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Consensus Summary: Myopia Management in High Myopia

Advisory Board Meeting Setup

Six world well-known independent experts (one chair and five panel members) from Asia and Europe with specific knowledge and expertise relating to high myopia and its management were invited to contribute to this meeting.

Consensus Summary

Myopia is defined as a condition in which the spherical equivalent refractive error (SER) of an eye is ≤-0.50D, low myopia (SER: ≤-0.50D - >-6.00D) and high myopia (≤-6.00D) when the ocular accommodation is relaxed.[1] Although the SER is important, greater emphasis needs to be placed on axial length (AL) and age of the child. In cases of established myopic patients (≥-4.00D) who may not have been using myopia management strategies, parental communication is equally if not more important to prevent progression to high myopia. Every dioptre of baseline myopia adds to the risk of progression to high myopia,[2] and increased risk of myopia related ocular complications (i.e., myopic macular degeneration (MMD), retinal detachment and glaucoma).

For patients with high myopia, it is difficult if not impossible to predict when myopia progression will stop because of multiple variables that influence progression. Factors influencing myopia progression in highly myopic patients include age of myopia onset, present age, previous progression history when compared to age and ethnicity matched children with the same level of myopia, parental history of high myopia, baseline refraction and lifestyle factors. All parties should understand their responsibilities in the journey.

Communication is at the core of the myopia management journey.

Managing expectations at all stages of the myopia management journey is important, emphasising that the overarching aim is to slow down excessive myopia progression. For patients who are already undergoing myopia management, assessment to the rate of progression (SER and AL) during the follow-up visits will form a key part of advice, management and discussion with the patient and parent.

Additionally, Ocular Coherence Tomography should be performed in patients with high myopia as part of their myopia management to detect early retinal changes that may be indicative of MMD. An age-related progression rate of ≤0.25D / ≤0.1mm over 6 months was considered acceptable (satisfactory). If the progression was greater, patients who were on monotherapy would likely benefit from combination treatment. When considering combination treatment for patients with myopia, suggested options included:

- Optical intervention (DIMS)/ Orthokeratology + Atropine
- Orthokeratology (nighttime) + Optical intervention (DIMS, daytime)
- Orthokeratology (nighttime) + Optical intervention (DIMS, daytime) + Atropine
- Contact Lenses (e.g. MiSight) + Atropine
- Contact Lenses (e.g. Extended Depth of Focus (EDOF) or Multifocal contact lenses) + single vision spectacle lenses

Future research and development for myopia management strategies based on current treatment efficacies for patients with high myopia should include combination treatment and long-term monitoring of pathological changes.

References

1. Flitcroft DI, He M, Jonas JB, Jong M, Naidoo K, Ohno-Matsui K, et al. IMI – Defining and classifying myopia: A proposed set of standards for clinical and epidemiologic studies. Invest Ophthalmol Vis Sci. 2019 Feb 1;60(3):M20–30.
2. Tricard D, Marillet S, Ingrand P, Bullimore MA, Bourne RRA, Leveziel N. Progression of myopia in children and teenagers: a nationwide longitudinal study. Br J Ophthalmol. 2022 Aug;106(8):1104-1109.

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Consensus: Myopia Management in High Myopia

HOYA
FOR THE VISIONARIES

Introduction

This Advisory Board meeting was designed to obtain expert opinions on myopia management in patients with high myopia. The key objectives of this meeting were:

- To understand and report on the structural and pathological complications of the eyes in patients with high myopia.
- To understand the protocol for treatment for this patient group.
- To understand the effectiveness of current myopia management strategies for patients with high myopia, gaps in evidence and discuss potential solutions for this patient group.

Advisory Board Meeting Setup

Six world well-known independent experts (one chair and five panel members) from Asia and Europe with specific knowledge and expertise relating to high myopia and its management were invited to contribute to this meeting. Four panel experts were ophthalmologists and two were optometrists.

In advance of the meeting, based on their area of expertise, the five panel members were asked to prepare a 10–15-minute presentation to cover a general introduction of high myopia and its definition, guidelines on prevention of high myopia and prompts relating the forementioned key objectives. These presentations were delivered at the start of the meeting and led onto a discussion.

Overview & Definition

Increasing prevalence of myopia and high myopia has led to an increasing prevalence of myopia related ocular complications and visual impairment. Although there has been a significant shift in the myopia management landscape, with a change in focus from emphasis on refractive surgery to diagnosis, categorisation, prevention and management of myopia and high myopia, there remain significant gaps in evidence and treatment strategies for patients with high myopia.

International Myopia Institute (IMI) has recently defined low and high myopia based on the degree of myopia. Myopia is defined as a condition in which the spherical equivalent refractive error (SER) of an eye is ≤-0.50D, low myopia is when the SER is ≤-0.50D and >-6.00D and high myopia where the SER is ≤-6.00D when the ocular accommodation is relaxed.[1] Although the SER is important, going forward greater emphasis needs to be placed on axial length (AL) and age of the child. Axial length growth curves describe the growth rate of the eye with age.[3] This relationship varies among different age groups, genders, and ethnicities (possibility of regional variations depending). Hence, consideration at what centile the child's AL falls based on their age, gender and ethnicity would categorise them as low, high, or pathological myopia.

Pathological myopia is defined as excessive axial elongation associated with myopia, which leads to structural changes in the posterior segment of the eyes (including posterior staphyloma, myopic maculopathy and high myopia associated optic neuropathy) leading to a loss of best corrected visual acuity.[1] Pathological myopia is characterized by the presence of structural abnormalities with eyes having myopic maculopathy equal to or more serious than diffuse atrophy and/or presence of posterior staphyloma. Pathological myopia has been ranked as the 2nd and 5th most common cause of blindness in four Caucasian studies.[4]

Structural and pathological complications of patients with myopia

The three most significant causes of blindness in pathological myopia are Myopic Macular Degeneration

(MMD, myopic macular neovascularization), myopic traction maculopathy and glaucoma (myopic ocular neuropathy).[5] These complications are results of an eye deformity characterized by posterior staphyloma. Posterior staphyloma is an outpouching of the wall of the eye and is a hallmark lesion of pathological myopia. Swept source Ocular Coherence Tomography (OCT) and Optos are particularly helpful imaging techniques in patients with high myopia.[2] Based on the currently available evidence, it is possible to predict the patient's risk of developing of MMD and Glaucoma.

MMD is characterized by extreme thinning of the choroid and Bruch's membrane. According to the META-PM Study Group, myopic maculopathy is classified into five categories: 0 – category; 1- no maculopathy; 2- tessellated fundus; 3- diffuse atrophy; 4-patchy atrophy; 5- macular atrophy.[6] Macular atrophy is almost always related to myopic macular neovascularization. Myopic macular neovascularization is the most common cause of central vision loss in patients with pathological myopia. Unpublished data from an observational study on a young Asian population of high myopes (Spherical Equivalent Refraction and Axial Length key risk factors) highlights the increasing prevalence of MMD.

Glaucoma is more difficult to diagnose in pathological myopia. The optic disc is often severely deformed and tilted making it difficult to diagnose based on nerve fibre layer changes and visual field assessment. Although glaucoma steadily progresses over many years if left untreated, it is noteworthy that it develops earlier in highly myopic eyes and is often overlooked and undiagnosed until much later in the disease process.

Guidelines for prevention of high myopia

Pre-myopia is a refractive state of an eye close to emmetropia in children where a combination of baseline refraction, age, and other quantifiable risk factors provide a sufficient likelihood of the future development of myopia to merit preventative interventions.[1] This is the starting point of the myopia management journey. Hence, myopia and its management should move from being considered as a standard of care to being routine care. From a public health perspective, parents and children should manage eye health in a similar manner to their dental health with children having routine eye examinations as soon as they are able to communicate.

Eye Care Professionals (ECPs) should educate parents and children about their lifestyle, duration of time spent outdoors and duration of time and distance from near tasks. Parents are often familiar with centile charts from their children's younger years. They form a good starting point for discussion on relevance and significance of myopia both as a visual performance and its relationship to changes in ocular health in the future. In line with the IMI recommendations, ECPs should consider use of age-appropriate objective methods when assessing risk of or presence of myopia. These include cycloplegic autorefraction, axial length measurement and/or keratometry readings. Axial length measurements should be used as a diagnostic and prognostic tool with a focus on monitoring relative change over time.

In cases of established myopic patients (>-4.00D) who may not have been using myopia management strategies, parental communication is equally if not more important to

prevent progression to high myopia. With a multitude of pharmacological, optical (spectacle and contact lens) myopia management strategies now available, ECPs should consider starting myopia control treatment early (or as soon as possible) and educate parents that the treatment is not a quick fix and will be continued into adolescent years and sometimes into adult years.

Communication is at the core of the myopia management journey and prevention is equal to or better than cure. Managing expectations at all stages of the myopia management journey is important, emphasising, that the overarching aim is to slow down excessive myopia progression. It is likely that there will be increments in the myopic refractive error varying with age, baseline refraction, previous progression history, lifestyle and environmental factors. It is crucial that all parties understand their responsibilities (parents, children and ECPs) and participation (e.g. compliance and aftercare) whilst being mindful that the myopia management strategy may change from time to time with a high possibility of the child requiring combination treatment with low dose atropine. Whilst ECPs are aware of the link between myopia and high myopia and ocular complications, communicating this message to parents in compassionate manner by changing focus from discussion of myopia related complications to maintain good ocular health will put the myopia management journey in a positive light for patients, parents and ECPs.

Effectiveness of current myopia management strategies for patients with high myopia

Most studies to date have investigated factors correlated with changes in axial length (AL) and spherical equivalent refraction (SER) in children and adolescents with low myopia. Only a handful of studies have specifically investigated AL and SER changes in highly myopic children and adolescents. Most participants in myopia management studies have low and moderate myopia and tested on children aged 6-16 years who show a conventional pattern of myopia onset and progression. Relatively little is known about myopia management in high myopia. Eleven studies have evaluated the effectiveness of optical and pharmacological interventions (none on environmental) at slowing axial elongation and myopia progression for high myopia.

Five clinical effectiveness studies investigated the role of atropine in high myopia and progressive myopia, one study using 1% atropine,[7] three studies using 0.5% atropine[8-10] and one study using 0.01% atropine.[12] The findings of all other four studies using higher doses of atropine (1% & 0.5%) indicate that these doses of atropine have a substantial treatment effect at slowing myopia progression in highly myopic patients, albeit with a higher incidence of side effects (cycloplegia and pupil dilation). Two studies evaluated the effectiveness of Defocus Incorporated Multiple Segment (DIMS) spectacle lenses in managing myopia progression in highly myopic patients.[12,13] Both studies report a decreasing effectiveness of DIMS spectacle lenses with increasing levels of myopia, suggesting a dose dependent (defocus +3.50D) effectiveness for low and moderate levels of myopia. Four studies investigated the effect of orthokeratology on axial

elongation in highly myopic patients.[14-18] Ortho-k lenses were equally effective in reducing myopia progression by slowing axial elongation in low, moderate and high myopia albeit with higher rates of corneal staining for higher levels

of myopic correction. A recent study by Lu et al. 2024 concluded that Ortho-k lenses were more effective than DIMS spectacle lenses in controlling axial elongation in patients with high myopia.[19]

Although there is a scarcity of evidence of effectiveness evaluation on highly myopic patients, it is important to consider the ethical implications of using this patient group as controls and/or prescribing monotherapy for myopia management in a randomized controlled trial (RCT). Combination treatment should perhaps be considered as the first line treatment in this patient group with studies conducted in a real-world setting.

When considering whether high myopia should be managed irrespective of age and into adult years, there are two key considerations here. To prevent risk of severe ocular complications and visual impairment, it is necessary to start early and treat for an extended duration of time. If on the other hand, myopia progression stops (< -0.25D progression over 2 y), myopia management interventions (particularly pharmaceutical) may no longer be necessary.

Protocol for treatment for patients with high myopia

When considering whether all patients with high myopia require myopia management treatment, it is important to distinguish between refractive myopia, pathological myopia and syndromic myopia. There is a dearth of evidence on myopia management in patients with syndromic, monogenic and secondary forms of myopia. Patients in these groups will require a multi-disciplinary approach and myopia management considered on a case-by-case basis.

Clinical evaluation of high myopia follows a similar process to that for lower levels of myopia and it is well known that the incidence of ocular complications in myopia and high myopia is correlated to axial length, refractive error, and age. There is a scarcity of literature on whether all myopes progress at the same rate. For patients with high myopia, it is difficult if not impossible to predict when myopia progression will stop, because of the number of variables that influence progression. Several factors influence myopia progression in highly myopic patients, and these include age of myopia onset, patient's age, patient's previous myopic progression history when compared to age and ethnicity matched children with the same level of myopia, parental history of high myopia, baseline refraction and lifestyle factors. Age of myopia onset and duration of myopia progression are known and well-evidenced significant risk factors for high myopia.[20] Children with myopia onset below 10 years of age are at risk for high myopia, and children with myopia onset below 8 years of age require more attention[21] with every dioptre of myopia at baseline adding to the risk of progression to high myopia.[2]

Communication of the importance of regular examinations in patients with high myopia to enable early detection of myopia, changes in refractive error and risk of ocular complications is paramount. An overview of baseline examination for highly myopic patients should include:

- History and symptoms discussion
  - Lifestyle questionnaire (duration of time outdoors, duration of screen use, duration of near work)
  - Previous relevant history: previous ocular history, number of myopic siblings, parental myopia, previous myopia management history
- Examination
  - Cycloplegic refraction
  - Binocular vision assessment and accommodative status
  - Anterior and posterior health examination
  - Intraocular pressure and visual field assessment
- Advice and execution of myopia management

To assess risk of ocular complications, posterior health examination should include fundus photography using a wide field fundus camera (Optos), Ocular Coherence Tomography (OCT) or Angio-OCT.

When considering myopia management, the following elements should form core elements of the clinical evaluation:

- Anterior eye examination
- Cycloplegic autorefraction
- Axial length measurements
- Intraocular pressure measurement (pharmacological intervention)
- Corneal topography

Categorisation into the high myopia category should be based on age-matched biometry measurements. With new emerging evidence on an almost weekly basis, ECPs are faced with challenges in implementing evidence-based care into their routine care. Algorithms such as the one developed by Tapasztó et al. might help provide practical assistance in choosing and developing an effective myopia management strategy tailer to each individual child[22] though updated versions that focus on age, centile charts, levels of myopia and different stages of structural and pathological complications of myopia was recommended as an area of future work.

For patients who are already undergoing myopia management, assessment to the rate of progression (SER and AL) during the follow-up visits will form a key part of advice, management and discussion with the patient and parent. A progression rate of ≤0.25D/ ≤0.1mm over 6 months was considered acceptable/satisfactory. If the progression was greater, patients who were on monotherapy would likely benefit from combination treatment. When considering combination treatment for patients with myopia, suggested options included:

- Optical Interventions (DIMS)/Orthokeratology + Atropine
- Orthokeratology (nighttime) + Optical intervention (DIMS, daytime)
- Orthokeratology (nighttime) + Optical intervention (DIMS, daytime) + Atropine
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- Contact Lenses (e.g., Extended Depth of Focus (EDOF) or Multifocal contact lenses) + single vision spectacle lenses

There is more evidence supporting the efficacy of red-light therapy in myopia management, but important safety concerns raised recently mean that these devices cannot be endorsed for use in simple myopia.[23-25]

Additional considerations for future research and development for myopia management strategies for patients with high myopia include:

— Effectiveness of myopia management strategies in patients with high myopia
— Developing optical interventions (spectacle and contact lenses) with customized defocus.
— Using simple objective devices to measure and monitor relative peripheral refraction.
— Development of customised lifestyle monitoring programmes (using customized light trackers, devices that monitor time spent doing near work and/or screen work, devices that monitor near work distance)
— Development of myopia management algorithms that focus on age, centile charts, levels of myopia and different stages of structural and pathological complications of myopia.
— Development of a register for high myopes (to include all relevant data relating to high myopia e.g., ethnicity, SER, AL, retinal images, OCT scans) through national and international collaborations.
— An evaluation of biomarkers for myopia progression (i.e. structural shifts in the retinal features, inflammation, retinal imaging, choroidal thickness) through data pooling.

* The opinions expressed in this consensus and by the experts Advisory Meetings are the current opinions of the individual experts and cited reference sources and do not reflect the opinions of HOYA. The opinions are presented for informational purposes only and are not intended as medical advice, diagnosis, or choice of treatment. Patients should always consult their Eye Care Professionals for diagnosis and treatment decisions.

References

1. Flitcroft DI, He M, Jonas JB, Jong M, Naidoo K, Ohno-Matsui K, et al. IMI – Defining and classifying myopia: A proposed set of standards for clinical and epidemiologic studies. *Invest Ophthalmol Vis Sci.* 2019 Feb 1;60(3):M20–30.

2. Tricard D, Marillet S, Ingrand P, Bullimore MA, Bourne RRA, Leveziel N. Progression of myopia in children and teenagers: a nationwide longitudinal study. *Br J Ophthalmol.* 2022 Aug;106(8):1104-1109.

3. Klaver C, Polling JR. Myopia management in the Netherlands. *Ophthalmic and Physiological Optics.* 2020 Mar 1;40(2):230–40.

4. Wong TY, Ferreira A, Hughes R, Carter G, Mitchell P. Epidemiology and disease burden of pathologic myopia and myopic choroidal neovascularization: an evidence-based systematic review. *Am J Ophthalmol.* 2014 Jan;157(1):9-25.e12. doi: 10.1016/j.ajo.2013.08.010. Epub 2013 Oct 5. PMID: 24099276.

5. Haarman AEG, Enthoven CA, Willem Tideman JL, Tedja MS, Verhoeven VJM, Klaver CCW. The complications of myopia: A review and meta-analysis. Vol. 61, Investigative Ophthalmology and Visual Science. Association for Research in Vision and Ophthalmology Inc.; 2020.

6. Ohno-Matsui K, et al. International photographic classification and grading system for myopic maculopathy. *Am. J. Ophthalmol.* 2015;159:877–883. doi: 10.1016/j.ajo.2015.01.022.

7. Fan DSP, Lam DSC, Chan CKM, Fan AH, Cheung EYY, Rao SK. Topical atropine in retarding myopic progression and axial length growth in children with moderate to severe myopia: A pilot study. *Jpn J Ophthalmol.* 2007 Jan;51(1):27–33

8. Chou AC, Shih YF, Ho TC, Lin LLK. The Effectiveness of 0.5% Atropine in Controlling High Myopia in Children. Journal of Ocular Pharmacology and Therapeutics. 1997 Feb;13(1):61–7.

9. Polling JR, Kok RGW, Tideman JWL, Meskat B, Klaver CCW. Effectiveness study of atropine for progressive myopia in Europeans. Eye (Basingstoke). 2016 Jul 1;30(7):998–1004.

10. Polling JR, Tan E, Driessen S, Loudon SE, Wong HL, van der Schans A, et al. A 3-year follow-up study of atropine treatment for progressive myopia in Europeans. Eye (Basingstoke). 2020 Nov 1;34(11):2020–8.

11. Agarwal P, Khurana A, Maan V, Sutar S, Chauhan L. Role of 0.01% atropine in high myopic children of Moradabad, India (RAMCOM Study). *Indian J Ophthalmol.* 2022 Dec 1;70(12):4400–4.

12. Liu J, Lu Y, Huang D, Yang J, Fan C, Chen C, et al. The Efficacy of Defocus Incorporated Multiple Segments Lenses in Slowing Myopia Progression: Results from Diverse Clinical Circumstances. Ophthalmology. 2023 May 1;130(5):542–50.

13. Long W, Chen K, Yu S, Liang Z, Zheng B, Zeng J, et al. One-year Efficacy of the Defocus Incorporated Multiple Segment Lens in Chinese Myopic Children. Optometry and Vision Science. 2023 Jan 1;100(1):111–6.

14. Zhu MJ, Feng HY, He XG, Zou HD, Zhu JF. The control effect of orthokeratology on axial length elongation in Chinese children with myopia. *BMC Ophthalmol.* 2014;14(1).

15. Yu L, Jin W, Mao X, Jiang J. Effect of orthokeratology on axial length elongation in moderate myopic and fellow high myopic eyes of children. *Clin Exp Optom.* 2021;104(1):22–7.

16. Charm J, Cho P. High myopia-partial reduction orthokeratology (HM-PRO): Study design. Contact Lens and Anterior Eye. 2013 Aug;36(4):164–70.

17. Lyu T, Wang L, Zhou L, Qin J, Ma H, Shi M. Regimen Study of High Myopia-Partial Reduction Orthokeratology. Eye Contact Lens. 2020 May 1;46(3):141–6.

18. Wang F, Wu G, Xu X, Wu H, Peng Y, Lin Y, et al. Orthokeratology combined with spectacles in moderate to high myopia adolescents. Contact Lens and Anterior Eye. 2023 Nov;102088.

19. Lu W, Ji R, Jiang D, Shi L, Ding W, Tian Y, Zhao C, Leng L. Different efficacy in myopia control: Comparison between orthokeratology and defocus-incorporated multiple segment lenses. Cont Lens Anterior Eye. 2024 Apr;47(2):102122.

20. Chua SY, Sabanayagam C, Cheung YB, Chia A, Valenzuela RK, Tan D, Wong TY, Cheng CY, Saw SM. Age of onset of myopia predicts risk of high myopia in later childhood in myopic Singapore children. *Ophthalmic Physiol Opt.* 2016 Jul;36(4):388-94.

21. Qin Z, Peng T, Zhang Z, Lou J, Wang C, Deng R, Xu M, Yu X, Chen W. Myopia progression and stabilization in school-aged children with single-vision lenses. *Acta Ophthalmol.* 2022 Jun;100(4):e950-e956.

22. Tapasztó B, Flitcroft DI, Aclimandos WA, Jonas JB, De Faber JHN, Nagy ZZ, Kestelyn PG, Januleviciene I, Grzybowski A, Vidinova CN, Guggenheim JA, Polling JR, Wolffsohn JS, Tideman JWL, Allen PM, Baraas RC, Saunders KJ, McCullough SJ, Gray LS, Wahl S, Smirnova IY, Formenti M, Radhakrishnan H, Resnikoff S, Németh J; SOE Myopia Consensus Group. Myopia management algorithm. Annexe to the article titled Update and guidance on management of myopia. European Society of Ophthalmology in cooperation with International Myopia Institute. *Eur J Ophthalmol.* 2023 Dec 12:11206721231219532. doi: 10.1177/11206721231219532. Epub ahead of print. PMID: 38087768.

23. Ostrin LA, Schill AW. Red light instruments for myopia exceed safety limits. *Ophthalmic Physiol Opt* 2024 doi: 10.1111/opo.13272 [published Online First: 2024/01/05]

24. Salzano AD, Khanal S, Cheung NL, et al. Repeated Low-level Red-light Therapy: The Next Wave in Myopia Management? *Optom Vis Sci* 2023 doi: 10.1097/OPX.0000000000002083 [published Online First: 2023/10/27]

25. Swiatczak B, Schaeffel F. Effects of short-term exposure to red or near-infrared light on axial length in young human subjects. *Ophthalmic Physiol Opt.* 2024 Apr 1. doi: 10.1111/opo.13311. Epub ahead of print. PMID: 38557968.