Topical Review: Studies on Management of Myopia Progression from 2019 to 2021

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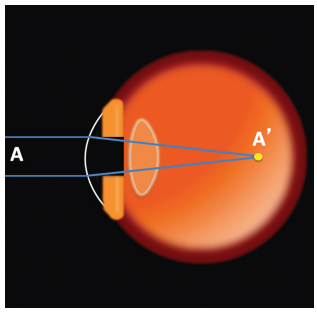
SIGNIFICANCE: Myopia is a common eye condition that increases the risk of sight-threatening complications. Each additional diopter increases the chance of complications. The purpose of this review was to make an overview of myopia control treatment options for children with myopia progression.

In this nonsystematic review, we searched PubMed and Cochrane databases for English-language studies published from 2019 to September 2021. Emphasis was given to selection of randomized controlled trials. Nineteen randomized controlled trials and two retrospective studies were included. Topical atropine and orthokeratology remain the most used treatments, whereas lenses with novel designs are emerging treatments. Overall myopia progression in the treatment groups for low-dose atropine and orthokeratology was lower than in the control groups, and their efficacy was reported in several randomized controlled trials and confirmed by various systematic reviews and meta-analysis. The findings of myopia progression and axial elongation for the MiSight, defocus incorporated multiple segment spectacle lens, highly aspherical lenslets, and diffusion optics technology spectacle lens were comparable. Public health interventions to optimize environmental influences may also be important strategies to control myopia. Optimal choice of management of myopia depends on treatment availability, acceptability to child and parents, and specific patient features such as age, baseline myopia, and lifestyle. Eye care providers need to understand the advantages and disadvantages of each therapy to best counsel parents of children with myopia.



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Myopia is a common eye condition caused by excessive elongation of the eye, resulting in blurred vision for distance. Approximately 30% of the world population had myopia in 2020. The prevalence is expected to rise to 50% by 2050.[1] Although the risk of complications is higher for high myopia, low and moderate myopia may also develop complications.[2,3] Each additional 1 D of myopia increases the risk of complications such as myopic maculopathy (58%), retinal detachment (30%), posterior subcapsular cataract (21%), and open-angle glaucoma (20%).[4] Risk factors for myopia include decreased time spent outdoors, number of years of education, increased time spent on near work, and parental myopia.[5–8] Recent data suggest an increased myopia incidence among children during the COVID-19 pandemic because of a significant decrease in outdoor time and increase in screen time.[9,10] Early age of myopia onset plays a fundamental role in myopia progression because 50% of children with myopia onset at 7 or 8 years of age develop high myopia in adulthood.[11] Children with spherical equivalent refractive error between −1.5 and −3 D at 10 years of age had a 46% risk of developing high myopia in adulthood, and treatment to slow the rate of progression is advisable.[12] The purpose of this review was to provide an evidence-based update of therapy options for myopia progression.

METHODS

In this nonsystematic review, we searched PubMed and the Cochrane databases for English-language studies published from 2019 to September 2021, for randomized controlled trials, meta-analyses, systematic reviews, and observational studies. We also manually searched the references of selected articles, reviews, meta-analyses, and practice guidelines. Selected articles were mutually agreed upon by the authors. Emphasis was given to selection of randomized controlled trials. Previous evidence-based reviews/

meta-analyses published before 2019 are generally available and were not included in this study.[13–16]

RESULTS AND DISCUSSION

Traditional spectacles are the most common and the cheapest option in the treatment of myopia. However, in children at risk of fast myopia progression, other options may be considered such as topical atropine, orthokeratology, contact lenses, or multifocal spectacles with novel technology and designs. Treatment combinations such as atropine with orthokeratology or with multifocal contact lenses or spectacles may also be used. Public health interventions, including lifestyle recommendations for optimization of environmental influences, are also important strategies to control myopia incidence.

Topical Low-dose Atropine

Atropine is an antimuscarinic agent and can be used as a monotherapy or as a combination treatment (Table 1). Atropine has been advocated as the first line of treatment in children with lower cost compared with other therapies. The effectiveness and safety of topical atropine were tested in numerous studies during a period of more than 30 years. One of the first randomized controlled trials was conducted in the 1980s and showed that 1% atropine eye drops were effective in the control of myopia progression.[19] The Atropine for Treatment of Myopia Studies (1 and 2) are landmark

TABLE 1. Major therapies available for treatment of myopia progression

Modality	Advantages and disadvantages	Mechanism of action	Other considerations
Topical atropine eye drops (1.0, 0.5, 0.1, 0.05, and 0.01%)	It reduces myopia progression and axial elongation in children in a dose-related manner, but a rebound phenomenon occurs with higher doses. The effectiveness and safety were tested in numerous studies during a period of 30 y.	Atropine is a nonselective muscarinic acetylcholine receptor antagonist. The underlying mechanisms by which it controls myopia progression remain unclear. It may influence retinal regulation and scleral muscarinic receptors leading to changes in the scleral matrix to reduce axial elongation.	Higher doses cause pupil dilation and increased sensitivity to light, loss of accommodation and near vision, itching, and discomfort. Allergic reaction is possible. Children using higher doses may need photochromic glasses (which darken on exposure to sunlight) if they experience photophobia or if their parents are worried about excessive light exposure. Progressive glasses (reading add) may be prescribed for children with near-vision difficulties. Low concentrations are well tolerated, and they are not associated with photophobia or reading problems.
Orthokeratology contact lenses	Most orthokeratology lenses are worn at night and then removed during the day. The effectiveness and safety were tested in numerous studies during a period of 30 y. The effectiveness was shown in a 12-y retrospective cohort study in Taiwan.[17]	They are corneal gas-permeable contact lenses that are designed to flatten the central cornea, leading to midperipheral steeping and peripheral myopic defocus. The exact mechanism underlying the myopia control effect remains unclear. However, animal and human studies support the theory of peripheral myopic defocus on the retina due to the inverted pattern of corneal peripheral refraction.	Some children report discomfort with lens wear. Risk of complications (e.g., microbial keratitis) is low. Corneal staining is a common finding, and it is recommended to evaluate corneal surface health regularly.
Multifocal soft contact lenses	They are worn during the day. Efficacy is related with compliance (better results for lens wear compliance of at least 6 d per week). The effectiveness was shown in a 3-y clinical trial.[18]	They provide myopic defocus of light in the periphery while allowing clear vision by focusing light on the central retina. The myopic defocus (light focused in front of the retina) may act as a signal to slow eye growth and reduce myopia progression. Dual-focus contact lenses are based on simultaneous defocus providing peripheral myopic defocus, and center distance contact lenses are based on peripheral defocus. EDOF lenses provide global retinal image quality optimized for points at and anterior to the retina. Points posterior to the retina are deliberately degraded.	Some children report discomfort with lens wear. Risk of complications (e.g., giant papillary conjunctivitis, infiltrative keratitis, ocular allergies, etc.) is low.
Multifocal and other design spectacles (bifocal or progressive addition lenses)	This nonpharmacological option is well tolerated by children and parents. There are only a few studies on DIMS and HAL lenses, and knowledge is based on short-term observations. PALs are not as effective as DIMS or HALT lenses.	DIMS are based on simultaneous defocus, providing peripheral myopic defocus. HAL spectacle lenses are based on volume of myopic defocus, providing peripheral myopic defocus.	Midperipheral blurred vision may occur. Rebound phenomenon is not known.

DIMS = defocus incorporated multiple segment; EDOF = extended depth of focus; HAL = highly aspherical lenslet; PALs = progressive addition lenses.

randomized clinical trials that proved the effectiveness of low-dose atropine (0.01%) with a long follow-up of 5 years in Singapore, but those studies were limited by the absence of a placebo control group.[20] The principal disadvantages of topical atropine therapy are a reduction of the amplitude of accommodation and photophobia with higher concentrations (0.1% and higher).[21] Nevertheless, the results from the Low-concentration Atropine for Myopia Progression (LAMP) study (3-year randomized controlled trial) in Chinese children showed that low-concentration adverse effects are mild and well tolerated.[22–24] The results from the LAMP study showed that 0.05% atropine conferred the best efficacy compared with 0.025 and 0.01% concentrations.[22–24] Increases in myopia in treated groups versus washout groups for the 0.05, 0.025, and 0.01% concentrations were – 0.28 ± 0.42 D (vs. –0.68 ± 0.49 D), –0.35 ± 0.37 D

TABLE 2. Myopia progression and axial elongation for the different treatment options available to control myopia in studies published in 2019 to 2021

Study	Modality	Duration and design	Ethnicity and age range (y)	Reduction in myopia progression in the treatment group vs. control at the final follow-up visit	
				SER (D)	AL (mm)
Low-dose atropine					
Yam et al.[22–24]	0.05, 0.025, and 0.01% atropine	3-y RCT (phases 1, 2, and 3)	Chinese (4–12)	0.05%: 0.4	0.05%: 0.16
				0.025%: 0.22	0.025%: 0.09
				0.01%: 0.18	0.01%: 0.05
Wei et al.[25]	0.01% atropine	1-y RCT	Chinese (mean, 9.64)	0.26	0.09
Saxena et al.[26]			Indian (6–14)	0.19	NS
Hieda et al.[27]		2-y RCT	Japanese (6–12)	0.22	0.14
Fu et al.[28]	0.01 and 0.02% atropine	1-y RCT	Chinese (6–14)	0.01%: 0.09	0.01%: 0.14
				0.02 vs. 0.01%: 0.04	0.02 vs. 0.01%: 0.04
OK					
Jakobsen and Møller[29]	Four-zone reverse geometry (Dreamlite [Procornea, LZ Eerbeek, The Netherlands])	1.5-y RCT	White (6–12)	—	0.24
Nakamura et al.[30]	Menicon Z Night Contact Lens (Menicon Co., Ltd., Nagoya, Japan), αORTHO-K (Alpha Corporation, Dulles, VA), and Emerald (Euclid Systems Corporation, Herndon, VA)	2-y retrospective	Japanese (mean, 9)	0.85	0.19
Xu et al.[31]	Spherical 4-zone (Mengdaiwei, Sino-American joint)	2-y retrospective	Chinese (8–16)	—	0.50
Multifocal contact lenses					
Chamberlain et al.[18]	MiSight 1 day	3-y RCT	White (8–12)	0.73	0.32
Walline et al.[32]	Biofinity +2.50	3-y RCT	White (7–11)	0.45	0.23
Sankaridurg et al.[33]	Myopic defocus and EDOF (4 designs)	2-y RCT	Chinese (7–13)	0.37–0.27	0.41–0.46
Multifocal spectacles					
Lam et al.[34,35]	DIMS	2-y RCT + 1-y HC	Chinese (6–12)	0.71	0.37
Bao et al.[36,37]	HAL	2-y RCT	Chinese (8–13)	0.80	0.35
Treatment combinations*					
Hao and Zhao[38,39]	0.01% atropine + OK	1-y RCT	Chinese (8–12)	0.18	0.14
Tan et al.[40]		1-y RCT	Chinese (6–11)	NS	0.09
Kinoshita et al.[41]		2-y RCT	Japanese (8–12)	—	0.11
Jones et al.[42]	0.01% atropine + SMCLs with a +2.50 D add power	3-y RCT	White and Asian (7–11)	NS	NS

*The results of treatment combinations are not relative to controls but relative to monotherapy. AL = axial length; DIMS = defocus incorporated multiple segment; EDOF = extended depth of focus; HAL = highly aspherical lenslet; HC = historical control; NS = differences were not significant; OK = orthokeratology; RCT = randomized controlled trial; SER = spherical equivalent refraction; SMCLs = soft multifocal contact lenses.

(vs. –0.57 ± 0.38 D), and –0.38 ± 0.49 D (vs. –0.56 ± 0.40 D), respectively. Increases in axial length in treated groups versus washout groups were 0.17 ± 0.14 mm (vs. 0.33 ± 0.17 mm), 0.20 ± 0.15 mm (vs. 0.29 ± 0.14 mm), and 0.24 ± 0.18 mm (vs. 0.29 ± 0.15 mm) for the 0.05, 0.025, and 0.01% concentrations, respectively (Table 2). In a 1-year randomized clinical trial including Chinese children (n = 220), 0.01% atropine eye drops slowed myopia progression, but the study was limited by an approximately 70% follow-up.[25] In the Atropine for the Treatment of Childhood Myopia in India including 100 Indian children, 0.01% atropine showed a significant reduction of spherical equivalent progression, but the changes in axial length were not statistically significant.[26] In a 2-year randomized controlled trial including Japanese children (n = 168), 0.01% atropine drops reduced myopia progression.[27] However, the reduction in myopia progression was observed only at the end of 2 years of treatment (a reduction of 0.22 D for spherical equivalent and0.14 mm for axial length compared with the placebo eye drops), and the effect was moderate. In another 1-year randomized controlled trial including Chinese children (n = 400), 0.02 and 0.01% atropine drops reduced myopia progression, but the effect was concentration dependent.[28] Pupil diameter, accommodative amplitude, and symptoms were similar between the two concentrations. In a recent real-world study (n = 183 children), although 0.01% atropine eye drops slowed axial length progression (0.08 mm), the effect was of minor clinical importance.[43] However, the use of 0.05% topical atropine in young White children with progressive myopia may lead to more adverse effects compared with 0.01%, which can compromise parent's acceptance or children's compliance.[44] The results from the published evidence on Asian populations demonstrate that 0.01% atropine seems to be less effective in the treatment of myopia progression. A new ongoing randomized controlled trial, The Myopia Outcome Study of Atropine in Children, may elucidate the results of efficacy of 0.01% atropine for myopia control in a Western European population.[45]

The efficacy and safety of eight atropine concentrations for myopia control in children were reported in a network meta-analysis.[46] The most beneficial atropine concentration for control of overall myopia progression was the 0.05%. Based on published studies and current knowledge, it seems that the atropine dose (aggressiveness of therapy) should be adjusted based on the risk factors and progression; the use of minimal concentration is advised (maximize the treatment effect with minimum adverse effects). Although many studies have been published about the efficacy and safety of atropine, there are key questions that have not been addressed, such as when to start atropine treatment and to what age should it be continued. Other questions remain unanswered such as frequency and time of application and tapering schedule. Nevertheless, the 3-year LAMP study results showed the benefits of continued low-dose atropine treatment for all concentrations for all 3 years compared with a washout regimen.[24] The rebound was clinically small for the three atropine concentrations and was least for older children. Thus, continuing treatment may be advisable for younger children.

Orthokeratology

Orthokeratology lenses are rigid oxygen-permeable contact lens with a reverse-geometry design that are worn overnight. The lenses reshape the cornea temporarily to correct refractive error and provide the advantage of clear vision during the day without the need for optical correction (Table 1). The basic mechanism of orthokeratology lenses is to change refraction reducing myopia by mechanically flattening the cornea and at the same time shortening of axial length.

The effectiveness and safety of orthokeratology lenses have been tested in numerous studies. The results of one of the first randomized clinical trials were reported in the 1980s with the Berkeley Orthokeratology Study.[47–49] In this randomized controlled trial, the authors compared myopia progression with orthokeratology lenses with a control group wearing conventional rigid contact lenses and concluded that it was possible to reduce myopia by about 1 D, but the results were not permanent, and quality of vision was unstable during nonwear periods. Since then, several studies were conducted, and the long-term effectiveness of orthokeratology lenses for myopia control has been shown in a 12-year retrospective cohort study in Taiwan.[17] In recent studies, orthokeratology lenses have been shown to reduce axial length elongation in White (randomized controlled trials) and Asian (study with retrospective design) children (Table 2).[29–31] In a 1.5-year randomized controlled trial, the average elongation in the orthokeratology group was 0.24 mm smaller than the control group in Danish children.[29] In this randomized controlled trial, there were no fast myopia progressors in the orthokeratology group, and no vision-threatening adverse events were reported. In a 2-year retrospective study, orthokeratology lenses reduced myopia progression by 0.85 D and axial length by 0.19 mm in Japanese children.[30] In another 2-year retrospective study, orthokeratology lenses reduced axial length progression by 0.50 mm in Chinese children.[31] The axial length growth was significantly reduced in bilateral myopic anisometropia with greater effects in the more myopic eye (difference of 0.07 mm).

The major concern with orthokeratology treatment is safety, but no severe events have been reported in a recent meta-analysis.[50] The incidence of microbial keratitis in children wearing orthokeratology lenses is low and with similar rates to daily-wear soft contact lenses.[51] Nevertheless, it is advisable to monitor corneal staining and mild corneal epithelial disorders, which are common findings, and it is important to prevent more serious corneal surface diseases that may lead to visual impairment.[29,52–54] Orthokeratology lenses are widely used and studied, but the dropout rates are usually high, and the number of subjects included is low. Also, the complications and causes of dropout are usually not well explained.

Contact Lenses with Novel Technology and Designs

Contact lenses with novel technology and designs are emerging treatments (Table 1) to control myopia progression.[55] MiSight (CooperVision, Inc., Pleasanton, CA) soft contact lenses present a dual-focus optical design that provides myopic defocus.[18] The lens comprises a central zone with the distance correction and concentric peripheral zones with additional positive power. In a 3-year randomized controlled trial, MiSight lenses slowed spherical equivalent progression by 0.73 D (–0.51 ± 0.64 D compared with –1.24 ± 0.61 D in the control group) and axial length elongation by 0.32 mm (0.30 ± 0.27 mm compared with 0.62 ± 0.30 mm in the controls; Table 2). In this study, only 75.5% of the children completed the study (53 MiSight children and 56 controls).[18] The results of the 7-year study showed that the myopia control gains with MiSight lenses were retained for the first 12 months after treatment cessation (Chamberlain P, et al. OVS 2021;98:E-Abstract 215130).

In another 3-year randomized controlled trial, Walline et al.[32] reported slower myopia progression and axial elongation with Biofinity multifocal soft contact lenses (CooperVision, Inc.) with a +2.50 add power (treated vs. control, –0.56 vs. –1.01 D and 0.39 vs. 0.62 mm).

A randomized controlled trial was conducted using silicone hydrogel contact lenses with four different designs.[33] The design with extended depth of focus that incorporated higher-order aberrations

to modulate retinal image quality (up to +1.75 or +2.50 D) provided the best performance. The results showed significant reductions in spherical equivalent progression and axial length elongation for the extended depth of focus design lenses in the treated groups compared with controls (spherical equivalent progression reduced by 0.27 to 0.37 D, and axial length elongation reduced by 0.41 to 0.46 mm).

Multifocal and Other Design Spectacle Lenses

Multifocal spectacles such as bifocal or progressive addition lenses have been tested in the treatment of myopia progression. In the past few years, lenses with novel designs have emerged (Table 1). Defocus incorporated multiple segment (DIMS) spectacle lenses (now marketed as Hoya MiYOSMART [HOYA Corporation, Tokyo, Japan]) are based on simultaneous defocus, providing peripheral myopic defocus.[34] The lenses consist of a central optical zone that corrects distance refractive error and numerous small circular segments of +3.50 D distributed in the midperipheral area. The results of a 2-year randomized controlled trial plus a 1-year follow-up study without randomization showed that the overall 3-year control effect was a reduction of myopia by 0.71 and axial length decrease by 0.37 mm (Table 2).[34,35] Highly aspherical lenses (Essilor Stellest [Essilor International, Charenton-le-Pont, France]) are aspherical lenses that deviate rays of light continuously in a nonlinear manner, creating a 3D quantity of light in front of the retina, defined as the volume of myopic defocus.[36] The results of the 2-year randomized controlled trial showed that highly aspherical lenslet lenses reduced myopia progression by 0.80 D and slowed axial length by 0.35 mm compared with the control group (Table 2), with better results for children wearing the lenses for at least 12 hours per day.[37] The Correction of Myopia Evaluation Trial showed that progressive addition lenses slowed myopia by 0.28 D for 3 years, whereas DIMS and highly aspherical lenslet lenses slowed myopia by 0.71 and 0.80 D for 3 and 2 years, respectively.[56,57] Vision Diffusion Optics Technology lenses from SightGlass Vision (Palo Alto, CA) reduce contrast signaling in the retina. The results of the 2-year randomized controlled trial The Control of Myopia Using Peripheral Diffusion Lenses Efficacy and Safety Study clinical study (n = 256 aged 6 to 10 years) showed that children who wore two different designs of diffusion optics technology lenses had a reduction in myopia progression by 0.52 D and a reduction in axial length progression by 0.21 mm compared with the control group (Rappon J, et al. IOVS 2022;63:ARVO E-Abstract 408).

Treatment Combinations

Randomized controlled trials showed that axial length elongation was lower in the combination group where 0.01% topical atropine and OK therapies were implemented compared with orthokeratology-only or atropine-only groups (Table 2). The results of a 1-year randomized controlled trial showed that Chinese children treated with a combination of orthokeratology and 0.01% atropine had better spherical equivalent (mean difference, 0.18 D) and axial length (mean difference, 0.14 mm) control compared with children who wore only orthokeratology lenses.[38,39] In another 1-year randomized controlled trial, axial length was significantly slowed by 0.09 mm with a treatment combination of orthokeratology and 0.01% atropine compared with orthokeratology alone.[40] Comparable results were found by Kinoshita et al.,[41] with a reduction of 0.11 mm in children using the combination therapy (orthokeratology and 0.01% atropine) compared with orthokeratology. Nevertheless, treatment combination therapy may be more effective in children with low baseline myopia because of pupil enlargement and enhanced optical effect of orthokeratology.[41] Fast myopia progressors and poor responders to orthokeratology may not respond well to combination therapy with 0.01% nightly atropine, and axial length elongation was similar to orthokeratology monotherapy.[58] The additive effect of treatment combinations is promising, but the effect seems stronger in the first 6 months of treatment, some children are nonresponders, and more research is necessary to study if the additive effect is long-lasting. However, it seems that not all treatment combinations are effective. For example, the Bifocal & Atropine in Myopia Study (3-year randomized controlled trial) results showed that the effect of combining 0.01% atropine with a soft multifocal contact lenses with a +2.50 D add power failed to demonstrate better myopia control than soft multifocal contact lenses alone.[42] Thus, several questions remain regarding combining 0.01% tropine with other treatments options, and further research is necessary to understand which treatment combinations are effective.

Time Spent Outdoors

Based on population-based and interventional studies, the IMI Prevention of Myopia and Its Progression article recommended schoolchildren to spend more time outdoors to reduce the incidence of myopia.[21] This is a safe and noninvasive strategy that can also be used to promote healthier lifestyles for children. Spending time outdoors has been shown to slow the change in axial elongation in a meta-analysis (a pooled mean difference of the outdoor group compared with the control group of –0.03 mm [95% confidence interval, –0.03 to –0.03 mm]) reducing the risk of myopia development.[59] It has been recommended that a child should spend 2 hours outdoors every day.[60–62]

The evidence for the effect of time outdoors on myopia progression remains mixed, which may indicate a small effect or an effect of limited clinical significance. Guo et al.[63] conducted a prospective interventional study implementing a school outdoor program (30 minutes every day for 1 year) and showed that the effect of extended outdoor time on the reduction of myopic progression was mainly observed in nonmyopic children. This is an opportunity for myopic control in need of further study.

Prognosis and Other Treatment Considerations

Compliance with treatment seems to be an important factor. As such, expectations for treatment should be discussed with parents before starting treatment, and careful planning is necessary to individualize the approach.

There are many unanswered questions that will have a significant impact on clinical prognosis. The loss of treatment benefit over time is a similar feature of all myopia-control randomized controlled trials, with most of the effect happening in the first year of treatment. Nevertheless, the effect has typically been clinically meaningful. There is no valid progression-based criterion for initiation of myopia control, and age at onset remains as one of the most important factors in predicting myopia progression.[64] Other risk factors influence progression, such as ethnicity, sex, and parental myopia.[65] Younger age was associated with poor treatment response, with younger children requiring 0.05% concentration (compared with 0.025 and 0.01%) to achieve similar reduction in myopic progression to that in older children receiving lower concentrations.[66] Thus, one approach might be to start with higher atropine concentrations in younger children and possibly switch later to lower doses. Although myopia progression diminishes with age, there are reports of myopia progression and axial

elongation in adults with high myopia.[1,12,67] Furthermore, not all children respond to treatment,[43] with some nonresponders showing myopia progression even into early adulthood.

It is not known yet if there is value in treating pre-myopes (spherical equivalent refraction ≤+0.75 and >–0.50 D) where a combination of baseline refraction, age, and other quantifiable risk factors suggests the likely development of myopia.[68] However, a spherical equivalent refraction <+0.75 D at age 8 years was predictive of the onset of juvenile myopia (area under the curve, 0.88), and baseline spherical equivalent seems to be the best single predictor of onset of myopia (area under the curve, 0.87 to 0.93).[69,70] The results of the addition of environmental and genetic factors to baseline spherical equivalent to improve the prediction of myopia have been mixed. In the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error study, baseline standard error at the age of 6 years and number of myopic parents improved the prediction of myopia onset, but the sensitivity of these factors was low.[71] Similarly, in the Singapore Cohort Of the Risk factors for Myopia study, the addition of other factors including sex, race, school, books per week, and parental myopia only marginally improved the prediction of high myopia.[72]

The use of percentile growth curves in clinical practice to monitor myopia progression has been proposed in a previous study, and baseline spherical equivalent measures (fifth percentile) provided the best identification of children with an increased risk of developing high myopia in adulthood.[73] In another study, increased axial length above the first quartile was predictive of high myopia (spherical equivalent ≤–5.00 D) in adolescent years.[74] Using data from the Generation R study, The Avon Longitudinal Study of Parents and Children, and The Rotterdam Study III, the authors developed European axial length charts to estimate the risk of developing high myopia.[75] There are a few online myopia calculators that help practitioners understand myopia and axial length progression over time. Those are based on progression curves generated from annual spherical equivalent progression data and allow the clinician to enter patient measurements and to visualize likely myopia progression for each child.

Machine learning algorithms have been validated using a large real-world data set to predict high myopia by 18 years with clinically acceptable accuracy among Chinese school-aged populations.[76] Studies using deep learning analytics have shown that it is possible to predict refractive error from retinal fundus imaging.[77] In a systematic review, the authors concluded that age-specific spherical equivalent is the strongest predictor of myopia, whereas the additive effect of data including lifestyle, genetic, and imaging data was inconclusive.[78] Future improvement of myopia progression prediction models for use in routine clinical practice may require the development of Web sites, phone applications, and other accessible tools.[79]

CONCLUSIONS

Management of myopia progression includes treatment with topical atropine, orthokeratology lenses, multifocal contact lenses, and spectacles with novel technology and designs. The optimal approach depends on treatment availability, parent's acceptance, and specific patient clinical features such as age, baseline myopia, or lifestyle. Topical atropine and orthokeratology lenses are treatments with proven effectiveness, although there are adverse effects with higher atropine concentrations or risk of microbial keratitis with orthokeratology lenses. The effect of atropine in prevention of myopic progression has been known for more than a hundred years, and numerous studies have been conducted. Nonetheless, further studies are necessary to inform on best doses and which dosages have least adverse effects. Contact lenses with novel design spectacle lenses are emerging treatments. These new myopia control treatments may be helpful, and the benefit seems greater than what has been found with 0.01% atropine. However, more data from different races and ethnicities are needed to fully understand the effect of concentration. Rebound is an important consideration, although it has been small in older children based on the results of the LAMP study and the MiSight study. More research is necessary on following up children who discontinued treatment modalities such as the DIMS or diffusion optics technology to determine rebound effects. Follow-up rates are mostly in children, and it is difficult to predict if treatment effects will persist with longer follow-up. Given the documented progression of myopia in many children, a long-term treatment approach in childhood and adolescence is necessary. It is also not clear whether the available myopia control treatments will be sufficiently powerful to prevent the development of pathologic myopia and its vision-threatening features in enough number of patients to warrant these interventions.

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