



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

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Abstract:	Myopia is becoming increasingly common in young generations all over the world, and it is predicted to become the most common cause of blindness and visual impairment in later life in the near future. Because myopia can cause serious complications and vision loss, it is critical to create and prescribe effective myopia treatment solutions that can help prevent or delay the onset and progression of myopia. The scientific understanding of myopia's causes, genetic background, environmental conditions, and various management techniques, including therapies to prevent or postpone its development and slow its progression, is rapidly expanding. However, some significant information gaps exist on this subject, making it difficult to develop an effective intervention plan. As with the creation of this present algorithm, a compromise is to work on best practices and reach consensus among a wide number of specialists. The quick rise in information regarding myopia management may be difficult for the busy eye care provider, but it necessitates a continuing need to evaluate new research and implement it into daily practice. To assist eye care providers in developing these strategies, an algorithm has been proposed that covers all aspects of myopia mitigation and management. The algorithm aims to provide practical assistance in choosing and developing an effective myopia management strategies tailored to the individual child. It incorporates the latest research findings and covers a wide range of modalities, from primary, secondary, and tertiary myopia prevention to interventions that reduces the progression of myopia.



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Myopia Management Algorithm.

Annex to the article titled Update and Guidance on Management of Myopia.

European Society of Ophthalmology in cooperation with International Myopia Institute

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Abstract

Myopia is becoming increasingly common in young generations all over the world, and it is predicted to become the most common cause of blindness and visual impairment in later life in the near future. Because myopia can cause serious complications and vision loss, it is critical to create and prescribe effective myopia treatment solutions that can help prevent or delay the onset and progression of myopia. The scientific understanding of myopia's causes, genetic background, environmental conditions, and various management techniques, including therapies to prevent or postpone its development and slow its progression, is rapidly expanding. However, some significant information gaps exist on this subject, making it difficult to develop an effective intervention plan. As with the creation of this present algorithm, a compromise is to work on best practices and reach consensus among a wide number of specialists. The quick rise in information regarding myopia management may be difficult for the busy eye care provider, but it necessitates a continuing need to evaluate new research and implement it into daily practice. To assist eye care providers in developing these strategies, an algorithm has been proposed that covers all aspects of myopia mitigation and management. The algorithm aims to provide practical assistance in choosing and developing an effective myopia management strategy tailored to the individual child. It incorporates the latest research findings and covers a wide range of modalities, from primary, secondary, and tertiary myopia prevention to interventions that reduce the progression of myopia.

Key words: myopia, pre-myopia, preventive medicine, screening, time spent outdoors, myopia control interventions, atropine, orthokeratology, management algorithm

Introduction

The major aim of this Algorithm Annex to the "Update and Guidance on Management of Myopia. European Society of Ophthalmology in cooperation with International Myopia Institute"¹ is to give practical advice to eye care providers in choosing and developing an effective myopia management strategy for their patients. The Annex presents current knowledge in the form of flowcharts and is focused on prevention and delaying onset and then slowing down progression: from environmental variables to avoid myopia onset, through screening and follow-up of pre-myopes to prevent or postpone myopia development, and eventually to myopia management to reduce myopia progression. The rapid increase in knowledge regarding myopia management could be challenging for the busy eye care provider but warrants an ongoing need to monitor new research and incorporate it into personal everyday practice.²

Limitations

Although extensive literature has been published on myopia management and is freely available, important knowledge gaps have remained, which can lead to difficulties in creating a robust myopia algorithm. In some areas, evidence is difficult to obtain e.g., it is becoming increasingly difficult to conduct randomized controlled trials (RCTs) involving a placebo arm, as this may now be considered unethical,^{3,4} and because there are individual variations in the progression of myopia, randomization in itself is challenging.⁵ The main aim of this sub-chapter is to explain the limits of a myopia management algorithm and to demonstrate the present gaps in knowledge in order to initiate additional research in these areas.

Why is it not possible to provide simple algorithm(s) or guideline(s), given the present state of the science of myopia control?

- There is a wide variety of differences among myopes currently reported in the literature, including, but not limited to, age of onset, sex, ethnicity, family history of myopia, growth rate, and environmental factors, including computer screen time/near work, outdoor time, work-rest regime.

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3 - There are few head-to-head comparisons (“randomized non-inferiority trials”) of the
4 various interventions available.^{6,7,8} The majority of studies focused on comparing
5 pharmacological and optical treatments against a non-active control. Results indicated that
6 these interventions could potentially slow down myopic progression and reduce axial
7 elongation, but the results are inconsistent. Limited evidence is available for the effects of
8 these interventions after two or three years, and there is still uncertainty about their long-
9 term effectiveness. There is therefore a need for more rigorous and longer-term studies
10 that compare various myopia control interventions, either used alone or in combination,
11 and for improved methods of monitoring and reporting adverse effects.⁹

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14 - There are no well-designed within-patient comparisons (“repeated cross-over trials”) of
15 the various interventions available, so it is not clear whether some interventions are more
16 effective than others in certain groups of patients.

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19 - Comparatively few studies have been carried out in non-Asian countries, making it unclear
20 if the efficacy and side effects of interventions are consistent across ethnic groups and
21 geographical regions, especially within Europe. However, recent studies conducted on
22 American and European populations have shown that pharmacological treatments, such as
23 0.01% atropine, demonstrate reduced progression of axial length and spherical equivalent
24 refraction after treatment.^{10,11}

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27 - Legislative rules differ across countries/regions in Europe; certain treatment regimens,
28 such as topical application of atropine eye drops may have to be used in an “off-licence”,
29 “off-label” or “no-label” mode. Practitioners may understandably be reluctant to use such
30 unlicensed preparations, as this may expose them to the risk of malpractice claims. In
31 addition, atropine eyedrops are generally only available from compounding pharmacies,
32 where variability in production and stability will affect dosage.¹²

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49 ***Open questions yet to be addressed (by RCTs, large independent real-life studies, or other***
50 ***study designs):***

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52 - There is a lack of prevalence data obtained using cycloplegia, as studies not using
53 cycloplegia overestimate the frequency of myopia.

54
55 - Which interventions (other than more time spent outdoors and low-dose atropine^{13,14}) can
56 be used prophylactically to prevent or delay onset of myopia? Could risk factor matrices or
57 scoring systems be useful here to identify when prophylactic use is most indicated?¹⁵
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3 - Which intervention to start and at what age?
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5 -- direct comparisons using – randomized non-inferiority trials examining the
6 efficacy of different treatments (as 1st line therapy).
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9 - What factors influence treatment decisions and treatment outcomes?
10 -- age of myopia onset? rate of previous myopic progression? family history? sex?
11 ethnicity? binocularity? pupil size? lifestyle conditions? social-economic status? etc?
12 and the interactions between these factors?
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16 - What is the optimal age to start treatment for different types of myopia (pre-school,
17 primary school, secondary school, and young adulthood)?
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19 - Is switching treatment modality effective, and if so, which to which intervention should a
20 patient be switched?
21
22 -- repeated cross-over trials to search for scientific evidence of “non-responders”
23 -- right time to switch to another intervention?
24
25 -- head-to-head comparisons of different switching orders and timings
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27 -- what action to take when intervention fails to control myopia progression?
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31 - Which combination therapy?
32 -- direct comparisons of different combination therapies using randomized non-
33 inferiority trials
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36 - More data (possibly a systematic review or meta-analysis) is required on the prevalence
37 (and possible characteristics) of patients who fail to respond to the various interventions.
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40 - Treatment duration and cessation?
41 -- comparative data on when and how to stop interventions? Research to test the
42 continuation of efficacy beyond 2-3 years is very limited. Issue of plateau
43 effects/rebound effects.
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49 ***Further points which are important:***

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51 - The lack of a centralised data repository for all clinical studies or trials. Although there
52 have been discussions about the creation of a central repository for all data that would
53 allow meta-analyses, no central repository has yet been set up.
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56 - The field of myopia control is constantly expanding, and new methods of myopia control
57 are being trialled regularly. This paper includes only the treatment modalities that are
58 currently regulated and widely used for myopia control and prevention.
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Solutions used to overcome the aforementioned limitations:

The main aim in developing this algorithm was to be as close as possible to the science-based evidence. A challenge exists primarily where no evidence is available. A compromise is to work on “best practices” or “consensus” basis by many experts in the field of myopia. Not doing so leads to a lack of guidance for practitioners to follow, resulting in confusion and poor adoption. The main process was the circulation of the drafts for expert commentary, and where necessary, methods inspired by the Delphi Panel¹⁶ were used to generate consensus in a structured way. The algorithm was developed by members of the board of the European Society of Ophthalmology in cooperation with invited experts and European authors of the International Myopia Institute. The algorithm was endorsed by the SOE executive board. In detail: The first author (BT) wrote the first draft of the algorithm, which was reviewed several times by the last author (JN). The last author wrote the initial draft of the introduction of the manuscript and the limitations of the project following a brainstorming process with four authors (JBJ, JAG, LSG, SR) through email. All authors received the initial draft of the whole text for evaluation, changes, and comments. After receiving all of the authors' responses, a second draft was created that included all of the suggestions, and a consensus questionnaire was developed on eight particular topics in which the authors' opinions differed. The consensus questionnaire and the second draft document, which included all of the authors' recommendations and also the text solutions on consensus subjects, were distributed to all authors. The manuscript and figures were revised based on the responses. This third draft was shared again, and after additional minor changes, it was approved by each author. The article was then delivered to the Board of the European Society of Ophthalmology, who shared it among their Board members and included it on the agenda for the Board meeting. The SOE Myopia Consensus Group was created when 16 Board members (in addition to the six original authors who are SOE Board members: WAA, JTHNDF, ZZN, PGK, IJ, and CNV) provided their views and agreement, and the SOE Executive Board endorsed the paper. The finalized version of the Myopia Algorithm manuscript was sent to all authors for final approval before it was eventually submitted to the journal.

Algorithm

Prevention or delay of myopia onset (primary prevention measures)

1. The main aim is to provide lifestyle advice for any child whereby the clinical evaluation indicates a possibility of reducing the risk of or at least delaying myopia onset. Delaying myopia onset is important because postponing the onset of myopia is expected to reduce the ultimate magnitude of myopia and hence the risk of future high and pathologic myopia.^{1,17-19} The most important primary prevention measures are listed in Table 1.

Table 1. Recommendation for primary prevention or delay of myopia onset for school-aged children (Level I is the highest evidence (details see in Elsevier evidence levels)²⁰)

Life situation	Recommendation	Level of evidence ²⁰
Time outdoor	1-2 hours of outdoor activity every day. ²¹⁻²³	Level I
Near work	Limit the length of time spent continuously reading or other near work to 30 to 45 minutes followed by a break. ^{24,25}	Level II
	Read from a greater distance: more than 20-30 cm. ²⁴⁻²⁷	Level III

Time spent outdoors is well recognized as a factor preventing the development of myopia (evidence: Level I).²⁰ It is recommended to spend as much time as possible in natural daylight (with appropriate skin protection from ultraviolet radiation), regardless of age. The

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3 timing, brightness and UV light exposure play important role in controlling myopia during
4 outdoor activity.²⁸⁻³⁰

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6 For school-aged children to have clinically significant protection from myopia inducing
7 stimuli, it is advised that the children participate in outdoor activities for at least 1-2 hours
8 every day.^{1,2,22,31}

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14 In parallel with more time spent outdoors, it may be beneficial to promote a healthy visual
15 environment to limit the length of continuous time spent at near work: reading at a short
16 distance or using a close-up screen (Level II and III evidence, Table 1). For any reading or
17 other activity performed at short distances, the distance should be increased to a minimum
18 of 20-30 cm.²⁴⁻²⁷ In addition, one may discuss whether, except for schoolwork, the time
19 spent with reading or with other activities at short distances should be reduced to no more
20 than 30 to 45 minutes,^{24,25} followed by an ideal break of 5-10 minutes (it may be more
21 effective to take longer breaks, such as five minutes per hour, than the well-known 20-20-20
22 ocular discomfort rules to lower the risk of myopia).^{32,33} Data issuing from the COVID-19
23 pandemic has indicated that using TV displays or projectors for online learning is preferable
24 to using tablets, mobile phones, or PC screens when trying to provide a less myopiagenic
25 environment for children.³⁴

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38 Natural daylight or exceptionally bright indoor light (over 2500 Lux) are beneficial to use
39 indoors (Level III evidence).^{26,35-40} The WHO's guidance on physical activity, sedentary
40 behaviour and sleep recommends that children under the age of two years avoid using
41 screens at short distances. For children up to five years old, screen time at short distances
42 should be limited to one hour per day.⁴¹ These recommendations were developed for a
43 wider child-health purpose but may also be helpful in relation to myopia. For children aged
44 five to twelve years, the Erasmus Myopia Research Group has argued that a maximum of
45 two hours per day may be a sensible recommendation.⁴²

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52 Education campaigns for myopia management and eye care awareness are supported by the
53 MyopiaEd toolkit, developed by the World Health Organization (WHO) and the International
54 Telecommunication Union (ITU). The toolkit provides evidence-based messages for targeted
55 digital communication and implementation guidance.⁴³

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3 A few studies have recently examined the impact of low dose atropine for the prevention or
4 delaying onset of myopia. Atropine at 0.025% and 0.05% was effective in delaying or
5 preventing the onset of myopia in pre-myopes (0.0D to +1.0D) compared to the control
6 group; however, this finding needs to be confirmed through additional research and it is
7 suggested that the concentration should be as low as possible to minimize adverse effects
8 and encourage compliance.^{13,14} (See a more detailed discussion of atropine treatment in the
9 tertiary prevention section, in points 10-11).
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18 2. The initial step of the algorithm is a cycloplegic refraction (Figure 1). The use of
19 cycloplegia is recommended to establish the diagnosis of pre-myopia or prevent an
20 overdiagnosis of myopia as well as to provide a robust and more repeatable baseline
21 measurement of myopia with which to compare future measures.^{44,45} If cycloplegia is not
22 performed, the eye care provider must ensure that the eye is unaccommodated.^{46,47}
23 Consideration of the uncorrected distance vision will aid in confirming or refuting the
24 presence of myopia where a non-cycloplegic result is utilised.
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30 Myopia is not very common (0.2–3.7%) in children under the age of six years, even in
31 Asia,^{1,48,49} suggesting that a screening examination for myopia may be most effective when
32 conducted around the age of six years. In children with myopia onset at an age of less than 6
33 years, forms of secondary myopia such as Stickler's syndrome and other conditions should
34 be considered/investigated.^{1,50,51}
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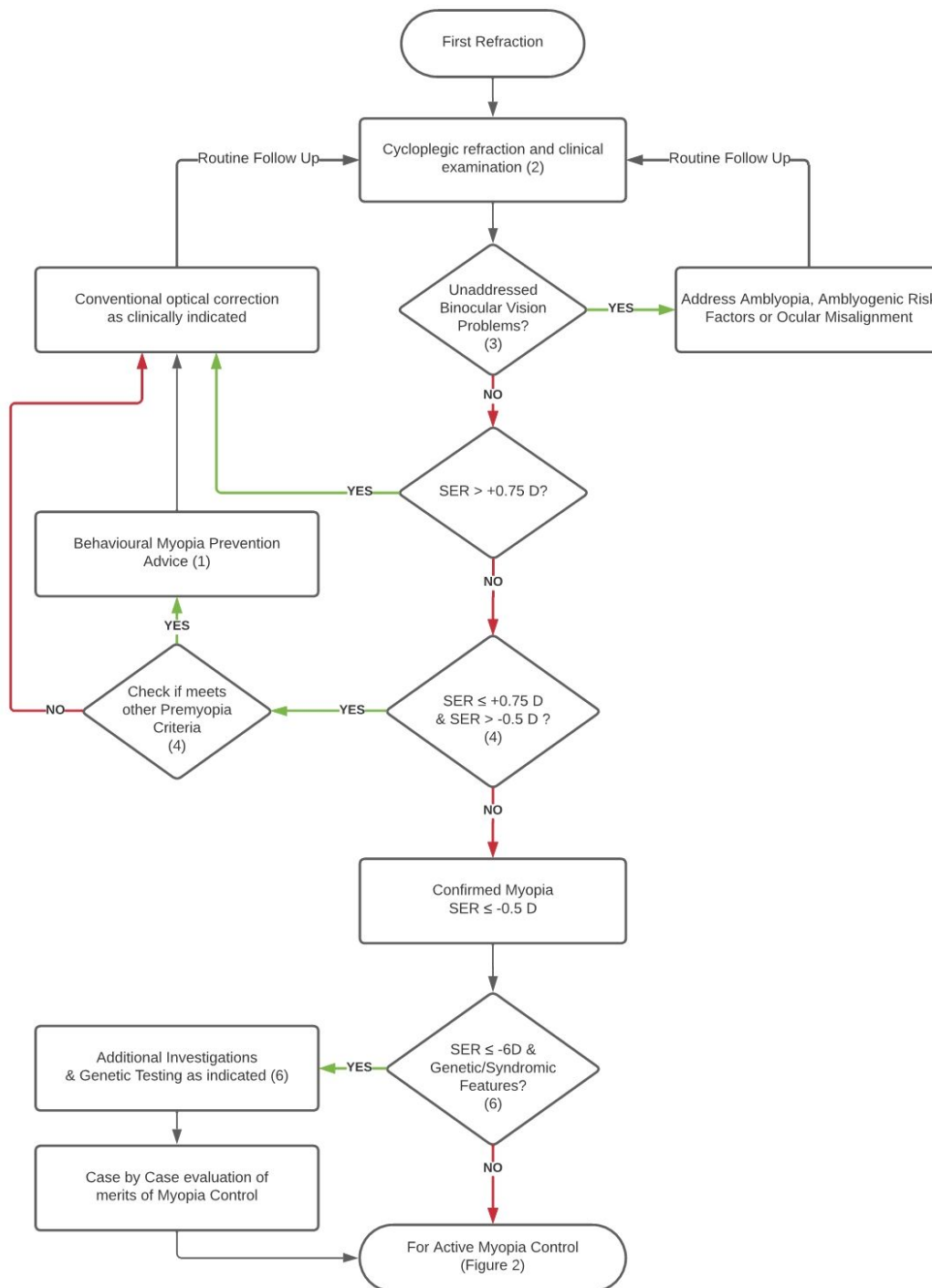


Figure 1. Initial refractive assessment flowchart. Algorithm for the primary and secondary prevention of myopia. Numbers refer to the stages identified in the text. The flowchart

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3 needs to be read from top to bottom, however at some decision points, certain responses
4 are going upward and eventually returning to an earlier level of the flowchart, showing the
5 necessity for repeated cycles to monitor and follow-up on myopia development and
6 intervention procedures. (D: diopter, SER: spherical equivalent refraction).
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10 11 12 **Screening of pre-myopes (secondary prevention measures)** 13

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16 3. Studies have shown a complex relationship between near-work, ocular accommodation,
17 and myopia development, with no clear causative relationship.⁵² Studies have found that
18 the accommodative convergence-to-accommodation (AC/A) ratio is elevated in myopic
19 children and has been documented to be elevated prior to myopia onset, as early as four
20 years prior. However, increased lag of accommodation has not been found to be predictive
21 of myopia onset or progression.⁵² Since providing a sharp image on the retina is important,
22 eye care practitioners should still assess the accommodation and convergence systems in all
23 children to ensure normal visual development.⁵²
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33 4. Pre-myopia is the refractive state of an eye which under cycloplegia has a spherical
34 equivalent between $\leq +0.75$ D and > -0.5 D. Children aged 6-8 years with pre-myopia have an
35 increased risk of future development of myopia, particularly in conjunction with other
36 quantifiable risk factors such as family history of myopia and ethnicity.⁴⁴ Analysis of the risk
37 factors for myopia must be carried out for every child. In addition to quantifiable risk factors
38 such as family history of parental myopia, ethnicity, age, and female sex, lifestyle factors
39 such as less time spent outdoors and more time spent in near work activities should be
40 explored (Table 2).^{1,19} Monitoring axial length changes is a valuable tool for screening and
41 follow-up of pre-myopes and also for myopia control because the visual consequences of
42 myopia are closely tied to axial elongation.⁵³⁻⁵⁵ A growth chart of the eye is a pillar for
43 myopia management. Children who are in the higher percentiles of axial length and those
44 who cross percentiles, indicating more than natural growth, are at increased risk for myopia
45 or even high myopia.^{56,57}
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56 To reduce the risk of myopia, it is recommended to regularly monitor pre-myopes using the
57 axial growth chart percentile curve.^{56,57} In terms of follow-up, the duration may vary for
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each individual based on factors such as risk factors and eye length. However, in general, a 6-month follow-up period is recommended.

Table 2. Risk factors associated with prevalence or progression of myopia

Ethnicity	East-Asians are at higher risk for myopia and high myopia. ^{1,58-62}
Sex	Females are at higher risk for myopia at about 9 years of age and above. ^{1,19,58,59}
Age of myopia onset	The annual progression is much greater for those with an early onset, and the most rapid progression between age 6-12 years. ^{1,58,63-70}
Parental myopia	Myopia is more likely to develop if one or both parents are myopic. ^{1,19,58} If both parents are high myopes the risk of fast progression is increased for the child. ⁷¹
Time spent outdoor	Increasing outdoor exposure is effective in preventing or delaying the onset of myopia. ^{1,19,58,59,72}
Education / Near work	More time (and longer continuous time) spent on near-work activities also in the context of less outdoor activity increases the likelihood of developing myopia. ^{1,19,58} There is a significant association between digital screen time in the context of more near work and myopia. ^{1,19,72}

Reduction of myopia progression (tertiary prevention measures)

5. It is the duty of every eye care provider to proactively discuss myopia control measures with parents and myopic children and offer appropriate interventions (a refractive error of -0.5 D or stronger under cycloplegia) or refer to an appropriate colleague if they do not feel comfortable managing myopia (Figure 2). Although the risk for visual impairment increases to 25% in eyes with an axial length greater than 26 mm and exceeds 90% when the axial

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3 length is over 30 mm,⁵³ it is essential to note that even low and moderate myopia at an
4 early age pose an increased risk.^{54,55} The need to promote suitable evaluation methods and
5 viable myopia control strategies is essential (environmental, optical, pharmacological). In
6 addition to the optimization of environmental influences (Table 1 and 2), the two basic
7 interventions for which there is currently the most evidence to support efficacy are optical
8 and pharmacological.
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14 There are several criteria to consider when deciding which option to choose. These include
15 the availability of the option in the patient's country, the practicality of the option given the
16 patient's lifestyle or financial situation, the eye care provider's familiarity with the
17 procedure, and the availability of appropriate instrumentation. If one intervention method
18 fails, another maybe tried, or methods can be combined.^{1,2,73,74}
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23 It should be noted that at present, while these interventions have been shown to be
24 efficacious in many children, children do not all respond equally, and some children do not
25 respond and continue to progress at pace. Eye care practitioners should not over-promise
26 and more research is needed to develop more targeted and personalised approaches to
27 myopia management.
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34 6. After diagnosing high myopia in pre-school children, it's important to determine if there
35 are any associated medical conditions that take priority. A comprehensive clinical history
36 and biometric evaluation are crucial. Further specialized investigations and multidisciplinary
37 evaluations may be necessary, requiring referral to a tertiary care facility following initial
38 diagnosis in primary care. While low-risk interventions can be used for childhood myopia,
39 there's limited evidence of effectiveness for high myopia and syndromic forms. Close
40 monitoring of refraction and axial length is recommended during therapeutic interventions.
41 Conducting randomized clinical trials for myopia interventions in syndromic and monogenic
42 myopia is impractical due to genetic heterogeneity. Pooling outcome data from different
43 clinical sites in disease registries is a viable option for evidence-based myopia management
44 in this complex subtype.¹⁸
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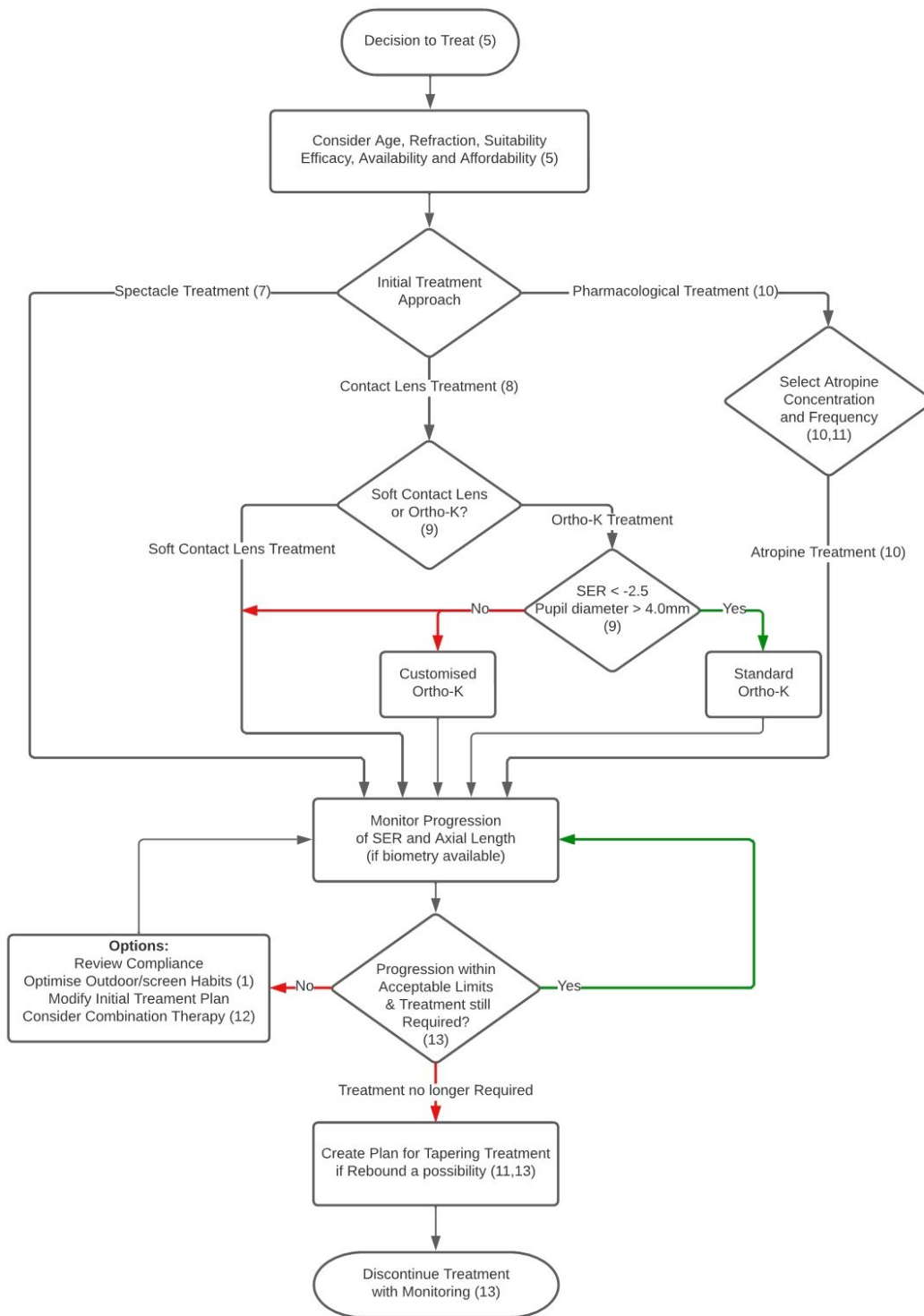


Figure 2. Treatment flowchart. Algorithm for reducing myopia progression. (Ortho-K: orthokeratology, SER: spherical equivalent refraction)

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5 7. Do not under-correct patients with myopia^{1,72,75} (low-certainty evidence, Cochrane-2023)⁹
6 nor over-correct.⁷⁶ The blue-light blocking glasses have no effect,⁷⁷ and the bifocal or
7
8 progressive additional eyeglasses have a small effect on myopia control.^{72,78}
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12 For spectacle correction, the most recent myopia control spectacle lenses are likely to be a
13 good starting point in younger patients as they have been shown to be effective (with the
14 caveats above) and they are the least invasive option.⁷⁹⁻⁸²
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20 8. In some situations, spectacles are not an option. A child may refuse to wear them for
21 various reasons including sport activities during which wearing spectacles is not feasible.
22 Research has demonstrated that the utilization of contact lenses can enhance the self-
23 perception and engagement of children and teenagers in various activities, resulting in
24 increased satisfaction with the correction of their refractive errors.⁴⁶
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31 When considering myopia management using contact lens corrections the evidence-based
32 options are multifocal soft contact lenses (moderate-certainty evidence, Cochrane-2023),⁹
33 positive spherical aberration contact lenses and night-time orthokeratological lenses
34 (moderate-certainty evidence, Cochrane-2023).⁹ Wearing single-vision rigid gas-permeable
35 or soft contact lenses has little to no effect on myopia progression and axial length
36 elongation.^{72,78}
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43 Dealing with higher myopia (-6.0 D or stronger), orthokeratology can be used along with
44 optical overcorrection during the day.⁸³ However, it is important to note that in this
45 situation, there are other options available, such as using anti-myopia spectacles or daytime
46 soft anti-myopia contact lenses.^{2,73}
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50 In the case of astigmatism, anti-myopia spectacles, regular or customized ortho-K contact
51 lenses may be used.⁷³ Alternatively, astigmatism could be corrected using spectacle lenses
52 in combination with an anti-myopia contact lens or a soft multifocal toric contact lens could
53 be used, because the uncorrected refractive astigmatism may influence axial elongation.⁸⁴
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3 The most serious complication of contact lens wear is microbial keratitis, for which the
4 lifetime risk associated with children using daily disposable soft contact lenses is low
5 (1:431). The risk is higher in orthokeratology (1:67).⁸⁵ However, both of these risks are still
6 lower than the risk of developing complications resulting in vision loss associated with high
7 myopia (greater than -6.0 D or AL >26 mm), which has a risk of 1:10, and similar to the risk
8 of developing complications resulting in vision loss associated with lower myopia (less than -
9 3.0 D or AL <26 mm), which ranges from 1:10 to 1:100.⁸⁵
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18 9. In conventional orthokeratology lenses, the number of diopters reduced on the corneal
19 surface aligns with those adjusted in the mid-periphery.⁸⁶ This balance plays a crucial role in
20 counteracting the myopic shift in the peripheral retina⁸⁷⁻⁸⁹ and aberrations, particularly
21 spherical aberrations and vertical coma.^{83,90,91}
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25 Pupil size matters. For pupils 4.0 mm or smaller, daytime soft anti-myopic lenses
26 outperform night-time ortho-K lenses.⁹²⁻⁹⁷ This is because the ortho-K lens's back optical
27 zone diameter (BOZD), which is responsible for distance visual acuity, is typically 6.0
28 mm. The slowing effect of soft contact lenses is better in narrow pupils, where this
29 therapeutic zone is within 5.0 mm.⁹⁸ The BOZD of an ortho-K contact lens in a case of 6.0
30 mm relates to a 3.1–3.5 mm treatment zone on the cornea.^{99,100}
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36 The effectiveness of myopia control increases with a greater difference in surface
37 power,^{93,101,102} as well as with a smaller treatment zone diameter^{92,94-96,103} (without
38 negatively affecting visual acuity) or a larger pupil size.^{92,93,95,97}
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42 Customized ortho-K lenses can boost the myopic shift effect and offer smaller optical zones
43 for narrow pupils, enhancing their efficacy in slowing progression. However, some authors
44 argue that the diameter of the optic zone has minimal impact on peripheral refraction,¹⁰⁴
45 and pupil size has no significant influence on myopic progression.¹⁰⁵ Other factors should be
46 considered in addition to their long-term effects on the rate of myopia development.¹⁰⁶
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52 10. Atropine is one of the pillars of myopia control (moderate-certainty evidence, Cochrane-
53 2023).⁹ During the past two decades, well-designed clinical studies have reported
54 compelling evidence of its growth inhibiting effect,¹⁰⁷⁻¹⁰⁹ but so far, its use has frequently
55 been off-label in many countries. (Further limitations of atropine have been discussed in the
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3 introduction.)¹² Atropine inhibits the progression of myopia in a dose-dependent manner,
4 but it also has dose-dependent rebound effects and dose-dependent adverse events.^{1,73,110}
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6 Although in the Low-concentration Atropine for Myopia Progression (LAMP) study, the
7 rebound effect was clinically small at all three concentrations (0.01%, 0.025%, 0.05%),
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9 discontinuing treatment at an older age and lower concentrations was associated with a
10 smaller rebound effect.^{109,110} At a low dosage of 0.01%, atropine has demonstrated
11 conflicting effects on axial elongation. While some studies reported an insufficient effect
12 (statistically not different from the placebo group),^{108,111,112} several recent studies indicate a
13 notable reduction in axial length growth.^{10,11,113,114} The frequency of application or dose may
14 be increased when lower doses are proving ineffective.¹⁰⁸
15
16 In children who are at risk of developing high myopia in adulthood, it has been
17 recommended by some authors to start with a dose of 0.5% atropine.¹¹⁵ In order to mitigate
18 any potential adverse reactions to this concentration, the use of photochromic glasses and
19 progressive addition lenses is also recommended.⁴²
20
21 Younger children require a higher (0.05%) concentration of atropine to obtain a similar
22 reduction in myopic progression as compared to older children because younger age is
23 associated with poor treatment response to low concentrations of atropine.¹⁰⁹ According to
24 a recent network meta-analysis, the three concentrations that were most effective for
25 controlling myopia were 1%, 0.5%, and 0.05%. The effects on pupil size and accommodation
26 amplitude were dose-related, and 0.05% was determined to be the most efficient
27 concentration for myopia control as measured by relative risk for total myopia
28 progression.¹¹⁶
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45 11. After the age of 12 years, children show less rebound after cessation of atropine. This
46 suggests that in children younger than 12 years of age, more consideration should be given
47 before stopping atropine than in children over 12 years of age.^{117,118}
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49 Evidence based guidelines regarding how to taper doses have not yet been established.
50 Sudden discontinuation of a higher dose of atropine can lead to an increased rate of myopic
51 refractive error progression,¹⁰⁷ although according to some publications, in the case of
52 lower doses, this is not substantiated by accelerated axial length growth.¹⁰⁸ Nevertheless,
53 when children have been treated with higher doses of atropine, a tapering schedule to low
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3 doses of atropine is recommended to minimize the risk of a rebound effect.¹¹⁵ Close axial
4 length monitoring would be useful to monitor for potential rebound during tapering.
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9 12. In combination therapy, optical interventions are paired with atropine (moderate-
10 certainty evidence, Cochrane-2020).¹¹⁹ Combination treatment was found to slow myopia
11 progression significantly more than each treatment alone.^{1,73,120}
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13 Studies demonstrated that combining low-dose atropine concentration with
14 orthokeratology resulted in greater myopia control effect compared to using
15 orthokeratology therapy alone.^{121,122,123} The articles describe the combined effect in
16 different ways. The potential mechanism for the combined effect of atropine treatment and
17 orthokeratology lenses is the increased retinal illumination resulting from a larger pupil
18 diameter, which can influence the myopic shift in the peripheral retina and enhance the
19 effect of ortho-K lenses. Moreover, a small but significant increase in pupil diameter leads to
20 higher levels of high-order aberrations, and the elevated aberrations may provide a visual
21 signal that slows eye growth, or the increased choroidal thickness may retard effective eye
22 elongation.¹²⁴
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34 There are studies suggesting that Defocus Incorporated Multiple Segments (DIMS)
35 technology combined with 0.01% atropine is more effective than DIMS lenses alone.^{125,6}
36 However the addition of 0.01% atropine to soft multifocal contact lenses with +2.50-D add
37 powers did not result in a better myopia control than the lenses alone.¹²⁶
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43 13. Myopia generally progresses most rapidly during the preteen years (6–12 years).^{127,64} By
44 the age of 15 years, progression occurs in 52% of cases; by the age of 18 years, it can occur
45 in 23% of cases. At the age of 21–24 years, myopia usually stabilises, except in those with
46 high myopia.^{64,128,129} Myopia can also occur between the ages of 20 and 30 years, which is a
47 complex process involving a combination of genetic and environmental factors.^{17,130}
48 Stabilisation is achieved when axial length progression is equal to or less than 0.06 mm per
49 year.^{130,131} However, it is important to note that axial elongation is age dependent.^{57,132}
50 It has been demonstrated that discontinuing the use of ortho-K lenses before the age of 14
51 years causes axial elongation to accelerate. This indicates that wearing ortho-K should not
52 be discontinued before the age of 14 years or possibly beyond.¹³³ After cessation of atropine
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3 therapy, axial length follow up is needed for an additional 6 to 12 months or longer to
4 ensure there is no rebound effect.¹¹⁸ Low-dose (0.05%, 0.1%) atropine therapy's effects
5 have been shown to last up to 4.5 years, and the rebound effect may also be less severe in
6 older age after long-term use.¹³⁴
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10 11 12 **Novel methods in myopia management**

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14 Current investigations have demonstrated that repeated Low-Level-Red-Light (LLRL) therapy
15 could effectively slow down the progression of myopia.¹³⁵⁻¹⁴¹ The therapy utilizes desktop
16 laser diode devices that emit long-wavelength light (635–650 nm). The follow-up period in
17 current trials has extended up to 2 years.¹³⁸ The treatment effects reported were significant,
18 surpassing those observed with other pharmacologic and optical interventions in terms of
19 magnitude. Furthermore, the LLRL treatment resulted in thickening of the choroid.^{138,140}
20 Nevertheless, the exact mechanism behind the shrinkage of the axial length remains
21 uncertain and cannot be attributed to changes in choroidal thickness alone. Discontinuation
22 of LLRL therapy showed only modest rebound effects.^{138,141} To date adverse event
23 monitoring has primarily relied on questionnaires,¹³⁸ measures of best-corrected visual
24 acuity, and limited utilization of optical coherence tomography (OCT) imaging.^{135,140} This
25 therapy requires further investigation to better understand its effectiveness, underlying
26 mechanisms, and potential long- and short-term adverse events. The latter are particularly
27 important since a recent case report demonstrates an example of possible retinal damage
28 associated with this type of therapy.¹⁴²
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44 **Conclusions:** The role of eye care providers is multi-faceted in ensuring the best available
45 therapy that corresponds to the specific requirements of myopic and pre-myopic children.
46 The proposed algorithm reflects real-life experience that show there is no one method that
47 works for everyone and that myopia management should be tailored to the individual child.
48 The use of axial length growth curve charts and an analysis of family and environmental risk
49 factors can help make well-informed decisions about myopia management and pre-myopic
50 lifestyle advice to delay the onset of myopia. It is important to monitor patients regularly to
51 determine whether the treatment they are receiving is working. If one strategy is not
52 sufficiently effective, a change or combination with another intervention can be considered.
53 By taking these factors into account, we can ensure that we are providing the most effective
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3 and personalized management approach for individuals with myopia. The area of myopia
4 management is subject to tremendous research and clinical focus and new evidence,
5 therapies and management options are emerging rapidly. Eye care practitioners have a
6 responsibility to keep up-to-date, respond to the dynamic evidence-base, and ensure their
7 practice continues to provide optimal care for patients.
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JAG discloses editorial board memberships: IOVS, TVST, OPO, grants panel: Fight for Sight UK, consultant for several companies, however the consultancy fee is paid directly by the company to an eye research charity chosen by the company;

RCB discloses editorial board memberships: Investigative Ophthalmology and Visual Science (IOVS), Current Eye Research, Scandinavian Journal of Optometry and Visual Science (SJOVS).

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