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REVIEW

# Cycloplegia in Children: An Optometrist's Perspective

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Erin Major[1]
Thomas Dutson[2]
Majid Moshirfar[2–4]

[1]Southern California College of Optometry, Marshall B. Ketchum University, Fullerton, CA, USA; [2]Hoopes Vision, Draper, UT, USA; [3]John A. Moran Eye Center, University of Utah School of Medicine, Salt Lake City, UT, USA; [4]Utah Lions Eye Bank, Murray, UT, USA

**Purpose:** To determine the current scope of practice with regards to cycloplegic examinations, specifically in the pediatric population.

**Methods:** A comprehensive literature review was conducted using PubMed, ScienceDirect, Elsevier, and Google Scholar databases using keywords such as "cyclopentolate"; "tropicamide"; "pediatric"; "cycloplegia"; "atropine"; and "cycloplegic" from inception to October 2019.

**Results:** Atropine has the strongest cycloplegic effect and is recommended for cases of large accommodative esotropia. Because of the undesired side effects and risks from atropine, cyclopentolate has been found to offer a very effective cycloplegia even for moderate to high hyperopia and has become the standard of care for traditional pediatric cycloplegic exams. Tropicamide has also been shown to offer adequate cycloplegia with less toxicity and side effects. Of all agents, tropicamide presents the least side effects and toxicity, whereas atropine presents the greatest. Cyclopentolate is a very safe cycloplegic agent that has risk of toxicity which increases with higher doses and concentrations.

**Conclusion:** The American Optometric Association's current pediatric cycloplegic guidelines have proven both safe and effective, as they recommend a conservative approach of using cyclopentolate 0.5% in infants and cyclopentolate 1% in those older than one-year old to avoid undesired side effects. Topical ophthalmic drops and spray instillation have both proved equally efficacious and therefore each have their place within a clinical setting. Using Cycolmydril under six months old and cyclopentolate 1% over 6 months old as recommended by the AAO, also provides a safe and effective guideline for cycloplegic examinations within the pediatric population.

**Keywords:** cycloplegic, cycloplegia, pediatric

## Introduction

A cycloplegic pediatric examination involves many moving parts and multiple decisions for the provider. Considerations should be made for which cycloplegic agents to use, optimal dosing, preferred method of instillation, indications for usage, and potential side effects. While the benefit of a cycloplegic examination is indisputable, there still exists some confusion and varied practice methods when it comes to cycloplegic examinations. These confusions can lead to limitations in the quest for a complete, accurate cycloplegic examination and can potentially delay patient care and treatment. Cycloplegic agents temporarily paralyze the accommodative system by acting on the ciliary body and blocking the receptor site of acetylcholine.[1] This is particularly helpful when examining the pediatric population, as their accommodative system is more robust, possibly leading to inaccurate refractive measurements.

Correspondence: Thomas Dutson
Hoopes Vision, Draper, UT, USA
Email dutson@hoopesvision.com

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Cycloplegia has long been considered the standard of care in several patient scenarios. These include children with constant or intermittent esotropia, fluctuating accommodation, patients with suspected pseudomyopia, unreliability and/or inability to perform retinoscopy or subjective refraction, as well as in patients with accommodative issues including insufficiency, fatigue, or spasm.[1] Other indications include children and adolescents with asthenopia, esophoria, or suspected latent hyperopia. Cycloplegia should also be considered in those with suspected amblyopia or strabismus, as well as those with a family history of visual issues. In their 2017 clinical practice guideline, the American Optometric Association (AOA) recommended cycloplegic examinations when first examining preschoolers in order to identify potential vision-limiting conditions including strabismus, amblyopia, and anisometropia.[2] From their 2017 Pediatric Eye Evaluations Preferred Practice Pattern, the American Academy of Ophthalmology also recommended cycloplegic examinations when examining children with amblyopia or strabismus.[3] As these conditions can lead to decreased vision (potentially long term), cycloplegic exams become necessary in diagnosing and treating these conditions early on.

## Methods

A comprehensive literature review was conducted using PubMed, ScienceDirect, Elsevier, and Google Scholar databases using keywords such as "cyclopentolate"; "tropicamide"; "pediatric"; "cycloplegia"; "atropine"; and "cycloplegic". In addition to a web-based search, literature regarding cycloplegic agents was also utilized. The search was conducted from inception to October 2019.

## Results

If relying on autorefraction for the prescription of a pediatric patient, one runs the risk of over-minusing a child's refractive error and obtaining an inaccurate measurement. One study commented that noncycloplegic autorefraction is "highly inaccurate" in school-aged children.[4] A particular study found that noncycloplegic autorefractive measurements revealed more minus refractive error when compared to cycloplegic measurements.[4] Another study looking at refractive error in primary school children found autorefraction in noncycloplegic conditions led to a more minus refractive error when compared to cycloplegic conditions.[5] The "fogging" mechanism of the autorefractors proves inadequate when compared to the accommodative power in the pediatric population. For these reasons, a cycloplegic examination in this age population is highly recommended. In fact, one study from 2010 even recommended cycloplegic refractions for patients as old as 20 due to underestimation of refractive error due to fluctuating accommodation.[6] The same study found that teenagers exhibit overaccommodation in noncycloplegic conditions, therefore leading to more myopic findings. Another 2015 study researching a slightly older population (ages 18–21) found an additional one to two diopters of latent hyperopia in young hyperopes and recommended cycloplegic refractions in young hyperopic adults with asthenopic symptoms.[7] This particular study used cyclopentolate 1% instilled twice, ten minutes apart, with an autorefractor measurement.

Among the pharmaceutical cycloplegic agents, of which there are five (Atropine, Homatropine, Scopolamine, Cyclopentolate, and Tropicamide), there have been several studies examining the effectiveness of each. Atropine has been regarded as the "gold standard" in a complete cycloplegic examination, as it is the strongest cycloplegic agent.[8,9] Effects of cycloplegia and mydriasis from atropine can last up to 14 days whereas scopolamine has a duration of action of three days.[7] Homatropine has a duration of action of one to three days with an onset of approximately one hour. Tropicamide has a stronger mydriatic effect compared to its cycloplegic action, lasting approximately one to two hours. Cyclopentolate is the most commonly used cycloplegic agent with an onset approximately 30 minutes after instillation and a duration of action up to 24 hours.

A study evaluating the efficacy of cyclopentolate compared to atropine revealed similar refractive findings, suggesting that cyclopentolate is sufficient in producing a cycloplegic exam.[10] Researchers in another study comparing atropine to cyclopentolate found that two drops of cyclopentolate 1%, instilled five minutes apart, produced a sufficient cycloplegic refraction for most pediatric patients.[10] The study did recommend the use of atropine examinations for children with large accommodative esotropia or cyclopentolate-induced psychosis. Another large multi-center study from 2008 revealed atropine resulted in a higher hyperopic refractive error when compared to cyclopentolate, although the difference was less than 0.50 diopters.[11] One study looking specifically at young hyperopic children (ages 2–10) with more than 2.50 diopters of hyperopia in at least one eye evaluated various cycloplegic regimens, finding atropine to be the best cycloplegic agent.[12] Atropine uncovered higher hyperopic refractive errors when compared to a combination of either tropicamide 0.5% and phenylephrine 0.5% or tropicamide 1% and cyclopentolate 1%. For cycloplegic exams, they

recommended the use of atropine in young (less than five years old) hyperopic children with dark irides and the use of tropicamide 0.5% and phenylephrine 0.5% in those older than five to avoid cyclopentolate toxicity. Overall, based on the small difference in refractive error and decreased side effects with cyclopentolate, researchers have recommended cyclopentolate for the majority of pediatric cycloplegic examinations unless a strong cycloplegia is otherwise indicated.

The AOA named cyclopentolate as the "cycloplegic of choice", although they offer the alternative of tropicamide 1% in situations where patients have an increased reaction to cycloplegic agents.[2] The American Academy of Ophthalmology also recommended the use of cyclopentolate 1% due to its similar mechanism of action to atropine with a shorter duration.[3] In a 2001 survey mailed to all members of the American Association for Pediatric Ophthalmology and Strabismus, 94% of practitioners used different cycloplegic agents in neonates compared to older children.[13] The most common agents used for neonates included Cyclomydril (cyclopentolate 0.2% and phenylephrine 1%), phenylephrine 2.5%, cyclopentolate 0.5% and tropicamide 1%. In older children, the most common agents included cyclopentolate 1%, tropicamide 1%, phenylephrine 2.5%, and atropine 1%.

Some practitioners choose to add phenylephrine to cycloplegic examinations, which acts as a mydriatic by activating the iris dilator, although it has no effect on the ciliary muscle.[14,15] One study looked at the effectiveness of adding tropicamide 0.5% and phenylephrine 0.5% (Tropherine) to cyclopentolate 1% when examining hyperopic children.[16] The study found that the addition of Tropherine actually produced a weaker cycloplegic effect when compared to cyclopentolate by itself, specifically in children under five years old with high hyperopia or fully accommodative esotropia. Although cyclopentolate produced a stronger cycloplegic effect alone, the study found the difference between refractive measurements was small and clinically insignificant. Another study looking at the effectiveness of tropicamide 1% in myopic children found residual accommodation less than 0.50 diopters, measured objectively with an autorefractor.[17] Based on their study, they concluded tropicamide 1% to be an effective standalone cycloplegic agent. When comparing atropine to tropicamide in cycloplegic exams for children with hyperopia, one study found that tropicamide was an adequate cycloplegic agent for children, even those with high hyperopic refractive errors, and had less toxicity than atropine.[18]

With regards to dosing of cyclopentolate, the AOA has recommended cyclopentolate 0.5% in infants younger than one year and the use of cyclopentolate 1% for patients older than one year.[2] The AAO suggests cyclopentolate 1% for infants six months or older and Cyclomydril (0.2% cyclopentolate and 1% phenylephrine) for those younger than six months.[3] The AAO recommend dosing based on the child's weight, iris color, and dilation history and suggests repeated dosing in those with darker pigmented irides, or the addition of phenylephrine hydrochloride 2.5% or tropicamide 1%. Aside from cyclopentolate, the AAO states that 0.5% tropicamide and 0.5% phenylephrine can produce "adequate dilation and cycloplegia". In a randomized clinical trial studying varying instillations of cyclopentolate 1%, the researchers found that a single drop is sufficient for a cycloplegic examination in pediatrics with any type of strabismus or refractive error.[19] The age group researched in this study was 3.5–20 and they compared the effectiveness of one drop versus two or three drops of cyclopentolate 1%.

With regards to method of instillation, the AOA recommends either spray or topical ophthalmic drops although they note that the use of spray administration in pediatric children with dark irides may not be sufficient.[2] One study looking at methods of instillation compared cycloplegic efficacy in those receiving topical ophthalmic drops in children whose eyes were open, ophthalmic drops in those whose eyes were closed, spray in those whose eyes were open, and spray in those whose eyes were closed. No statistical significant difference was discovered between the groups.[20] Two separate studies looking at drop versus spray instillation found cycloplegia induced by spray instillation to be more tolerable and equally effective as eyedrops.[20,21]

Certain side effects of cycloplegic agents, though rare, should be considered. There are several serious potential side effects that can occur with atropine including fever, tachycardia, convulsions, and delirium (better known by the saying "blind as a bat, hot as a hare, dry as a bone, red as a beet, mad as a hatter").[10] Atropine is also contraindicated in those with Down syndrome due to increased sensitivity to the cardiac effects.[10,22] Although atropine is more often associated with central nervous system side effects including delirium, cyclopentolate has a similar mechanism of action and therefore, similar side effects. These include ocular side effects such as increased pressure, potential corneal damage or cloudy vision as well as systemic side effects similar to atropine. One case report documents a case of a 15-month-old child with cyclopentolate-

induced delirium.[23] Another case report revealed toxicity in a 6-year-old child after cyclopentolate after three drops of cyclopentolate 1%.[24] He developed mydriasis, incoherent speech, visual hallucinations, and dry mouth. Tropicamide also poses risks of systemic complications such as allergic reactions, drowsiness, and irritation, but it is not likely to cause the symptoms of tachycardia, convulsions, delirium or fever.[25] Topically applied phenylephrine has been shown to create systemic hypertension and tachycardia if applied at 10% concentration or higher dosages.[25] Aside from using the proper dosage, studies also recommend applying pressure on the nasolacrimal sac when adding cycloplegic drops to reduce systemic side effects.

## Discussion

Cycloplegic examinations within the pediatric population are invaluable to patients and providers alike. As evidenced by the research reviewed, there are varied practice patterns when it comes to cycloplegic examinations in pediatrics, and mildly contradictory findings between the studies. There is no one correct cycloplegic modality, and a practitioner has a choice on what is best for each specific patient. Given the information reviewed, a practitioner must take into consideration the risks of using cycloplegic agents in addition to the efficacy of the medication used. It is of the authors' opinion that cycloplegia should be recommended for first-time pediatric examinations. In addition, a conservative approach is recommended to follow the AOA guideline of using the lowest concentration of drug that yields the desired cycloplegia. The concentrations recommended by the authors are cyclopentolate 0.5% in infants up to one year old and cyclopentolate 1% in those older than one. If cyclopentolate is contraindicated, Tropicamide 0.5% or 1% are a very safe consideration with good cycloplegic benefits for non-strabismus infants. Tropicamide offers the lowest risk profile from all of the cycloplegic agents, and although it may not have as strong of a cycloplegic effect, it has a very useful place in cycloplegic exams with children. It is also of the authors' opinion that using phenylephrine hydrochloride 1% or 2.5% is safe to use with the pediatric population, but should be added for its mydriatic benefits and does not benefit the cycloplegic response of tropicamide or cyclopentolate. Atropine should not be overlooked in its ability to uncover refractive error from large accommodative esotropic cases. Cyclomydril (0.2% cyclopentolate and 1% phenylephrine) is recommended by the AAO for infants under 6 months old compared to the AOA recommendation of 0.5% cyclopentolate for the same age group. It is of the authors' opinion that following either the AOA or AAO guidelines will provide a safe and effective cycloplegic examination for this youngest population. In addition, topical ophthalmic drops and spray instillation have both proven equally efficacious and therefore each have their place within a clinical setting. Following the guidelines of the AOA and AAO will direct practitioners to provide safe cycloplegic examinations among the pediatric population.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

All authors declare that they have no conflicts of interest.

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