The Significance of Cycloplegia in The Diagnosis of Refractive Errors: Indications, Benefits, and Risks in Pediatric Patients. A Review

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SUMMARY

Quality of vision in children currently represents a significant global public health issue. Early diagnosis and treatment are crucial for ensuring optimal visual development during childhood. On January 1, 2026, a new screening program was launched in the Czech Republic entitled "Early Detection of Serious Eye Defects (VZOV) in Children Under 3 Years of Age." Several countries worldwide have established national guidelines defining the characteristics and components of high-quality eye examination for pediatric patients. While approaches may differ regarding the organization of pediatric eye care and the specific roles of the particular specialists involved, there is complete consensus regarding the principles governing the treatment of refractive errors. Cycloplegics and mydriatics are essential in pediatric ophthalmology, as they enable the diagnosis and treatment of certain eye conditions. Cycloplegia is considered most valuable for the accurate assessment of refractive errors. However, the occurrence of certain adverse effects – particularly in susceptible patients – has prompted a review of the literature regarding the benefits and risks associated with their use. These risks are categorized into local and systemic adverse effects; the latter are rare and occur primarily in patients with specific risk factors.
Key words: cycloplegic, cyclopentolate, benefits, risks, adverse effects, refraction, accommodation

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INTRODUCTION

Quality of vision in children currently represents a significant global public health issue. It is estimated that one out of five children of pre-school age suffers from visual disorders [1–3]. In the United States of America approximately one out of four schoolchildren wear visual correction aids. With reference to the fact that problems with vision may worsen over time, timely diagnosis and treatment are of crucial importance in order to ensure optimal visual development in childhood.

The epidemiology of visual disorders and ocular pathologies in children includes refractive errors (long-sightedness, short-sightedness, astigmatism and anisometropia), which are the most common causes of correctable visual impairment in children [4].

Long-sightedness (hypermetropia) has a high prevalence in small children aged up to 5 years. It is estimated that more than 20% of these patients have a value of ≥ 2.00 diopters [5,6]. It has been determined that long-sightedness (≥ 2.00 diopters) constitutes a significant risk factor for the development of strabismus and blunt-sightedness (amblyopia) in children aged up to 5 years.

Short-sightedness (myopia) usually develops in children in early school age, and its severity increases as the patient's age advances. The age of onset is typically within the range of 7 to 16 years. In the CLEERE (Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error) study, short-sightedness developed in one out of six children aged between 5 and 16 years (Asian, Hispanic, Afro-American, Native American and Caucasian origin) during school attendance. More than 75% of new cases of short-sightedness appeared between the ages of 9 and 13 years. The prevalence of short-sightedness in children of school age has been increasing in recent years, and the defect is beginning to manifest itself at a lower age [7]. The results of the NHANES (National Health and Nutrition Examination Survey) study on adolescents aged between 12 and 17 years indicate that the prevalence of short-sightedness has increased from 24% in 1971–1972 to 33.9% in the period of 1999–2004 and is continuing to grow [8].

Recommended procedures for a new screening program

On January 1, 2026, a new screening program was officially launched in the Czech Republic entitled "Early Detection of Serious Eye Defects (VZOV) in Children Under 3 Years of Age." The aim is to ensure the timely detection of critical refractive errors in children in the risk period of visual development, i.e. from 6 months to 3 years of age. With the aid of the program it is possible to detect significant refractive (dioptric) errors in the pediatric population and thereby gain the opportunity to start treatment in time. With reference to the fact that pediatric patients being examined are children younger than 3 years of age, the chosen path for realizing the screening program is interdisciplinary cooperation with general practitioners for children and adolescents, together with orthoptists and vision therapists, which has culminated in the compilation of a methodology for screening vision in the Czech Republic [9]. Thanks to this program, we have come to occupy a leading position in the field of prevention not only in Europe, but on a worldwide scale. In 2025 the VZOV pilot project was launched, and the first results show a detection of positive findings of severe refractive errors in 9.1% of the examined children.

Multiple countries worldwide have established national guidelines defining the characteristics and components of high-quality eye examination for pediatric patients [10,11]. An example may be provided by the American Academy of Ophthalmology, which publishes a series of guidelines as part of its services for its members, entitled the "Preferred Practice Pattern" (PPP). All the guidelines of the PPP series are regularly reviewed by the relevant professional group and updated according to requirements. In order to ensure they are up to date, each PPP guideline is valid for a period of five years from the date of approval, unless replaced with a new version.

Recommended procedures may differ regarding the organization of pediatric eye care and within the specific competences of the individual specialists involved. However, there is complete consensus regarding the principles governing the treatment of refractive errors.

Refraction and its significance in the treatment of ocular pathologies

It is known that determination and prescription of accurate correction of refractive error is the first step in the treatment of any ocular pathology. It is unthinkable that an underlying ocular pathology could be further complicated by amblyopia due to absent or insufficient correction of refractive error, which would depreciate the remainder of functional vision. Objective determination of the value of refraction in children younger than 15 years of age always requires a refractive examination in cycloplegia. Subjective determination of refraction may be possible in older children, but even in this case it must be substantiated with a cycloplegic refraction examination. We do not consider the age limit of 15 years to be definitive for the need to apply cycloplegia when determining accurate correction.

Approximately 6% of one-year-old children have a significant refractive error. Hypermetropia and anisometropia markedly increase the risk of onset of amblyopia and strabismus. Therefore, accurate refraction and an appropriate prescription for correction of ametropia are essential in the treatment of both amblyopia and strabismus. At present, the established practice is that children with hypermetropic refractive errors (up to +4.00 diopters) who do not have strabismus, whose visual acuity and binocular functions are developing in a manner corresponding to their age, and in whom there is no presence of significant anisometropia or astigmatism, do not require glasses. The situation is different regarding children who belong to risk groups, i.e. prematurely born, suffering from neurological disorders and syndromes associated with abnormal ocular manifestations. The reasonable lower threshold for prescribing glasses is +1.50 dioptric sphere. The principles for prescribing correction are binding, as presented in Table 1.

Accommodation

Most children with uncorrected hypermetropic anisometropia have asymmetric (81%) rather than symmetric (19%) accommodation. Furthermore, 2/3 of these children have aniso-accommodation, while 1/3 have "anti-accommodation", i.e. they accommodate more to distance than close up. Anti-accommodation is not firmly fixed but is rather controlled by visual input and is subject to short-term variations. A marked adjustment takes place when full glasses correction is applied. This indicates that a mechanism must exist by which it is possible to control accommodation for a shorter time in each eye independently, even if this is rarely necessary in the majority population.

When addressing disorders of accommodation, we prioritize quality of vision over alignment. There is no sense whatsoever in anti-correction for divergent strabismus with accommodative disorder, in fact it further worsens the deviation. In the cases associated with accommodative disorder, we apply addition (from +2.5 to +3.0 diopters) to the full value of refraction measured in cycloplegia in the form of bifocal or multifocal glasses, or progressive contact lenses. Accommodation can be assessed on the basis of a comparison of visual acuity for distance and near vision and the use of dynamic retinoscopy (the Nott method is recommended in order to determine lag of accommodation), or the pull-away method for determining the amplitude of accommodation. Accommodative flexibility can be assessed based on a test with accommodative flippers (+/-2.00 diopters) when reading at the near distance. Cooperation of the pediatric patient is essential for this test, and as a result it is recommended from the age of 8 years upwards. A far simpler method for estimating disorders is comparison of the refraction values measured by autorefractor before and after cycloplegia, with appropriate motivation of the pediatric patient during the examination.

Cycloplegia

There are several recommendations circulated by word of mouth regarding which cycloplegic to use on children. Above all, it is necessary to be aware of the difference between mydriasis and cycloplegia. Table 2 presents the options for the use of mydriatics and cycloplegics in childhood.

Table 1. Mandatory principles for prescribing corrections for refractive errors

Hyperopia spherical refractive error up to +2 D, without astigmatism, without strabismus, without amblyopia	Correction isn´t necessary
Hyperopia - spherical refractive error exceeding +2.5 D, without astigmatism, without strabismus, without amblyopia	Correction of at least two-thirds of the refractive error under cycloplegia
Hyperopia - spherical defect + astigmatism + amblyopia	Precise full correction of both spherical and cylindrical errors based on cycloplegic refraction values + pleoptic treatment dosed according to the severity of amblyopia
Hyperopia - spherical refractive defect + astigmatism + amblyopia + strabismus	Full correction of both spherical and cylindrical errors precisely according to cycloplegic refraction values + pleoptic treatment + orthoptics following resolution of amblyopia and stabilization of the angle 10–20 degrees: surgery within 1 year; > 25 degrees: surgery within 6 months + orthoptics to achieve quality binocular vision
Myopia - spherical refractive error with and/or without astigmatism, without strabismus, without amblyopia	full correction of both spherical and cylindrical errors, precisely according to cycloplegic refraction values
Myopia - spherical refractive error with and/or without astigmatism + amblyopia	Full correction of both spherical and cylindrical errors, precisely according to cycloplegic refraction values + pleoptic treatment dosed according to the severity of amblyopia
Myopia - spherical refractive error with and/or without astigmatism + amblyopia + strabismus	Full correction of both spherical and cylindrical errors, precisely according to cycloplegic refraction values + pleoptic treatment + orthoptics following resolution of amblyopia and stabilization of the angle 10–20 degrees: surgery within 6 months > 25 degrees: surgery within 3 months, with continued orthoptic care to achieve quality binocular vision
Anisometropie	Full correction of both spherical and cylindrical errors in both eyes With full spectacle correction, the tolerance for aniseikonia in children is: • up to 4–5 D of spherical difference between the two eyes (for both myopia and hypermetropia) • up to 3 D of cylinder (for astigmatism) • If contact lenses and spectacle correction are not tolerated in cases of aniseikonia, refractive surgery may be considered

D – diopter

Atropine and cyclopentolate are considered as recommended cycloplegics, while tropicamide and phenylephrine-hydrochloride are used mainly for mydriasis. Further confusion has been caused by the suitability of the different concentrations of substances at different ages in childhood, and the need for repeat application. Table 3 presents the dosage and a comparison of the efficacy of mydriatic and cycloplegic substances.

The adverse side effects resulting from the use of mydriatics and cycloplegics remain the subject of debate but can be divided into local and systemic [12,13].

Local effects include burning sensation, hyperemia, punctate keratitis, photophobia, and blurred vision. Systemic effects mainly cover impairments of speech. Deterioration of verbal fluency following the use of anticholinergics is explained by means of a mental deficit caused by a decrease of acetylcholine in the central nervous system, since the task of verbal fluency places large demands on cognitive processing. Visual or tactile hallucinations may also occur, caused by anticholinergic compounds such as cyclopentolate, which may trigger analogous psychotic symptoms in healthy individuals such as visual or tactile hallucinations (false sensations of touch, movement or temperature on the body, which have no actual external origin). The cortical muscarinic receptors are responsible for improving the signal-to-noise ratio in the neurons. Therefore, the absence of cortical acetylcholine may cause irrelevant sensory and internal information (processed in parallel on a subconscious level) may enter consciousness. Finally, ataxia may occur because cholinergic transmission plays an important role in the modulation of brain function. The consequence is an alteration of the muscarinic acetylcholine receptors in the cerebellum, which is associated with motor problems

Table 2. Use of mydriatics and cycloplegics in children

	Atropin 0,5%	Cyclopentolate 0,5%–1%	Tropicamide 1%	Phenylephrin 0,25% and 10%
Active substance	Atropinsulfas monohydricus	Cyclopentolate-hydrochlorid	Tropicamide	Fenylefrin-hydrochlorid
Pediatric population	Suitable for use in children from 3 months of age	It is not suitable for use in premature infants or infants under 3 months of age. For most infants under 12 months of age, a 0.5% concentration can be used, and for older children, a 1% concentration	Administration is contraindicated in newborns and infants. Suitable from 1 year of age	Administration is contraindicated in children under 12 years of age. It is not recommended for the 12–18 age group
Dosage	One drop in each eye for 3 days before the examination	1 drop in each eye For heavily pigmented irises, a second drop may be administered after 5 minutes, or the treatment combined with another active substance	1–2 drops in each eye at 5-minute intervals	1 drop in each eye

Table 3. Dosage and comparison of the efficacy of mydriatic and cycloplegic agents

Active substance	Dosage	Residual accommodation	Maximum mydriasis	Maximum cycloplegia	Resolution of mydriasis	Resolution of cycloplegia
Atropin	1 drop of 1% for 3–4 days	0.5–1.1 D	30–40 min	60–180 min	7–10 days	6–12 days
Scopolamin	1–2 drops of 0.25%	0.99–1.6 D	20–130 min	30–60 min	3–7 days	3–7 days
Homatropin	1–2 drops of 2–4 %	1.6–2.5 D	40–60 min	30–60 min	1–3 days	1–3 days
Cyclopentolat	1–2 drops	0.5–1.75 D	20–60 min	25–75 min	1 day	6–24 hours
Tropicamid	1–2 drops	1.3–6.5 D	20–30 min	30 min	1 day	0.5–6 hours

D – diopter, min – minutes

Table 4. Significant side effects of individual mydriatics and cycloplegics

Atropine is considered the gold standard due to the greater degree of cycloplegia it induces. However, its prolonged duration of action, significant toxicity (**tachycardia, tremor, lethargy, delirium, seizures, and respiratory depression**), and the need for follow-up examination several days after administration mean that it is usually avoided as a first-line choice, particularly in pediatric patients
Homatropine Compared to cyclopentolate, homatropine is an inferior cycloplegic agent; it also exhibits high inter-individual variability in its cycloplegic effect and is characterized by a **moderately high to high toxicity profile, particularly regarding CNS effects**
Skopolamine Even at low doses, scopolamine can affect the central nervous system (CNS) due to its ability to cross the blood-brain barrier with remarkable ease. **Its primary CNS effects are drowsiness and confusion**; however, it can also induce euphoria and amnesia
Tropicamide While it is a treatment choice for cycloplegic and mydriatic procedures, particularly in children, it has both advantages and disadvantages. It exhibits a rapid, transient effect with low systemic impact but greater variation in residual accommodation
Cyclopentolate increases **the permeability of the blood-ocular barrier; therefore, caution is required in children with epilepsy, neurological disorders, or Down syndrome, as well as in geriatric patients, patients with low blood pseudocholinesterase levels, users of CNS-active substances, and patients with a history of drug dependence**

CNS – central nervous system

and impaired coordination. As a result, it is recommended to avoid the use of 2% cyclopentolate solution to use solutions with a lower concentration, ideally in combination with another mydriatic agent such as phenylephrine. Also, compression of the lacrimal canals following application limits the absorption of the drug, thereby reducing the risk of systemic adverse effects.

Table 4 summarizes the significant side effects of individual mydriatics and cycloplegics. The current guidelines incline towards the use of cyclopentolate. Adequate cyc-

loplegia, achieved after application of 1% cyclopentolate eye drops into the eye and measured 30 to 60 minutes after administration, is sufficient for determining correction. For children younger than six months of age, cycloplegics and mydriatics are used in a lower concentration in order to reduce the risk of toxicity. Furthermore, it is important to be aware that during the period following the application of eye drops the patient is under supervision in a healthcare facility, whereas atropine dispensed to parents for home application for a period of three days before the eye examination is administered entirely without medical supervision. Routine use of atropine for the diagnosis of cycloplegia or mydriasis is usually considered useless. However, in patients with darkly pigmented irises, cyclopentolate may prove to be insufficient in order to induce complete cycloplegia. In such situations, we either repeat the application a second time, but in some cases it is necessary to use atropine. In order to attain sufficient mydriasis, it makes no sense to administer the same active agent repeatedly, but rather to add or start the local application of phenylephrine.

It is recommended to repeat measurement of cycloplegic refraction every 12 months in order to monitor changes in glasses prescription. Earlier repetition is indicated for children during the age of maximum eye growth and also in the case that vision does not improve as expected, for example with indicated occlusion, if visual acuity is worse with glasses, or in the case of minor residual esotropia. In these situations, it is necessary to measure refraction once again, and at the same time to conduct a repeat examination of the ocular fundus and consider an alternative diagnosis.

CONCLUSION

Considering the critical period for the development of sight, it is essential to insist on the correct method of treatment, i.e. adequate correction of refractive error and always full correction of astigmatism. Without adequate correction it is not possible to assess all the further parameters of vision, such as alignment of the eyes and binocular function in strabismus, or to evaluate the success of treatment for amblyopia. If full correction is indicated, then we apply it in its full value immediately at the first examination, and not in the form of a gradual increase over the course of several years. Any under-correction of hypermetropic refraction markedly reduces or eliminates the effectiveness of amblyopia treatment, while in myopia under-correction has a stimulating effect for the growth of the axial length of the eye. For ophthalmologists to intervene in patients' visual development, and to have the right to do so, they must have detailed knowledge of the physiological course of visual development, as well as the differences thereof in risk patients, the values of the physiological range of visual acuity at the given age, and they must understand the development of refraction. Errors in determining accurate correction, which continue to occur, lead to iatrogenic impairment of visual development [14].

Disorders of vision may lead to problems in the regular development of children [15,16], affecting their academic results [17], manifesting in social interactions, and in the realm of self-confidence [18]. Visual disorders with their origin in childhood may also manifest themselves in adulthood and influence the level of education, working life and social interactions of the individuals concerned [19]. Timely detection of visual disorders is especially important in children with developmental and mental disabilities [20,21]. A markedly higher incidence of problems with vision (e.g. strabismus, refractive errors, and nystagmus) is recorded in these children than in children without such disabilities [22].

REFERENCES

1. Wen G, Tarczy-Hornoch K, McKean-Cowdin R, et al. Prevalence of myopia, hyperopia, and astigmatism in non-Hispanic white and Asian children: Multi-Ethnic Pediatric Eye Disease Study. Ophthalmology. 2013;120(10):2109-2116. doi: 10.1016/j.ophtha.2013.06.039
2. Giordano L, Friedman DS, Repka MX, et al. Prevalence of refractive error among preschool children in an urban population: the Baltimore Pediatric Eye Disease Study. Ophthalmology. 2009;16(4):739-746. doi: 10.1016/j.ophtha.2008.12.030
3. Friedman DS, Repka MX, Katz J, et al. Prevalence of amblyopia and strabismus in white and African American children aged 6 through 71 months: the Baltimore Pediatric Eye Disease Study. Ophthalmology. 2009;116 (11):2128-2134. doi: 10.1016/j.ophtha.2009.04.034
4. Tarczy-Hornoch K, Cotter SA, Borchert M, et al. Prevalence and causes of visual impairment in Asian and non-Hispanic white preschool children: Multi-Ethnic Pediatric Eye Disease Study. Ophthalmology. 2013;120(6):1220-1226. doi: 10.1016/j.ophtha.2012.12.029
5. Loba P, Gotz-Więckowska A, Hautz Wm Bakunowicz-Łazarczyk A. Guidelines for the management of strabismus in children Klinika Oczna. 2012;124(3):127-130.
6. Multi-Ethnic Pediatric Eye Disease Study Group. Prevalence of myopia and hyperopia in 6- to 72-month-old African American and Hispanic children: the multi-ethnic pediatric eye disease study. Ophthalmology. 2010;117(1):140-147.e3. doi: 10.1016/j.ophtha.2009.06.009
7. Kleinstein RN, Sinnott LT, Jones-Jordan LA, et al. New cases of myopia in children. Arch Ophthalmol. 2012; 30:1274-1279.
8. Vitale S, Sperduto RD, Ferris FL 3rd. Increased prevalence of myopia in the United States between 1971-1972 and 1999-2004. Arch Ophthalmol. 2009;127(10):1632-1639. doi: 10.1001/archophthalmol.2012.1449
9. Metodický pokyn k provádění včasného záchytu závažných očních vad u dětí v ČR 1a. Příloha č. 1 Informace pro zákonného zástupce dítěte, 1b. Příloha č. 2 Doporučený postup očního vyšetření u nejmenších dětí a dětí předškolního věku v běžné oftalmologické ambulantní praxi Věstník 5/2025 Metodiky a stanoviska MZ CR. Czech.
10. Sprunger DT, Lambert SR, Hercinovic A, et al. American Academy of Ophthalmology Preferred Practice Pattern Pediatric Ophthalmology/Strabismus Panel. Esotropia and Exotropia Preferred Practice Pattern®. Ophthalmology 2023;130(3):P179-P221. doi: 10.1016/j.ophtha.2022.11.002
11. The Royal College of Ophthalmologists Guidelines for the Management of Strabismus in Childhood. March 2012.
12. Ocular cyclopentolate: A mini review concerning its benefits and risks. Therapeutics and Clinical Risk Management. Micromedex Cyclopentolate. 2021;17:1021-1028.
13. Contreras-Salinas H, Orozco-Ceja V, Romero-López MS, et al. Ocu-

lar Cyclopentolate: A Mini Review Concerning Its Benefits and Risks. Clin Ophthalmol. 2022;16:3753-3762. doi: 10.2147/OPTH.S388982
14. Zobanová A. Recommended procedure for eye examination for infants and children of pre-school age in regular outpatient practice. Cesk Slov Oftalmol. 2017;73(5-6):225-230.
15. Goldstand S, Koslowe KC, Parush S. Vision, visual-information processing, and academic performance among seventh grade school children: a more significant relationship than we thought? Am J Occup Ther. 2005;59(4):377-389. doi: 10.5014/ajot.59.4.377
16. Atkinson J, Nardini M, Anker S, et al. Refractive errors in infancy predict reduced performance on the movement assessment battery for children at 3 1/2 and 5 1/2 years. Dev Med Child Neurol. 2005;47(4):243-251. doi: 10.1017/s0012162205000472
17. Roch-Levecq AC, Brody BL, Thomas RG, Brown SI. Ametropia, preschoolers' cognitive abilities, and effects of spectacle correction. Arch Ophthalmol. 2008;126(2):252-258. doi: 10.1001/archophthalmol.2007.36
18. Menacker SJ. Visual function in children with developmental disabilities. Pediatr Clin North Am. 1993;40(3):659-674. doi: 10.1016/s0031-3955(16)38557-1
19. Akinci A, Oner O, Bozkurt OH, et al. Refractive errors and ocular findings in children with intellectual disability: a controlled study. J AAPOS 2008;12(5):477-481. doi: 10.1016/j.jaapos.2008.04.009
20. Mojon-Azzi SM, Kunz A, Mojon DS. Strabismus and discrimination in children: are children with strabismus invited to fewer birthday parties? Br J Ophthalmol. 2011;95 (4):473-776. doi: 10.1136/bjo.2010.185793
21. Davidson S, Quinn GE. The impact of pediatric vision disorders in adulthood. Pediatrics. 2011;127(2):334-339. doi: 10.1542/peds.2010-1911
22. Salt A, Sargent J. Common visual problems in children with disability. Arch Dis Child. 2014;99(12):1163-1168. doi: 10.1136/archdischild-2013-305267