MYOPIA MANAGEMENT OPTIONS: WHO, WHEN, WHAT, AND HOW

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With the February 2019 publication of the International Myopia Institute (IMI) White Paper reports, a line was drawn in the sand. Involving more than 80 academics and taking 18 months, the IMI reports present robust peer consensus on a wide scope of topics relating to the research of myopia mechanisms, product research and development, clinical and industry best practices, and the public health message. In a spirit similar to the Tear Film and Ocular Surface Society Dry Eye Workshop (TFOS DEWS & DEWS II) reports, the IMI reports create a picture of the current landscape of myopia research and practice with an eye toward the future.

The core message of the IMI Clinical Management Guidelines report is simply: Do something—something more than prescribing a single-vision correction to a progressing myope.[1] Depending on mode of practice, individual practitioners may have access to few or all corrections that have been scientifically investigated for reducing the speed of axial elongation in progressive myopia, including specific spectacle lens options, multifocal soft contact lenses, orthokeratology (ortho-k), and atropine.

The basis of myopia management starts with prescribing the best vision correction, which also provides efficacy for myopia control, necessitating a longsighted view of the future risks of pathology while holding in check the shortsighted concerns of treatment risks, such as those inherent with pharmacologic or contact lens options.[2] Which option should you choose for the young progressing myope in your chair? This article aims to collate a vast amount of research into clear messages and imperatives for clinical practice.

WHOM TO MANAGE: THE PRE-MYOPE

The IMI—Defining and Classifying Myopia Report clearly describes the heretofore disputed diagnosis of a pre-myope, a child at significant risk of myopia onset, based on application research evidence.[3]

The four key principles for assessing risk of myopia onset include:

- **Family history.** One myopic parent increases risk three-fold; two myopic parents doubles this risk again.[4]
- **Visual Environment.** Less than 90 minutes a day spent outdoors increases risk, particularly when combined with more than three hours a day spent on near-work activities (outside of school time).[5]
- **Binocular Vision.** Children with higher accommodative convergence (AC/A) ratios, typically seen with esophoria, have an increased risk of myopia development within one year of more than 20 times.[6] Accommodative lag also may be a risk factor, but there is conjecture.[7] Intermittent exotropia also has been associated with onset of myopia.[8]

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- **Current Refraction.** The most significant risk factor for future myopia is if a child exhibits 0.50D or less of manifest hyperopia at age 6 to 7. This risk is independent of family history and visual environment.[9]

In addition, the fastest rate of refractive change in myopic children occurs in the year prior to onset,[10] so the child who is less hyperopic than age-normal should be closely monitored, particularly if concurrent risk factors are evident.

What treatment should you offer the pre-myope? The most robust evidence-based management is to provide education about visual environment, particularly achieving at least 90 minutes a day outdoors.[11] Managing binocular vision disorders makes sense from an orthoptic and visual comfort point of view, but despite the links between specific binocular vision disorders and myopia onset, the specific influence of managing these disorders on myopia onset has not been assessed.

One study undertaken in China evaluated the use of 0.025% atropine for at least 12 months in children from 6 to 12 years old with spherical equivalent refraction of less than +1.00D, defining this as pre-myopia. Of the 24 children in the treatment group, only 21% became myopic, while 54% of the 26 children in the control group did become myopic.[12] This study has not been replicated, and applying these findings to clinical management for pre-myopia would involve a robust informed consent process with parents.

WHEN TO MANAGE: CHILDHOOD

Research indicates that any myopic child is likely to be a progressor until proven otherwise. The commencement of a myopia management strategy as early as possible is evidence-based practice, particularly by age 9.

The following factors are linked to faster childhood myopia progression:

- **Age.** The younger a child is when he or she becomes myopic, the faster the myopia will progress, with children 7 years of age progressing by at least 1.00D per year, then halving that by age 11 to 12 years.[13]
- **Family History.** Children with two myopic parents have been shown to be the fastest progressors in single-vision spectacle and atropine corrections. Children with one myopic parent progress less than the former but more than the child without such family history.[14,15]
- **Visual Environment.** Near work at less than 20cm working distance and durations of longer than 45 minutes have been linked with increased myopia progression.
- **Ethnicity.** Asian ethnicity has been linked to faster myopia progression.[13,16]
- **Binocular Vision.** Clinicians should observe for esophoria, accommodative lag, and intermittent exotropia. In myopia control studies of progressive-addition spectacle lenses (PALs), children with esophoria in single-vision spectacle control groups were found to progress more quickly,[17] and children with a larger baseline accommodative lag in the PAL groups showed statistically greater treatment effect.[18] Children with lower baseline accommodative amplitude have shown a greater myopia control response to ortho-k contact lens wear compared with normal accommodators.[19] While the effect of controlling intermittent exotropia (IXT) on controlling myopia has not yet been studied, 50% of children with IXT are myopic by age 10 and 90% by age 20.[8]

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Myopia tends to stabilize in about half of young people by around age 15, increasing to 77% by age 18 and 90% by age 21.[20] Myopia progression still exists in young adults, as a Scandinavian case series showed that 45% progressed by at least 0.50D in their 20s.[21] Around 20% of myopic contact lens-wearing adults ages 20 to 40 years will progress by 1.00D or more over five years.[22] When it comes to late-onset myopia, occurring at 16 years or older, a large study from the United Kingdom observed that 49% of 44-year-olds were myopic, with a surprising 81% being late onset.[23] There is also considerable evidence of myopia onset and progression among specific occupational groups during demanding tertiary study courses, with medicine, law, and engineering providing a few examples.[24-26]

Beyond these studies, there is a scarcity of longitudinal data showing the normal course of myopia progression in young adulthood in any population, and no data on control of myopia specific to young adult progression. Hence, any application of risk factors and treatments involves some extrapolation, and care must be taken to provide reasonable expectations and informed consent for any myopia management process in this population.

HOW TO MANAGE: DESCRIBING MYOPIA CONTROL EFFICACY

Typically, myopia control studies present their results as a percentage control rate, i.e., the amount of reduced progression of refractive change or axial length growth provided by the treatment in comparison to the control group. Understanding and communicating percentage

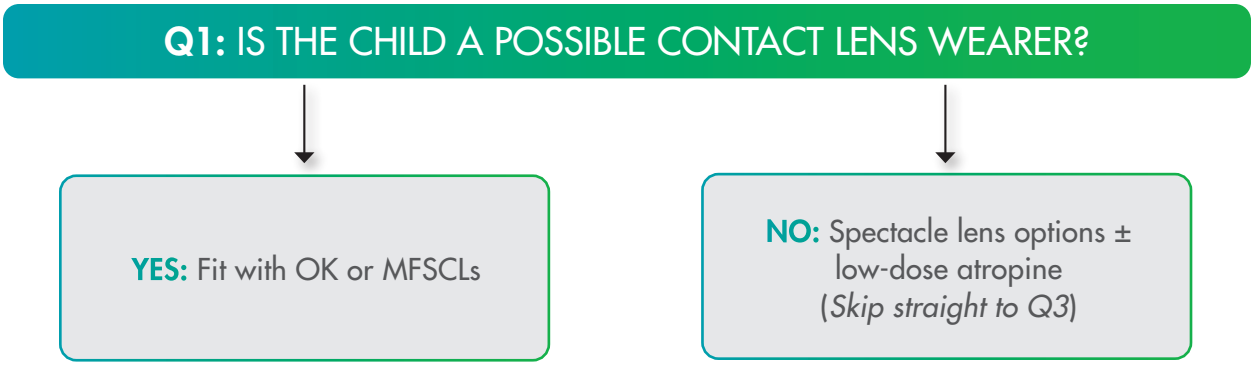

Figure 1. Clinical decision tree for myopia management, Question 1.[48]

rates of myopia control can be complex, as the study design and control group parameters affect the final outcome in a single study. For example, an older control group generally will show lower progression and a lower percentage efficacy, so meta-analyses provide the best indication.

A recent meta-analysis of eight multifocal and novel myopia control soft contact lenses found a mean efficacy of 30% to 50%,[27] and similar meta-analyses undertaken on ortho-k studies showed a 45% to 50% mean efficacy.[28,29]

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A key paper on low-dose atropine published in 2016 compared 0.5%, 0.1%, and 0.01% concentrations, and in the first two years of the study found greater efficacy with the higher dosage.[30] For the next year, all treatment was ceased, and the higher-dosage groups showed a greater percentage of rebound, defined as progression of 0.50D or more in that year. The third phase of this study saw all participants treated with 0.01% atropine for an additional two years, with the final outcomes showing that the children who had been treated with 0.01% atropine throughout had the lowest mean rate of progression over the total five years.[31] This group discontinued treatment for one year in the middle of the study, and there was no control group throughout the five years, so a precise percentage efficacy cannot be calculated.

When compared with a concurrent control group, however, a newer study found that 0.01% has a minimal effect on axial length control; 0.025% offers around 30% and 0.05% around 50% efficacy for reducing axial elongation. These lower concentrations appear to have minimal side effects of mydriasis and cycloplegia compared to previously studied concentrations of 0.1% and higher.[32]

Taken together, these findings enable practitioners to simplify the myopia management efficacy message to parents. Generally, we can expect around 50% efficacy from multifocal soft contact lenses, ortho-k, or 0.025% to 0.05% atropine. The concept of reducing progression by about half is simple to understand for practitioners, easy to explain to parents, and clarifies the immediate expectation that there is nothing we can prescribe yet that will halt the progression of childhood myopia. We can only work to slow it.

WHAT TO PRESCRIBE FOR MYOPIA MANAGEMENT

The first responsibility of an optometrist is to correct vision. Thus, the logical frontline choice for myopia management is a treatment that corrects ametropia and provides myopia control, thus contact lens options. Considering that multifocal soft contact lenses and ortho-k have similar myopia control efficacy on meta-analysis,[33] practitioners can make a selection based on a patient's suitability, and the practitioner's access to and experience with various modalities, expecting that a similar myopia management result is likely to be achieved.

The answers to the following three questions may help with this decision.

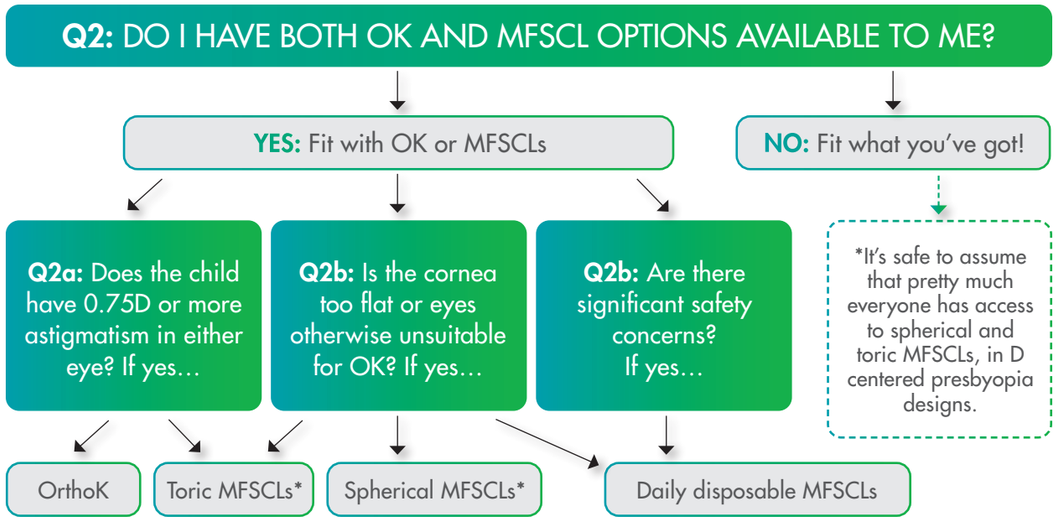

Figure 2. Clinical decision tree for myopia management, Question 2.[48]

Question 1: Is the child a willing and suitable contact lens wearer (Figure 1)?

Question 2: Do I have the appropriate modalities available to me? If the answer to Question 1 is yes, then your prescribing decision will be a combination of what is available to you in practice and factors specific to your patient, such as astigmatism and safety concerns. Currently, there are several ortho-k lens designs: daily disposable myopia-controlling and multifocal contact lenses (spherical), and monthly distance-center spherical and toric multifocal designs. It is safe to assume that almost everyone has access to the latter, regardless of mode of practice. Thus, any patient willing and able to wear contact lenses should be able to access one of these options. See Figure 2 for a flowchart of these contact lens prescribing considerations.

Another several thousand words could be written about the different types of contact lens options. In the marketplace, some of these designs have been robustly studied and some are claiming reasonable similarity of design and, hence, efficacy. For my take on which multifocal soft contact lens is best, another few thousand words are available for consumption and pondering at https://myopiaprofile.com/understand-the-options, where specific literature reviews on multifocal soft contact lens efficacy, function, refractive outcomes, and safety are discussed.

Similarly, the customization of ortho-k lenses to improve myopia control efficacy is a hot topic. At this stage, it has been shown that reducing the central optic zone diameter of an ortho-k lens will have a measured change on topographical effect,[34] but the influence of this on peripheral refraction and whole-eye aberrations is complex,[35] and the effect of this on myopia control efficacy has not yet been examined in a peer-reviewed format. For this reason, it is fair to consider any ortho-k contact lens design to have similar efficacy for myopia control, as several designs have performed similarly on meta-analysis.[28]

Question 3: Is the patient's binocular vision normal or abnormal? The next level up in customizing a myopia management treatment choice, particularly in terms of spectacle lenses, is consideration of binocular vision function. We know that single-vision spectacle lenses provide no useful efficacy for myopia control, and in fact, are used as control corrections in myopia control studies, demonstrating the untreated progression of childhood myopia.[13] Progressive-addition and bifocal spectacle lenses have shown reasonable research results for myopia control, and novel designs have been developed. Figure 3 summarizes how binocular vision function has been shown to interact with myopia control efficacy and visual comfort. This is particularly important for spectacle lens options.

WHAT TO PRESCRIBE: SPECTACLE LENSES

There is speculation about PAL or bifocal spectacles having any useful effects for myopia control,[36,37] just as there is speculation about peripheral refraction being a factor in myopia development and progression.[38,39] It is important to be aware of the indications and evidence for spectacle lens myopia control, as this is likely the first correction we will prescribe, particularly for younger children when the child (or perhaps the parent) is not ready for contact lenses. Spectacle lenses are also an important adjunct treatment for soft contact lens wearers as a back-up correction and if atropine is being prescribed as a first-line treatment.

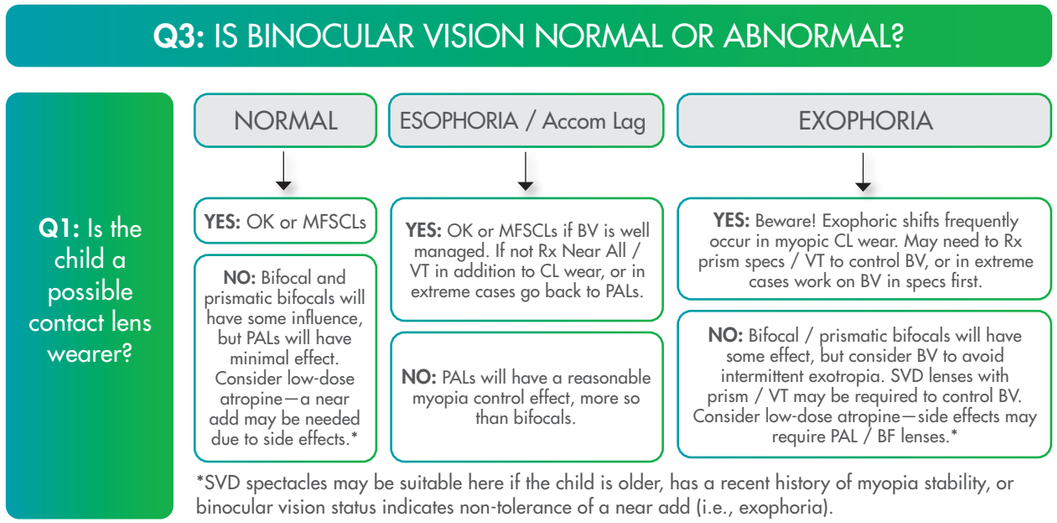

Figure 3. Clinical decision tree for myopia management, Question 3.[48]

Studies of PALs for myopia control show negligible results when single adds are applied to all children; however, when applied to children with esophoria and accommodative lag, the results become more impressive at 30% to 40% efficacy and start to approach that of contact lens studies.[17,18]

By comparison, a three-year bifocal study found 40% to 50% efficacy for a +1.50D add E-seg bifocal with 3 base-in (BI) prism incorporated.[40] Does this mean bifocals or the included prism are more effective than PALs? Perhaps, or maybe this finding had more to do with the study design that, first, ensured that all participants were demonstrated myopia progressors in the year prior to study entry and, second, by considering binocular vision. The use of the BI prism was designed to balance accommodation and vergence systems, not to reduce the response of either system. In a prior study, these authors had tested a combination of adds and BI prism, measuring accommodative lag and exophoric shifts. The +1.50D add with 3 BI right and left ensured that there was no change to lag or phoria once a patient was wearing the bifocal, essentially making the treatment mechanism about the large area of differential focus provided by the add section of the lens rather than the effect on binocular vision.[41] The BI prism ensured that the exophoric children did not get more exophoric with the add, but would not necessarily have provided the orthoptic correction for esophoria that is typically desired when prescribing a near add.

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How well did the bifocal work? Cheng et al[40] investigated a standard bifocal with a +1.50D add, and the same add with the 3 BI prism for each eye. After three years of wear, they found a moderate myopia control effect—around 35% for axial length and 50% for refractive change—in children who were orthophoric and exophoric in their baseline single-vision correction. These results are similar to those found with contact lens options on meta-analysis[27,28] and the newest study on 0.025% and 0.05% atropine.[17]

Regarding the influence of binocular vision, Cheng and colleagues found a minimal effect in the baseline esophoric children, but the group was small, so there

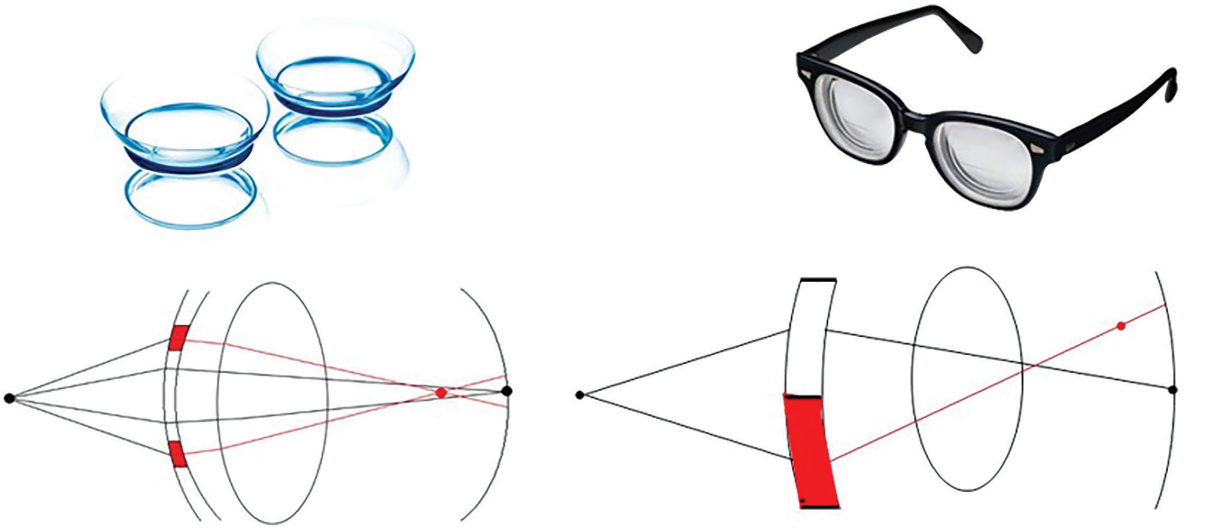

Figure 4. Simultaneous defocus demonstrated in a multifocal soft contact lens/ortho-k (left) and bifocal spectacle lens (right). The red zones indicate the areas of relative 'add' compared to the distance correction. The red ray traces and dots indicate the myopic retinal defocus produced by these 'add' zones, both on-axis and peripherally.

was less statistical power.[40] When analyzed by accommodative lag, the two-year results showed a similar effect of both bifocal types in children with high accommodative lag (>1.00D) but a better result with the prismatic bifocals in children with low accommodative lag.[42]

Which spectacle lens option should you use in practice? If you measure esophoria and accommodative lag in single-vision correction, a PAL is an evidence-based myopia control choice. If you measure orthophoria, exophoria, or normal accommodation (lag <1.00D) in single-vision correction, a bifocal or prismatic bifocal is the better choice (Figure 3). A child with low accommodative lag (<1.00D) may respond better to the bifocal lens with prism to minimize the influence of the add on binocular vision function. Keep in mind, however, that if an add makes an exophoric child break down into intermittent exotropia, this condition has been associated with myopia progression (Figure 3).[8]

Even though the numbers of esophores were small in the bifocal study, the fact that they didn't work well for the esophores in a study where the bifocal add was counteracted with BI prism (to intentionally have a minimal influence on binocular vision) indicates that binocular vision likely does play a role for some children, and contact lens research is confirming an interaction between accommodative response in multifocal and ortho-k treatments and myopia control efficacy.[43,44]

HOW: MECHANISMS OF MYOPIA CONTROL

Myopic eyes have been shown to have relative peripheral hyperopia (RPH), which is theorized to drive eye growth to the point of hyperopic defocus behind the retinal plane. This theory has been demonstrated in numerous animal models,[38] but, as yet, a clear relationship between altering RPH and myopia control efficacy across these treatments has not been proven. There is speculation that peripheral refraction may be a factor in myopia development and progression,[38,39] just as there is speculation about binocular vision playing a role via spectacle lens treatments.[36,37] Another optical influence, simultaneous defocus, could be at play.

Instead of thinking of peripheral refraction, think of how a distance-center multifocal will cast zones of clear retinal focus (the distance portion/s) and also zones of myopic defocus (the add portion/s) across the retina. This can be imagined as an on-axis depth-of-focus effect (see the red zones and focus depicted in the contact lens example of Figure 4) or also on the peripheral retina (the bifocal spectacle lens example of Figure 4). In animal studies, creating these conflicted zones of retinal defocus appears to influence the retina to pay attention to the more myopic plane, essentially halting eye growth, rather than the eye averaging the two planes.[45] In PAL or bifocal spectacle lenses, the large zone of add in the inferior lens creates a relative peripheral myopic shift on the superior retina (the red zone and focus shown in the right image of Figure 4). One study has found a relationship between the amount of relative peripheral myopia created by the inferior add zone and the myopia control effect of PALs.[46]

The concept of simultaneous defocus has been applied in a new spectacle lens technology for myopia control. The award-winning Defocus Incorporated Multiple Segments (DIMS) spectacle lens, developed at Hong Kong Polytechnic University, was recently released in

Asia. The DIMS lens has a 10mm clear central optical zone with the distance correction and is covered with +3.50D lenslets with regions of the distance correction between the lenslets. The intended result is that wherever a child looks through the lens, he or she will experience 50% of retinal focus as the distance correction and 50% of the +3.50D add. The DIMS lens looks like a single-vision lens but could work more like a contact lens because of its innovative design, and it has shown contact-lens-level results of 50% refractive control and 60% axial length control in the newly published two-year study.[47]

THE BOTTOM LINE

The imperative for managing myopia as a preventive eye health measure is clear: to reduce the lifelong risk of myopia-associated pathology and visual impairment. The options are numerous, and all eyecare practitioners have access to at least some of these spectacle and contact lens designs. Research outcomes and industry innovations continue to add new tools to our myopia management arsenal. The responsibility lies with each individual practitioner to first initiate the conversation about myopia risks and reasons to control them, and then to stay informed about new developments while providing these spectacle, contact lens, and pharmaceutical treatments to young myopic patients. **CLS**

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MORE RESOURCES

The International Myopia Institute Clinical Management Guidelines is a landmark, peer-consensus paper that details evidence-based best practices for and management of the pre-, stable, and progressing myope, including risk factor identification, examination, selection of treatment strategies, and guidelines for ongoing management.

Considerations for practitioners—such as informed consent, prescribing off-label treatment, and guides for communication with patients and parents—are detailed. In addition, the future research directions of myopia interventions and treatments are discussed.

Also provided are clinical references, resources, and recommendations for continuing professional education in this growing area of clinical practice. This resource is free to download from iovs.arvojournals.org. Supplementary digital content is also available with numerous links to online resources, including key reference papers, professional education websites, and peer discussion groups (click the 'Supplements' button in the black tab just under the paper title).

The free web-based resource Contact Lens Update, Issue #47, is dedicated to the IMI White Papers. In addition to my editorial, it includes summaries of each of the seven white papers by researchers at the Centre for Ocular Research and Education at the University of Waterloo, a conference highlight on understanding efficacy, and a free, two-page downloadable Clinical Insight article on applying the Clinical Management Guidelines in practice (contactlensupdate.com).

For more online education, the Brien Holden Vision Institute (BHVI) Global Myopia Centre is a gateway to the well-known BHVI Myopia calculator, guidelines, and online training courses (globalmyopiacentre.org).

The Myopia Profile website (myopiaprofile.com) is an extensive, freely available resource with clinically relevant blog content, organized into five learning portals to help practitioners customize their own learning journey. Communication resources for in-office use are also available for download. A new online course has been developed from this material for a more guided learning journey, and this is also free to access. There is a companion industry-only Facebook group of the same name, which includes almost 6,000 members from more than 50 countries.

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