RESEARCH PAPER

Pediatric High Myopia: A Comprehensive Review of Vision-Threatening Complications and Contemporary Management Strategies

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ABSTRACT

Background: Pediatric high myopia is an emerging global public health concern associated with progressive axial elongation and a substantial risk of vision-threatening complications. Early onset myopia is strongly linked to a higher likelihood of developing pathological sequelae in adulthood, necessitating timely intervention strategies.

Objective: To comprehensively review the spectrum of complications and evaluate contemporary management approaches for pediatric high myopia.

Methods: A structured literature review was conducted using major databases, including PubMed, ScienceDirect, Google Scholar, and ProQuest. Studies involving pediatric populations with high myopia were included, focusing on both complications and therapeutic interventions. Eligible study designs comprised randomized controlled trials, cohort studies, and observational studies.

Results: Pediatric high myopia is associated with a range of ocular complications, including myopic macular degeneration, retinal detachment, glaucoma, and early-onset cataract. Diagnostic evaluation relies on multimodal imaging, particularly optical coherence tomography. Contemporary management strategies include pharmacological interventions such as low-dose atropine, optical approaches including defocus-modifying lenses and orthokeratology, and lifestyle modifications such as increased outdoor activity. Among these, atropine and defocus-based optical therapies demonstrate the most consistent efficacy in slowing myopia progression and axial elongation.

Conclusion: Pediatric high myopia requires early identification and a multimodal management approach to mitigate long-term visual morbidity. Advances in myopia control strategies provide promising outcomes, although individualized treatment and long-term monitoring remain essential.

Keywords: *Myopia, High Myopia, Child, Myopic Degeneration, Atropine*

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INTRODUCTION

Myopia has emerged as one of the most significant global public health challenges, with an alarming increase in prevalence over recent decades, particularly among pediatric populations. Current projections estimate that nearly half of the world's population may be affected by myopia by 2050, with approximately 10% developing high myopia, a condition strongly associated with irreversible visual impairment and blindness.[1–3] The burden is especially pronounced in East and Southeast Asia, where the prevalence among school-aged children has reached epidemic proportions, highlighting the urgent need for early detection and intervention.[4,5]

Pediatric high myopia, typically defined as a spherical equivalent of ≤ −6.00 diopters or axial length exceeding 26 mm, is of particular concern due to its association with progressive axial elongation and structural ocular changes.[6] Unlike adult-onset myopia, early-onset myopia tends to progress more rapidly, resulting in a greater cumulative risk of developing pathological complications later in life.[7] The underlying pathophysiology is complex and multifactorial, involving genetic predisposition, environmental influences such as prolonged near work, and reduced outdoor activity, which has been consistently identified as a modifiable risk factor.[8–10]

The clinical significance of pediatric high myopia lies in its strong association with vision-threatening

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complications. These include myopic macular degeneration, retinal detachment, glaucoma, and early-onset cataract, all of which contribute substantially to visual morbidity.[11–13] Structural changes such as posterior staphyloma, chorioretinal atrophy, and progressive thinning of retinal and choroidal layers are frequently observed, even in childhood, suggesting that pathological processes may begin much earlier than previously recognized.[14,15] Advances in ocular imaging modalities, particularly optical coherence tomography (OCT) and OCT angiography, have enabled earlier detection of subtle retinal and choroidal alterations, thereby improving risk stratification and monitoring.[16]

Given the progressive and potentially irreversible nature of high myopia, effective strategies to control myopia progression in children have become a central focus in contemporary ophthalmology. Current approaches encompass pharmacological, optical, and behavioral interventions. Low-dose atropine has demonstrated consistent efficacy in reducing myopia progression and axial elongation, with recent randomized controlled trials supporting its dose-dependent effectiveness and favorable safety profile.[17–19] Optical interventions, including defocus-modifying spectacle lenses, multifocal contact lenses, and orthokeratology, aim to alter peripheral retinal defocus and have shown significant benefits in slowing axial elongation.[20–22] In addition, increased outdoor activity has been widely recommended as a preventive strategy, with evidence suggesting a protective effect against myopia onset and, to a lesser extent, progression.[23]

Despite substantial advances, several challenges remain. Variability in treatment response, differences in study populations, and the lack of universally accepted treatment protocols complicate clinical decision-making. Furthermore, most existing studies focus on general myopia rather than specifically addressing high myopia in children, leading to gaps in evidence regarding optimal management strategies for this high-risk group.

Therefore, this review aims to provide a comprehensive and updated synthesis of the current evidence regarding pediatric high myopia, with a particular focus on vision-threatening complications and contemporary management strategies. By integrating recent findings from clinical and observational studies, this review seeks to support evidence-based clinical practice and highlight areas requiring further research.

METHODS

Study Design and Reporting Guidelines

This study was conducted as a structured literature review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The methodology was designed to ensure transparency, reproducibility, and comprehensive identification of relevant studies.

Search Strategy

A systematic literature search was performed across four electronic databases: PubMed, ScienceDirect, ProQuest, and Google Scholar. The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to pediatric high myopia, complications, and management. The primary search terms included:

("high myopia" AND "children" AND "complications") OR ("myopic macular degeneration" OR "retinal detachment" OR "glaucoma" OR "cataract"), and ("high myopia" AND "children" AND "treatment" OR "myopia control" OR "atropine" OR "orthokeratology" OR "defocus lenses"). The search was limited to articles published within the last five years (2020–2025) to ensure inclusion of the most recent evidence. Reference lists of eligible articles were also manually screened to identify additional relevant studies.

Eligibility Criteria

Studies were included if they met the following criteria: (1) involved pediatric populations (age <19 years) with high myopia (spherical equivalent ≤ −6.00 diopters or equivalent axial length criteria); (2) reported on either complications or management strategies of high myopia; (3) utilized study designs such as randomized controlled trials, cohort studies, case-control studies, or observational studies; and (4) were published in English with accessible full-text articles.

Exclusion criteria included: (1) review articles, editorials, or conference abstracts; (2) studies focusing exclusively on low or moderate myopia without separate analysis of high myopia; (3) non-English publications; and (4) studies with insufficient methodological details or incomplete outcome reporting.

Study Selection

All retrieved records were screened in two stages. First, titles and abstracts were assessed for relevance based on predefined inclusion and exclusion criteria. Second, full-text articles were evaluated for eligibility. Duplicate records were removed prior to screening. The study selection process was documented using a PRISMA flow diagram, detailing the number of records identified, screened, excluded, and included in the final analysis.

Data Extraction

Data from eligible studies were extracted using a standardized form. Extracted variables included: author, year of publication, study design, sample size, age range, type of intervention, duration of follow-up, and outcome measures. For management studies, primary outcomes included changes in spherical equivalent (diopters) and axial length (millimeters). For complication studies, extracted data focused on the type of complication and diagnostic modalities used.

Quality Assessment

The methodological quality and level of evidence of included studies were assessed using the Oxford Centre for Evidence-Based Medicine (OCEBM) 2011 Levels of

Evidence. Randomized controlled trials were categorized as higher-level evidence, while observational studies and case series were classified accordingly. Risk of bias was qualitatively evaluated based on study design, sample size, and reporting completeness.

Data Synthesis

A qualitative synthesis of the included studies was performed due to heterogeneity in study design, interventions, and outcome measures. Findings were grouped into two main domains: (1) vision-threatening complications of pediatric high myopia and (2) contemporary management strategies for myopia control. Key trends, consistencies, and discrepancies across studies were analyzed and summarized narratively.

RESULTS

Study Selection and Characteristics

The initial database search identified a total of 1,613 records. After removal of duplicates and screening of titles and abstracts, studies were assessed for full-text eligibility based on predefined criteria. A total of 47 studies were included in the final qualitative synthesis, consisting of 23 studies on management strategies and 24 studies on complications of pediatric high myopia.

The included studies comprised randomized controlled trials, cohort studies, and observational studies. Sample sizes varied widely, ranging from small case series to large population-based cohorts. Most studies involved pediatric participants aged between 4 and 18 years, reflecting the critical window for myopia onset and progression.

Synthesis of Findings

The overall evidence supports a multimodal approach to pediatric high myopia management. Pharmacological therapy and optical interventions provide the most consistent benefit in reducing progression, while lifestyle modifications contribute primarily to prevention. Early identification of complications through imaging remains essential to reduce long-term visual morbidity.

Table 1. Synthesis of Evidence on Complications and Management of Pediatric High Myopia

Author	Year	Country	Domain	Intervention/Complication	Mechanism/ Pathophysiology	Key Outcomes	Level of Evidence	Clinical Implication
Deng et al.	2023	China	Complications	Myopic maculopathy	Axial elongation causing chorioretinal degeneration	Retinal thinning, early macular changes	Cross-sectional	Early OCT screening required
Zhang et al.	2024	China	Complications	Peripheral retinal degeneration	Peripheral retinal stretching and degeneration	Lattice degeneration, staphyloma	Cross-sectional	Risk of retinal detachment increases
Jiang et al.	2024	China	Complications	Myopic macular degeneration	Progressive choroidal and retinal atrophy	Diffuse and patchy atrophy	Observational	Requires long-term monitoring
Magliyah et al.	2019	Indonesia	Complications	Retinal detachment	Vitreoretinal traction in elongated globe	Rhegmatogenous RD in pediatric cases	Cohort	Early detection critical
Kim et al.	2018	South Korea	Complications	Optic disc changes	Axial elongation affecting ONH morphology	Disc tilt, RNFL changes	Prospective	May mimic glaucoma
Ahn et al.	2020	South Korea	Complications	Optic nerve alteration	Structural remodeling during myopic shift	RNFL/GCIPL changes	Observational	Requires differentiation from glaucoma
Yam et al. (LAMP)	2018–2024	Hong Kong	Pharmacological	Atropine (0.01–0.05%)	Dose-dependent modulation of scleral growth	Reduced SE and axial elongation	RCT	Most effective first-line therapy
Zadnik et al. (CHAMP)	2023	USA/Europe	Pharmacological	Atropine (0.01–0.02%)	Neurotransmitter modulation	Moderate reduction in progression	RCT	Population variability noted
Agarwal et al.	2022	India	Pharmacological	Atropine 0.01%	Inhibition of axial elongation	Significant SE reduction vs control	Cohort	Safe and effective low-dose option
Lam et al.	2019–2023	Hong Kong	Optical	DIMS lenses	Peripheral myopic defocus	~50–60% reduction in progression	RCT	Strong non-pharmacologic option
Bao et al.	2021	China	Optical	HAL lenses	Volume defocus mechanism	Significant reduction in axial elongation	RCT	Highly effective spectacle-based therapy
Chamberlain et al.	2023	USA	Optical	Dual-focus contact lens	Simultaneous myopic defocus	Reduced SE and axial length	RCT	Comparable to atropine efficacy
Walline et al.	2020	USA	Optical	Multifocal soft contact lens	Peripheral defocus	Slower myopia progression	RCT	Effective alternative therapy
Charm & Cho	2013	Hong Kong	Optical	Orthokeratology	Corneal reshaping and defocus	Reduced axial elongation (~60%)	Prospective	Requires infection monitoring
He et al.	2015	China	Lifestyle	Outdoor activity	Increased dopamine release	Reduced myopia onset	RCT	Preventive strategy
Trier et al.	2016	Denmark	Pharmacological	7-methylxanthine	Increased scleral rigidity	Minimal reduction in axial growth	Cohort	Limited clinical use

Complications of Pediatric High Myopia

Pediatric high myopia was consistently associated with early structural ocular changes and a spectrum of vision-threatening complications. Myopic maculopathy was the most frequently reported finding, characterized by chorioretinal atrophy, lacquer cracks, and early degenerative changes. Imaging studies, particularly optical coherence tomography, demonstrated reduced retinal and choroidal thickness even in pediatric populations. Peripheral retinal abnormalities, including lattice degeneration and related lesions, were commonly identified and are clinically relevant due to their association with an increased lifetime risk of retinal detachment. Structural alterations of the optic nerve head, such as disc tilting and peripapillary atrophy, were also observed and may overlap with early glaucomatous changes. Evidence also suggested an association between high myopia and early-onset cataract, although findings across studies were less consistent. Overall, these results indicate that pathological changes may begin in childhood and progress over time, emphasizing the need for early surveillance.

Effectiveness of Pharmacological Interventions

Pharmacological therapy, particularly atropine, demonstrated the most consistent efficacy in controlling

myopia progression. Multiple randomized controlled trials reported a dose-dependent reduction in both spherical equivalent progression and axial elongation.

Low-concentration atropine, especially within the range of 0.01% to 0.05%, showed favorable outcomes with minimal side effects. Higher concentrations were associated with greater efficacy but also increased adverse effects and rebound phenomena. Variability in treatment response was observed across populations, suggesting potential influences of genetic and environmental factors.

Effectiveness of Optical Interventions

Optical interventions designed to induce peripheral myopic defocus demonstrated significant effectiveness in slowing myopia progression. Defocus-based spectacle lenses, including multisegment and lenslet technologies, consistently reduced progression rates compared to single-vision correction. Multifocal soft contact lenses also showed meaningful reductions in spherical equivalent progression and axial elongation, with several studies reporting effects comparable to pharmacological therapy. Orthokeratology was associated with a reduction in axial elongation; however, safety concerns such as microbial keratitis remain important considerations. Conventional single-vision lenses did not demonstrate a significant effect on myopia control, supporting their role as refractive correction rather than therapeutic intervention. Increased outdoor activity was consistently identified as a protective factor for myopia onset. Evidence from both randomized and observational studies indicated that greater exposure to outdoor light was associated with a reduced incidence of myopia in children. However, its effect on slowing progression in established high myopia appeared to be more limited.

DISCUSSION

This review highlights that pediatric high myopia represents a distinct and high-risk clinical entity characterized by early structural ocular changes and a substantial lifetime risk of vision-threatening complications. The findings synthesized from recent studies demonstrate that pathological processes associated with high myopia may begin during childhood, reinforcing the importance of early identification and timely intervention.[24–26]

One of the most important observations is the early onset of retinal and choroidal alterations in pediatric patients. Structural changes such as retinal thinning, reduced choroidal thickness, and early manifestations of myopic maculopathy have been consistently reported, even in asymptomatic children.[27–29] These findings suggest that axial elongation is not merely a refractive issue but a progressive degenerative process involving multiple ocular tissues. The presence of peripheral retinal degeneration further increases the long-term risk of retinal detachment, emphasizing the need for comprehensive retinal evaluation in this population.[30,31]

In addition to posterior segment complications, alterations in the optic nerve head, including disc tilting and peripapillary atrophy, were frequently observed. These changes may overlap with early glaucomatous features, posing a diagnostic challenge in pediatric patients.[32,33] The differentiation between myopia-related structural changes and true glaucomatous damage remains critical, as misinterpretation may lead to over- or under-treatment. Although the association between high myopia and early-onset cataract has been reported, current evidence remains heterogeneous, indicating the need for further longitudinal studies.[34]

Regarding management, pharmacological intervention with low-dose atropine remains the most consistently supported strategy for controlling myopia progression. Evidence from randomized controlled trials demonstrates a clear dose-response relationship, with concentrations between 0.01% and 0.05% providing an optimal balance between efficacy and safety.[35–37] However, variability in treatment response across different populations suggests that genetic and environmental factors may influence therapeutic outcomes, highlighting the importance of individualized treatment approaches.[38]

Optical interventions have also shown substantial efficacy, particularly those designed to induce peripheral myopic defocus. Technologies such as DIMS and HAL lenses, as well as multifocal contact lenses, have demonstrated significant reductions in both refractive progression and axial elongation.[39–41] These modalities offer non-pharmacological alternatives or adjuncts to atropine therapy and are increasingly incorporated into clinical practice. Orthokeratology also provides meaningful control of axial elongation, although its use requires careful patient selection and monitoring due to potential complications such as microbial keratitis.[42]

Lifestyle modification, particularly increased outdoor activity, remains an important preventive strategy. While its effect on slowing progression in established high myopia appears limited, its role in delaying onset is well supported. The underlying mechanism is thought to involve increased retinal dopamine release in response to bright outdoor light exposure, which inhibits axial elongation.[43]

The current evidence supports a multimodal approach to pediatric high myopia management, integrating pharmacological, optical, and behavioral strategies.[44-45] Combination therapy may provide synergistic effects, although high-quality evidence comparing combined versus monotherapy remains limited. Furthermore, the heterogeneity of study designs, treatment protocols, and outcome measures presents a challenge in establishing standardized clinical guidelines.

Several limitations should be acknowledged. First, although this review focused on recent evidence, variability in study populations and methodologies may affect generalizability. Second, the majority of studies

were conducted in Asian populations, where myopia prevalence is highest, potentially limiting applicability to other ethnic groups. Third, long-term data on the safety and sustained efficacy of emerging therapies remain limited. Future research should focus on longitudinal studies evaluating long-term outcomes of early intervention, as well as the development of personalized treatment algorithms based on genetic, environmental, and biometric risk factors. Advances in imaging and biomarker identification may further enhance early detection and risk stratification. Pediatric high myopia is a progressive condition with significant potential for long-term visual morbidity. Early diagnosis, regular monitoring, and implementation of evidence-based multimodal management strategies are essential to reduce the burden of disease and improve visual outcomes.

CONCLUSION

Pediatric high myopia is a progressive condition associated with axial elongation and an increased risk of vision-threatening complications, including myopic maculopathy, retinal detachment, glaucoma, and early-onset cataract, with established evidence supporting the efficacy of low-dose atropine and defocus-based optical interventions in slowing progression. This review highlights that structural retinal and choroidal changes may occur earlier in childhood than previously recognized and emphasizes the importance of a multimodal, individualized management approach integrating pharmacological, optical, and lifestyle strategies. It also identifies gaps in current evidence, particularly regarding variability in treatment response and the lack of standardized clinical algorithms, underscoring the need for further longitudinal studies to optimize outcomes.

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Conflicts of Interest

The authors declare that there are no conflicts of interest related to this study.

Ethical Approval

This study is a literature review and does not involve human participants or animal subjects. Therefore, ethical approval was not required.

Author Contributions

ZK contributed to conceptualization, data collection, data analysis, and manuscript drafting.

NS contributed to supervision, critical revision, and validation of clinical content.

MNA contributed to methodological design, interpretation of findings, and final manuscript review.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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