia in already myopic school age children.[3–6] While a large number of these studies have been done on Asian children in places such as Singapore,[4,5] there is a growing amount of research from other countries with a more racially-diverse group of subjects.[7–9] From these studies, we know that children who develop myopia early are more likely to progress rapidly, for a longer period of time and are likely to become the next generation of high myopes.[6] Children who develop myopia later are less likely to progress rapidly.[6,10]

Early studies[11] suggest that most myopia progression in children slows or plateaus around the age of 15 for girls, and a little later for boys. However, there is considerable variability between individuals. More recent studies[4,5] have deliberately excluded older children, effectively putting a question mark around what age is safe to stop myopia prevention interventions.

History of atropine

While there are several available treatment options for myopia,[12] this article will focus on the use of 'low dose atropine.' The atropine story began back in the 1960s with a group of American ophthalmologists discovering that Atropt (1%) was effective at slowing (or stopping) refractive change,[13] which was confirmed with a randomised control trial, Atropine for the Treatment of Myopia (ATOM1), in 2006.[4] The primary side-effects of glare (from pupil dilation) and near blur (from the pharmacologically-induced accommodation paralysis) were generally treated in practice with transitions or sunglasses and multifocals.

However, in 2012, the results of ATOM2 were released,[5] comparing a number of dosages (0.5%, 0.1%, and the intended control, 0.01%). The extremely low dose 0.01% was discovered to be equally effective at slowing the progression of the refraction over time as the 1% (although perhaps with less effect on the axial length)[14] and resulted in almost no side-effects. This finding has now been repeated in a number of studies.[15]

Currently, the only commercially-available version of atropine in Australia remains Atropt 1%, used for amblyopia therapy. Unfortunately, 0.01% is only available via compounding pharmacists, of which there are only a limited number across Australia. To prescribe the lower dose, Optometry Australia recommends writing '0.01% Atropine Eye Drops – MUST BE COMPOUNDED' to prevent confusion.

I have had this occur with one of my patients who took their prescription for low dose atropine to their local pharmacist who dispensed the 1.0% Atropt. I discovered the mix up when they presented three months later, off the atropine drops, as they had found the most recent ones to give 'much more glare' than the original bottle.

Adverse reactions to atropine 0.01% drops are rare.[5] They have negligible

effect on accommodation and pupil size and no effect on near visual acuity. Allergic reactions were reported in about four per cent of the original study's atropine 1.0% dose[4] and in the later study's atropine 0.1% and 0.5% groups[14] (similar to most preserved eye drops).[4] There were no reported cases of allergic reactions in the atropine 0.01% group.[14]

The compounding pharmacy we use has some concern about the ongoing sterility of the compounded form, so they only send out one bottle (one month's supply) at a time and recommend patients keep the drops in the refrigerator. I usually recommend the drops are inserted at night (with higher doses, for example 0.1%, this allows some of the cycloplegic effect to wear off before morning). The average cost of a month's worth of compounded atropine (of any dose) is currently around $50 including postage.

Some later studies from the ATOM2 study group have looked at the effects of atropine long-term (for up to five years).[17] There have been no negative long-term effects found, despite looking in detail at accommodation, pupil size[18] and electroretinograms after cessation of atropine.[18] At present, we have sufficient evidence that atropine eye drops are an effective and safe method of slowing myopia progression. Over time, it should become clearer as to what is the optimal dose and time frame. What also seems likely is the beneficial combination of low dose atropine and another treatment such as orthokeratology. However, there as yet are no studies to support this hypothesis.

Myopia intervention

Myopia is increasing, and it is starting with young children. Prescribing an intervention early is the best way to delay significant myopia. Low dose atropine is a safe and extremely well-tolerated intervention that slows refractive progression by at least 50 per cent.[5,14] It is an excellent choice especially for young patients who are progressing quickly, and who may be reluctant (or who have parents who are reluctant) to begin intervention in a contact lens form.

Given that any degree of myopia may cause increased risk of eye disease, our practice recommends myopia treatment as soon as progression is detected. Keeping them at -1.00 will be more useful in the long run than allowing them to progress to -3.00, and then starting them on therapy. However, be aware that some of the studies[5] have been done on higher myopes and as such, our evidence in the low myopia group is still developing. Similarly, for those who are continuing to progress into their university studies, use of low dose atropine may be helpful, but as yet no studies have looked in detail at myopia progression in adults.

To help you have this conversation with patients, the BHVI has an excellent tool (the myopia calculator: calculator.brienholdenvision.org/) which you can use to demonstrate what the impact of a treatment may be on the progression of myopia for someone like the child in your chair (for example: Asian child, age six, already at -3.00). Of course, the actual child may have a different response to the treatment than the average found from studies, but it does give you a starting point to discuss available options. I have found that many parents are quite concerned about their child's quickly progressing refraction, however many are unaware that there are now good treatments to slow this problem. Have the conversation where possible with the family of any young developing myope, and discover along with them the satisfaction of seeing that refraction go nowhere.

	Relative risk (compared to an emmetrope) at		
Condition	**-2.00D**	**-6.00D**	**-10.00D**
Retinal detachment	3 x higher	21 x higher	44 x higher
Myopic macular degeneration	2 x higher	41 x higher	349 x higher
Cataract (PSC)	2 x higher	3 x higher	6 x higher
Glaucoma	2 x higher	3 x higher	

Table 1. Relative risk (compared to an emmetrope)[2] (adapted from Flitcroft 2012[2])

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Orthokeratology in myopia control

An effective tool to slow progression

Natalie Buckman
MOptom BVisSci MPH

School of Optometry and Vision Science

Queensland University of Technology

Managing progressing myopia has changed over the past decade as multiple myopia-control tools have become available. However, one of these tools has been used for decades to provide visual freedom to our patients across a range of ages for myopia, astigmatism and mild hyperopia correction: orthokeratology (OK) lenses.

The research demonstrating the myopia-control effects from OK-lens wear has generated interest in proactively learning how to safely fit OK and offer this option to our young progressing myopic patients. One of the greatest advantages of OK is the lifestyle freedom of clear vision unaided through the day, and the correction being applied and removed within a controlled setting at home. It is this unique aspect of OK that often draws parents and children to consider it as a first line option for visual correction, with the benefit of myopia control. In addition to providing clear vision, OK and contact lens wear have been shown to increase confidence, with patients reporting preferred vision, appearance, peer perception and academic performance.[1] With increasing public awareness of OK and its myopia control benefits, it is more common now for patients to present to your practice, interested in this visual correction option.

The most ethical approach to myopia control in practice involves shared-decision making between the clinician and patient after discussing all treatment options (including no treatment), potential benefits and harms, patient values, preferences and circumstances.[2] This is particularly important in starting treatment for a progressing myopic child, where an informed decision is vital and there is a clear agreement between the clinician and patient to attend regular eye reviews, follow-up care and maintenance recommendations when opting for OK. In-house resources that summarise the evidence and act as a decision aid can help facilitate an informed, shared-care decision.

How does OK slow myopia progression?

The defocus of the peripheral light in the eye is theorised to slow myopia progression and stabilise eye growth.[3] Studies demonstrate induced relative myopic shifts in peripheral refraction from OK treatment which supports this theory for OK myopia control effects.[3] There are anecdotal reports and discussion among clinicians about attempting to modify OK lens design (aiming for a smaller optic zone diameter) for 'more effective myopia control.' There is research underway to investigate whether custom-designed OK lenses could potentially be more effective in myopia control. A recent poster presented at ARVO (The Association for Research in Vision and Ophthalmology) 2019 brings this theory into question, where a reduced treatment zone diameter of 0.93 mm had no significant difference in effect on peripheral refraction between test and control OK lenses.[4] Research has also shown the effect of OK in changing eye muscle coordination, particularly near binocular vision postures shown to be risk factors for myopic progression.[5] Whether it is peripheral refraction, binocular vision, altered higher-order aberrations and/or other factors at play, there is still some mystery as to the exact mechanism of the myopia control effect from OK.

We can be confident, however, in its demonstrated myopia-slowing effects. The Retardation of Myopia in Orthokeratology (ROMIO) randomised control study and Myopia Control Using Toric Orthokeratology (TO-SEE) study reported 46 per cent and 56 per cent slower axial length elongation of children aged six to 12 years wearing OK lenses compared to the control group wearing spectacles.[6] Through further research and understanding of how OK achieves myopia control, we may one day have evidence-based methods of customising OK to optimise its myopia control effects.

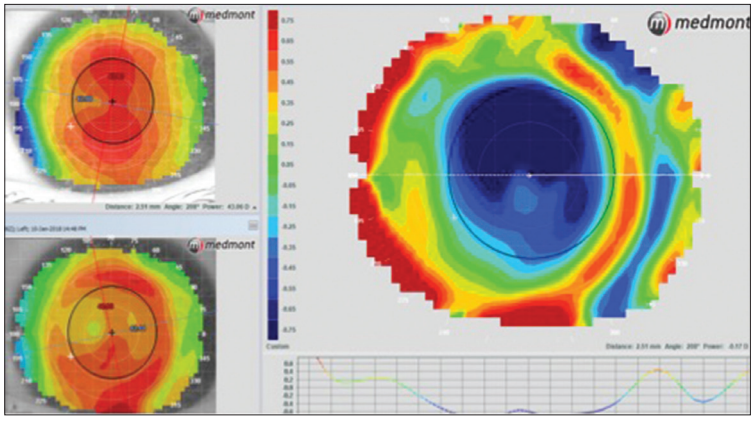

Figure 1. Right Lens OK Correction for Patient X. There is a small central pseudoisland as the patient had not used a lubricant prior to OK removal with a lens sucker.

Is OK safe for children?

As with any medical intervention, the patient and parent/guardian should be made aware of the safety aspects, risks and ways of minimising these risks and emergency procedures. Research indicates that the risk of microbial keratitis is low; there is an estimated

incidence of 7.7 per 10,000 years of lens wear.[7] Reports on microbial keratitis associated with OK mostly pre-date stricter contact lens regulation in China and East Asian countries, with modifiable risk factors identified as poor hygiene, contact with contaminated water and poor regulation and training of practitioners.[8] The Contact Lens Assessment in Youth (CLAY) study representing 1,800 lens-wearing years in seven-to-19 year-olds identified the incidence of corneal infiltrative events in children as no higher than in adults, and significantly lower in the youngest age range of eight-to-11 years.[9] This suggests that fitting of OK in children has a lower risks of infection than fitting OK in adults. It is also important to consider that in the setting of myopia control we are aiming to reduce lifetime risks of myopia-related pathology by slowing myopia progression.

Tips for fitting OK safely

- Competence in diagnosing and managing potential adverse effects of OK
- Appropriate diagnostic instruments: corneal topographer, slitlamp
- Appropriate OK lens material (high oxygen permeability [Dk] rating)
- Regular reviews and follow-up of no-show patients
- Assess compliance
- Monitor for vision, corneal topography or ocular health changes
- Regular replacement of OK lenses, cases, lens removal tools
- Clear patient and parent/guardian instruction with written materials
- You may also consider written consent forms
- Discussion of signs and symptoms of infection, reporting problems immediately and procedures to follow. Provide an emergency contact number for 24-hour access.

What age is appropriate to fit OK for myopia control?

Research[6] has shown that myopia control treatment for children at a younger age halved the risk of rapid progression in fast-changing myopia. This study indicated the ideal age to commence OK for myopia control benefit is six to less than nine years old, where OK-wear significantly reduced the risk of rapid progression by 88.8 per cent.[6] Older children also demonstrated reduced myopic progression and slower eyeball growth, for those with fast progressing myopia.[6]

How is fitting OK different for children compared to adults?

It is important to use plain language when discussing OK with a child, and it is imperative to confirm the child's understanding by asking them to demonstrate and discuss their OK process. Repetition of OK care and maintenance is important, particularly at the three-month review in children.[10] In some cases, additional education and/or follow-up visits may be needed initially.

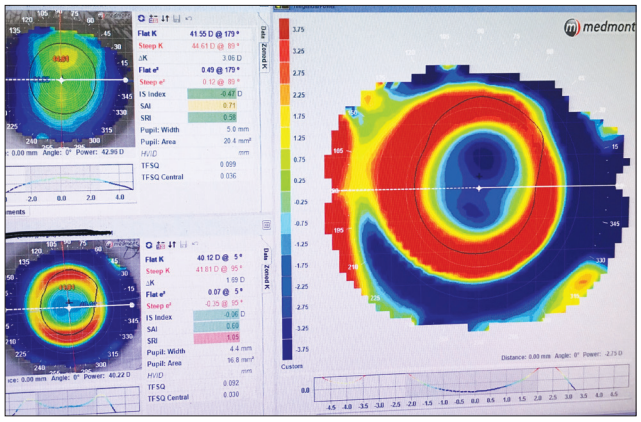

Figure 2. Right eye Rotationally Asymmetric OK lens correction of a 10-year-old boy with right refraction -3.50/-1.50X5 and R flat K 42.08, steep K 44.19

CASE REPORT

The following case example illustrates the benefit of OK in a patient with one emmetropic eye and fast-progressing myopia in the contralateral eye.

The management of anisometropia with contact lens wear can improve patient cosmesis, comfort through reduced aneisokonia and improve treatment compliance.[11] In the case of having one emmetropic eye, and one eye with refractive error, vision correction compliance can be more challenging when patients do not notice any functional vision issues. In such cases, finding a refractive correction tool that the patient will continue to use is important in reducing the risk of amblyopia, strabismus or, in the case of myopia in adolescents, potential further myopia progression due to under correction.[12]

Patient X presented as a 13-year-old male in March 2017 with a history of progressive myopia in the right eye only (-2.25 D progression in two years) and emmetropia in the left eye. He had a history of spectacle non-compliance, which, upon questioning, was due to inconvenience for sports and discomfort wearing spectacles.

Ocular examination showed cycloplegic refraction of R -4.50/-0.50X170 VA 6/6-1 L+0.25 VA 6/6+. Binocular vision testing revealed no strabismus nor underlying binocular vision disorder. Ocular health was unremarkable, with no posterior staphyloma present, and no signs of connective tissue disorders. Axial length measurement with IOLMaster was R 25.88 mm L 24.13 mm. He reported no family history of myopia or eye conditions, and no general health conditions, nor medications.

The referring optometrist had suggested consideration of contact lenses, as Patient X was not interested in spectacle correction. Soft and rigid lens options were discussed. Patient X was interested in monocular OK as he played many outdoor sports in dry, dusty environments in North Queensland, and thus preferred to avoid wearing correction outdoors.

After discussing the importance of care

Continued page 26

Ortho K

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and maintenance, risks of infection and need for strict compliance with OK, patient X was fitted with a right OK lens which achieved vision of 6/6, and left uncorrected vision of 6/6. After several initial follow-ups, six monthly reviews showed stable vision and topography of the right eye (Figure 1).

Examination in December 2018 showed a slight myopic shift in the left eye only, with left unaided vision of 6/7+2 and dry retinoscopy and dry refraction of L-0.25 VA6/6+1. Axial length with IOLMaster was R 26.00 mm L 24.33 mm. Binocular vision was unremarkable, with no abnormal accommodative lag/near esophoric posture noted. The left eye is being monitored at this stage.

Discussion

In myopia control, compliance with vision correction is important, as under correction has been shown to increase myopia progression.[12] Prior to commencing contact lens and/or therapeutic interventions, it is important to assess spectacle compliance first.

This case demonstrates an immediate halt in the right eye myopia progression once right eye OK was commenced. This is likely from better compliance with vision correction, and potentially also due to OK lens myopia control effects.

The left eye requires monitoring as further myopia progression may indicate the need for vision correction.

Conclusion

In offering myopia correction, it is important to ensure shared decision-making between the patient and clinician. In cases of non-compliance with vision-correction wear it is important to investigate potential reasons for this, and assess if other treatment options would be more suitable for the patient, considering both their lifestyle and preferences. This highlights a case of better visual correction compliance with OK compared to spectacle wear.

OK offers great vision correction, lifestyle benefits, and is one of our most effective tools in slowing myopia progression. With the ability to correct corneal astigmatism and customise the design for different-shaped eyes and prescriptions, it is an important tool for optometrists to discuss with children/adolescents with progressing myopia. Optometrists offering this tool need to ensure an informed, shared-decision with patient and parent/guardian, and have appropriate systems in place to ensure safe OK fitting.

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School

Professor Ian Morgan
BSc PhD

Research School of Biology, Australian National University, Canberra, ACT

Amanda French
BAppSci (Orth) Hons

Dr Kathryn Rose
GradDipNeurosci PhD

Discipline of Orthoptics, Graduate School of Health, University of Technology Sydney, Ultimo, NSW

We have all used the term 'school myopia,' but often, it has been no more than a description of a condition that appears during the school years, along with the prevailing, if somewhat contradictory, belief that myopia was predominantly, if not exclusively, a genetic condition.[1]

With the emergence of an epidemic of school myopia in East and Southeast Asia, a deeper understanding of school myopia has emerged over the past few years. There, the prevalence of school myopia has increased roughly three-fold over the last 50 years, with around 80 per cent of those completing 12 years of school now myopic (Figure 1). In the same parts of the world, the prevalence of high myopia (more severe than -6.00 D) has increased even more spectacularly (10–20-fold), with 10–20 per cent of students in their final years of schooling now highly myopic.[2] High myopia is generally associated with an increased risk of pathological myopia, which, in general, cannot be prevented or corrected by standard optical correction.[3]

These rapid changes are not consistent with the idea that school myopia is overwhelmingly genetically determined, since population gene pools cannot change that fast. Environmental factors must be involved. In a recent review,

myopia: a new perspective

we have discussed in some detail why the debate in this area has been so confused.[4]

The two epidemics of myopia and high myopia are closely connected. In the current epidemic of myopia there has been an increasingly early onset of myopia, with over 50 per cent of children myopic by the end of primary school.[5] A large proportion of children develop myopia at an age when progression is still rapid, with more time for progression before myopia stabilises late in the young adult years. Thus, an epidemic of myopia inevitably leads to an epidemic of high myopia, with increased loss of vision due to pathological myopia.

Environmental factors

Two environmental factors appear to play a major role in the emergence of the current epidemic.[2] The first is increased exposure to education. In the past, in societies where children received little formal education, the prevalence of myopia was only one to two per cent, most of which was probably genetic myopia. But as societies have developed more intensive mass education systems, the prevalence of school myopia has increased, no more so than in East and Southeast Asia.

The association between myopia and education is remarkably consistent, with children achieving higher school grades more likely to be more myopic.[6] Similarly, in adults, final refraction is on average higher in those who have completed more years of schooling or achieved higher qualifications.[7] But these associations do not establish causality, although some of the social correlations result from what are close to intervention trials. For the purists, the direction of causation, from education to myopia, has recently been demonstrated in a Mendelian randomisation study.[8]*

In parallel, children who spend more time outdoors are less likely to develop myopia. This is not a simple substitution effect, in which more time outdoors means less study, since the most at risk are children who combine lots of near work with little time outdoors, whereas children who combine lots of near work with lots of time outdoors are protected.[9] Causality has been demonstrated in randomised school-based interventions,[10] and the proposed causal mechanism, increased release of dopamine from the retina in the brighter light outdoors during daylight hours, has been confirmed in studies on experimental myopia.[11] The 'high prevalence of myopia' societies report much lower amounts of time spent outdoors by children than in western societies, where the prevalence of myopia is lower. Thus, it is likely that the epidemic of myopia in East and Southeast Asia results from a combination of intense education and limited time outdoors. It is currently unclear if time outdoors slows progression as well as onset, but marked seasonal effects on progression suggest that it might.

Prevention protocols

This new picture provides a clear link to prevention: through reducing educational pressures and increasing time outdoors. Reducing educational pressures may be difficult, given the importance of education in modern societies. However, it may be possible to modify some of the features of East

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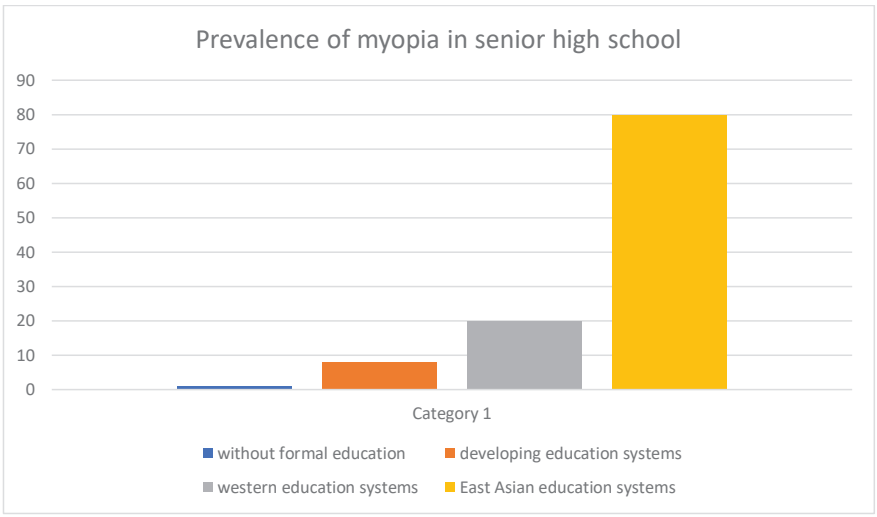

Figure 1. In East Asia, around 80 per cent of those completing 12 years of school are myopic

School myopia

From page 27

Asian education that contribute to the development of myopia, such as the very early onset of educational pressures, with homework starting in pre-school, long school days with little time outdoors, heavy homework loads and extensive use of coaching classes. These features seem be related to intense competition for selective pathways that culminate in the final university entrance examination.

While change in these areas may be difficult, introducing more time outdoors into school programs is likely to be more feasible, provided that it does not intrude too much on the core business of education. Using existing optical, pharmacological and behavioural interventions for slowing myopia progression,[12] it should now be possible to nearly eliminate all but the clearly genetic forms of high myopia. Increased time outdoors is already a core part of national myopia prevention in Singapore and Taiwan, and is likely to have a significant part in mainland China's developing myopia prevention protocols.

What does all this mean for Australia? In clinical practice, control of myopia progression now has to go hand in hand with correction. A number of optical and pharmacological approaches to prevention appear to work, but not all are strongly backed by evidence. Clinicians therefore need to investigate thoroughly the underlying evidence on the approaches they offer to clients. It also makes sense for clinicians to encourage more outdoor time, since myopia prevention does not appear to involve UV exposures and vitamin D levels, and is thus fully compatible with Australian skin protection policies.

One issue for the future is whether Australia will face increasing levels of myopia, as some modelling suggests. While there has been some increase in the prevalence of myopia in Australian children, this largely appears to be due to the increasing proportion of Australians of East Asian ancestry, who bring with them their cultural attitudes to education, and thus more myopia. In children of European ancestry, the prevalence of myopia is still under 20 per cent at the end of the school years (Figure 2). In those of East Asian ancestry, the prevalence of myopia may actually decline over time, if these communities increase engagement in outdoor activities, including sport. This development could be encouraged within schools.

Other developments could, in contrast, lead to increases. In the past, we have heard repeated calls to adopt East Asian educational practices. In addition, there is increasing interest in the provision of universal pre-school education, to better prepare children from disadvantaged backgrounds for schooling. We need to ensure that this is delivered in a way that avoids the early onset of myopia now so common in East Asia. There is also considerable interest in the development of vertical pre-schools and schools. These could be a matter of concern, if they are designed in a way that limits student access to time outdoors.

Overall, the new understandings of school myopia offer the realistic promise of effective control of progression of myopia, and some prospect of overall reductions in prevalence. But at the same time, there are likely to be future challenges, and we need to keep an eye out for proposed changes in education that could compromise these advances.

*Footnote: Mendelian randomisation uses genetic variation as a natural experiment to investigate the causal relations between potentially modifiable risk factors and health outcomes in observational studies. The assumptions and limitations of the approach have been clearly reviewed.[13] In the case of myopia, genes associated with a small but measurable increase in years of schooling were also associated with increased myopia, where genes associated with a small increase in myopia were not associated with an increase in years of schooling.[8]

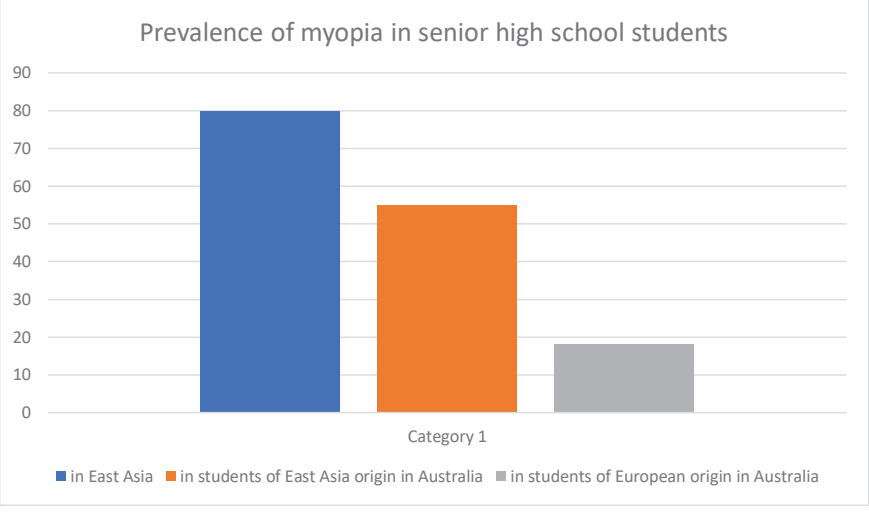

Figure 2. The prevalence of myopia is still under 20 per cent for children of European ancestry at the end of their school years

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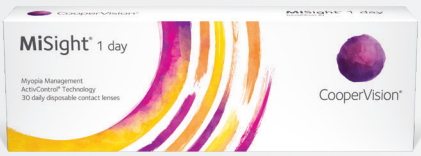

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