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Amblyopia Preferred Practice Pattern®

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PEDIATRIC OPHTHALMOLOGY/STRABISMUS PREFERRED PRACTICE PATTERN® DEVELOPMENT PROCESS AND PARTICIPANTS

The **Pediatric Ophthalmology/Strabismus Preferred Practice Pattern® Panel** members wrote the Amblyopia Preferred Practice Pattern® guideline (“PPP”). The PPP Panel members discussed and reviewed successive drafts of the document, meeting in person twice and conducting other review by e-mail discussion, to develop a consensus over the final version of the document.

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Preferred Practice Patterns Committee 2017

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The Amblyopia PPP was then sent for review to additional internal and external groups and individuals in July 2017. All those returning comments were required to provide disclosure of relevant relationships with industry to have their comments considered (indicated with an asterisk below). Members of the Pediatric Ophthalmology/Strabismus Preferred Practice Pattern Panel reviewed and discussed these comments and determined revisions to the document.

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FINANCIAL DISCLOSURES

In compliance with the Council of Medical Specialty Societies' Code for Interactions with Companies (available at www.cmss.org/codeforinteractions.aspx), relevant relationships with industry are listed. The Academy has Relationship with Industry Procedures to comply with the Code (available at www.aao.org/about-preferred-practice-patterns). A majority (100%) of the members of the Pediatric Ophthalmology/Strabismus Preferred Practice Pattern Panel 2016–2017 had no financial relationship to disclose.

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The disclosures of relevant relationships to industry of other reviewers of the document from January to July 2017 are available online at www.aao.org/ppp.

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OBJECTIVES OF PREFERRED PRACTICE PATTERN® GUIDELINES

As a service to its members and the public, the American Academy of Ophthalmology has developed a series of Preferred Practice Pattern® guidelines that **identify characteristics and components of quality eye care**. Appendix 1 describes the core criteria of quality eye care.

The Preferred Practice Pattern® guidelines are based on the best available scientific data as interpreted by panels of knowledgeable health professionals. In some instances, such as when results of carefully conducted clinical trials are available, the data are particularly persuasive and provide clear guidance. In other instances, the panels have to rely on their collective judgment and evaluation of available evidence.

These documents provide guidance for the pattern of practice, not for the care of a particular individual. While they should generally meet the needs of most patients, they cannot possibly best meet the needs of all patients. Adherence to these PPPs will not ensure a successful outcome in every situation. These practice patterns should not be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed at obtaining the best results. It may be necessary to approach different patients' needs in different ways. The physician must make the ultimate judgment about the propriety of the care of a particular patient in light of all of the circumstances presented by that patient. The American Academy of Ophthalmology is available to assist members in resolving ethical dilemmas that arise in the course of ophthalmic practice.

Preferred Practice Pattern® guidelines are not medical standards to be adhered to in all individual situations. The Academy specifically disclaims any and all liability for injury or other damages of any kind, from negligence or otherwise, for any and all claims that may arise out of the use of any recommendations or other information contained herein.

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Innovation in medicine is essential to ensure the future health of the American public, and the Academy encourages the development of new diagnostic and therapeutic methods that will improve eye care. It is essential to recognize that true medical excellence is achieved only when the patients' needs are the foremost consideration.

All Preferred Practice Pattern® guidelines are reviewed by their parent panel annually or earlier if developments warrant and updated accordingly. To ensure that all PPPs are current, each is valid for 5 years from the approved by date unless superseded by a revision. Preferred Practice Pattern guidelines are funded by the Academy without commercial support. Authors and reviewers of PPPs are volunteers and do not receive any financial compensation for their contributions to the documents. The PPPs are externally reviewed by experts and stakeholders, including consumer representatives, before publication. The PPPs are developed in compliance with the Council of Medical Specialty Societies' Code for Interactions with Companies. The Academy has Relationship with Industry Procedures (available at www.aao.org/about-preferred-practice-patterns) to comply with the Code.

Appendix 2 contains the International Statistical Classification of Diseases and Related Health Problems (ICD) codes for the disease entities that this PPP covers. The intended users of the Amblyopia PPP are ophthalmologists.

METHODS AND KEY TO RATINGS

Preferred Practice Pattern guidelines should be clinically relevant and specific enough to provide useful information to practitioners. Where evidence exists to support a recommendation for care, the recommendation should be given an explicit rating that shows the strength of evidence. To accomplish these aims, methods from the Scottish Intercollegiate Guideline Network¹ (SIGN) and the Grading of Recommendations Assessment, Development and Evaluation² (GRADE) group are used. GRADE is a systematic approach to grading the strength of the total body of evidence that is available to support recommendations on a specific clinical management issue. Organizations that have adopted GRADE include SIGN, the World Health Organization, the Agency for Healthcare Research and Quality, and the American College of Physicians.³

- ◆ All studies used to form a recommendation for care are graded for strength of evidence individually, and that grade is listed with the study citation.
- ◆ To rate individual studies, a scale based on SIGN¹ is used. The definitions and levels of evidence to rate individual studies are as follows:

I++	High-quality meta-analyses, systematic reviews of randomized controlled trials (RCTs), or RCTs with a very low risk of bias
I+	Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
I-	Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
II++	High-quality systematic reviews of case-control or cohort studies High-quality case-control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal
II+	Well-conducted case-control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
II-	Case-control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
III	Nonanalytic studies (e.g., case reports, case series)

- ◆ Recommendations for care are formed based on the body of the evidence. The body of evidence quality ratings are defined by GRADE² as follows:

Good quality	Further research is very unlikely to change our confidence in the estimate of effect
Moderate quality	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
Insufficient quality	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate Any estimate of effect is very uncertain

- ◆ Key recommendations for care are defined by GRADE² as follows:

Strong recommendation	Used when the desirable effects of an intervention clearly outweigh the undesirable effects or clearly do not
Discretionary recommendation	Used when the trade-offs are less certain—either because of low-quality evidence or because evidence suggests that desirable and undesirable effects are closely balanced

- ◆ The Highlighted Findings and Recommendations for Care section lists points determined by the PPP Panel to be of particular importance to vision and quality of life outcomes.
- ◆ All recommendations for care in this PPP were rated using the system described above. Ratings are embedded throughout the PPP main text in italics.
- ◆ Literature searches to update the PPP were undertaken in March 2016 in the PubMed and Cochrane databases. Complete details of the literature searches are available in Appendix 4.

HIGHLIGHTED FINDINGS AND RECOMMENDATIONS FOR CARE

Treatment of refractive error alone can improve visual acuity in children who have untreated anisometropic and strabismic amblyopia. Visual acuity of children who have bilateral refractive amblyopia also can substantially improve with refractive correction alone.

Most children who have moderate amblyopia (20/40 to 20/80) respond to initial treatment consisting of 2 hours of daily patching or weekend atropine

Following treatment of amblyopia caused by strabismus, anisometropia or both combined, continued monitoring and treatment, if needed, is associated with long-term stability of the visual acuity improvement.

Suitable treatment options for amblyopia may include optical correction, patching, pharmacological treatment, optical treatment, Bangerter (translucent) filters, and/or surgery to treat the cause of amblyopia.

Patching may be effective in older children and teenagers, particularly if they have not previously been treated.

INTRODUCTION

DISEASE DEFINITION

Amblyopia is a unilateral or, less often, bilateral reduction of best-corrected visual acuity (BCVA) that usually occurs in the setting of an otherwise normal eye. It is a developmental disorder of the central nervous system that results from the abnormal processing of visual images, which leads to reduced visual acuity. Less commonly, amblyopia occurs in association with a structural abnormality involving the eye or visual pathway. Patients with amblyopia experience a reduction in visual acuity that cannot be attributed only to the effect of the structural abnormality; such eyes may also have a deficit in contrast sensitivity and accommodation. Often the fellow eye is not normal but has subtle structural and functional deficits.⁴

Amblyopia is caused by an abnormal visual input early in life. It has traditionally been classified by cause as follows:⁵

- ◆ Strabismic
- ◆ Refractive
 - ◆ Anisometropia
 - ◆ High bilateral refractive (isoametropic)
- ◆ Visual deprivation
 - ◆ Media opacities
 - ◆ Ptosis
- ◆ Occlusion (reverse)

Strabismic Amblyopia

Constant, nonalternating, or unequally alternating tropias (typically esodeviations) are likely to cause amblyopia. Strabismic amblyopia is thought to result from competitive or inhibitory interaction between neurons processing the nonfusible inputs from the two eyes, which leads to domination of cortical vision centers by the fixating eye and chronically reduced responsiveness to input by the nonfixating eye.

Refractive Amblyopia

Amblyopia may develop because of untreated unilateral or bilateral refractive errors. Anisometropic amblyopia, a form of unilateral amblyopia, develops when unequal refractive error causes the image on one retina to be more poorly focused than in the fellow eye. This form of amblyopia may occur in combination with strabismus. Anisometropic amblyopia is thought to result partly from the direct effect of image blur on the development of visual acuity in the involved eye and partly from interocular competition or inhibition similar to (but not necessarily identical to) that responsible for strabismic amblyopia. Greater degrees of anisometropia or astigmatism result in increased risk and severity of amblyopia.⁶⁻⁸

Bilateral refractive amblyopia (isoametropic) is a less common form of refractive amblyopia that results in a bilateral reduction in visual acuity. It is thought to result from the effect of blurred retinal images alone.

Visual Deprivation Amblyopia

Visual deprivation amblyopia is caused by complete or partial obstruction of the visual axis, resulting in a degraded retinal image. A common cause is a congenital or early-onset cataract. Corneal opacities, infectious or noninfectious intraocular inflammation, vitreous hemorrhage, and ptosis are also associated with visual deprivation amblyopia. Deprivation amblyopia is the least common form of amblyopia, but it is often the most severe and difficult to treat. Amblyopic visual loss resulting from a unilateral obstruction of the visual axis tends to be worse than that produced by bilateral deprivation of similar degree because interocular competition adds to the direct amblyogenic impact of severe image degradation. Visual acuity

can be 20/200 or worse. Newborns with a visually threatening unilateral cataract have a better prognosis when the cataract is removed and optical correction is in place by 2 months of age.⁹⁻¹¹

In children younger than 6 years of age, dense central cataracts are likely to cause amblyopia. Similar lens opacities acquired after 6 years are generally less amblyogenic. Polar cataracts, around which retinoscopy can be performed readily, and lamellar cataracts, through which a reasonably good view of the fundus can be obtained despite difficult retinoscopy, typically cause mild to moderate amblyopia or may have no effect on visual development. In some cases, there is an associated refractive error that needs to be corrected.

Vision loss in the setting of a structural abnormality of the retina or vitreous (e.g., optic nerve hypoplasia, myelinated nerve fiber layer, retinopathy of prematurity, uveitis) may have a component of treatable amblyopia.^{12, 13}

Subtle or unrecognized abnormalities of the retina or optic nerve in amblyopic eyes may also contribute to vision loss.¹⁴⁻¹⁶ In some cases, these conditions are associated with a refractive error that needs to be corrected.

Occlusion (Reverse Amblyopia)

Occlusion amblyopia (reverse amblyopia) is a specific form of deprivation amblyopia that may be seen after therapeutic patching or cycloplegia of the nonamblyopic eye. In one prospective randomized trial, visual acuity in the fellow eye was reduced by two lines or more in 1% of children patching 6 or more hours per day and in 9% of children given one drop daily of topical atropine after 6 months of treatment.¹⁷ In many of the atropine cases, visual acuity was tested with the incorrect eyeglasses. In nearly every case, the fellow eye visual acuity returned to baseline with no active therapy, simply with discontinuation of the current therapy. In subsequent studies of lower doses of patching and atropine, lower rates of reverse amblyopia were noted.^{18, 19}

PATIENT POPULATION

Children 1 to 17 years of age with amblyopia or who have risk factors for development of amblyopia.

CLINICAL OBJECTIVES

- ◆ Identify children at risk for amblyopia
- ◆ Examine the child with amblyopia risk factors at the earliest possible age
- ◆ Inform the patient, as appropriate, the family/caregiver, and the primary care provider about the diagnosis, associated conditions like refractive error and strabismus, treatment options, care plan, and prognosis
- ◆ Treat infants and children who have amblyopia in order to improve visual function, and to reduce the likelihood of vision-related disability^{20, 21}
- ◆ Re-evaluate the child and adjust the treatment plan as necessary

BACKGROUND

PREVALENCE AND RISK FACTORS

Amblyopia is an important public health problem because of its prevalence among children and because visual impairment from amblyopia is lifelong and can be profound.²² Both amblyopia and its treatment can have a substantial impact on quality of life.²³⁻²⁵ Prevalence estimates from population-based studies in children age 6 to 71 months²⁶⁻²⁹ range from 0.7%³⁰ to 1.9%,²⁶ whereas school-based studies of older children typically report higher rates (range: 1.0% to 5.5%) depending on the population studied and the definition used.^{8, 28, 30-45} Bilateral amblyopia is less frequent than unilateral amblyopia, but the reported proportion varies considerably, from as low as 5% up to 41% of all cases of amblyopia.^{27, 29, 30, 39, 41-43}

Unilateral amblyopia is associated with strabismus in 19% to 50% of cases and with anisometropia in 46% to 79% of cases.^{27, 29, 41, 42} Approximately 50% of children with esotropia have amblyopia at the time of initial diagnosis.^{46, 47} Odds of amblyopia are 1.5 to 40 times greater when anisometropia is

present, and 2.7 to 18 times greater when strabismus is present.^{7, 27, 41, 48, 49} Amblyopia risk factors are more common in children who are premature, small for gestational age,⁵⁰⁻⁵⁸ have developmental delay,⁵⁸ or have a first-degree relative with amblyopia.^{59, 60} Environmental factors, including maternal smoking and drug or alcohol use during pregnancy, have been reported to be associated with an increased risk of amblyopia or strabismus in some studies.⁶¹⁻⁶⁷ However, some population-based studies have not found an association between amblyopia and maternal smoking.^{26, 27, 41}

NATURAL HISTORY

With rare exception, amblyopia results in lifelong visual loss if it is untreated or inadequately treated in early childhood.^{68, 69} All children should have periodic vision screenings. The potential for successful treatment of amblyopia is greatest in young children, though recent studies show that treatment in older children can improve visual acuity.⁶⁸⁻⁷²

Deprivation amblyopia due to significant media opacities through the first 3 postnatal months produces profound and permanent reductions in high contrast (e.g., grating or optotype) acuity, typically to 20/200 or worse in the affected eye(s).^{53, 54, 73, 74} Deprivation developing after 3 months of age can lead to less profound visual acuity reduction.^{53, 54, 73, 74} Even brief visual deprivation in infancy can cause amblyopia. Early deprivation is strongly associated with development of sensory nystagmus in bilateral cases and strabismus in both unilateral and bilateral cases.^{75, 76} Deprivation at later ages shows a slower rate of vision loss, and the child is more likely to respond to treatment.⁷⁴

Similar but less severe visual acuity deficits are seen in children who have untreated refractive or strabismic amblyopia. In these cases, reduced acuity in one or both eyes may be evident in infancy. When an amblyopia risk factor develops later in life, the risk of amblyopia is reduced.⁷³

Amblyopia is a considered risk factor for the development of strabismus and subnormal binocularity. In young children, amblyopia treatment may improve vision and may foster the development of binocular vision.

RATIONALE FOR TREATMENT

Timely treatment of amblyopia usually improves visual acuity and binocularity,^{17, 77} and it decreases the likelihood of severe visual handicap if there is loss of vision in the fellow eye later in life. It is also cost-effective.^{78, 79} A single study found amblyopic children read more slowly due to fixation instability and increased frequency of saccades compared with nonamblyopic children with treated strabismus and normal controls, suggesting an additional benefit of treatment.⁸⁰ However, there is insufficient evidence that this contributes to diminished academic achievement. The lifelong risk of visual impairment in the fellow eye is approximately doubled for patients with amblyopia.⁸¹ A retrospective study found that vision loss originating from the fellow eye was more likely to occur in children who have amblyopia when compared with children who do not have amblyopia.⁸² Accidental trauma with injury of the fellow eye was associated with more than one-half of the cases of total vision loss.⁸² In older subjects, loss of visual acuity in the fellow eye is usually related to retinal abnormalities such as retinal vein occlusion, age-related macular degeneration, and other macular disorders.²¹

Untreated or insufficiently treated amblyopia may have an impact when the patient is considering a potential career choice. There are specific visual acuity and binocularity requirements, including stereopsis, for a variety of career fields, such as military service, law enforcement, aviation, and surgery.^{83, 84} However, there is insufficient evidence that amblyopia is an impediment to education or career performance.^{68, 85-89}

Maintenance of good vision in each eye with appropriate amblyopia treatment is an important part of successful management of strabismus.^{90, 91} If the visual system is structurally sound, all children with amblyopia should be offered treatment regardless of age.⁹²⁻⁹⁴

CARE PROCESS

PATIENT OUTCOME CRITERION

- ◆ Improved visual function

DIAGNOSIS

The initial evaluation of a child suspected of having amblyopia includes a comprehensive ophthalmic evaluation,⁹⁵ with attention to risk factors for amblyopia such as strabismus, anisometropia, a positive family history for strabismus or amblyopia, and the presence of a media opacity or structural defects.

History

Although a history generally includes the following items, the exact composition varies with the child's problems and needs:

- ◆ Demographic data, including sex, date of birth, and identity of parent/caregiver
- ◆ The identity of the historian and relationship to the patient
- ◆ The identity of health care providers involved in the child's care
- ◆ The chief complaint and reason for the eye evaluation
- ◆ Current eye problems
- ◆ Ocular history, including prior eye problems, diseases, diagnoses, and treatments
- ◆ Systemic history, birth weight, gestational age, prenatal and perinatal history that may be pertinent (e.g., alcohol, tobacco, and drug use during pregnancy), past hospitalizations and operations, and general health and development, including the presence of developmental delay or cerebral palsy
- ◆ Current medications and allergies
- ◆ Family history of ocular conditions and relevant systemic conditions
- ◆ Review of systems

Examination

The eye examination consists of an assessment of the physiological function and the anatomic status of the eye and visual system. Documentation of the child's level of cooperation with the examination can be useful in interpreting the results and in making comparisons among examinations over time. In general, the examination may include the following elements:

- ◆ Binocular red reflex (Brückner) test
- ◆ Binocularity/stereoacuity testing
- ◆ Assessment of visual acuity and/or fixation pattern
- ◆ Binocular alignment and ocular motility
- ◆ Cycloplegic retinoscopy/refraction with subjective refinement when indicated
- ◆ Funduscopy examination

For details on color vision testing, pupil examination, external examination, anterior segment examination, and visual field testing, refer to the Pediatric Eye Evaluations PPP, Section II. Comprehensive Ophthalmic Examination.⁹⁵

Binocular Red Reflex (Brückner) Test

In a darkened room, the examiner sets the ophthalmoscope lens power at "0" and directs the ophthalmoscope light toward both eyes of the child simultaneously from approximately 18 to 30 inches (45 to 75 centimeters). It is not necessary to dilate the pupils to perform the Brückner test, because subtle differences are difficult to detect when the pupils are dilated.⁹⁶ To be considered normal, a symmetric red reflex should be observed from both eyes. Opacities within the red reflex, a markedly diminished reflex, the presence of a white or yellow reflex, or asymmetry of the red reflexes are all considered abnormal. The appearance of the red reflex varies based on retinal pigmentation variation, and, thus, varies by race/ethnicity. Significant hyperopia will present as an inferiorly placed brighter crescent in the red reflex. Significant myopia presents as a superiorly placed brighter crescent.

Binocularity/Stereoacuity Testing

Binocularity, or binocular vision, has several different components, including sensory fusion, stereopsis (third degree sensory fusion), fusional vergence (motor fusion), and other coordinated binocular eye movements. Sensorimotor fusion is sensitive to disruption by

amblyopia, strabismus, refractive error, and deprivation. Binocular vision may be affected to different degrees depending on the underlying diagnosis, and tests to evaluate each of these components of binocular vision vary accordingly. The Worth 4-Dot Test is used to evaluate first- and second-degree sensory fusion, the Randot Stereo Test is used to evaluate third-degree sensory fusion, and a prism bar or rotary prism is used to evaluate fusional vergence.^{97, 98} Assessment of stereoacuity is an important component of binocular alignment testing because high-grade stereoacuity is associated with normal alignment. Testing of sensory function should be performed before using any dissociating examination techniques (e.g., covering an eye to check monocular visual acuity, cover testing to assess alignment). Binocular alignment testing should be done before cycloplegia, because alignment may change after cycloplegia.

Assessment of Visual Acuity and/or Fixation Pattern

Fixation

Visual acuity measurement of the infant and toddler involves a qualitative assessment of fixation and tracking (following) eye movements. Fixation and following are assessed by drawing the child's attention to the examiner or caregiver's face or to a hand-held light, toy, or other fixation target and then slowly moving the target. Fixation behavior can be recorded for each eye as "fixes and follows" or "central, steady, and maintained," along with any qualifying findings, such as eccentric, not central, not steady, or not maintained.

Fixation preference can be assessed by observing the vigor with which the child objects to occlusion of one eye relative to the other. Children resist covering an eye when the fellow eye has limited vision.⁹⁹⁻¹⁰¹ Grading schemes can be used to describe fixation preference. For strabismic patients, fixation pattern is assessed binocularly by determining the length of time that the nonpreferred eye holds fixation. Fixation pattern can be graded by whether the nonpreferred eye will not hold fixation, holds momentarily, or holds for a few seconds (or to or through a blink), or by observation of spontaneous alternation of fixation. The clinical value of fixation preference testing is limited, especially for nonstrabismic patients with a known difference in refraction or for strabismic patients who show a strong fixation or no strabismus.^{100, 102-104} For children with small-angle strabismus or no strabismus, the induced tropia test is typically done by holding a base-down prism of 10 to 20 prism diopters or base-in prism over one eye and then over the other eye and noting fixation behavior.^{101, 105, 106}

Qualitative assessment of visual acuity should be replaced with a recognition visual acuity test based on optotypes (letters, numbers, or symbols) as soon as the child can perform this task reliably.

Visual Acuity

Recognition visual acuity testing, which involves identifying optotypes and the names for letters, numbers, or symbols, is preferred for assessment of visual acuity to detect amblyopia. The optotypes may be presented on a wall chart, computer screen, or hand-held card. Visual acuity is routinely tested at distance (10 to 20 feet or 3 to 6 meters) and at near (14 to 16 inches or 35 to 40 centimeters). Visual acuity testing conditions should be standardized so that results obtained over a series of visits can be readily compared. High-contrast charts with black optotypes on a white background should be used for standard visual acuity testing.^{107, 108}

A child's performance on a visual acuity test will be dependent on the choice of chart and the examiner's skills, rapport with the child, and the child's level of cooperation. To reduce errors, the environment should be quiet and free of distraction. Younger children may benefit from a pretest on optotypes presented at near, either at the start of testing or in a separate session. Before monocular testing, the examiner should ensure that the child is able to perform the test reliably. Allowing children to match optotypes on the chart to those found on a hand-held card will enhance performance, especially in young, shy, or cognitively impaired children. Visual acuity testing of children with special needs can provide quantitative information about visual impairment and reduce concerns of

parents/caregivers about the child's vision.¹⁰⁸ A shorter testing distance or flip chart can also facilitate testing in younger children.¹⁰⁹

Visual acuity testing should be performed monocularly and with best refractive correction in place. Ideally, the fellow eye should be covered with an adhesive patch or tape. If such occlusion is not available or not tolerated by the child, care must be taken to prevent the child from peeking and using the "covered" eye. Sometimes the child will not allow any monocular occlusion, in which case binocular visual acuity should be measured. Monocular visual acuity testing for patients with nystagmus or latent nystagmus requires special techniques such as blurring of the fellow eye with plus lenses or using a translucent occluder rather than an opaque one. Binocular visual acuity testing can also be performed on these patients to gain additional information about typical visual performance.

The choice and arrangement of optotypes on an eye chart can significantly affect the visual acuity score obtained.¹¹⁰⁻¹¹² Optotypes should be clear, standardized, and of similar characteristics, and they should not reflect a cultural bias.¹⁰⁷ LEA SYMBOLS® (Good-Lite Co., Elgin, IL), a set of four symbol optotypes developed for use with young children, are useful because each optotype blurs similarly as the child is presented with smaller symbols, increasing the reliability that individual symbols will be identified.^{110, 113} Another method for testing the young child uses a chart containing only the letters H, O, T, and V.^{110, 114} Because the LEA SYMBOLS Chart and the HOTV Chart include only four possible responses, these charts facilitate testing of younger children. Children who cannot name the symbols on the LEA SYMBOLS Chart or the letters on the HOTV Chart may be able to match them using a hand-held card or by stepping on the four individual cards

Several other symbol charts have serious limitations in testing visual acuity of young children and are, therefore, less useful. These include Allen pictures,¹¹⁵ the Lighthouse Chart, and the Kindergarten (Sailboat) Eye Chart.^{116, 117} The optotypes in these charts are not standardized because each optotype is presented in a culturally biased or a nonstandardized format.¹¹⁸ The Tumbling E Chart is conceptually difficult for young children and leads to high untestability rates.¹¹⁶

The desirable optotypes for older children are Sloan letters.¹¹⁹ Snellen letters are less desirable because the chart design is not standardized, the individual letters are not of equal legibility, and the spacing of the letters does not always meet World Health Organization standards.^{107, 120-123}

The arrangement of optotypes on an eye chart is important.¹¹⁸ Optotypes should be presented in a full line of five whenever possible.¹¹¹ If a child needs assistance knowing which optotype to identify, the screener may point to the optotype and immediately remove the pointer. The majority of optotypes must be correctly identified to "pass" a line. A similar number of optotypes on each line with equal spacing is preferred. In the setting of amblyopia, visual acuity testing with single optotypes is likely to overestimate acuity¹²⁴⁻¹²⁶ because of the crowding phenomenon; that is, it is easier to discriminate an isolated optotype than one presented in a line of optotypes. Therefore, a more accurate assessment of monocular visual acuity is obtained in amblyopia with the presentation of a line of optotypes. In order to preserve the crowding effect of adjacent optotypes, optotypes should not be covered or masked as the examiner points to each successive symbol. If a single optotype must be used to facilitate visual acuity testing for some children, the single optotype should be surrounded (crowded) by bars placed above, below, and on either side of the optotype to account for the crowding phenomenon and to avoid overestimating visual acuity.¹²⁷⁻¹²⁹ An age-appropriate and consistent testing strategy on every examination is essential.

Forced preferential looking using Teller Acuity Cards (Stereo Optical Co., Inc., Chicago, IL) can provide a general assessment of resolution visual acuity in infants, and the patient's acuity can be compared with normative data, but this method of testing overestimates recognition visual acuity in children with amblyopia.^{130, 131}

For details of visual acuity testing charts, see Appendix 3 in the Pediatric Eye Evaluations PPP.⁹⁵

Binocular Alignment and Ocular Motility

The corneal light reflection, binocular red reflex (Brückner) test, and cover tests are commonly used to assess binocular alignment. Cover/uncover tests for tropias and alternate cover tests for the total deviation (latent component included) in primary gaze at distance and near should use accommodative targets. Cover tests require sufficient visual acuity and cooperation to fix on the desired target. Ocular versions and ductions, including into the oblique fields of gaze, should be tested in all infants and children. Eye movements may be tested using oculocephalic rotation (doll's head maneuver) or assessed by observing spontaneous eye movements in the inattentive or uncooperative child.

Cycloplegic Retinoscopy/Refraction

Determination of refractive errors is important in the diagnosis and treatment of amblyopia or strabismus. Patients should undergo cycloplegic refraction with retinoscopy, followed by subjective refinement when possible.⁹⁷ Dynamic retinoscopy, done prior to cycloplegia, provides a rapid assessment of accommodation and may be helpful in evaluating a child with asthenopia who has high hyperopia or a child with accommodative insufficiency.^{132,133} This technique requires the examiner to evaluate the change in the retinoscopic reflex from a "with" motion toward neutrality when the patient fixates on a small target on the retinoscope.

Adequate cycloplegia is necessary for accurate retinoscopy in children because of their increased accommodative tone compared with adults. At present, there is no ideal cycloplegic that is safe, has rapid onset and recovery, provides sufficient cycloplegia, and has no local or systemic side effects.¹³⁴ Cyclopentolate hydrochloride 1% is useful because it produces rapid cycloplegia that approximates the effect of topical ophthalmic atropine 1% solution but with a shorter duration of action.¹³⁵ Cyclopentolate 1% solution is typically used in term infants over 6 months old. The dose of cyclopentolate should be determined based on the child's weight, iris color, and dilation history. In eyes with heavily pigmented irides, repeating the cycloplegic eyedrops or using adjunctive agents, such as phenylephrine hydrochloride 2.5% (which has no cycloplegic effect) or tropicamide 1.0%, may be helpful to achieve adequate dilation to facilitate retinoscopy and ophthalmoscopy.¹³⁴ Tropicamide (0.5%) and phenylephrine hydrochloride (0.5%) may also be used in combination to produce adequate dilation and cycloplegia. For children younger than 6 months of age, an eyedrop combination of cyclopentolate 0.2% and phenylephrine 1% is often used.¹³⁶ In some children, higher concentrations may be necessary.

In rare cases, topical ophthalmic atropine sulphate 1% solution may be necessary to achieve maximal cycloplegia.¹³⁵ The use of topical anesthetic prior to the cycloplegic reduces the stinging and promotes penetration of subsequent eyedrops.¹³⁷ Uncommon short-term side effects of cycloplegic and dilating agents may include hypersensitivity reactions, fever, dry mouth, rapid pulse, nausea, vomiting, flushing, somnolence, and, rarely, behavioral changes (i.e., delirium). Punctal occlusion may be useful to reduce these side effects. If the reaction is severe, physostigmine may be given.

Funduscopy Examination

The optic disc, macula, retina, vessels, and the choroid should be examined, preferably using an indirect ophthalmoscope and condensing lens after adequate dilation is achieved. It may be impossible to examine the peripheral retina of the awake young child.

Examination of the peripheral retina with an eyelid speculum and scleral depression may require swaddling, sedation, or general anesthesia.

CRITERIA FOR DIAGNOSIS

A diagnosis of amblyopia requires detection of a visual acuity deficit (see Table 1) and identification of the likely cause. Amblyopia in the absence of strabismus, unequal refractive error, media opacity, or structural abnormality is rare.¹³⁸ A careful search for an alternative diagnosis with associated visual loss should be carried out if an obvious cause is not present.

TABLE 1 DIAGNOSTIC CRITERIA FOR AMBLYOPIA

Assessment	Finding
Unilateral Amblyopia	
Response to monocular occlusion	Asymmetric objection
Fixation preference	Failure to initiate or maintain fixation
Preferential looking	Interocular difference* of two or more octaves
Best-corrected visual acuity	Interocular difference of two or more lines
Bilateral Amblyopia	
	Age 3 to ≤4 years: visual acuity worse than 20/50
	Age 4 to ≤5 years: visual acuity worse than 20/40
Best-corrected visual acuity	Age >5: visual acuity worse than 20/30
Note An amblyogenic factor needs to be present along with the visual acuity deficit *A 2-octave difference is a 4-card difference in the full set of Teller Acuity Cards.	

MANAGEMENT

Prevention

Vision screening is important to identify factors that predispose to amblyopia.^{70, 139, 140} The earlier that clinically significant refractive error and strabismus are detected and treated, the greater the likelihood of preventing amblyopia.¹⁴¹ (See Table 3 in the Pediatric Eye Evaluation PPP for guidelines for refractive correction in infants and young children.⁹⁵) When amblyopia is present, it appears that the potential for successful treatment is greatest in young children, although improvement in visual acuity can reasonably be expected in older children and teenagers.¹⁴²⁻¹⁴⁴ A study of treatment of moderate strabismic and/or anisometropic amblyopia demonstrated that the visual acuity of the amblyopic eye improved to 20/30 or better 6 months after initiating treatment in approximately three-quarters of children under 7 years of age.¹⁷

Children with risk factors for amblyopia should have at least one comprehensive ophthalmic examination, generally when the risk factor is identified. Amblyopia risk factors include uveitis; ptosis; gestational age of less than 30 weeks; a birth weight less than 1500 grams; delayed visual or neurologic maturation of unclear etiology;⁹⁵ cerebral palsy; syndromes with ocular involvement, such as Down syndrome; and a family history of amblyopia, strabismus, childhood cataract, or childhood glaucoma.

Choice of Therapy

Success rates of amblyopia treatment decline with increasing age.^{70, 145, 146} However, an attempt at treatment should be offered to children regardless of age, including older children and teenagers. The prognosis for attaining normal vision in an amblyopic eye depends on many factors, including the age of onset; the cause, severity, and duration of amblyopia; the history of and response to previous treatment;⁷⁰ adherence to treatment recommendations;¹⁷ and concomitant conditions.

Several strategies are used to improve visual acuity in amblyopia. The first is to correct the causes of visual deprivation. The second is to correct refractive errors that are likely to cause diminished visual acuity. The third is to promote use of the amblyopic eye by occluding or blurring the fellow eye. Although not always achievable, the goal of treatment is equal visual acuity between the two eyes. The recommended treatment should be based on the child's age, visual acuity, and adherence and response to previous treatment as well as the child's physical, social, and psychological status.

Treatment for amblyopia in children includes:

- ◆ Optical correction of significant refractive errors^{70, 147-149}
- ◆ Patching^{17, 18, 77, 150}
- ◆ Pharmacological treatment^{17, 19, 70, 77, 150-155}

- ◆ Optical treatment (e.g., overplus)¹⁵⁶
- ◆ Bangerter (translucent) filters (Ryser Optik AG, St. Gallen, Switzerland)¹⁵⁷
- ◆ Surgery¹⁵⁸⁻¹⁶⁰

Appendix 3 shows results of randomized controlled trials of amblyopia therapy done by the Pediatric Eye Disease Investigator Group.

Optical Correction

Treatment of refractive error alone is the initial step in care of children 0 to 17 years of age with amblyopia.^{70, 142, 155, 156} (*moderate quality, strong recommendation*)

Correction of refractive error for 18 weeks can improve visual acuity in the amblyopic eye by two or more lines in at least two-thirds of children 3 to 7 years old who have untreated anisometropic amblyopia.¹⁴⁸ A study in children 7 to 17 years old found that amblyopia improved two or more lines with optical correction alone in about one-fourth of the children.⁷⁰ In one study, visual acuity of children who had bilateral refractive amblyopia substantially improved with refractive correction.¹⁶¹ Even children who had strabismus while wearing eyeglasses experienced substantial improvement in the amblyopic eye with optical correction alone.¹⁶²

In general, eyeglasses are tolerated well by children, especially when there is improvement in visual function. Obtaining an accurate fit and maintaining proper adjustment facilitate acceptance. Flexible single-piece frames with head straps are useful in babies and young children; straps, cable temples, and spring hinges are helpful in keeping eyeglasses on active young children. Impact-resistant lenses provide greater safety and are preferable for children, especially if they are amblyopic.

Patching

Patching is an appropriate choice for treatment for children who do not improve with eyeglasses alone or who experience incomplete improvement.^{18, 159} (*moderate quality, strong recommendation*)

The improvement in visual acuity with patching is likely related to the associated decrease in neural signals from the fellow or nonamblyopic eye, as demonstrated by recordings from the visual cortex in experimental animals.^{163, 164} Patching is best administered by applying an opaque adhesive patch directly to the skin surrounding the fellow eye. Prescribed eyeglasses are worn over the patch. A cloth patch mounted on the eyeglass frame is a less preferred alternative because children can easily look around the cloth patch.

A randomized clinical trial found that 6 hours of prescribed daily patching produces an improvement in visual acuity that is similar in magnitude to occlusion therapy prescribed for all but 1 waking hour when treating severe amblyopia (20/100 to 20/400) in children under 7 years of age (see Appendix 3).¹⁶⁵ In children who have moderate amblyopia (20/40 to 20/80), initial therapy of 2 hours of prescribed daily patching produces an improvement in visual acuity that is similar in magnitude to the improvement produced by 6 hours of prescribed daily patching.¹⁸ The treatment benefit achieved by the patching appears stable through at least 15 years of age.¹⁶⁶

Children treated with patching may develop occlusion amblyopia.^{91, 165, 167} Strabismus may first be observed or worsen during patching, but a similar proportion of children have improvement in strabismus.^{91, 167} Mild skin irritation from the adhesive is common with patching (41% of a treatment cohort); the irritation is moderate or severe in an additional 6%,¹⁷ but it can be minimized by switching to a different patch or applying skin lotions to irritated areas when the child is not wearing the patch. The parent/caregiver needs to be advised that children wearing a patch should be monitored carefully to avoid accidents. In addition, even if the parents and child are committed to treatment, they may have some distress associated with it.^{25, 168}

Patching should be considered for older children and teenagers, particularly if they have not previously been treated.⁷⁰ (*moderate quality, discretionary recommendation*)

Patching as initial therapy after refractive correction should be considered for children with moderate amblyopia (20/40 to 20/80) (*moderate quality for treatment of amblyopia, strong recommendation*) with a prescribed dose of 2 hours of daily patching or weekend atropine.^{17,18} (*moderate quality for amount of time treatment, discretionary recommendation*)

Pharmacological Treatment

Pharmacological treatment that produces cycloplegia of the nonamblyopic eye is an appropriate choice for treatment for children who do not improve with eyeglasses alone.^{17, 19, 144, 145} (*moderate quality, strong recommendation*)

Pharmacological treatment may be used to treat amblyopia, and it works best when the nonamblyopic eye is hyperopic. The cycloplegia optically defocuses the nonamblyopic eye, most often with atropine 1% solution. This technique may also be considered in the presence of latent nystagmus, occlusion failure, or for maintenance treatment.^{17, 169}

Atropine 1% ophthalmic solution administered to the nonamblyopic or fellow eye is an effective method of treatment for mild to moderate amblyopia in children 3 to 15 years of age, and there has been some success with amblyopia worse than 20/80.^{17-19, 77, 150, 151} The benefit achieved by pharmacologic treatment of amblyopia due to strabismus, anisometropia, or both appears stable through 15 years of age.¹⁶⁶

Pharmacological treatment has been prescribed using a variety of dosage schemes to the fellow eye. Traditionally, daily dosing was used and has been shown to be as effective as patching for initial treatment.¹⁷ Atropine 1% given on two consecutive days per week for 4 months was as effective as once daily atropine 1% for moderate amblyopia, treated for 4 months.¹⁹ Modest improvement of 4.5 lines (95% CI, 3.2–5.8 lines) from twice weekly dosing has been reported for children from 3 to 12 years of age with severe amblyopia.¹⁷⁰ There may be a small benefit to augmenting atropine therapy with a plano lens over the hyperopic fellow eye for children who have stopped improving with atropine 1%.¹⁷¹ (See Appendix 3.)

Pharmacologic therapy for amblyopia may have side effects. It has been associated with transient reduction of visual acuity in the nonamblyopic eye, especially when used in combination with reduced hyperopic correction.¹⁷² Transient reduction of visual acuity in the fellow eye is reported more often with atropine therapy compared with patching for amblyopia management.¹⁷ Monitoring the visual acuity of each eye of a child being treated is essential. Fellow eye acuity can be assessed more accurately when atropine is discontinued at least 1 week before testing. In a few cases, atropine 1% has been associated with the development of esotropia, but an equal proportion of children have improvement of pre-existing strabismus.^{91, 150} Atropine 1% solution has been reported to cause photosensitivity in 18% of children and conjunctival irritation in 4%.¹⁷ Photosensitivity may limit the use of atropine in areas that have high sun exposure. Adverse systemic effects include dryness of the mouth and skin, fever, delirium, and tachycardia. Use of atropine 1% for amblyopia in children younger than 3 years has not been studied in clinical trials, and this age group may be more susceptible to toxicity.

Applying direct digital pressure over the lacrimal sac and puncta for 20 to 30 seconds may reduce systemic absorption and toxicity when using atropine or other cycloplegic agents. Atropine 1% needs to be used with caution during the first year of life because of the greater potential for systemic side effects.

Optical Treatment

Altering the refractive correction of the fellow eye, typically blurring at distance by adding 1.00 to 3.00 diopters of plus sphere, has been used to treat amblyopia.^{173, 174} However, the effectiveness of this technique has been variable and has not been evaluated in randomized clinical trials.¹⁵⁶

Bangerter (Translucent) Filters

Filters are an appropriate choice for treatment for children with mild amblyopia who do not improve with eyeglasses alone.¹⁵¹ (*moderate quality, strong recommendation*)

An option for mild to moderate amblyopia is the Bangerter filter (Ryser Optik AG), which is a translucent filter that adheres to the eyeglass lens of the fellow eye. This filter has been used mostly as maintenance treatment after initial treatment with either patching or atropine. The effectiveness of the filters as primary treatment for amblyopia compared with 2 hours per day of patching was the subject of a randomized controlled trial.¹⁵⁷ On average, the patching and filter groups had similar improvement in visual acuity for moderate amblyopia.

Surgery

Surgery to treat the cause of amblyopia may be indicated when the cause of the amblyopia can be attributed to opacification of the ocular media, such as cataract, nonclearing vitreous opacity, and corneal opacities, or blepharoptosis, which are severe enough to prevent successful amblyopia therapy without surgical correction. Although strabismus surgery may facilitate amblyopia management in selected cases, it usually does not eliminate the need for amblyopia treatment.¹⁵⁸

Opacification within the posterior segment from hemorrhage or inflammatory debris may produce deprivation amblyopia and necessitate vitrectomy. If subluxation of a clear lens causes significant optical defocus that is not correctable with eyeglasses or contact lenses, a lensectomy with subsequent optical rehabilitation may be necessary.¹⁵⁹

The role of refractive surgery in treating anisometropic amblyopia is controversial. Keratorefractive surgery for children is an off-label use of an FDA-approved device. Studies have shown that photorefractive keratectomy can be safely performed for children with anisometropic amblyopia who are noncompliant with refractive correction.¹⁶⁰ Best-corrected visual acuity and stereopsis improved, even in older children.¹⁶⁰ Photorefractive keratectomy and other refractive procedures may have a future role in the management of amblyopia in certain children who fail conventional treatment.

Alternative Therapies

Vision Therapy

Vision therapy (also termed “orthoptics,” or eye exercises) is defined as a doctor-prescribed, nonsurgical program of visual activities to improve visual acuity and binocularity.¹⁷⁵ These include computer programs, prisms, filters, metronomes, vergence activities, accommodation activities, antisuppression activities, and eye-hand coordination exercises.¹⁷⁶ These are often conducted in an office setting with a therapist, supplemented with home exercises. These treatments have also been promoted for the treatment of amblyopia as an adjunct to patching.^{177-178, 179} However, there is insufficient evidence to recommend vision therapy techniques.^{176, 180}

Binocular Therapy

Binocular therapy has been used to treat amblyopia in children with no strabismus or small-angle strabismus with some binocularity. Images are presented dichoptically; high-contrast images are presented to the amblyopic eye and low-contrast images are presented to the fellow eye. The binocular treatment was adapted to an iPad® (Apple, Inc., Cupertino, CA) device as a “falling blocks” game, which uses red-green anaglyphic eyeglasses to allow dichoptic presentation. Although early nonrandomized studies were promising,¹⁸¹⁻¹⁸⁴ results from a recent randomized trial failed to demonstrate that game play prescribed 1 hour per day was as good as patching prescribed 2 hours per day.¹⁸⁵ (See Appendix 3.) Although research is ongoing, there is insufficient evidence to recommend binocular therapy for treatment of amblyopia.

Acupuncture

Two clinical trials have demonstrated some benefit of acupuncture in the treatment of anisometropic amblyopia.^{186, 187} Acupuncture for amblyopia requires further investigation, including evaluation of cost-effectiveness.¹⁸⁸ The effect of acupuncture on strabismic amblyopia has not been studied. The mechanism of action for acupuncture in the treatment of amblyopia is unknown.

Liquid Crystal Display Eyeglasses

Intermittent occlusion therapy using liquid crystal eyeglasses has been introduced as an alternative treatment for amblyopia that may be associated with better treatment compliance. The eyeglasses alternate between a clear and opaque lens before the fellow eye. There are a few publications suggesting efficacy,^{189, 190} and one prospective report finds that they are similar to patching in effectiveness.¹⁹¹

Follow-up Evaluation

The purpose of the follow-up evaluation is to monitor the response to therapy and adjust the treatment plan as necessary. Determining the visual acuity of the amblyopic eye is the primary goal of the follow-up evaluation, but it is also important to include interval history, especially adherence to the treatment plan; side effects of the treatment; and visual acuity in the fellow eye. Visual acuity measurement is often difficult in children, and it helps to maintain a consistent care team and testing environment over the follow-up period. Using similar charts in a setting comfortable for the child enhances the ability to obtain reliable results at follow-up visits. Visual acuity results in either eye can vary because of changes in refractive error, poor test reliability, reverse amblyopia, and persistent cycloplegia in an atropine-treated eye.

In general, a follow-up examination should be arranged 2 to 3 months after initiation of treatment, but timing will vary according to the intensity of the treatment and the age of the child. The visual acuity outcome is highly dependent on performance at the follow-up examination as well as on adherence to treatment. These factors should be considered when the treatment regimen is adjusted as follows:^{192, 193}

- ◆ If the visual acuity in both eyes is unchanged and the visual acuity data are reliable and adherence with therapy has been good, increasing treatment intensity or changing treatment modality should be considered. For example, if currently patching the fellow eye 2 hours per day, increasing patching to 6 hours per day or switching to pharmacologic treatment should be considered. Increasing the patching dosage to 6 hours daily results in more improvement in visual acuity after 10 weeks compared with continuing 2 hours daily (mean difference of visual acuity adjusted for acuity at randomization = 0.6 line; 95% confidence interval, 0.3–1.0; $P=0.002$).¹⁹⁴ Alternatively, some clinicians intensify treatment by adding topical atropine. One study found no benefit to increasing treatment intensity by adding atropine to the patching regimen for a child who has stabilized on 6 hours per day of patching.¹⁹⁵
- ◆ If the visual acuity in the amblyopic eye is improved and the fellow eye is stable, the same treatment regimen should be continued.
- ◆ If the visual acuity in the amblyopic eye is decreased and the fellow eye is stable, visual acuity should be retested, the pupillary examination for evidence of an afferent pupillary defect should be retested, the refractive status should be rechecked, and adherence in greater depth should be assessed. Some children fail to demonstrate any improvement in visual acuity despite adherence to the treatment regimen. In these cases, the ophthalmologist should consider an alternative diagnosis, such as optic nerve hypoplasia, subtle macular abnormalities, or other anterior visual pathway disorders.
- ◆ If the visual acuity in the fellow eye is decreased by two or more lines, visual acuity should be retested, the refractive status of both eyes should be rechecked, and the diagnosis of reverse amblyopia and alternative diagnoses should be considered. If the diagnosis of reverse amblyopia is made, the treatment should be interrupted and follow-up should take place within a few weeks. The visual acuity should be retested to determine whether it has returned to the pretreatment level prior to resuming amblyopia therapy. If the decline in vision persists, the child should be evaluated for an optic neuropathy.

- ◆ If the visual acuity stops improving and is within one line of the fellow eye over a period of 3 to 6 months, decreasing or stopping the treatment should be considered.

Consensus suggestions for adjusting patching or atropine treatment dosage during treatment are detailed in Table 3.

TABLE 3 RECOMMENDATIONS FOR ADJUSTING DOSAGE IN AMBLYOPIA

Indication to Change	Treatment
Visual acuity is not improved after 3 months.	Maintain or Increase patching or atropine, or consider alternative therapy.
Severe skin irritation develops with patching.	Select alternative therapy.
Visual acuity is not improved with occlusion.	Taper or terminate treatment.
Treatment is futile (e.g., organic lesion).	Taper or terminate treatment.
Strabismus and/or diplopia develop.	Temporarily stop treatment and monitor.
Visual acuity decreases in the fellow eye by two or more lines.	Temporarily stop treatment, review diagnosis, and monitor. Consider treating previously amblyopic eye.
Visual acuity is stabilized at normal or near normal over a period of 4 or months confirmed on two or more visits.	Taper or terminate therapy.

NOTE: These recommendations are generated by consensus based on professional experience and clinical impressions.

When the ophthalmologist is convinced that maximal visual acuity for the child has been obtained, treatment intensity can be tapered to maintenance therapy.¹⁹⁶ Maintenance methods include lower-dose occlusion, full- or part-time optical treatment, use of Bangerter (translucent) filters, or part-time cycloplegic treatment. If visual acuity in the amblyopic eye is maintained as therapy is tapered, the treatment may be stopped but with follow-up still planned, because approximately one-fourth of children successfully treated for amblyopia experience a recurrence within the first year off treatment.^{150, 154} For children treated with 6 or more hours of daily patching, data suggest that the risk of recurrence is greater when patching is stopped abruptly than when it is reduced to 2 hours per day prior to cessation.¹⁹³ To minimize the possibility of recurrent amblyopia, ametropia should continue to be corrected with either eyeglasses or contact lenses until visual maturity is reached, typically by the early teens. In cases of recurrent amblyopia, patching or pharmacologic treatment will usually restore the visual acuity to its previous best-corrected level.⁷⁰

The outcome of therapy depends in large part on patient adherence to the treatment plan. Adherence to treatment recommendations may be compromised if the child does not like the patch, eyeglasses, or eyedrops. In one study of 419 children 3 to 7 years old, a slightly higher degree of acceptability was reported for those treated with atropine compared with patching based on a parent questionnaire.¹⁷ Parents/caregivers of pediatric patients who understand the diagnosis and rationale for treatment are more likely to adhere to treatment recommendations.¹⁹⁷⁻¹⁹⁹ A study that used an educational cartoon story for 4-year-old children beginning occlusion therapy for amblyopia demonstrated improvement in adherence to the treatment plan.¹⁹⁹ It is also important to obtain the commitment of older children to the proposed treatment program. Because improved communication produces better results, written instructions are helpful for the parent/caregiver to understand, remember, and reinforce the plan.¹⁹⁷

For children with unilateral vision impairment due to amblyopia, the risk of lost vision in the better eye due to disease or injury has been estimated to be approximately 1:1000.⁸² Because of this, amblyopic children who have vision of 20/50 or worse need to wear proper protective eyewear full time, even if they do not benefit from optical correction. A frame approved by the American National Standards Institute Standard No. Z87.1 with impact-resistant lenses (ASTM F803) should be worn daily and for low-eye-risk sports. For most ball and contact sports, impact-resistant goggles should be worn, and integrated head and face protection should be added for higher risk activities.^{98, 200} Functionally monocular patients should use approved

protective eyewear when participating in contact sports or other potentially harmful activities, such as those that involve pellet guns, paintballs, and personal use of fireworks.²⁰¹⁻²⁰⁷ Special goggles, industrial safety glasses, side shields, and full-face shields should be used in these cases. Functionally monocular patients should be aware of the need to have regular eye examinations throughout their lives.

PROVIDER AND SETTING

Although the performance of certain diagnostic procedures (e.g., visual acuity measurement, motility testing) may be delegated to appropriately trained auxiliary personnel (e.g., certified orthoptist) supervised by the ophthalmologist, interpretation of these procedures requires the clinical training, judgment, and experience of the ophthalmologist. Certified orthoptists may manage amblyopia in conjunction with the ophthalmologist. Consultation with or referral to an ophthalmologist who has expertise in the diagnosis and treatment of amblyopia may be desirable for cases in which the diagnosis or management is in question or when the amblyopia appears unresponsive to treatment.

When surgery is part of the treatment plan, the operating ophthalmologist should ideally perform the preoperative evaluation, because this will allow the surgeon to formulate the surgical plan and establish a relationship with the patient prior to surgery. The surgical facility should comply with local, state, and federal regulations and standards governing the setting of care. Inpatient surgery may be necessary if there is a need for complex anesthetic or surgical care, multiple procedures, or postoperative care requiring an acute-care setting.

COUNSELING AND REFERRAL

Amblyopia is a long-term problem that requires commitment from the child, parent/caregiver, and ophthalmologist to achieve the best possible outcome. The ophthalmologist should discuss the findings of the evaluation with the parent/caregiver and, when appropriate, with the child. The ophthalmologist should explain the disorder and the proposed therapy, including duration, as well as recruit the family in a collaborative approach to therapy. Provision of additional instructions on paper, reading materials and video information about the condition could promote better understanding. Parents/caregivers of children who understand the diagnosis and rationale for treatment are more likely to adhere to treatment recommendations.^{197, 198}

SOCIOECONOMIC CONSIDERATIONS

Amblyopia is a medical condition that requires medical treatment.²⁰⁸ Health care insurance plans should cover management of all types of amblyopia, including timely screening, treatment, and monitoring for recurrence, because treatment is associated with long-term vision improvement. Detection includes maintaining a schedule of vision screening during childhood and adolescence consistent with the Bright Futures initiative of the U.S. Health and Human Services (<http://brightfutures.aap.org>) and the U.S. Preventive Services Task Force recommendations.¹⁴⁴ Children identified with amblyopia or risk factors need to have access to a comprehensive eye examination and optical correction, such as eyeglasses and contact lenses. Optical correction is, in most cases, the first step in the medical management of amblyopia.

Data about the long-term socioeconomic impact on an individual with amblyopia are limited. Rahi et al reported that 429 of 8861 individuals (4.8%) in a birth cohort in the United Kingdom had residual unilateral amblyopia.⁸⁵ They found no association between reduced visual function at 16 years of age and having a paying job at 33 years of age for either men or women. Furthermore, although there were visual acuity requirements for various jobs, only one amblyopic person did not meet the visual requirements for his/her current occupation. When compared with a control group, there was no difference in the self-reported assessment of poor health, depression, sports involvement, or work injury.

Despite this report, a doubled risk of bilateral visual impairment in patients with amblyopia has been reported.⁸¹ In older subjects, loss of visual acuity in the fellow eye is usually related to retinal abnormalities such as retinal vein occlusion, age-related macular degeneration, and other macular disorders.²¹ Amblyopia treatment in childhood improves visual acuity and binocularity^{17, 77} and, therefore, decreases the likelihood of severe visual handicap if there is loss of vision in the fellow eye later in life.

APPENDIX 1. QUALITY OF OPHTHALMIC CARE CORE CRITERIA

*Providing quality care
is the physician's foremost ethical obligation, and is
the basis of public trust in physicians.
AMA Board of Trustees, 1986*

Quality ophthalmic care is provided in a manner and with the skill that is consistent with the best interests of the patient. The discussion that follows characterizes the core elements of such care.

The ophthalmologist is first and foremost a physician. As such, the ophthalmologist demonstrates compassion and concern for the individual, and utilizes the science and art of medicine to help alleviate patient fear and suffering. The ophthalmologist strives to develop and maintain clinical skills at the highest feasible level, consistent with the needs of patients, through training and continuing education. The ophthalmologist evaluates those skills and medical knowledge in relation to the needs of the patient and responds accordingly. The ophthalmologist also ensures that needy patients receive necessary care directly or through referral to appropriate persons and facilities that will provide such care, and he or she supports activities that promote health and prevent disease and disability.

The ophthalmologist recognizes that disease places patients in a disadvantaged, dependent state. The ophthalmologist respects the dignity and integrity of his or her patients, and does not exploit their vulnerability.

Quality ophthalmic care has the following optimal attributes, among others.

- ◆ The essence of quality care is a meaningful partnership relationship between patient and physician. The ophthalmologist strives to communicate effectively with his or her patients, listening carefully to their needs and concerns. In turn, the ophthalmologist educates his or her patients about the nature and prognosis of their condition and about proper and appropriate therapeutic modalities. This is to ensure their meaningful participation (appropriate to their unique physical, intellectual and emotional state) in decisions affecting their management and care, to improve their motivation and compliance with the agreed plan of treatment, and to help alleviate their fears and concerns.
- ◆ The ophthalmologist uses his or her best judgment in choosing and timing appropriate diagnostic and therapeutic modalities as well as the frequency of evaluation and follow-up, with due regard to the urgency and nature of the patient's condition and unique needs and desires.
- ◆ The ophthalmologist carries out only those procedures for which he or she is adequately trained, experienced and competent, or, when necessary, is assisted by someone who is, depending on the urgency of the problem and availability and accessibility of alternative providers.
- ◆ Patients are assured access to, and continuity of, needed and appropriate ophthalmic care, which can be described as follows.
 - ◆ The ophthalmologist treats patients with due regard to timeliness, appropriateness, and his or her own ability to provide such care.
 - ◆ The operating ophthalmologist makes adequate provision for appropriate pre- and postoperative patient care.
 - ◆ When the ophthalmologist is unavailable for his or her patient, he or she provides appropriate alternative ophthalmic care, with adequate mechanisms for informing patients of the existence of such care and procedures for obtaining it.
 - ◆ The ophthalmologist refers patients to other ophthalmologists and eye care providers based on the timeliness and appropriateness of such referral, the patient's needs, the competence and qualifications of the person to whom the referral is made, and access and availability.
 - ◆ The ophthalmologist seeks appropriate consultation with due regard to the nature of the ocular or other medical or surgical problem. Consultants are suggested for their skill, competence, and accessibility. They receive as complete and accurate an accounting of the problem as necessary to provide efficient and effective advice or intervention, and in turn respond in an adequate and timely manner.
 - ◆ The ophthalmologist maintains complete and accurate medical records.
 - ◆ On appropriate request, the ophthalmologist provides a full and accurate rendering of the patient's records in his or her possession.

- ◆ The ophthalmologist reviews the results of consultations and laboratory tests in a timely and effective manner and takes appropriate actions.
- ◆ The ophthalmologist and those who assist in providing care identify themselves and their profession.
- ◆ For patients whose conditions fail to respond to treatment and for whom further treatment is unavailable, the ophthalmologist provides proper professional support, counseling, rehabilitative and social services, and referral as appropriate and accessible.
- ◆ Prior to therapeutic or invasive diagnostic procedures, the ophthalmologist becomes appropriately conversant with the patient's condition by collecting pertinent historical information and performing relevant preoperative examinations. Additionally, he or she enables the patient to reach a fully informed decision by providing an accurate and truthful explanation of the diagnosis; the nature, purpose, risks, benefits, and probability of success of the proposed treatment and of alternative treatment; and the risks and benefits of no treatment.
- ◆ The ophthalmologist adopts new technology (e.g., drugs, devices, surgical techniques) in judicious fashion, appropriate to the cost and potential benefit relative to existing alternatives and to its demonstrated safety and efficacy.
- ◆ The ophthalmologist enhances the quality of care he or she provides by periodically reviewing and assessing his or her personal performance in relation to established standards, and by revising or altering his or her practices and techniques appropriately.
- ◆ The ophthalmologist improves ophthalmic care by communicating to colleagues, through appropriate professional channels, knowledge gained through clinical research and practice. This includes alerting colleagues of instances of unusual or unexpected rates of complications and problems related to new drugs, devices or procedures.
- ◆ The ophthalmologist provides care in suitably staffed and equipped facilities adequate to deal with potential ocular and systemic complications requiring immediate attention.
- ◆ The ophthalmologist also provides ophthalmic care in a manner that is cost-effective without unacceptably compromising accepted standards of quality.

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APPENDIX 2. INTERNATIONAL STATISTICAL CLASSIFICATION OF DISEASES AND RELATED HEALTH PROBLEMS (ICD) CODES

Amblyopia, which includes entities with the following ICD-10 classifications:

	ICD-10 CM
Amblyopia, unspecified	H53.00-
Strabismic amblyopia (suppression)	H53.03-
Deprivation amblyopia	H53.01-
Refractive amblyopia, including anisometropic and isoametropic amblyopia	H53.02-
Amblyopia, suspect	H53.04-

CM = Clinical Modification used in the United States; (-) = 1, right eye; 2, left eye; 3, bilateral; 9, eye not specified

Additional Information:

- For bilateral sites, the final character of the codes indicates laterality. An unspecified side code is also provided if the side is not identified in the medical record. If no bilateral code is provided and the condition is bilateral, assign separate codes for both the left and right side.
- When the diagnosis code specifies laterality, regardless of which digit it is found in (i.e., 4th digit, 5th digit, or 6th digit), most often you will find:
 - Right is 1
 - Left is 2
 - Bilateral is 3
 - Unspecified always follows the conventions under “unspecified” above (i.e., either a 0 or 9 depending on whether it is a 4th, 5th, 6th, or 7th digit)

APPENDIX 3. PEDIATRIC EYE DISEASE INVESTIGATOR GROUP CLINICAL TRIALS, 2002– 2016

TABLE A3 PEDIATRIC EYE DISEASE INVESTIGATOR GROUP STUDIES WITH PUBLISHED RESULTS, 2002–2016

Study	No. of Patients (age at enrollment)	Follow-up Period	Result
Randomized trial comparing occlusion vs. pharmacologic therapy for moderate amblyopia ¹⁷ (ATS 1)	419 (3 to <7 years)	6 months	<ul style="list-style-type: none"> • VA improved in both groups: 3.16 lines in occlusion group; 2.84 lines in atropine group • Mean difference = 0.34 lines (95% CI, 0.05 to 0.6) • VA \geq20/30 and/or improved by \geq3 lines in 79% of occlusion group and 74% of atropine group
Randomized trial comparing occlusion vs. pharmacologic therapy for moderate amblyopia ¹⁵⁰ (ATS 1)	419 (3 to <7 years)	2 years	<ul style="list-style-type: none"> • VA improved in both groups: 3.7 lines in occlusion group; 3.6 lines in atropine group • Mean difference = 0.01 lines (95% CI, -0.02 to 0.04) • Atropine or patching for an initial 6-month period produced a similar improvement in amblyopia 2 years after treatment
Randomized trial comparing part-time vs. full-time patching for severe amblyopia ¹⁶⁵ (ATS 2A)	175 (3 to <7 years)	4 months	<ul style="list-style-type: none"> • VA improved in both groups: 4.8 lines in the 6 hours patching group; 4.7 lines in the full-time patching (all hours or all but 1 hour per day) group • Mean difference = 0.02 lines (95% CI, -0.04 to 0.07)
Randomized trial comparing part-time vs. minimal-time patching for moderate amblyopia ¹⁸ (ATS 2B)	189 (3 to <7 years)	4 months	<ul style="list-style-type: none"> • VA improvement in both groups was 2.40 lines • Mean difference = -0.007 lines (95% CI, -0.050 to 0.036) • VA \geq20/32 and/or \geq3 lines in 62% of patients in both groups • VA improvement similar for 2 hours of daily patching and 6 hours of daily patching
Evaluation of treatment of amblyopia ⁷⁰ (ATS 3)	507 (7 to 17 years)	6 months	<ul style="list-style-type: none"> • For moderate amblyopia in children 7 to <13 years old, 36% achieved 20/25 or better with optical correction/occlusion/atropine use compared with 14% with optical correction alone ($P<0.001$) • For severe amblyopia in children 7 to <13 years old, 23% achieved 20/40 or better with optical correction/patching compared with 5% with optical correction alone ($P<0.004$) • For moderate amblyopia in teenagers 13 to 17 years old, 14% achieved 20/25 or better with optical correction/occlusion compared with 11% with optical correction alone ($P=0.52$) • For severe amblyopia in teenagers 13 to 17 years old, 14% achieved 20/40 or better with optical correction/occlusion compared with 0% with optical correction alone ($P=0.13$)

TABLE A3 PEDIATRIC EYE DISEASE INVESTIGATOR GROUP STUDIES WITH PUBLISHED RESULTS, 2002–2016 (CONTINUED)

Study	No. of Patients (age at enrollment)	Follow-up Period	Result
Randomized trial comparing daily atropine vs. weekend atropine for moderate amblyopia ¹⁹ (ATS 4)	168 (3 to <7 years)	4 months	<ul style="list-style-type: none"> VA improvement in both groups was 2.3 lines Mean difference = 0.00 (95% CI, -0.04 to 0.04) 47% of daily group and 53% of the weekend group had either VA \geq20/25 or greater than or equal to that of the nonamblyopic eye
Prospective noncomparative trial to evaluate 2 hours of daily patching for amblyopia ¹⁴⁸ (ATS 5 – eyeglasses-only phase)	84 (3 to <7 years)	Up to 30 weeks	<ul style="list-style-type: none"> Amblyopia improved with optical correction by \geq2 lines in 77% Amblyopia resolved with optical correction in 27% (95% CI, 18% to 38%)
Randomized trial to evaluate 2 hours of daily patching for amblyopia ²⁰⁹ (ATS 5 – randomization phase)	180 (3 to <7 years)	5 weeks	<ul style="list-style-type: none"> After a period of treatment with eyeglasses until vision stopped improving, patients treated with 2 hours of daily patching combined with 1 hour of near visual tasks had an improvement in VA of 1.1 lines compared with 0.5 lines in the control group Mean difference (adjusted) = 0.07 lines (95% CI, 0.02 to 0.12, $P=0.006$)
Randomized trial comparing near vs. distance activities with occlusion ²¹⁰ (ATS 6)	425 (3 to <7 years)	17 weeks	<ul style="list-style-type: none"> At 8 weeks, improvement in amblyopic eye VA averaged 2.6 lines in the distance activities group and 2.5 lines in the near activities group (95% CI for difference, -0.3 to 0.3 line) Groups appeared statistically similar at the 2-week, 5-week, and 17-week visits At 17 weeks, children with severe amblyopia improved a mean of 3.7 lines with 2 hours of daily patching
Treatment of bilateral refractive amblyopia ¹⁶¹ (ATS 7)	113 (3 to <10 years)	1 year	<ul style="list-style-type: none"> Binocular VA improved on average 3.9 lines (95% CI, 3.5 to 4.2) At 1 year, 74% had binocular VA of 20/25 or better
Randomized trial comparing atropine vs. atropine plus a plano lens for the fellow eye in children 3 to 6 years old ¹⁷² (ATS 8)	180 (3 to <7 years)	18 weeks	<ul style="list-style-type: none"> Amblyopic eye VA was 20/25 or better in 29% of the atropine-only group and in 40% of the atropine plus plano lens group ($P=0.03$) More patients in the atropine plus plano lens group had reduced fellow eye acuity at 18 weeks; however, there were no cases of persistent reverse amblyopia
Randomized trial comparing occlusion vs. atropine for amblyopia ¹⁵⁵ (ATS 9)	193 (7 to <13 years)	17 weeks	<ul style="list-style-type: none"> Similar improvement in VA in both groups Amblyopic eye VA of 20/25 or better in 17% of atropine group and 24% of the patching group (95% CI, -3% to 17%)
Randomized trial comparing Bangerter filters vs. occlusion for the treatment of moderate amblyopia in children ¹⁵⁷ (ATS 10)	186 (3 to <10 years)	24 weeks	<ul style="list-style-type: none"> Similar improvement in VA in both groups Amblyopic eye VA of 20/25 or better in 36% of Bangerter group and 31% of patching group ($P=0.86$) Patching was not superior (95% CI difference between groups, -0.06 to 0.83 line)

TABLE A3 PEDIATRIC EYE DISEASE INVESTIGATOR GROUP STUDIES WITH PUBLISHED RESULTS, 2002–2016 (CONTINUED)

Study	No. of Patients (age at enrollment)	Follow-up Period	Result
Randomized trial to evaluate combined patching and atropine for residual amblyopia ¹⁹⁵ (ATS 11)	55 (3 to <10 years)	10 weeks	<ul style="list-style-type: none"> • Before enrollment, eligible subjects had no improvement with 6 hours daily patching or daily atropine • Intensive treatment group had 6 hours of prescribed daily patching combined with daily atropine; weaning group had 4 weeks of reduced treatment, then stopped • Amblyopic eye VA improved similarly in both groups, an average of 0.56 lines in the intensive group (95% CI, 0.18 to 0.93) and 0.53 lines in the weaning group (95% CI, -0.04 to 1.10)
Nonrandomized prospective trial of eyeglasses alone for strabismic and strabismic-anisometropic combined amblyopia in children ¹⁶² (ATS 13)	146 (3 to <7 years)	28 weeks	<ul style="list-style-type: none"> • Mean 2.6 lines improvement (95% CI, 2.3 to 3.0) • 75% improved ≥ 2 lines and 54% improved ≥ 3 lines • Resolution in 32% (95% CI, 24% to 41%) • Treatment effect was greater for strabismic amblyopia than for combined-mechanism amblyopia (3.2 vs. 2.3 lines; adjusted $P=0.003$)
Randomized trial comparing increased patching with the same dosage for amblyopia that has stopped improving ¹⁹⁴ (ATS 15)	169 (3 to <8 years)	10 weeks	<ul style="list-style-type: none"> • Amblyopic eye VA improved an average of 1.2 lines in the 6-hour group and 0.5 lines in the 2-hour group (difference in mean VA adjusted for acuity at randomization 0.6 lines; 95% CI, 0.3 to 1.0; $P=0.002$). • Improvement of 2 or more lines occurred in 40% of participants patched for 6 hours vs. 18% of those who continued to patch for 2 hours ($P=0.003$).
Randomized trial comparing adding a plano lens to the atropine vs. the same atropine dosage for amblyopia that has stopped improving ¹⁷¹ (ATS 16)	73 (3 to <8 years)	10 weeks	<ul style="list-style-type: none"> • Amblyopic-eye VA improved a mean of 1.1 lines with the plano lens and 0.6 lines with atropine only (difference adjusted for baseline VA +0.5 line; 95% CI, -0.1 to +1.2)
Randomized trial comparing levodopa plus patching vs. placebo with patching ²¹¹ (ATS 17)	138 (8 to <13 years)	18 weeks	<ul style="list-style-type: none"> • Amblyopic eye acuity improved by an average of 5.2 letters (1.1 lines) in the levodopa group and by 3.8 letters (0.8 line) in the placebo group (difference adjusted for baseline VA, +1.4 letters; 1-sided $P=0.06$; 2-sided 95% CI, -0.4 to 3.3 letters) • No serious adverse effects from levodopa were reported during treatment
Randomized trial comparing a binocular game vs. part-time patching ¹⁸⁵ (ATS 18)	385 (5 to <12 years)	16 weeks	<ul style="list-style-type: none"> • Falling block design • Amblyopic eye acuity improved by an average of 1.05 lines in the binocular group and 1.35 lines in the patching group (difference adjusted for baseline VA, 0.31 lines; 1-sided 95% CI, 0.53 lines) • Improvement with binocular game play was not as good as with patching

NOTE: In the ATS, mild to moderate amblyopia is defined as VA in the amblyopic eye of 20/80 or better; severe amblyopia is defined as VA in the amblyopic eye of 20/100 to 20/400.

Further information about the published results of the Amblyopia Treatment Study is available from the Pediatric Eye Disease Investigator Group (<http://pedig.jaeb.org/Publications.aspx>).

ATS = Amblyopia Treatment Study; CI = confidence interval; RCT = randomized clinical trial; VA = visual acuity

LITERATURE SEARCHES FOR THIS PPP

Literature searches of the PubMed and Cochrane databases were conducted in March 2016; the search strategies are found on www.aao.org/ppp. Specific limited update searches were conducted after March 2016.

SUGGESTED READING

- ◆ Taylor and Hoyt's Pediatric Ophthalmology and Strabismus, 5th ed. Edinburgh; New York: Elsevier, 2017.
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RELATED ACADEMY MATERIALS

Basic and Clinical Science Course

- Pediatric Ophthalmology and Strabismus (Section 6, 2017–2018)

Focal Points

- Advances in the Management of Amblyopia (2010)

Patient Education Downloadable Handout

- Amblyopia (2017)
- Amblyopia Patching (2016)
- Pseudostrabismus (2017)
- Strabismus Children (2016)

Patient Education Video

- Strabismus Surgery for Children (Pediatrics Patient Education Video Collection - 2015)
- Treating Amblyopia (Pediatrics Patient Education Video Collection - 2015)

Preferred Practice Pattern® Guidelines - Free download available at www.aao.org/ppp

- Comprehensive Adult Medical Eye Evaluation (2015)
- Esotropia and Exotropia (2012)
- Pediatric Eye Evaluations (2012)

To order any of the Related Academy Materials, except for the free materials, please contact the Academy's Customer Service at 866.561.8558 (U.S. only) or 415.561.8540 or www.aao.org/store.

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