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Strategies to slow down the progression of myopia: A systematic review

Adelia Rizka Amila,[1]* Nurul Ainun Azizi,[2] Putri Sri Rizky,[3] M. Rizwan Nurhuda,[3] Nogi Suryasna,[4] Aldy Rahman,[5] Dastin Andre[6]

[1]Sukamara Regional General Hospital, Central Kalimantan, Indonesia
[2]Rachma Husada General Hospital, Special Region of Yogyakarta, Indonesia
[3]KH. Mansyur Regional General Hospital, South Kalimantan, Indonesia
[4]Pariaman City Regional General Hospital, West Sumatra, Indonesia
[5]Sukamara Community Health Center, Central Kalimantan, Indonesia
[6]Pangeran Jaya Sumitra Regional General Hospital, South Kalimantan, Indonesia

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***Corresponding author:**
amilaadelia@gmail.com

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Systematic Review

ABSTRACT

Globally, the prevalence of myopia or nearsightedness is rising quickly, which presents a serious public health concern. By 2030, approximately half of the world's population is expected to be impacted. Untreated nearsightedness can have serious health consequences, such as avoidable blindness and an estimated $244 billion in lost productivity worldwide each year. Serious difficulties might arise from untreated myopia, which frequently starts in childhood. Efforts to delay the progression of myopia have focused on the following three main intervention types: optical, pharmaceutical, and environmental. More investigation and methodical assessments are necessary to combat the expanding myopia epidemic. A systematic review was carried out in accordance with PRISMA criteria to evaluate existing strategies for slowing the progression of myopia. From the beginning to November 2024, a thorough search was carried out in ISRCTN, PubMed, ScienceDirect, and ClinicalTrials.gov, resulting in an analysis of 9833 articles, ultimately selected 16 RCTs involving 3,062 subjects. A standardized technique was used to evaluate the articles' quality after duplicate publications, review articles, and incomplete articles were eliminated. This study found that Soft Contact Lenses (SCL), Atropine (AT) eye drops, and Orthokeratology (OK) lenses are all useful for treating pediatric nearsightedness. SCL, especially bifocal varieties, slows the progression of myopia, although their usage may be restricted by pain and hygienic concerns. Despite its efficacy varying, low-dose AT (0.01%) also slows progression, and cautious dosing is necessary due to concerns about rebound effects when therapy ends. OK lenses considerably minimize axial elongation, particularly when used in conjunction with AT; however, there are concerns of infection and maintenance. The most successful treatments seem to be combination ones, such as OK lenses with AT, although they demand strict commitment. In conclusion, SCL, AT, and OK may be useful for slowing the progression of myopia.

INTRODUCTION

Myopia or near-sightedness is a serious refractive condition that is increasingly being acknowledged as a major public health issue. In terms of prevalence, this eye condition is referred to as the one with the fastest global growth.[1] By 2030, myopia is expected to affect around half of the population worldwide, which will present significant challenges for eye care systems around the globe.[2] This "myopia epidemic" frequently affects more than 80% of young adults in East Asian nations like China, Japan, South Korea, and Singapore.[3] Myopia cases have increased significantly in recent decades, even in areas like Europe and North America that have previously had lower prevalence rates. For instance, in the United States, the overall incidence of myopia has almost doubled over the last 25 years, affecting about 42% of the population.[4] Over the previous 60 years, Europe has also witnessed a threefold increase.[5] Forecasts suggest that by the end of

the twenty-first century, nearly all people on the planet could have myopia if current trends continue. In Indonesia, myopia cases among school-age children are rising, with rates over 30% in some cities, while refractive disorders affect 24.7% of the population, including 10% of the 66 million school-age children.[6]

The substantial rise in myopia has several consequences, impacting both individual health and broader socioeconomic systems. Untreated myopia, one of the leading causes of vision loss worldwide, mostly affects children and teenagers.[7] According to the World Health Organization (WHO), one of the main causes of avoidable blindness is untreated refractive defects.[8] Uncorrected shortsighted is predicted to trigger a global productivity loss of $244 billion annually, highlighting the economic consequences of myopia.[9] Extreme myopia greatly raises the chance of serious outcomes such as glaucoma, myopic macular degeneration, and detached retina, adding to the burden on healthcare systems and emphasizing the need for prompt interventions.[10]

Myopia among children frequently starts earlier in life, leading to longer progression times and an increased risk of severe refractive defects as an adult.[11] Children's growth in development of myopia can differ greatly; Asian children exhibit axial elongation at a higher pace than their European peers, by approximately 0.20 D each year.[12] This rapid progression highlights the necessity for targeted treatments based on genetic and demographic determinants and calls for earlier interventions.

Efforts to curb myopia progression have concentrated on three primary types of interventions: optical, pharmacological, and environmental. By causing peripheral defocus to lessen axial elongation, optical interventions like spectacle lenses, soft contact lenses (SCL) and orthokeratology (OK) lenses have been proven to successfully halt the growth of myopia.[13] Among these, SCL and OK are especially noteworthy for offering both vision correction and myopia management benefits.[14] Pharmacological approaches have been proven to be very successful, especially when atropine (AT) eye drops are used.[15] Clinicians choose AT because it can reduce the progression of myopia by about 30–50% with little adverse effects at low dosages (0.01%). Higher concentrations (0.5%-1.0%) may be more effective but can lead to more pronounced side effects, including photophobia and diminished accommodation.[16]

Despite these advancements, substantial hurdles remain. The effectiveness of these interventions can vary significantly among different populations, and the long-term effects of the treatments are not fully understood. Furthermore, cultural, socioeconomic, and logistical factors can restrict access to these interventions in various areas, especially in low-resource environments.[17] The variability of findings across studies emphasizes the need for systematic evaluations to determine the most effective strategies for diverse populations.[18]

Numerous studies have examined strategies to delay the progression of pediatric near-sightedness thus far. Since the previous systematic review and meta-analysis, a considerable number of new papers have been published, and we believe it is important to clarify this point. As a result, we conducted a systematic assessment to review and draw conclusions about updated strategies to reduce the growth of myopia. This review aimed to assist in decision-making and public health policies by evaluating the relative efficacy of optical and pharmaceutical therapies. Furthermore, it highlights areas for future development, including the need for personalized approaches and the exploration of combinations to optimize outcomes. The goal of this review is to enhance the lives of those affected by myopia and lessen its global burden.

METHODS

This systematic review followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 standards.[19]

Eligibility criteria

Studies were eligible if they examined interventions to control myopia in children under the age of 18, with a minimum continuation of one year, and reported axial length (AL) and/or spherical equivalent (SE) changes. We included all types of pediatric myopia, including mild,

moderate, high, and progressive forms, provided the studies met the RCT criteria and outcome reporting.

The inclusion criteria selected studies that focused on pediatric populations (<18 years), had a randomized controlled design, reported either axial length or spherical equivalent changes, and included at least one year of follow-up. Studies were excluded if they were non-RCTs, did not focus on myopia progression interventions, or were only available in abstract format.

Search strategy

We executed a thorough search across several databases, including PubMed, ScienceDirect, ClinicalTrials.gov, and ISRCTN, up to November 11, 2024. ARA and DA stated the development of the data search strategy by using related keywords and referring to medical subject headings (MeSH) and keywords such as “Soft Contact Lenses,” “Atropine,” “Orthokeratology Lenses,” and “Myopia Control.” The results of this search were then combined and duplicated.

Study selection

Based on its inclusion and exclusion criteria, the PRISMA statement recommendations were followed in the use of the approach in this study. Duplications and chosen research were eliminated by the assitance of Rayyan AI. To determine the formulation of suitable problems to be included in this study, three reviewer pairs (ARA and NAA; PSR and MRN; NS and AR) checked the titles and abstracts. Full-text publications were then examined to verify eligibility. If disagreements arise during the writing process, DA serves as a mediator, and a collaborative discussion will be held to find a solution.

Data extraction and quality assessment

ARA and NAA, as the authors, extracted the data, which are poured into a table via Google Sheets according to this study. If the authors have different opinions, DA acts as a mediator arranged a discussion. Finally, the articles are screened and synthesized into a qualitative systematic review. The Cochrane ROB (Risk of Bias) 2 tool was used to evaluate the studies' possibility of bias (Figure 1), conducted independently by DA. Any discrepancies were settled through group discussions.

Figure 1. Cochrane ROB 2 tool for quality assessment

RESULTS

The database search yielded 9833 publications in total (Figure 2), which were then filtered using the eligibility criteria outlined in the research selection process. Out of these, 187 articles passed the screening, leading to 129 articles selected for full-text evaluation. After three levels of screening, 16 articles relevant to this systematic review were chosen for detailed reading and analysis. All sixteen studies included were RCTs, involving a total of 3,062 subjects.

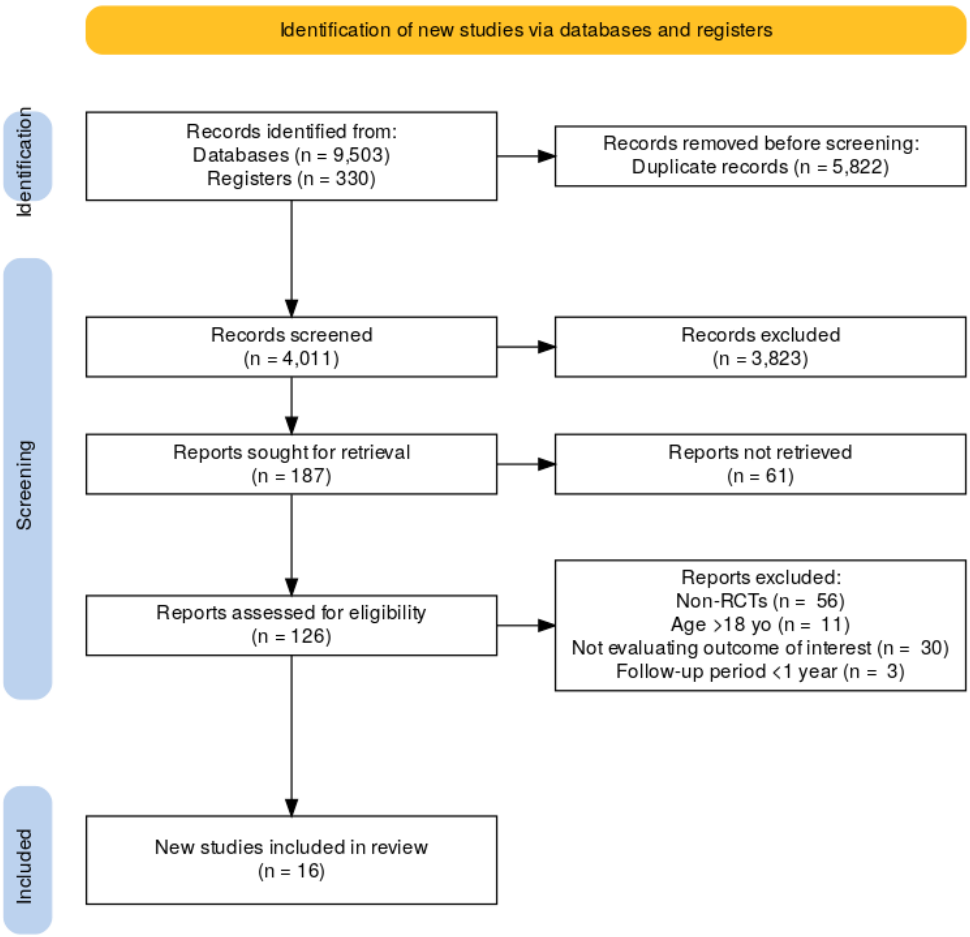

Figure 2. PRISMA flow chart

Table 1 presents the five studies investigating the effectiveness of SCL in reducing the myopia progression. When compared to Single Vision Soft Contact Lense (SVSCL), the usage of Bifocal Soft Contact Lense (BFSCL) was linked to a 72% decrease in the development of myopia over a year.[20] Defocus Incorporated Soft Contact (DISC) lenses had a comparable effect, slowing the progression of myopia by 25% and AL by 31% over a two-year period, with more pronounced effects observed when the lenses were used for over 7 hours daily. The Bifocal Lenses in Nearsighted Kids (BLINK) study reported that High Add Power (HAP) Multifocal Lenses (MFL) (+2.50 D) reduced the development of myopia to -0.60 D over three years, which was more effective compared to Medium Add Power (MAP) lenses (+1.50 D) and Single-Vision Lenses (SVL) (-1.05 D).[22,23]

Table 1. Summary of SCL studies

Author (Year)	Methodology	N	Region	Follow-up (years)	Findings
Thomas A Aller et al. (2016)[20]	RCTs	86	Multi-national	1 year	The study indicates that BFSCLs are effective in slowing down the growth of AL and the progression of myopia in children with rapidly-worsening myopia. The BFSCL group significantly reduced their AL by 80% and slowed the progression of their myopia by 72% when compared to the SVSCL group. Only 5% of SVSCL users exhibited similar outcomes, while 26-29% of BFSCL users had no progression or hyperopic changes.

Author (Year)	Methodology	N	Region	Follow-up (years)	Findings
Jeffrey J Walline et al. (2020)[21]	RCTs	294	Multi-national	3 years	HAP MFL lenses were better at slowing the progression of myopia than MAP and SVL lenses. Additionally, both the SVL and HAP groups had lower AL. According to these results, lenses with greater add capabilities may be able to more effectively control myopia.
Carly Siu et al. (2013)[22]	RCTs	221	Hong Kong, China	2 years	More so than SVL, DISC lenses decreased AL and halted the growth of myopia. Compliance was important; longer daily wear periods resulted in a larger slowdown in the progression of myopia. DISC lenses are especially good at slowing the progression of myopia in Asian youngsters, who frequently see it happen quickly.
Alba M Garcia-Del Valle et al. (2020)[23]	RCTs	58	Spain	1 year	With a 51% decrease, Esencia lenses outperformed SVL in slowing the advancement of myopia and AL. The safety profiles and visual performance of both lenses were comparable, indicating that Esencia lenses are a viable treatment choice for pediatric myopia.
Shan-Chih Lee et al. (2024)[24]	RCTs	115	Taiwan	1 years	The effectiveness of Pegavision and MiSight lenses in lowering AL and managing the progression of myopia were comparable. Both lenses showed similar effectiveness in delaying the onset of myopia and were safe, well-tolerated, and had little side effects.

AL: Axial Length, BFSCL: Bifocal Soft Contact Lenses, DISC: Defocus Incorporated Soft Contact, HAP: High Add Power, MAP: Medium Add Power, MFL: Multifocal Lenses, SVL: Single-Vision Lenses, SVSCL: Single Vision Soft Contact Lenses

Eight studies evaluated the effect of AT at varying concentrations (Table 2). Over a year, AT 0.01% decreased the advancement of myopia by 34.2% in comparison to a placebo.[26] Higher concentrations, such as 0.5%, exhibited stronger effects, reducing myopia progression by 0.40 D over the same period. AT 0.01% provided a better safety and tolerability profile but was less efficacious than 0.1% or 0.5%.[30,31] On the other hand, some research revealed that there was no evident effect of AT 0.01% on the development of myopia.[28,32]

Table 2. Summary of AT studies

Author (Year)	Methodology	N	Region	Follow-up (years)	Findings
Karla Zadnik et al. (2023)[25]	RCTs	576	Multi-national	3 years	When compared to a placebo, AT 0.01% dramatically slowed the advancement of AL and myopia. AT 0.02% decreased AL but had less impact on the evolution of myopia. While there were no significant adverse effects, AT 0.02% increased photophobia. The best and safest treatment for pediatric myopia was determined to be AT 0.01%.
Shifei Wei et al. (2020)[26]	RCTs	484	China	1 year	Compared to the placebo group, children who used AT 0.01% saw a smaller

Author (Year)	Methodology	N	Region	Follow-up (years)	Findings
					decrease in AL and a slower progression of myopia. Fewer children in the AT group had severe progression, whereas more displayed modest progression. Conjunctivitis and photophobia were reported as mild side effects, indicating that AT 0.01% is a safe and somewhat effective treatment for myopia.
Niklas Cyril Hansen et al (2023)[27]	RCTs	97	Denmark	2 years	In comparison to the placebo, the 0.1% AT group demonstrated modest decreases in the progression of myopia and AL, whereas the 0.01% dose had even less pronounced but still advantageous effects. While the 0.1% dose resulted in pupil dilatation and decreased accommodation amplitude, the 0.01% dose produced negligible adverse effects. There was an observation of a dose-response connection, and the 0.01% level considered as the safer option.
Henry H L Chan et al. (2022)[28]	RCTs	61	Hong Kong	1,5 years	The AL and SE refraction alterations did not differ significantly between the AT and placebo groups. Initial retinal responses, however, had an impact on treatment results; children with lower retinal responses advanced more quickly. Children who might most benefit from AT 0.01% could be identified with the use of retinal electrical profiling.
Anders Hvid-Hansen et al. (2023)[29]	RCTs	97	Denmark	6 months – 1 year	AT 0.1% had smaller, non-significant effects than AT 0.01%, although both considerably reduced the advancement of AL and myopia as compared to a placebo. While the 0.01% dose exhibited few adverse effects, the larger amount resulted in increased pupil dilatation and accommodation problems. This implies that bigger doses have more dangers, even though they are more effective.
Audrey Chia et al. (2012)[30]	RCTs	400	Singapore	2 years	With lower increases in AL and SE refraction at increasing concentrations, atropine 0.5% and 0.1% were more effective than 0.01% at halting the advancement of myopia. AT 0.01% was a safer alternative, particularly for younger children or those who are more sensitive to side effects, because it had fewer adverse effects, such as pupil dilatation and accommodation problems, although being less effective.
Yan-Rong Wang et al. (2012)[31]	RCTs	126	China	1 year	AT 0.5% was found to be both safe and effective for children with low myopia, with acceptable tolerance and minimal side effects. When compared to a placebo,

Author (Year)	Methodology	N	Region	Follow-up (years)	Findings
					it dramatically reduced AL and myopia progression.
Michael X Repka et al. (2023)[32]	RCTs	187	United States	2 years	The AT and placebo groups did not significantly differ in the progression of myopia or AL. Since no changes were identified after 30 months of follow-up, the study raised questions regarding the widespread use of AT 0.01% in the therapy of myopia across various groups.

AL: Axial Length, AT: Atropine, SE: Spherical Equivalent

The use of OK was investigated in three studies, which are listed in Table 3. In contrast to Conventional Treatment Zone (CTZ) lenses, which had an elongation of 0.26 mm over 18 months, OK lenses with a Smaller Treatment Zone (STZ) produced an AL of 0.17 mm.[33] Compared to 0.20 mm with OK lenses alone, the AL was considerably slower at 0.10 mm when AT 0.01% was added.[34] Binbin Li et al. verified this combination effect, demonstrating that the AL gap stayed constant over a two-year period, measuring 0.10 mm in the first year and 0.09 mm in the second.[35]

Table 3. Summary of OK studies

Author (Year)	Methodology	N	Region	Follow-up (years)	Findings
Ganyu Gong et al. (2024)[33]	RCTs	140	China	1,5 years	Although STZ lenses had a wider defocus ring and could somewhat lower visual quality because of higher spherical aberrations, they were more effective than CTZ lenses at reducing AL. Although STZ lenses are more effective at reducing myopia, careful observation and patient education are necessary due to the possibility that they may affect visual quality.
Shiao Yu et al. (2022)[34]	RCTs	60	China	1 year	AL development was more successfully reduced by the OK lenses and AT 0.01% combination than by control therapies, particularly in the first four months. Although pupil-related side effects should be well observed, this combination therapy demonstrated an additive impact with a rise in pupil diameter, indicating that it is a successful strategy for managing high-risk myopia.
Binbin Li et al. (2024)[35]	RCTs	60	China	2 years	Over the course of two years, the combination of OK lenses with AT 0.01% consistently decreased AL, with notable decreases in the first and second years as compared to OK alone. For children with moderate to high myopia progression, combination therapy is a safe and effective treatment because of its long-term benefits and lack of serious adverse effects.

AL: Axial Length, AT: Atropine, CTZ: Conventional Treatment Zone, OK: Orthokeratology, STZ: Smaller Treatment Zone

DISCUSSION

The most recent studies on three crucial strategies for lowering children's myopia—OK, AT eye drops, and SCL—are compiled in this systematic review. The results highlight the need for customized approaches to meet the demands of individual patients by demonstrating that the effectiveness, safety, and viability of various therapies vary.

Soft contact lenses are one of the optical strategies shown to be effective in slowing the progression of myopia. Comparing BFSCLs to SVSCLs, Chamberlain et al. found that BFSCLs decreased AL elongation by 62% and myopia development by 52% during a one-year period.[36] This important impact demonstrates how peripheral defocus regulates ocular development since controlling the course of myopia requires altering retinal image signals. Further confirming the efficacy of these specialty lenses, DISC lenses showed a 31% decrease in AL and a 25% reduction in myopia development over a two-year period.[37]

These results were corroborated by the BLINK trial, which showed that HAP MFL (+2.50 D) outperformed MAP lenses (+1.50 D) and SVL, lowering AL by 0.23 mm and myopia progression by 0.46 D over a 3 years span.[38] All of these results point to the promise of SCL as a non-invasive, reversible treatment for childhood myopia.

However, the success of SCL is heavily reliant on patient compliance. For instance, the DISC lens trial indicated that children wearing lenses for over 7 hours daily experienced up to a 58% reduction in myopia progression compared to those with less wear.[37] Practical issues such as lens discomfort, hygiene maintenance, and possible complications like dry eye syndrome may hinder their broader implementation. Therefore, educating patients and caregivers is crucial for ensuring compliance and optimizing results.[39,40]

SCL also struggles to address cases of extremely high progression rates or myopia-related complications. Future studies should aim to enhance lens designs to be more comfortable and adherence, as well as assess their effectiveness in conjunction with other therapeutic options like pharmacological treatments.

Atropine eye drops, especially in low doses, have been proven effective in slowing myopia progression, though higher doses offer greater efficacy with more side effects. Over the course of a year, low-dose AT (0.01%) has been shown to reduce AL by 22% and myopia progression by approximately 34.2% when compared to a placebo. This result is consistent with a comprehensive evaluation by Huang et al. that demonstrated the efficacy and tolerance of low-dose AT in the treatment of myopia. With a decrease in AL of 0.16 mm/year and a reduction in myopia progression of 0.40 D/year, higher doses, such as 0.5%, have demonstrated even greater efficacy.[41] These higher dosages, however, have significant adverse effects, such as pupil dilatation and increased glare sensitivity, which may restrict their usefulness, particularly for kids participating in school-related activities.[42]

Notably, variations in treatment outcomes among different populations have been observed. For instance, studies were out in the US showed no appreciable variations between AT 0.01% and a placebo in terms of reducing the advancement of myopia, raising concerns regarding its general efficacy.[43,44] Such variability may stem from genetic, environmental, or lifestyle differences, highlighting the potential for retinal electrophysiological profiling to predict treatment responses.[45] Findings suggest that children with weaker baseline retinal responses may gain greater benefits from AT therapy, indicating a need for tailored treatment strategies.

A significant concern is the rebound effect that occurs after stopping AT treatment, particularly with higher doses. This phenomenon emphasizes the necessity for carefully designed tapering protocols to mitigate rebound progression. Future research should investigate optimal dosing strategies and long-term approaches to maintain treatment effects,[46] as documented in various studies where children returned to their pre-treatment progression rates following cessation of AT.[47]

Orthokeratology lenses have been shown to effectively slow myopia progression. It has been demonstrated that OK lenses are quite successful in slowing the advancement of myopia. Zhu et al. found that AL decreased by 0.17 mm throughout the course of 18 months with smaller treatment zone (STZ) lenses as opposed to 0.26 mm with regular treatment zones.[48] This

improvement is attributed to the enhanced defocus effect afforded by a wider peripheral defocus ring, which likely aids in the regulation of axial growth. Moreover, combining OK lenses with low-dose AT (0.01%) further enhances these benefits, reducing AL by an additional 0.10 mm compared to the usage of OK lenses alone.[49] This synergistic effect underscores the promise of combination therapies for achieving more effective myopia management.

Additionally, the effectiveness of this combined approach is illustrated in studies showing consistent reductions in AL over two years.[50] Research indicates that OK can significantly slow axial elongation in children, with some studies revealing reductions in AL growth by up to 63% compared to traditional spectacle eyewear.[48] This supports the findings of a comprehensive review that found OK to be a safe and efficient way to treat myopia.[51]

Nevertheless, OK presents practical challenges, including the requirement for careful lens maintenance and concerns regarding corneal infections. Regular follow-ups are crucial for evaluating lens fit and ocular health, which can be a burden for both patients and healthcare providers.[49] Additionally, visual quality could decline due to increased spherical aberrations associated with STZ lenses, impacting patient satisfaction and necessitating thorough counselling and monitoring.[52]

OK are particularly appropriate for older children or adolescents with moderate to high progression rates who can manage the demands of lens care. Future investigations should focus on optimizing lens designs that enhance both efficacy and visual comfort.[53] Examining the factors leading to accelerated AL post-OK treatment may also yield insights for improving treatment results.[52]

Both soft contact lenses and orthokeratology lenses have been proven more effective than glasses in slowing myopia progression in children, particularly due to their ability to reduce peripheral hyperopic defocus. It has been shown that children's AL and the advancement of refractive error are considerably decreased by both SCL and OK lenses use. Because contact lenses, especially OK, can lessen peripheral hyperopic defocus, they are more successful than glasses in treating severe myopia, according to a systematic review by González-Meijóme et al.[54] This is especially important for youngsters because myopia tends to develop more quickly in this age range, emphasizing the importance of early correction.[55]

It is widely acknowledged that AT eye drops are safe and have a moderately effective effect on reducing the growth of myopia, particularly when used at low concentrations (0.01%). Low-dose AT is a great choice for younger patients because research indicates that it can successfully slow the progression of myopia while minimizing negative effects.[56,57] However, the effectiveness of AT may fluctuate based on individual characteristics, such as age and parental myopia history.[58,59]

Combining orthokeratology lenses with low-dose atropine offers enhanced myopia control, though it may require greater commitment from both patients and caregivers. The combination of OK lenses with low-dose AT seems to provide the best control over myopia. Research suggests that managing the progression of myopia can be improved with this integrated strategy.[60,61] For instance, combining AT with OK significantly slowed the progression of myopia in teenagers, according to a research by Guo et al., indicating that this combination would be especially helpful for people with moderate myopia.[60] Adherence may be hampered by these combo medicines' high commitment requirements for both patients and caretakers.[59]

Clinicians should consider a number of aspects while deciding on a treatment plan, such as the patient's age, lifestyle, family preferences, and risk of progression. Treatment selection should be individualized to optimize results. For example, younger children may derive more benefit from AT, given its favorable safety profile, while older children or adolescents with faster progression rates may be more suited for SCL or OK.[55,62] Cost-effectiveness and geographic location-based access restrictions should also be taken into account. According to research, the most economical way to slow the onset of childhood myopia is to use eye drops containing 0.05% atropine. Orthokeratology (OK) and soft contact lenses (SCL) are more expensive but may also be affordable; nonetheless, patients in low-resource settings may find OK more difficult to access. Given the severe effects of untreated myopia, myopia treatment is extremely useful and well

worth the effort, even in the face of cost and accessibility issues.[63,64]

This review has several limitations. First, although the review included a large number of participants and recent RCTs, the absence of a meta-analysis limits quantitative conclusions regarding comparative efficacy. This decision was based on the considerable heterogeneity in study designs, treatment protocols, dosage variations, and follow-up durations across the included trials. Second, the long-term safety and rebound effects after treatment cessation remain underexplored in many studies. Third, although this review included studies from diverse regions, the generalizability of results to all global populations, particularly low-resource settings, may be limited.

Moreover, future studies should address economic factors, as treatment accessibility and affordability remain major barriers in low- and middle-income countries. Cost-effectiveness evaluations and practical implementation strategies are critical to ensure equitable myopia control.

CONCLUSION

This systematic review provides updated insights into the effectiveness of SCL, AT eye drops, and OK lenses in slowing the progression of pediatric myopia. The findings demonstrate that each of these interventions can reduce axial elongation and refractive error progression, with combination therapies—particularly OK lenses paired with low-dose atropine—showing the most promising outcomes. Thus, the review effectively confirms the research question by identifying current evidence-based strategies to manage myopia progression in children. These findings are significant as they reinforce the growing body of evidence supporting early and tailored interventions to mitigate the long-term visual and socioeconomic impacts of myopia. In particular, the integration of optical and pharmacological strategies may offer superior outcomes compared to monotherapies alone, thereby shaping future clinical approaches and public health guidelines.

However, this review has several limitations. The absence of a meta-analysis due to heterogeneity in study designs, treatment protocols, and outcome measures restricts quantitative comparison. Furthermore, long-term safety data, rebound effects after treatment cessation, and applicability in low-resource settings remain underexplored. Future research should focus on standardizing treatment protocols, evaluating long-term outcomes, and conducting cost-effectiveness studies. Investigating personalized treatment algorithms—considering factors such as genetics, baseline refractive error, and compliance—will also be essential to improve outcomes and ensure accessibility across diverse populations.

CONFLICT OF INTEREST

Regarding this study, the authors disclose no financial or business ties that might be seen as potential conflicts of interest.

REGISTRATION AND PROTOCOL

The protocol for this review has been registered with PROSPERO (CRD42024513404) to maintain transparency and avoid duplication of efforts.

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DATA AVAILABILITY STATEMENT

The authors kindly note that they did not receive any outside funding, institutional support, or outside help in the development of this work.

SUPPLEMENTARY MATERIAL(S)

No supplementary materials are provided with this article. All relevant content is included within the main text and reference list.

AUTHOR CONTRIBUTIONS

The review procedures were created by ARA, who also helped with data gathering, article screening, data analysis, manuscript drafting, and English editing. Data gathering, article screening, and manuscript preparation were all done with assistance from NAA, PSR, and MRN. AR and NS helped write the draft and screen the articles. DA proofread and made revisions to the paper. The final manuscript has been read and approved by all writers.

DECLARATION OF USING AI IN THE WRITING PROCESS

The authors manually evaluated and validated each selection, however Rayyan AI software was used to help with the article selection process in compliance with the PRISMA guidelines. Furthermore, this review article's typographical and grammatical problems were fixed by artificial intelligence techniques before being proofread by a professional. The authors affirm that the study data was neither generated or interpreted by artificial intelligence (AI) and that all intellectual content, interpretation, and findings are wholly original.

LIST OF ABBREVIATIONS

AL: Axial Length, AT: Atropine, BLINK: Bifocal Lenses in Nearsighted Kids, BFSCL: Bifocal Soft Contact Lenses, CTZ: Conventional Treatment Zone, DISC: Defocus Incorporated Soft Contact, HAP: High Add Power, MFL: Multifocal Lenses, MAP: Medium Add Power, OK: Orthokeratology, PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses, ROB: Risk of Bias, SCL: Soft Contact Lenses, SE: Spherical Equivalent, Single-Vision Lenses (SVL), SVSCL: Single Vision Soft Contact Lenses, STZ: Smaller Treatment Zone.

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