Eye Muscle Problems in Children and Adults: A Guide to Understanding

By Burton J. Kushner, MD
The John W. and Helen Doolittle Professor of Ophthalmology
University of Wisconsin Department of Ophthalmology and Visual Sciences, Madison

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Dedication

The gods split these creatures into two parts, creating male and female humans. The belief is that each one of us, on a deeply subconscious level, knows that something is missing within ourselves, and we seek wholeness.

—Rephrased from Plato, The Symposium

For Dale

My missing half

Acknowledgements

This book represents a substantial revision of the excellent monograph written in 1974 by Charles Windsor, M.D. and Jane Hurtt, R.N., A.A., *Eye Muscle Problems in Childhood: a Manual for Parents — second edition*. Although their booklet is now about 40 years old, it has remained the best guide available for informing parents, patients and primary care physicians about the complex subject of eye muscle problems. Both authors have generously given me permission to update and modify their publication.

I would also like to thank the tens of thousands of patients who have entrusted me with their care over the past 40 years. Their questions inspired this book. There are no “dumb questions” when it comes to medical matters. If a question exists in a patient’s mind, it should be addressed. If that question remains unasked or unanswered, or if the answer is not understood, not only the doctor-patient relationship may suffer, but adverse medical consequences may follow.

Table of Contents

Preface

Why Have I Written This Book?

In recent decades patients have assumed a more active role in understanding their medical conditions and in making informed decisions about their health care. I assume you are reading this book because you, your child, or someone you care about has an eye muscle disorder. Perhaps your doctor did not satisfactorily answer your questions. Possibly you had questions you did not ask. Maybe you are just seeking a better grasp of what you were told at the doctor's office in order to better evaluate the treatment options you were given. Alternatively, you are just seeking confirmation that you, or your child, are being treated properly.

The purpose of this book is to help you understand the complex subject of eye muscle disorders and to address your unasked or unanswered questions, so that you can make informed decisions regarding treatment choices. In the following pages, I will attempt to explain the perplexing and mysterious subject of the *lazy eye* in a patient-friendly way that can be easily understood.

If knowledge is power, one of its powers is to enable us to make wise and informed decisions that influence our future. Hopefully after reading this book you will feel more empowered to make considered choices regarding the treatment of your child, yourself, or your loved one. Let this book be an adventure of discovery about a pair of eyes, and how they should work together. Let it be an exploration that simulates a visit to the office of a caring and understanding physician who has unlimited time to answer questions and explain treatment options in a clear and understandable fashion. I wrote this book because, regrettably, not everyone is fortunate enough to be under the care of such an idealized doctor.

How to Use This Book

Because people differ in the amount of technical information they desire, I have followed a layered approach to presenting this material.

Basic Information: Information that is considered basic and important for you to read in order to understand a given topic is accompanied by the symbol of stacked books. If you limit your reading to the basic material for a particular topic, you will have sufficient grasp of the subject to understand related material.

Advanced Information: A graduate identifies information that delves more deeply into the technical aspects of a topic, and which expands on the basic material to give you a more thorough understanding of a subject. If you do not wish to explore these more advanced aspects, you may skip over this information. I consider this material to be "extra credit" for those readers who have a greater interest in particular aspects of eye muscle problems.

Important Point: A string around an index finger denotes an important point. This identifies a particularly useful fact or concept that is worth remembering.

Frequently Asked Questions: A question mark will identify frequently asked questions. I encourage you to read all of them. During my 39 years in practice, certain questions re-occur. Perhaps you have these same questions. Perhaps they are ones you have not thought about yet, but would find the answers helpful. The answers to these frequently asked questions are of benefit to all readers.

Myth: There are many myths and misconceptions that relate to the subject of the *lazy eye*. These represent misleading and incorrect information that will confuse your understanding of this subject. The trashcan is the appropriate place for these incorrect ideas.

Try This Experiment: To help you understand certain subjects, I may suggest you perform simple experiments. These will be identified by this scientific symbol.

Regarding Unfamiliar Medical Terms

Doctors tend to speak in their own language. They often use terms that may be unfamiliar to you. It is important that you become acquainted with some of these terms if you are going to learn about eye muscle problems and *"lazy eye."* When an unfamiliar term appears for the first time in this book, a simple definition will be given. Each time the term subsequently appears, it will be written in italics. There is also a Glossary at the end of the book in which all italicized terms are listed alphabetically and definitions given (see Chapter 14, page 107). Feel free to refer to the Glossary if you come across an italicized word for which you may have forgotten the definition.

Before you can start on this journey of discovery, there are two very important terms with which you should become familiar.

Strabismus: This is the medical term to describe any type of misalignment of the eyes. If someone's eye crosses (turns in), drifts outward toward the ear (is "wall-eyed") or is misaligned vertically (points too high or too low), that person has *strabismus.* Substitute words that have the same meaning include "eye muscle imbalance" or "wandering eye."

Amblyopia: This refers to vision that is decreased because the eye has been ignored or "shut off." A common slang term for *amblyopia* is *lazy eye.* With *amblyopia*, the vision is said to be "lazy," because even with proper glasses (if needed), the vision initially is still not normal (however, it may normalize with treatment). The brain has not learned, or has forgotten, how to see with the eye. The most common cause of *amblyopia* is a misalignment of the eye (*strabismus*). However, the two conditions are not the same. As you will learn in Chapter V your child can have *amblyopia* without any misalignment of the eyes (without *strabismus*), or he may have misaligned eyes yet good vision (has *strabismus* but no *amblyopia).* Many people incorrectly use the term *lazy eye* to describe an eye that is misaligned or deviates. Strictly speaking, however, the term *lazy eye* should be reserved for describing lazy vision and not to describe a misaligned eye.

Regarding Gender

In order to avoid the complex use of gender-neutral pronouns such as (s)he or he/she, I arbitrarily will use either he or she, alternating back and forth equally.

Regarding Eye Doctors

In recent years, the differences in the scope of practice between *ophthalmologists* and *optometrists* (see page 109) have become less distinct, and this has resulted in some controversy. In this book, I wish to avoid that controversy. In most places I simply refer to "eye doctor" rather than specifying *ophthalmologist* or *optometrist*, unless the issue is one in which the distinction is clear.

Regarding Right and Left Eyes

Throughout this book, when I refer to a “right eye” or a “left eye,” I will be describing the eye from the viewpoint of the person whose eye it is. The girl shown in the photograph below has a crossed eye. Although it is her right eye that is deviated, it is to your left as you look at her picture.

In the chapters that follow, I would describe this situation as demonstrating a deviated **right** eye and a properly aligned **left** eye.

Topic Checklist

You may wish to read this entire book to get a good general understanding of eye muscle problems. However, if you want to find the material that most directly relates to your own problem, or that of your child, you may wish to show the following checklist to your eye doctor, and have her check those specific subjects that are pertinent to your particular situation. You can then go directly to those sections that your doctor has checked. This is not intended to limit your reading (much useful information may be obtained by reading the entire book). It is intended to help you sharpen your focus on any particular topic.

	Pages
☐ Adjustable Sutures	85
☐ *Amblyopia* (decreased vision)	47-56
☐ *Botox* (Botulinum Toxin)	86
☐ Convergence	35
☐ *Esotropia* (cross-eyed)	42, 44, 59-69, 91-2
☐ Exercises (*orthoptics*)	90
☐ *Exotropia* (wall-eyed)	42, 44, 65-71
☐ Glasses to treat *strabismus*	91-2
☐ *Hypertropia* (eyes that turn up or down)	42, 71-3
☐ Miotics	65
☐ Pseudostrabismus	40-1
☐ Psychologic Effects of Strabismus	95-6
☐ Reading Disability & Dyslexia	97-8
☐ Refractive Errors (*nearsighted, farsighted, astigmatism*)	22-43
☐ Surgery	75-86
☐ Uncommon Forms of *Strabismus*	*95*

Chapter 1
Your First Visit to the Eye Doctor

Imagine that you suddenly noticed your six-month-old daughter's right eye momentarily crossed inward toward her nose. It only lasted a few seconds, so perhaps you were not certain it really happened. Then her eye turned in again. After a few days this began to occur with increasing frequency, and her eye stayed crossed in for longer periods. After discussing the problem with your family doctor or pediatrician, he suggested you see an eye doctor.

Many scary thoughts might have been going through your mind. Could your baby need glasses? She is certainly too young for glasses! Might she need an operation? That also sounded worrisome. What if she had something even more serious than an eye problem? Could she have a brain tumor? Hopefully she will just outgrow the problem; don't all babies' eyes cross?

You might have had these, and many other questions. The first visit to an eye doctor for your child, if she is suspected of having an eye muscle problem, may naturally be a source of anxiety or concern. Knowing what to expect in advance is the best way to prepare for the visit and minimize stress for you and your child. Fortunately, examining the eyes of children is usually fun — both for the patient and the doctor — and the vast majority of eye muscle problems in children can be treated successfully.

Basic Information

Preparing for the Examination

The doctor will want to know some important details regarding your child's eye problem. Often these are questions that you may not be able to readily answer without having thought about them ahead of time. It is wise to pay attention to the following issues prior to the visit to the eye doctor.

- How was the problem discovered? Is it something you or other relatives have noticed, or was it only detected by your family doctor or pediatrician?
- Does only one of your son's eyes appear to have the problem? If so, which one?
- What does his eye do that appears abnormal? Does it turn in, out, up or down?
- Is the problem always present, or is it intermittent? If it is intermittent, does any particular activity cause it to occur? For example, is it likely to happen when he looks at things close up, far away, only to one side, or when he is tired?
- How long ago did the problem begin and — importantly — is it getting better or worse?
- Do you feel your son sees normally?
- Has his growth and development been normal? If you have older children, it may be useful to compare your son who has the eye problem to his older siblings in this regard. Did he sit up and take his first step at the same age as his older sister?
- It is also useful to know if other relatives had a misalignment of an eye, such as a *crossed eye* (an eye that deviates in toward the nose), a *wall eye* (an eye that deviates outward toward the ear), or "lazy" or poor vision in one eye that could not be corrected with glasses (*amblyopia*). If so, how were they treated? Was it with glasses, patching, exercises, or surgery? If your son is bothered by *double vision*

(seeing two of something when there is actually only one), it is important to describe if the two images are separated vertically (one on top of the other), horizontally (side by side) or both. Does the *double vision* go away if one eye is closed? What if the other eye is closed?

- Do you feel your son's eye looks "lazy" in photographs? If so, it is useful to bring sample photographs to the doctor, so she can observe exactly what you are describing. I find this particularly helpful when children have the appearance of an eye that appears to be misaligned, but in fact is normal (see *pseudostrabismus* on pages 40 and 41).

Thinking about all these questions (and of course — the answers) prior to your appointment will help the eye doctor arrive at an accurate diagnosis and treatment plan.

If the person with the eye muscle problem (you or your child) has already undergone prior eye muscle surgery by another doctor, it will be important for your new doctor to have records describing that surgery. You should arrange for the previous doctor's office, or the hospital at which the surgery was performed, to send a copy of the "operative report" to your new eye doctor. This is important because planning for any further surgery is often based on exactly what surgery had been performed in the past. I find that hospitals frequently retain records for a great many years, and usually operative records from the distant past can be obtained with sufficient perseverance.

If you are seeking a second opinion, or are transferring care to a new doctor, providing the new doctor with a copy of office records of prior care is an excellent idea. Often the management of *strabismus* is influenced by how the problem has changed over prior years. Is the problem better or worse today than a year ago? What treatments have been tried and proved unsuccessful? Your new eye doctor will not want to repeat treatments that have not worked in the past. Providing the new doctor with copies of prior glasses prescriptions will also give her a sense of how the problem has progressed over time. It is preferable to have this material sent to your new doctor in advance, rather than you bringing them with you for your first appointment. That will give the new doctor the opportunity to review them ahead of time and determine if any additional information is needed.

An eye examination in a young child is always more successful if she is awake, alert, and cooperative. If there is a particular time of day when your daughter is predictably apt to be fussy or tired, avoid making an appointment at that time. If your child is a baby, and if she tends to be less fussy while taking a bottle or using a pacifier, plan on bringing one along to the doctor's office. A bottle or pacifier may save the day.

Are you wondering how your infant's eyes can be examined and how glasses can be prescribed accurately, when she cannot yet read (let alone talk)? It is an interesting and fun process, which we are now ready to learn about.

What Will Happen at the Eye Doctor's Office?

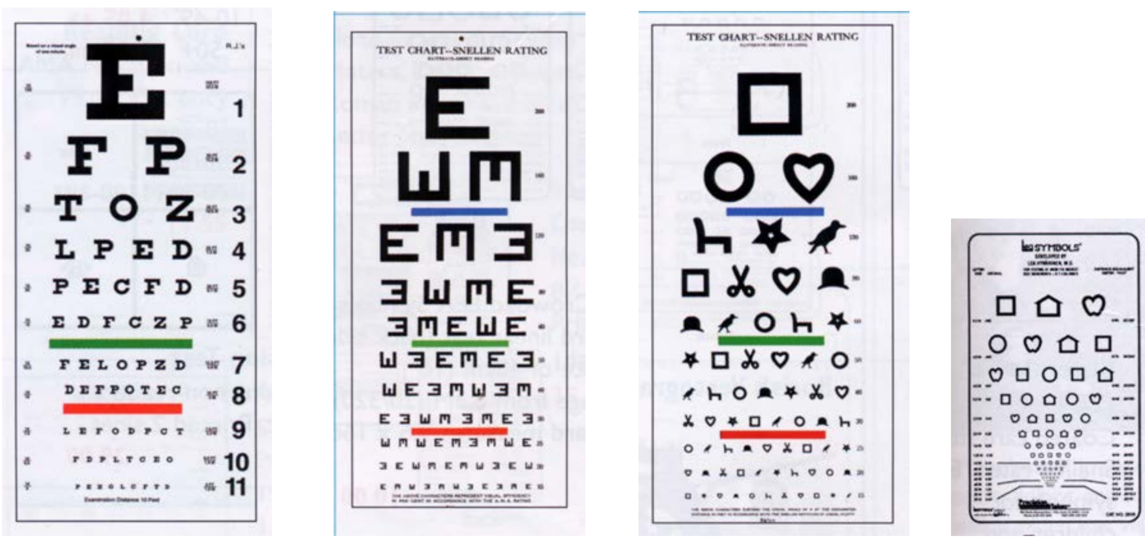
You should allow a couple of hours for your child's first visit to an eye doctor.

Medical History

Your visit to the eye doctor will probably begin with the doctor, nurse, technician, or *orthoptist* (a paramedical professional who is a specialist in the diagnosis and treatment of eye muscle problems and *amblyopia*) who will take a history of the problem that prompted the appointment. Being prepared to answer the questions listed on pages 10 and 11 will be helpful. You may want to bring along a written list of issues, questions, and goals for the appointment.

Examination

Visual Acuity One of the most important aspects of the examination will be the determination of *visual acuity* (how far down the eye chart a person can read). Most people are familiar with the *Snellen letter chart* that is used in adult examinations and with children old enough to identify letters. It is the "eye chart" with large letters at the top, and progressively smaller letters toward the bottom. (See Figure 1-1) The visual acuity of an eye is usually expressed as a fraction, for example 20/20. (See page 108 for an explanation of what these familiar numbers mean.)



A **B** **C** **D**

Fig 1-1 Examples of four types of vision charts. The one on the left (A) is the standard *Snellen letter chart*. It is used when testing adults, or children who are old enough to read letters. The other three charts can be used for children who cannot identify letters. Figure 1-1B is the *E-Chart*. Figures 1-1C and D are examples of different types of picture charts.

Determination of *visual acuity* in children who are too young to read letters can be done in a variety of ways. For children between the ages of 2½ and 4 *visual acuity* can often be tested with the *E-Chart*. This test consists of a group of capital letter Es oriented in different directions as shown in Figure 1-1B. The Es are graduated in size, just as the letters on the *Snellen letter chart*. Your daughter would be asked to orient her fingers to match, or describe the direction in which the three parallel lines in the letter E are oriented. They may be pointing right, left, up, or down. The smallest line of Es that she can correctly identify will indicate her *visual acuity*.

Another test that can be used in children of this age is called the *HOTV test*. It involves matching letters. Your daughter holds a card that contains the four letters H, O, T and V. The examiner points to letters on a vision chart made up solely of those four letters. Your daughter then matches the letter being shown to her by pointing to the same letter on the card. In addition there is a similar test that also contains the letters U and A. (See Figure 1-2)

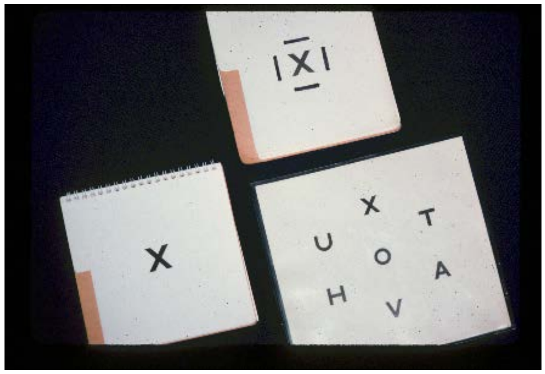


Fig 1-2 The letters used in one of the letter-matching tests. The examiner shows the child a letter on a flip card on the left. The child holds the card on the right and matches the same letter by pointing.

If your child is over 2½ years of age and cannot yet name letters, you may wish to practice the *E-Chart* or the *HOTV test* prior to the doctor's visit. A sample letter E, and set of cards with the letters HOTVUA are included in the supplements at the end of this book. If your daughter can successfully perform either of these tests, let the eye doctor know at the start of the examination.

Another vision test that can be used in children who cannot read, and are too young for the *E-Chart* and matching test, is the picture chart (also shown in Figure 1-1). This is very similar to the *Snellen letter chart*; however, it consists of different-sized pictures of common objects such as a birthday cake, a duck, car, etc. Although this test is useful for young children who can talk but cannot yet do the *E-Chart* or *HOTV matching test*, it is not as accurate as tests that require your child to identify or match letters.

For a child who is too young for the picture test, your eye doctor may have to approximate vision based on his ability to visually track small objects and reach for them. By determining if your baby favors one eye over the other; your eye doctor can tell if vision is better in one eye than the other.

Exactly which of the above tests will be used for your child will be determined based on your child's age, and his ability to understand the different tests. The examiner will use the most accurate test that is appropriate for your child.

Eye Alignment

In addition to determining your child's *visual acuity*, an important part of the visit to the eye doctor will include assessing and measuring any misalignment of your daughter's two eyes and how adequately the eye muscles work. This will be accomplished by having her look at objects at the far end of the room and also close up, while the examiner holds up a light or a *prism* (a special triangular shaped lens — see page 93 and Figure 10-3) to quantify how much her eye(s) deviate. Most eye doctors have appealing objects for young children to look at such as animated toys, pictures, or cartoon movies to make this part of the examination fun for your child. In addition, the examiner will have your daughter look in different directions (up, down, right, left) to see if any of her eye muscles appear excessively weak or overly strong. All of these measurements will be used for comparison before and after treatment to monitor her progress.

The Rest of the Eye Examination

If your child is old enough, certain tests may be performed that are designed to answer the questions "does your daughter actually use her eyes together?" or "does she have the potential to do so if her eyes are straightened?" These tests may involve counting colored lights while wearing special colored glasses, or looking at 3-D pictures while she wears Polaroid glasses which tests for one type of depth perception.

A thorough study of the anatomic parts of both eyes is an important aspect of the eye exam. The eye doctor wants to determine if there are any structural abnormalities of the outside or inner parts of your child's eyes. In this examination, which only takes a few moments, the eye doctor looks at your daughter's eyes with special magnifying lenses or instruments. One such instrument, the "ophthalmoscope," permits the doctor to carefully examine the inner components of the eyes. He wants to do this because sometimes crossing of an eye is the result of a structural abnormality of the eye such as a *cataract* (a clouding of the *crystalline lens* that is inside the eye), an abnormality of the *retina* (the light-sensitive layer of tissue that lines the inside of the eyeball), or of the *optic nerve* (the nerve that carries vision from the eye to the brain). In other words, crossing of the eye may be a signal or clue to other ocular health problems. Very rarely, a tumor of the *retina* (called a "retinoblastoma") may cause an eye muscle imbalance. A thorough eye examination of a young child, including a careful examination of the *retina*, may lead to the detection of this uncommon cancerous tumor. If it is discovered early enough, it can be treated successfully.

As we will see in Chapter 6, the determination of any *refractive error* of the eyes is crucial for the management of eye muscle disorders. What do I mean by *refractive error*? If your child's eye has a *refractive error*, that means her eye is out of focus. Remember the last time you took a photograph and the picture came out blurred? If that happened, the camera was not properly in focus. In a similar manner, an eye must be properly in focus for vision to seem clear. Thus, *refractive errors* are abnormalities of the optical system of the eye. They include *hyperopia* (farsightedness), *myopia* (nearsightedness), or *astigmatism* (an optical distortion that will affect vision at both near and far viewing distances). Details of these conditions will be explained further in Chapter 2.

If you have ever been to an eye doctor, your *refractive error* was probably determined with input from you. Your eye doctor held different lenses in front of each of your eyes and asked you which lenses improved your vision and which made it worse. Most young children do not have the ability to answer questions of this type. If your child is too young to accurately respond to questions about the quality of his vision with different lenses, his *refractive error* can still be determined with great precision using a different technique. It can be done objectively, without requiring any responses from your son. The eye doctor looks in his eyes with a special instrument while holding various lenses in front of each eye. By observing the reflections coming back from the eyes through the different lenses, the eye doctor can determine the correct lenses to put your son's eyes in proper focus. This allows her to tell if your son needs glasses, and if so, exactly what strength the glasses should be. This technique is much like focusing a camera, in which the photographer can put a subject in focus, without any verbal responses from the person he is photographing. With this procedure, a skilled eye doctor can determine the *refractive erro*r of a child of any age (even a newborn), typically in a few minutes. However, with this method it is also essential that your son's *pupils* (the black circles in the middle of the colored part of the eyes) be dilated to put the focusing muscle completely at rest. Otherwise his eyes could change focus during the examination and cause incorrect findings. For this reason, a dilating medication must be put in your son's eyes to relax the focusing muscle and put it at rest while his *refractive error* is being determined. This typically involves the instillation of one or several eye drops, and waiting approximately 40 minutes for his pupils to dilate. Most children tolerate the eye drops quite well; however, some do find them momentarily unpleasant and uncomfortable. Nevertheless, dilating drops are an absolutely indispensable part of a proper eye examination in a child, both for determining the *refractive error* and for examining the inside of the eyes. If you or your child are particularly concerned about the discomfort of the eye drops, a "numbing" drop (Novocaine) can be given prior to the actual dilating drop. This option does eliminate much of the worry some children have regarding this part of the examination.

Most eye doctors who are accustomed to and comfortable with examining small children have skills to put the child at ease and make the eye examination fun.

Question: I am concerned about the dilating drops. Are they really necessary for my daughter, and are they safe?

Answer: The dilating drops your daughter will receive have been used by eye doctors for a great many years. Barring some very uncommon and unforeseen side effect, or medication allergy, they are known to be extremely safe when administered properly. Infrequently, very small children may get warm or flushed after receiving dilating drops. This is not of any major concern and usually wears off quickly. For many patients, the dilating drops are the least favorite part of the eye examination. However, they are both necessary and safe. While your daughter's *pupils* are dilated, bright light will not damage or harm her eyes. However, she will be somewhat more sensitive to bright lights until the medication wears off. She can either wear sunglasses or merely squint her eyes in bright light to remain comfortable until the drops have worn off. Most eye doctors provide disposable sunglasses for patients who do not bring their own. In addition, your daughter's eyes will probably be a bit out of focus for near viewing, such as reading a book, while her *pupils* are dilated. It is best for her to plan to avoid doing close work, such as using a computer, reading, or doing homework, until after the medication has worn off. She can probably return to school immediately after her eye examination; she will be able to listen and participate in class but may have difficulty reading books. Usually there is less blurring of her distance viewing, so driving a car (for older patients) or engaging in sports is usually not a problem.

Myth: While a child's pupils are dilated, it is not safe for her to swim or wear contact lenses. Water or foreign material may get into her eyes through the dilated pupils and cause damage.

Fact: There is no harm to her eyes if she swims, wears contact lenses, or engages in any other activity while her eyes are dilated.

Question: How long do the drops take to work, and how soon will they wear off.

Answer: The focusing muscle within the eyes is much stronger in children than in adults (yes — that is correct — stronger, not weaker). Consequently, the drops used in children take longer to work, and longer to wear off in adults. Proper dilation of a young child who has *strabismus* requires approximately 40 minutes and will usually last for about 24 hours. In older children (teenagers), and in adults, dilation can often be accomplished with a shorter-acting drop that works in 20 minutes and may wear off in several hours. (For older children and adults who may need to resume reading as soon as possible, a reversal drop can be given at the end of the examination to hasten the return of clear close-up vision.) If you are interested in receiving this, ask your eye doctor for reversal drops. I have found that most young children would rather not receive a reversal drop. They are much happier putting up with the mild blur and light sensitivity caused by dilation than receiving another eye drop. Reversal drops seem more important for older patients who wish to return to work or reading as soon as possible. Interestingly, the time it takes for dilation to take effect, and the speed with which it wears off, is related to eye color. People with dark brown eyes dilate more slowly and stay dilated longer. If your child is very small, or he does not dilate well (typically because he has dark brown eye color), his eye doctor may recommend that he return for a follow-up visit after you have instilled a dilating medication (atropine) for several days in a row at home prior to this second examination. This allows for more complete relaxation of the focusing muscle in a child whose eyes do not dilate sufficiently in the doctor's office.

Question: My child has an eye muscle problem. He is old enough to answer questions about whether different lenses improve his vision. Does he need to have his pupils dilated when the doctor measures his refractive error?

Answer: Yes he does. Most children (and even the majority of adults) with eye muscle problems do not have the ability to relax the focusing muscle in their eyes while undergoing the examination. This can result in an inaccurate assessment of the refractive error. In addition, the dilated pupils allow careful examination of the inside of his eyes. For these reasons most people with strabismus need to have their pupils dilated as part of a complete eye examination.

Question: I took my child to the doctor because I suspected she has a *lazy eye*. He told me there was nothing wrong, but he did not dilate her eyes. Should I be concerned?

Answer: For reasons stated above, dilation is an essential part of the examination of a child suspected of having a *lazy eye*. Your child has not been examined fully, and you should get a second opinion.

Question: I took my 6-month-old child to the eye doctor because his left eye crosses. The doctor told me a six-month-old child is too young to be examined, and that I should bring him back in a year or so. Does this sound like proper advice?
Answer: No! Although sometimes minor problems in a very young child are best treated with "letting a little more time go by," an examination is still possible and crucial at any age a problem is suspected. Although many eye doctors are experienced and comfortable with examining small children, some are not.

Important Point: A child of any age — even a newborn — is not too young to undergo a thorough eye examination. If your eye doctor is not able to perform a satisfactory examination on your small child, you should consider a second opinion by an eye doctor who specializes in treating children.

Question: My son has *strabismus*. How often will his eyes need to be dilated?
Answer: In general, a child with an eye muscle problem will need to have a dilated eye examination approximately once per year. The main purpose of dilation is to determine if glasses are needed, and if so, their exact prescription. Just as your growing son may need a different size of trousers each year, his glasses prescription will need to be re-evaluated yearly.

Question: I would like to avoid waiting 40 minutes in the doctor's office for the dilating drops to work. Can I just put them in my child's eyes at home 40 minutes before his yearly eye examination? **Answer**: Generally, no! Many aspects of the eye examination (e.g. testing of vision, evaluating eye muscle balance and checking *pupil* function, to name a few) must be carried out before your child's eyes are dilated. Consequently the eye doctor will need to examine your child before her eyes have been dilated. Sometimes, patients may find it more convenient to do the examination in 2 parts. They can have one visit to the eye doctor, which includes all aspects of the examination that need to be performed prior to dilation. Then they have a second visit a week or so later for which the child has received eye drops at home prior to the examination. This has the advantage of eliminating the 40-minute wait for dilation in the doctor's office, but it has the disadvantage of necessitating a second visit to the doctor's office before complete information about your child's eye condition can be gathered.

Advanced Information: There are some situations in which a more accurate measurement of an infant's *visual acuity* than can be obtained by assessing her ability to visually track objects as was described on page 13 is desired. Special tests are available in many university pediatric eye clinics and the offices of some eye doctors who specialize in treating children that can provide such information. One of these tests is the "visual evoked potential" (or VEP). This is a non-invasive and painless test. A technician will temporarily tape some wires to your baby's scalp. These are similar to the wires that would have been taped to your chest if you ever had an electrocardiogram. Your child will then observe different-sized striped patterns on a television screen. Just as the electrocardiogram detected your heartbeat painlessly and quickly, the visual evoked potential detects your child's brain activity when she is observing patterns of different sized stripes. From this information, the eye doctor can determine how well your baby can see. Another test is "preferential looking" in which a child is shown striped patterns of differing sizes. By observing the child's visual behavior as progressively smaller patterns are presented, the examiner can make an accurate measurement of your baby's *visual acuity*.

Now that you know what to expect when you bring your child to the eye doctor, you are ready for the next step on our journey of discovery — learning about the eye and how it works.

Chapter 2
How Our Eyes Work

Basic Information
Parts of the Eye and How It Works

The eye is a miraculous organ. Philosophers have described it as being the window of the soul. Before we can understand how our two eyes work together as a team, we need to understand how each eye sees individually. This chapter will give you a brief overview of how the eye works, which is the first step in understanding *strabismus* and *amblyopia*.

It is said that most of mankind's greatest inventions were modeled on, or copied from nature. The development of the airplane and sonar, for examples, were inspired by observations of birds and bats. The camera is a man-made version of the eye, and comparison of the eye to a camera is useful in understanding how the eye works.

How a Camera Works

Assume you want to take a photograph of your daughter. A camera is designed so that the light rays bouncing off her are focused to form an image of your daughter on the light-sensitive film or electronic detector, which makes a permanent reproduction of her. To get a picture that is not blurry, her image on the film or electronic detector must be crisp and clear. This is accomplished by focusing the lens of the camera — the glass protuberance on the camera's front. (see Figure 2-1 for a diagram of the parts of a camera).

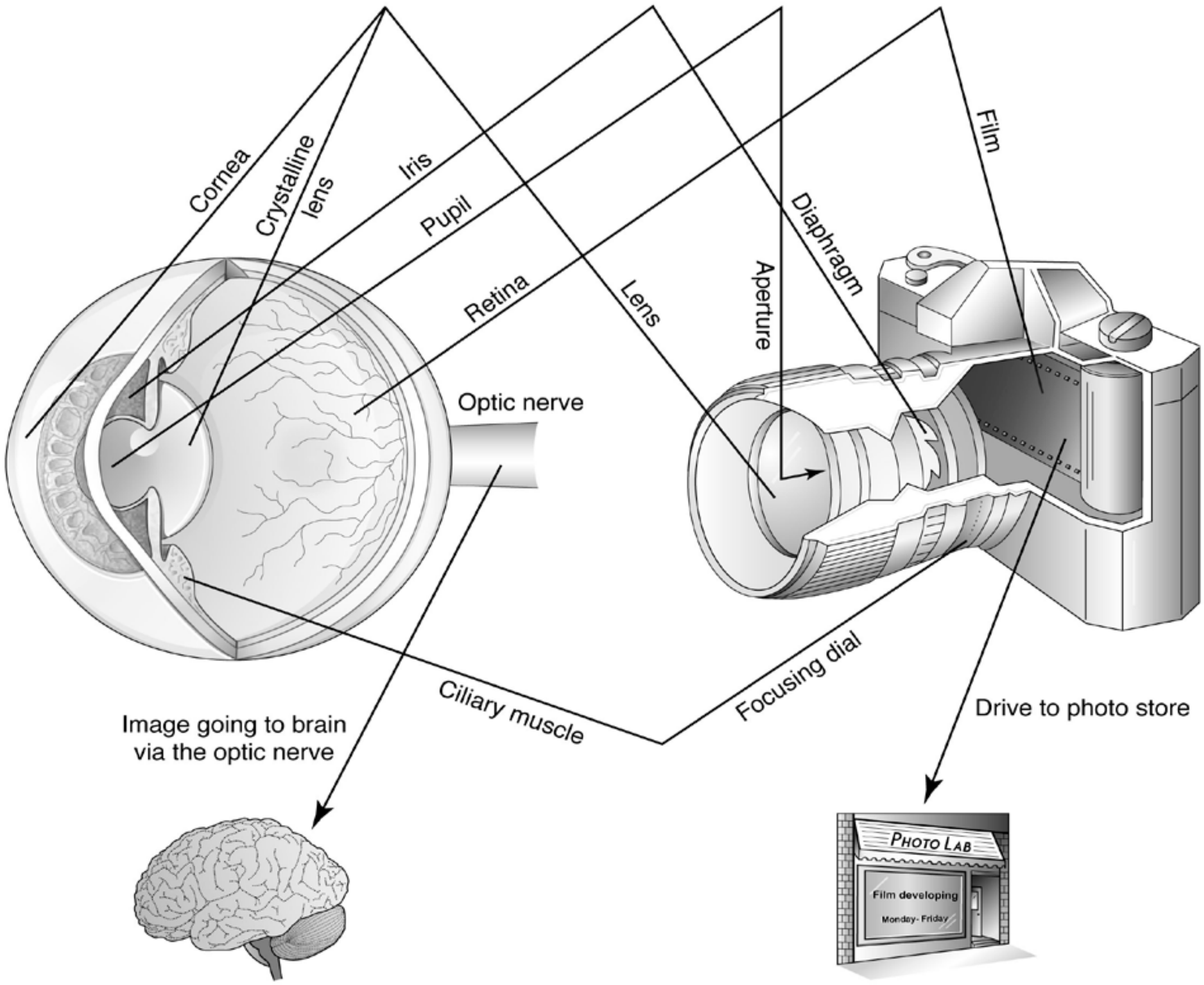


Fig 2-1 On the left is a cutaway view of an eye and on the right is a camera. Lines connect similar components.

If you use a manual camera, you must do this yourself by turning the focusing dial, which moves the lens slightly forward or backwards. If your camera has automatic focusing, the camera itself performs this task electronically. Can you recall having looked through a magnifying glass? It had to be positioned at just the right distance from the object you were looking at or your view appeared blurred and out of focus. This positioning of the magnifying glass is similar to the process of focusing a camera to make your daughter's image sharp and clear.

The camera must also control the amount of light that reaches the film or electronic detector. This is done by the diaphragm, which is just behind the lens. It is a doughnut shaped structure which can be dialed up or down, to increase or decrease the size of the hole in its middle (which is like "the hole in the doughnut") and thereby controls the amount of light that passes through. Next is the shutter. This is a little trap door that opens or closes to either permit or stop light from entering the camera. Finally, in the back of the camera is the film or electronic detector. This is the light sensitive material that preserves the image that was focused on it. After the picture is taken, you will need to walk or drive to the photo processing store to have the picture developed and printed. Alternatively, with digital photography you can conduct this stage on your home computer. Finally, you will have the finished picture of your daughter that you can look at with pride and smile.

How the Eye Works

Much like a camera, the eye is an organ that focuses light sharply on a light sensitive tissue to record a scene. (See again Figure 2-1 for a comparison of the parts of the eye and the parts of a camera). In the eye, there are two structures that act like the lens in a camera. The very front of the eye is a clear structure (much like the crystal on a watch) called the *cornea*. It is one of the two “lenses” of the eye; however it cannot change its focus. A second structure in the eye, called “the *crystalline lens*” sits behind the pupil. The *crystalline lens* is able to change its shape by means of the *ciliary muscle* (as described below) and thus alter the focus of light passing through. In the eye, this type of adjustment is made by the *crystalline lens* automatically and without our thinking about it. The *cornea* and *crystalline lens* focus light on the light sensitive tissue on the inside of the eye — the *retina* — which is described below. The *iris* — the part that determines our eye color (blue, brown, etc.) is a doughnut shaped structure between the *cornea* and the *crystalline lens*. By contracting or relaxing, the muscles in the *iris* can alter the size of the hole in its middle — the *pupil*. The *pupil* is the black circle in the center of the *iris* and is like the hole in the doughnut (the *iris*). The *pupil* is only black because there is no light inside the eye. It is comparable to the opening in the center of the diaphragm of a camera, through which light passes. In dark situations, the *pupil* enlarges to let more light pass through; in brighter settings it constricts to limit the amount of light entering the eye.

Within the eye, surrounding the *crystalline lens* is a ring of muscle called the *ciliary muscle*. It is attached to the crystalline lens by tiny threads called *zonules.* The *ciliary muscle* can relax and contract, and actually change the shape of the *crystalline lens* of the eye. This alters the distance for which an eye is in focus. The action of the *ciliary muscle* is like the focusing dial on our camera.

Eyelids that can open and close are like the shutter of the camera. They can permit or prevent light from entering the eye.

Lining the inside of the back inside surface of the eye is a thin layer of tissue called the *retina*. This is the light sensitive structure in the eye and is analogous to the film in a camera, or the electronic detectors (pixels) in a digital camera. Just as each molecule on the surface of photographic film darkens or lightens depending on how much light strikes it, each cell in the *retina* creates a greater or lesser electrical signal varying with the amount of light it receives. This is the first step in the actual creation of a visual image.

Next the electrical signal created by the *retina* is sent via a large nerve (called the *optic nerve*) to the back part of the brain (called the occipital cortex) where vision is processed. The transmittal of the image by the *optic nerve* could be likened to your trip to the photo processing store to have a photograph developed. The occipital cortex turns this electrical signal into a visual picture. Think of this as the photo lab for a camera that uses film or your computer if you use a digital camera. Finally, the higher parts of the brain that deal with conscious thought perceive the visual image and can cause a response to it. This might include directing the arms to reach for an object, generating emotions of happiness or sadness, or causing the face to break into a smile, just as proud parents may beam when seeing a photograph of their beautiful child.

There are six muscles that steer the eye, which can be compared to the hands of the photographer who can point the camera in different direction. It is by means of these muscles that a person can "steer" her eyes toward whatever she wishes to see.

Refractive Errors: In Chapter 1, I introduced the term *refractive error*. It is now time to understand it better. A *refractive error* describes the situation when an eye is out of focus. It means that *myopia* (*nearsightedness*), *hyperopia* (*farsightedness*) or *astigmatism* is present. If we return to our analogy of a camera, a *refractive error* may be like having a perfectly good and perhaps expensive camera, but not focusing it properly. It is not a weak camera or a bad camera. It is simply a camera that is out of focus. Similarly, an eye with a r*efractive error* is not a weak eye. It is simply an eye that is out of focus. Eyeglasses contain lenses that can focus the image sharply on the *retina* and clear up blurry vision. Much as inches are used for measuring length, and pounds for measuring weight, the unit for measuring the strength of a lens is a *diopter*. The more *diopters* of power in a lens, the stronger (and thicker) it is.

An eye that has no *refractive error*, (has neither *myopia*, *hyperopia*, nor *astigmatism)*, is said to be *emmetropic*, or "neutral." This means, by definition, that when the focusing muscle of the eye (the *ciliary muscle*) is relaxed, the eye is in focus for far distant objects. Consequently if this same normal eye looks at something close up, the object will appear out of focus, or blurred. This is similar to using a camera that is set for distance focus to photograph a near object. The picture will be out of focus. Just as you would need to change the focus of the camera, the eye needs to change focus too. It does this through a process called *accommodation*. When an eye *accommodates*, the *ciliary muscle* contracts and changes the shape of the *crystalline lens* to make it more convex (or spherical) permitting clear focus for near viewing. *Accommodation* requires a certain amount of work for the eye. The ability to do this work gets progressively weaker as we age. It is the loss of *accommodation* that is responsible for the inevitable need for bifocals, or different glasses for distance and near viewing, when we are in our mid 40s. The loss of the ability to *accommodate* to permit clear near vision is called "presbyopia." In lay terms it is also referred to "the *farsightedness* of old age."

Hyperopia (Far-sighted): *A hyperopic or farsighted* eye is slightly shorter than normal. The distance between the back of the eye (the *retina*) and the front of the eye (the *cornea*) is less than in a normal eye. Consequently light rays entering the eye fall on the *retina* before they have traveled a sufficient distance to come into sharp focus. In lay terms this is referred to as "*farsighted*." However, this term is somewhat misleading when applied to children. A *hyperopic* or farsighted child has a strong ability to compensate for and overcome *farsightedness*, and can see clearly far and near. (see pages 27-29.)

Important Point: You may hear your child is "a bit *farsighted*." That does not mean she cannot see clearly at near, even though the term *farsighted* implies that. Perhaps you have been told that in spite of *farsightedness*, your child does not need glasses. That would be a proper recommendation for most children who are mildly *farsighted*.

Important Point: A slightly *hyperopic* (*farsighted)* child may still see clearly (but not **clearer**) with weak *hyperopic* glasses, even if he does not really need them. A mild *hyperopic* (*farsighted)* lens will still permit clear vision in a *hyperopic* child by doing some of the focusing for him. Normally he can compensate for mild *hyperopia* by *accommodating*. Unfortunately, many children are prescribed these mild reading lenses for non-specific symptoms such as headaches or difficulty with reading. If your child has been prescribed mild *hyperopic* (*farsighted)* glasses (under one and half *diopters*), does not feel they are helpful, and does not have *strabismus*, there is a good likelihood the glasses are unnecessary. You should consider a second opinion.

Question*:* My child is *farsighted*. How long will she need glasses?

Answer: One of the most important things I have learned in the years I have been in practice is to never try and predict the length of time a child will need glasses. The average child under 5 years of age is between 1 and 2 *diopters hyperopic* (*farsighted)*, and that is the normal situation. On average, children get a bit more *hyperopic* (*farsighted)* until about age 7, and then they begin to lose *hyperopia*. The average child loses about 1½ *diopters* of *hyperopia* between age 7 and the end of his growth years (approximately age 16). All of our existing information is, however, based on averages — and an average is just that — an average, rather than the expected. Some children lose more *hyperopia* (*farsightedness)* with growth and some less. I have cared for children who were 5 *diopters hyperopic* (that is a large amount) at one year of age, who were 9 *diopters hyperopic* (a **very** large amount) by their teenage years. I have also cared for children who were only 1½ *diopters hyperopic* when they were quite young, and who were exactly the same 10 to 15 years later. Finally, I have seen the occasional child who was as much as 6 *diopters hyperopic* when young, who completely outgrew it by adolescence. Such children are the exception. As a general rule, if a child is more than 3 *diopters hyperopic*, there is a reasonable likelihood she will need to stay in glasses indefinitely. If she is less than 2 *diopters hyperopic*, there is a reasonable likelihood she may outgrow the need of glasses.

Important Point: One exception is the presence of a marked asymmetry to the optics of the two eyes. Because a child's eyes often lose or gain *hyperopia* or *myopia* symmetrically, if she starts out with them being unequal, that inequality may remain. Because it is important that both eyes send equally clear images to the brain, such a child may need to continue with glasses indefinitely.

A *myopic* eye is an eye that is slightly longer than normal. The distance between the back of the eye (the *retina*) and the front of the eye (the *cornea*) is greater than in a normal eye. Consequently light rays entering the eye come into sharp focus somewhere in the middle of the eye, before they fall on the retina. In lay terms this is referred to as *nearsighted*. (see pages 29-30)

Question: My child is *nearsighted* and keeps needing stronger prescriptions each year. Should I be concerned about his eyes getting weaker?
Answer: It is very natural to think, "needing stronger lenses means his eyes are getting weaker." Actually, as described above, it is the shape and size of the eyes that determines the strength of the lenses needed for clear vision. In a sense, needing a stronger *myopic* lens is no different than you child needing bigger trousers this year as compared to last. Yet if he needs bigger trousers, we do not think of his legs getting weaker. I write this with full awareness of the concern parents have about their child needing strong glasses. I realize that we think of a child getting taller as something good, and we think of thick glasses as something bad. But at least as far as it being a sign of vision failing, the progression of *myopia* does not signify a serious problem. The only exception to this is when *myopia* reaches rather high levels (about 8 *diopters*) where the large size of the eye can be accompanied by stretching and thinning of the *retina*.

Astigmatism is when the front surface of the eye, the *cornea*, is more curved in one direction than another — more like a football than a round ball. *Astigmatism* will result in blurring of vision with both near and distance viewing.

The *refractive error* is the amount of *myopia, hyperopia,* or *astigmatism* that is present. It does not yet tell us what someone sees. It merely tells what type of lens is necessary to place an image in sharp focus on the *retina*, which is the first step in the vision process.

Question: I was told my son is *legally blind* without his glasses. Should I be concerned?
Answer: It is never correct to say someone "is *legally blind* without glasses," if his vision is normal with glasses. The term *legally blind* means that *visual acuity* is 20/200 or poorer (see page 28) when he is wearing the best possible glasses. A *visual acuity* of 20/200 means he can only read the large letter at the top of most vision charts from a distance of 20 feet. If someone only has that level of vision, and it cannot be corrected with glasses, there must be some eye disease such as a *cataract* or a *retina* problem affecting eyesight; it must be something other than a simple *refractive error (myopia, hyperopia or astigmatism).* Such an individual sees the world differently than a nearsighted person who is also 20/200 without their glasses, but can see normally with glasses. A person who only sees 20/200 because of nearsightedness, would still be able to see things clearly close up, such as when reading a book. Someone who is truly *legally blind* could not. Saying someone is *legally blind* without glasses, is misleading and alarmist if their vision is correctable with appropriate glasses.

Advanced Information
The *Macula:* One area in which the analogy of the eye to a camera breaks down is with respect to the *macula*. This is a very small area, about 1/4 of an inch in diameter, in the center of the *retina*. It is in direct line with the *pupil* and is the portion of the *retina* responsible for our straight-ahead vision. (see Figure 2-2). In the center of the *macula* is a pinpoint sized spot called the *fovea*. The *fovea* provides the very sharpest vision. When you look "at" something, its image is falling on your *fovea* and everything to the side of what you are looking "at" is seen with peripheral vision. Although the very center

of a photograph might contain the main subject of the picture, this area of photograph is not really the equivalent of the *macula*. With photography, the entire area of a picture can be equally sharp and clear. In the eye, the *macula* is the only part of the *retina* that is capable of perceiving an image that is sharper than 20/200.

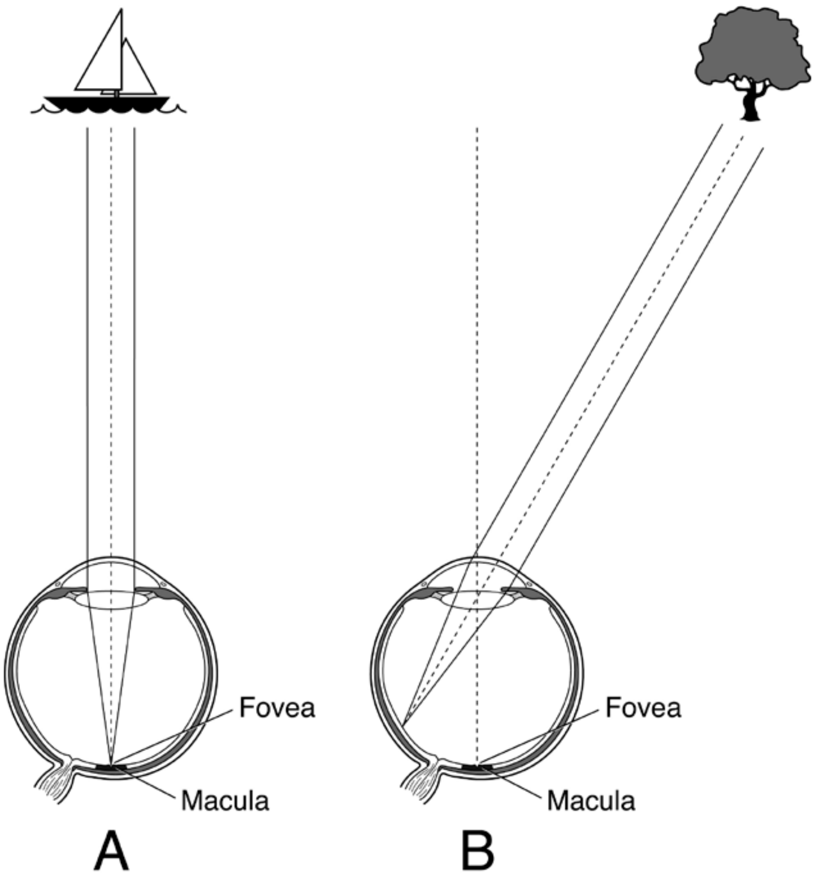


Fig 2-2 A) The light rays coming from the sailboat fall on the *fovea*. The image of the sailboat will appear sharp. B) The tree is not straight ahead of the eye, so it will be seen with peripheral vision. The light rays coming from the tree fall on the peripheral *retina* instead of the *fovea*. It will not be seen a clearly as the sailboat in Fig 2-2A.

Try This Experiment. If you need glasses, and they are the correct prescription for you, wear them while doing this experiment. Position yourself so you are facing something with writing on it, perhaps this book. Look at the words straight ahead of you. The words should be clear. Now look just to the side of the page. Without looking back toward the page, try and read the words with your peripheral vision. If you did this correctly, the words would be out of focus because their image was not falling on your *macula*. You have just experienced what *visual acuity* of 20/200 looks like!

Advanced Information

About Lenses: A convex lens is one that is thicker in the middle than at the edges. It will bend light rays so they converge behind the lens (see Figure 2-3A). Convex lenses correct for *hyperopia (farsightedness*) and are called "plus power" lenses. A concave lens is thinner in the middle than at the edges, and causes light rays to diverge (see Figure 2-3B). Concave lenses correct for *myopia* (*nearsightedness*) and are called "minus power" lenses. An *astigmatic* lens is one in which the front surface is curved like a football, rather than a round ball (see Figure 2-3C). Because the amount of curvature of a lens determines its strength, an *astigmatic* lens will focus horizontal lines differently than vertical ones. This type of lens corrects for astigmatism.

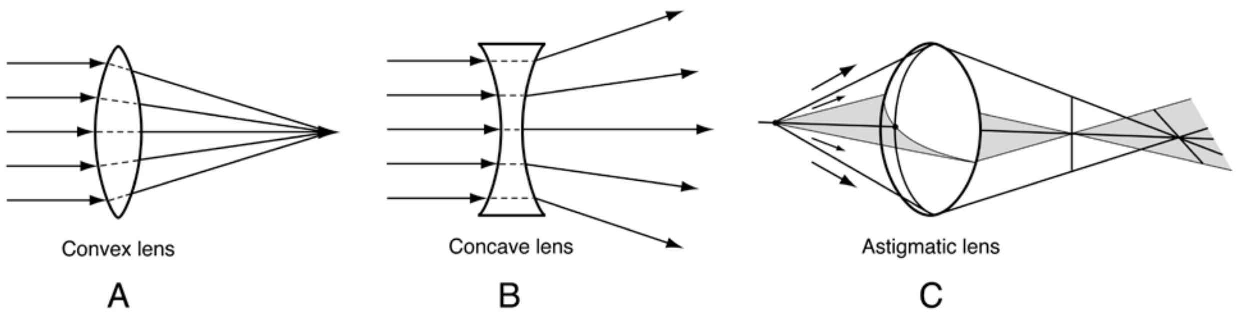


Figure 2-3 A) A convex (*farsighted*) lens causes light rays to converge. B) A convex lens causes light rays to diverge. C) This astigmatic lens has a front surface that is more curved horizontally than vertically (like the surface of a football). It will cause vertical and horizontal beams of light to come into focus at different distances behind it.

Advanced Information

More about *Emmetropia* (a "normal" or neutral eye): An eye is *emmetropic* if it has no refractive error. When an *emmetropic* eye is relaxed (not *accommodating*) it is in focus for far away objects (see Figure 2-4). If an emmetropic eye then looks at something close-up, the object will be blurred and out of focus unless the eye changes its focus by accommodating.

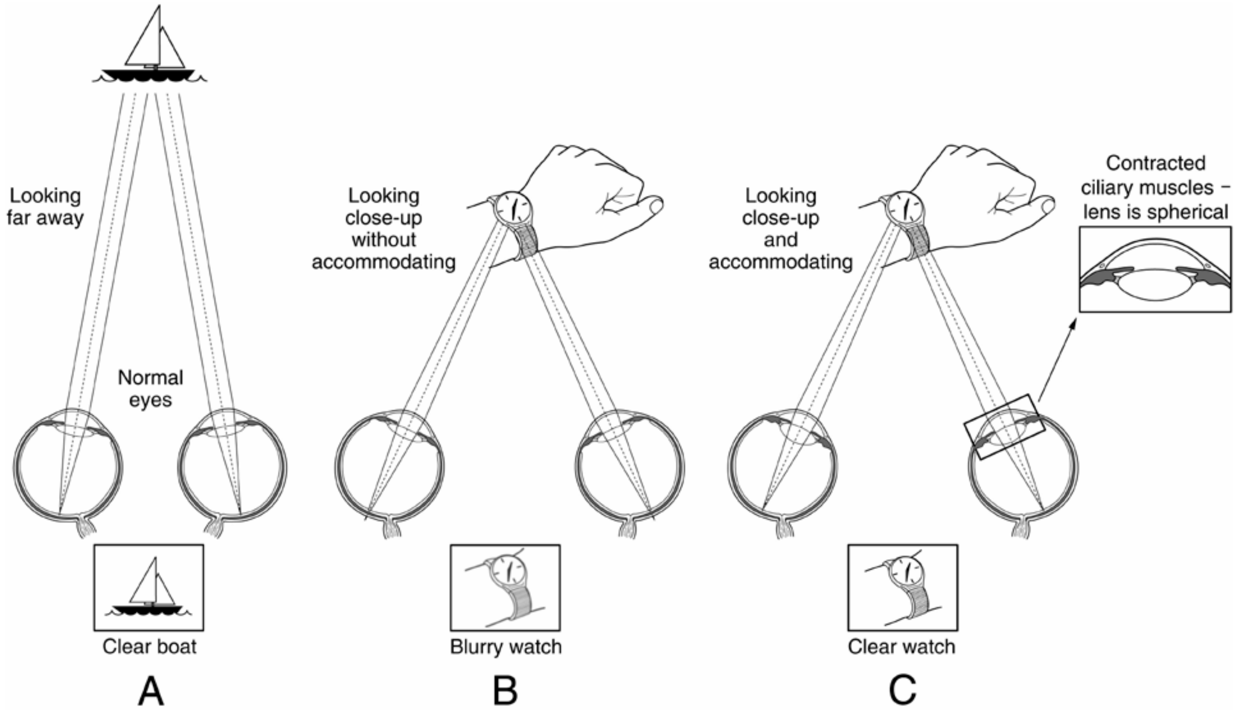


Fig 2-4 This shows the *emmetropic* or "neutral" eye. A) In the relaxed state it is in sharp focus for distant objects. The sailboat would be seen clearly B) The image of a near object would impinge on the retina of a neutral eye before it comes into focus if the *ciliary muscle* is relaxed. The point at which the image would be focused lies somewhere behind the *retina*. C) If the focusing muscle contracts and makes the shape of the lens more convex, the image of a near object will be sharply focused on the retina resulting in a clear picture.

Advanced Information

More about *Hyperopia (Farsightedness)*: In the relaxed state, the image of a far distant object is not in focus on the retina but would come into focus somewhere behind the retina (see Figure 2-5). Depending on the amount by which the eye is out of focus, and the age of the person, a *hyperopic* (*farsighted)* eye can clear up the image of a distant object by *accommodating*. If the amount of *hyperopia* is great, or the ability to *accommodate* is decreased due to older age, a convex lens in front of the eye will serve the same purpose as *accommodation* in sharpening the focus of the object on the *retina*. For near viewing, even more *accommodation* is necessary to sharpen the image.

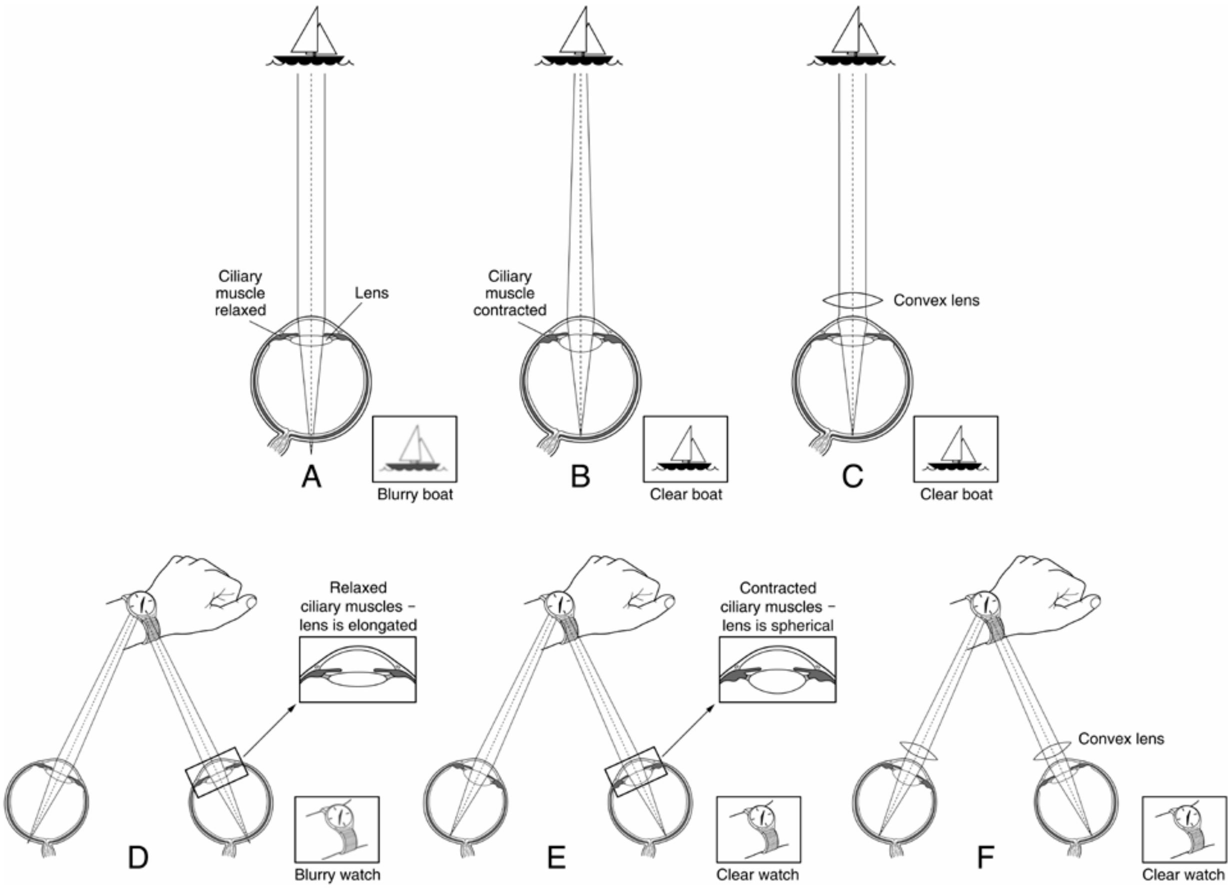


Fig 2-5. A) Distant objects would not be in sharp focus on the retina in a hyperopic eye if the ciliary muscle is relaxed. They would be in focus behind the retina. B) If the focusing muscle contracts and makes the shape of the lens more convex (*accommodation*), the image of distant objects will be sharply focused on the *retina* resulting in a clear picture. C) If the eye does not have the ability to *accommodate* sufficiently to correct for *hyperopia*, either because of a large amount of *hyperopia* or older age, a convex lens in front of the eye will serve the same purpose as *accommodation* and bring the image in sharp focus on the *retina*. D) The image of near objects would be even more out of focus on the retina of a *hyperopic* eye when the ciliary muscle is relaxed. The point at which they would come into focus lies even further behind the retina than for distant objects. E) *Accommodating* even more than is needed for distance viewing will place the images of the near objects in sharp focus on the retina of a *hyperopic* eye. F) If the eye does not have the ability to *accommodate* sufficiently to correct for *hyperopia,* or cannot perform the additional *accommodation* needed for near viewing, either because of a large amount of *hyperopia* or older age (presbyopia), an even stronger convex lens in front of the eye is needed to bring a near image in sharp focus on the retina. Thus if a person needs a different spectacle lens for distance and near viewing, a bifocal is needed.

Thus for the *hyperopic (farsighted)* eye, near viewing requires more effort than distance viewing, but vision is not necessarily worse for viewing near objects. A young person who is *hyperopic (farsighted)* may see well at distance and near without glasses, because she can easily compensate for *farsightedness* (by *accommodating*). With increasing age and decreasing ability to *accommodate*, a *hyperopic (farsighted)* person will first notice problems with near viewing, where more *accommodation* is needed. Later, as the ability to *accommodate* gets even less, a *hyperopic (farsighted)* person will need glasses to help with distance viewing also.

Most children are actually a small amount *hyperopic (farsighted)*, about 1-2 *diopters*. This is the normal situation. Most children do not need glasses to correct it, because they can easily *accommodate* and completely compensate for this amount of *hyperopia*.

Advanced Information

More about *Myopia (Nearsightedness)*: In a *myopic (nearsighted)* eye, the image of a distant object is in sharpest focus somewhere in the middle of the eyeball, in front of, rather than on the *retina*. Consequently, objects in the distance appear blurred. (see Figure 2-6) Near objects, however are already in focus on the surface of the retina when the eye is relaxed and will be seen clearly without glasses.

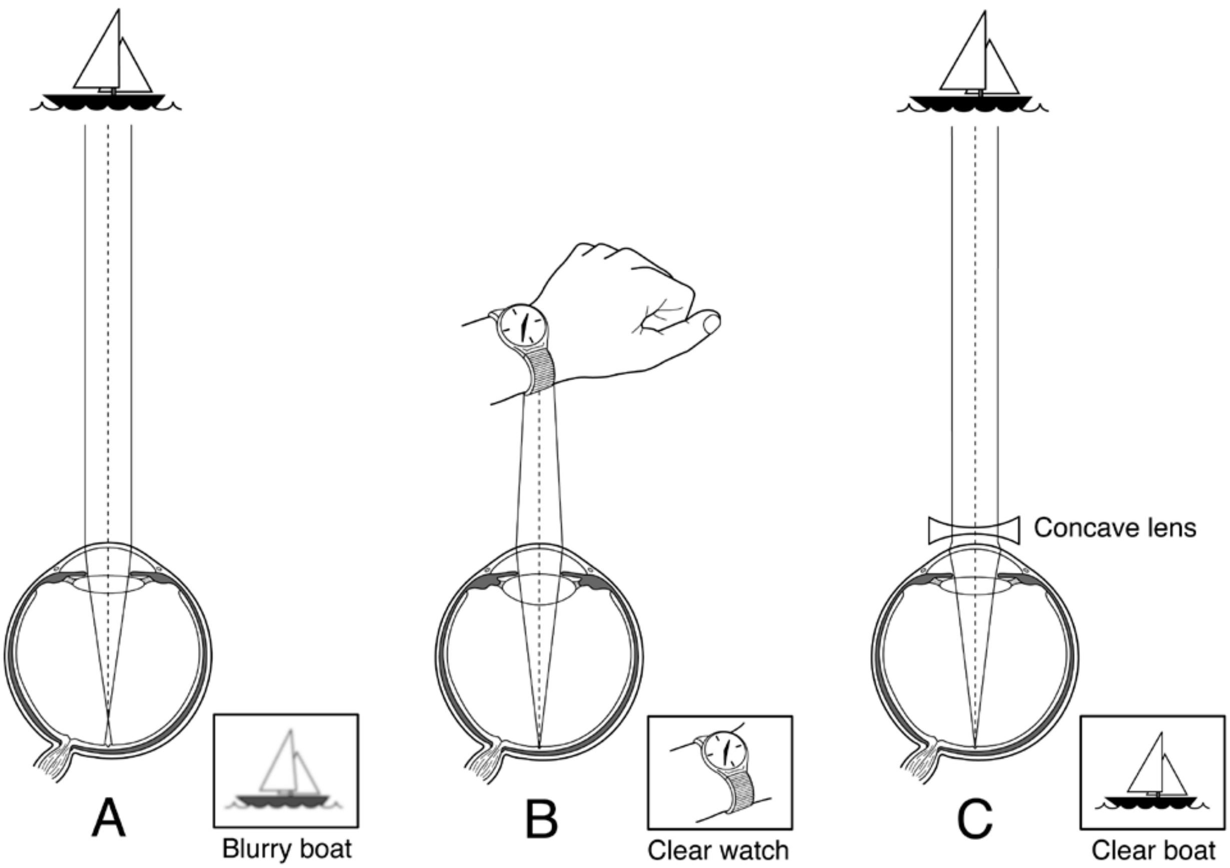


Fig 2-6 A) A *myopic* is an eye that is too long for its lens power. The image of distant objects is in focus in front of the *retina*. B) Objects viewed at near with a *myopic* eye are in focus on the *retina* when the eye is relaxed (*accommodation* is not needed). C) A concave lens in front of a *myopic* eye will place distant objects in sharp focus on the *retina*.

That is why a *myopic* person is said to be *nearsighted* (has "near sight"). *Accommodation* is not needed in a *myopic (nearsighted)* eye for viewing objects close up. The amount of *nearsightedness* determines the distance from the eye at which objects will appear with greatest clarity. The reason that middle aged people who are *myopic (nearsighted)* take their glasses off to read close-up is because their eyes are already in focus for near without having to do the very thing they have difficulty with — *accommodating*. When it comes to distance viewing, there is no equal but opposite process to *accommodation* which could cause the light rays entering a *nearsighted* eye to diverge and be in focus on the *retina*. A concave lens in front of the eye is necessary to sharpen the focus for distance.

Because a *myopic (nearsighted)* eye is an eye that is too long for its lens power, *myopia* tends to get worse as a child grows — the eye grows as the body grows. Usually the increase in *nearsightedness* tends to level off at the end of the growth years, typically around age 16.

Advanced Information

Armed with an understanding of the different types of *refractive errors*, we can understand the different components of a spectacle prescription. This is an example of a hypothetical prescription:

	Sphere	Cylinder	Axis	Add
OD	+2.25	+ 1.00	axis 180 degrees	+2.00
OS	+3.00	+ 1.00	axis 30 degrees	+2.00

The abbreviations OD and OS are common medical terms derived from Latin to stand for the right and left eyes respectively. The first number is called the **sphere**, which describes the amount of *myopic (nearsighted)* or *hyperopic (farsighted)* correction. In the above example, the right eye has two and quarter *diopters* of plus or *hyperopic* (*farsighted)* power. The left lens (OS) has 3 *diopters* of power (see Figure 2-7 for an example of how such a pair of spectacles would be constructed.) The second number is the **cylinder**. It represents the amount of *astigmatism.* For our hypothetical patient, each eye has one *diopter* more *hyperopia (farsightedness)* in the plane with the greatest amount of *hyperopia* than in the plane with the least. The third entry is the **axis**, which describes how the cylinder should be oriented to have the *astigmatism* correction in the lens match that of the eye. This number is much like the markings on a compass which indicate direction in degrees. If you were to think of a lens in a pair of glasses as being like a clock dial (see Figure 2-7A) zero degrees corresponds to the location of 3 o'clock, ninety degrees corresponds to 12 o'clock, and one hundred eighty degrees corresponds to 9 o'clock. In the example above the orientation of the cylinder, which corrects the *astigmatism* in the right eye, should be running horizontally at the 180 degree location. In the left eye, the axis is at 30 degrees. That means it is 30 degrees counterclockwise from the horizontal orientation, or located at the two o'clock location. The number denoting the astigmatism axis has nothing to do with whether the astigmatism is worse in either eye. The lenses just need to be oriented differently. This prescription is for bifocal glasses, which means it will include an additional correction for near viewing called the **add**. The above prescription calls for 2 diopters of additional *hyperopic* correction in the bifocal segment.

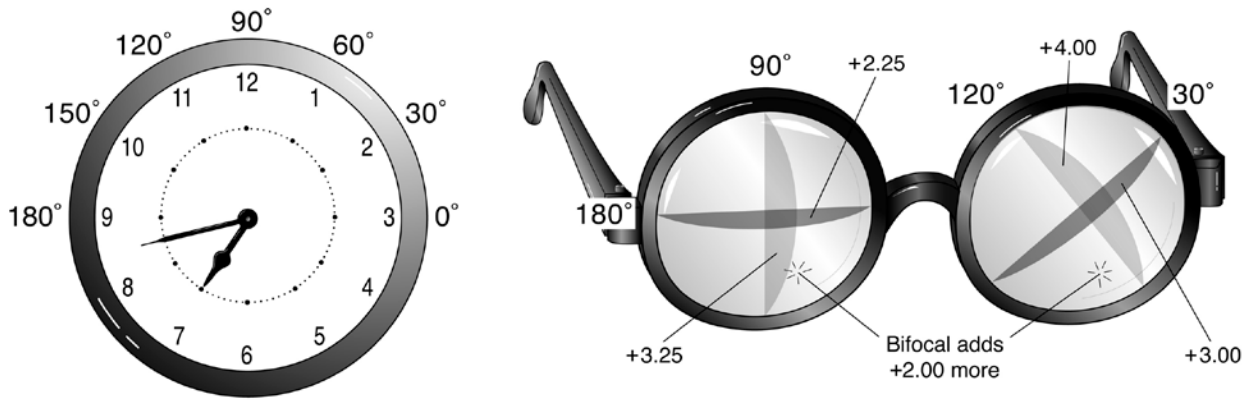


Figure 2-7 A) this depicts a clock dial, with the corresponding location of the convention to denote degrees in a spectacle lens. For example, if a cylinder (*astigmatism correction)* was oriented between the 2 and 8 o'clock position, it would be designated as being at 30 degrees. B) This pair of glasses contains the above described hypothetical prescription. In the right lens (which is seen to your left when you are looking at the picture), there are 2.25 *diopters* of plus (*hyperopic*) power in the lens. There is also 1 *diopter* of *astigmatism*. For reasons that are complex and beyond the scope of this book, a cylinder lens (*astigmatic lens)* actually adds power 90 degrees from its orientation. Because there is one *diopter* of astigmatism at axis 180 degrees, there is an additional one *diopter* (for a total of 3.25 *diopters*) in the 90 degree position (which is 90 degrees clockwise from the 180 degree orientation. Consequently the above picture shows +3.25 *diopters* in the thicker shaded cross-section that runs to the 90 degree location. Also, there is an 2 additional *diopters* in the bifocal add portion of the lens. The left lens contains 3 *diopters* of plus (*hyperopic*) power, with and additional 1 *diopter* of cylinder at the 30 degree position (which would correspond to 2 o'clock.) This puts the orientation of the +4.00 *diopters* of correction (the +3.00 of sphere plus an additional +1.00 of cylinder) at 120 degrees (or 11 o'clock).

Now that we have learned how an individual eye sees, we can move on to the fascinating process of how the eyes team together.

Chapter 3
Teamwork of the Two Eyes

How do our eyes coordinate together as a team? It is a truly fascinating process.

Basic Information

Fusion of Images from the Two Eyes:
Humans have what is called *binocular vision*, which means you see one image of the world even though you have two eyes. By a process know as *fusion* your brain makes one picture out of the two (one coming from each eye), and you only perceive one image. (see Figure 3-1)

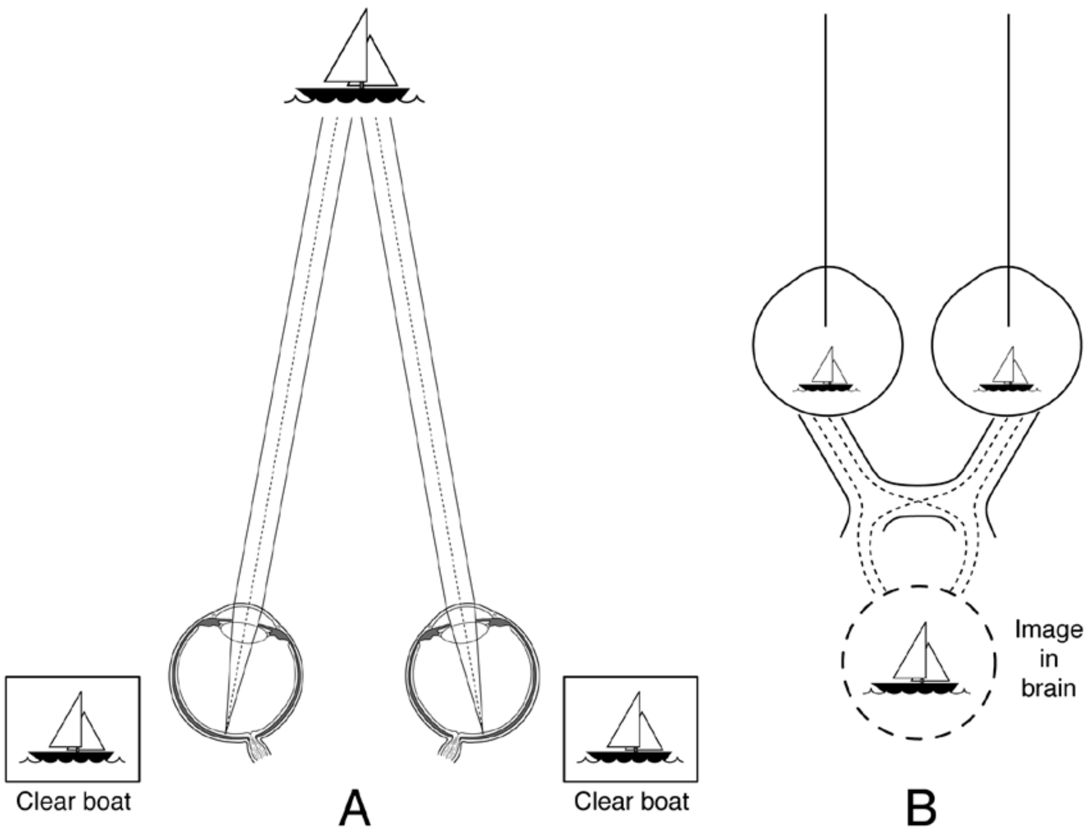


Fig 3-1 The process of fusion. A) Both eyes are looking straight ahead at a sailboat. An image of the sailboat is formed on the retina of each eye. B) The two images of the sailboat, one from each eye, are sent back to the brain. The brain then puts the two pictures together to make one picture through a process known as *fusion*.

What is Necessary for Fusion to Occur?

In order for *fusion* to occur, both of your eyes need to be looking directly at the same object at the same time. Let us assume it is the sailboat shown in Figure 3-1. This means that the line of vision from each of your two eyes must meet at the sailboat, and the image of the sailboat is falling on the center of your *retina (the fovea)* of each of your eyes. Because your two eyes are approximately 2½ to 3 inches apart, they each see the sailboat from almost — but not exactly

— the same angle. Consequently your two *retinas* each receive a slightly different picture of the sailboat. Both pictures are sent back to your brain, which blends the two pictures into one through a mental process called *fusion*, and you only see one boat. This is just as though two cameras are each taking a picture of the same object at the same time from almost the same point. The pictures are so much alike you can scarcely tell them apart from one another. This is what actually happens because each of your eyes works like a camera.

In addition, *fusion* is aided by the images from each eye being equally clear. If the images of the sailboat in each eye are too different — for example the image from one eye is clear and the other very blurred, or if your two eyes are not looking at the same object (one eye looking at the sailboat and the other eye looking at something else) your brain cannot *fuse* the two different images. In this situation your vision might either be blurred or double — you would see two of everything. Small things, like the print on this page would be particularly difficult to make out. The double images would be almost impossible for you to read. The process of *fusion* is not present at birth but develops gradually in early childhood.

What Makes Eyes Move?

If you are suddenly distracted to another object, your eyes may shift away from the sailboat. You may turn your head, but you do not have to. Your eyes can shift to the right or left without any effort or thought on your part. This happens very rapidly — as automatically as the movement of your eyes across this page as you read. But what actually happens?

Eyes move because the brain tells them to, either consciously or subconsciously, by instructing the *extraocular muscles* (so called because they are muscles that are on the outside surface of the eye) to relax or contract. Each eye has six of these muscles. (see Figure 3-2).

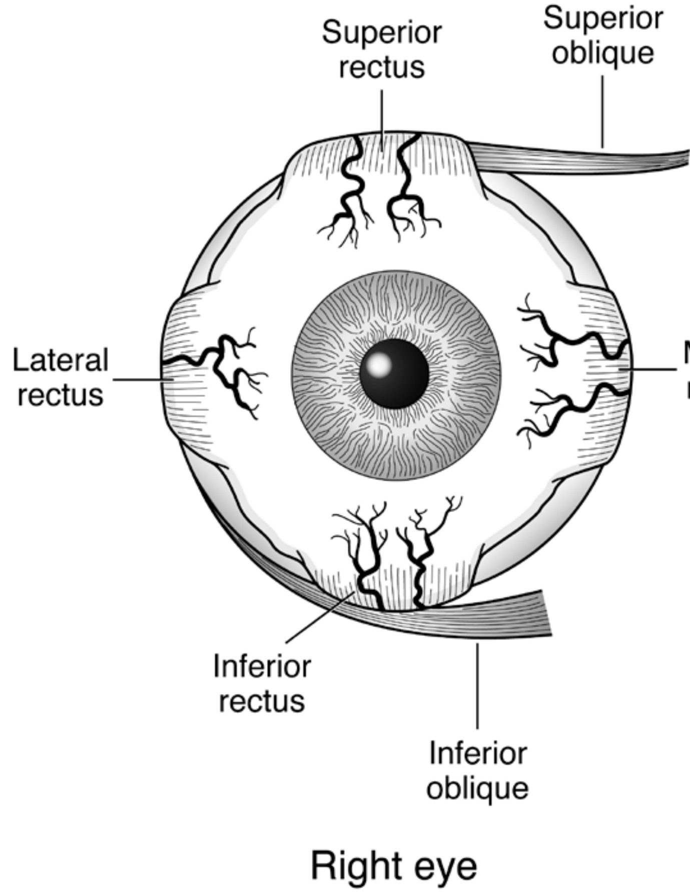


Fig 3-2 The location of the six extraocular muscles of a right eye. The medial rectus rotates the eye inward toward the nose. The lateral rectus rotates the eye outwards toward the ear. The superior rectus and the inferior oblique muscles rotate the eye upward. The inferior rectus and the superior oblique muscles rotate the eye downward. These muscles are on the surface of the eye under the white layer of *conjunctiva*. The 4 rectus muscles are approximately 4 to 8 millimeters back from where the white meets the colored part of the eye; the 2 oblique muscles lie farther back.

There are three major nerves that come from the brain to these muscles and control their function. When the brain directs the eyes to look at something, the proper muscles for the desired movement immediately pull on the eyes to change their direction of gaze so that the image of the particular object is falling on the *fovea* in each eye. This process occurs automatically and in fractions of a second.

The Eyes as a Team

The movement of the two eyes as a team can be aptly compared to a team of horses. See Figure 3-3. The muscles move the eyes in the same way that reins are used to pull on the horses' heads to make them turn. If you can imagine each horse having three reins running to each side of its head, you will have a fairly good picture of how the extraocular muscles move the eyes. Each horse in Figure 3-3 has a total of six reins to control its the direction of its head, one to turn right, one left, two to pull it upward, and two to lower it. If you want to turn a horse to the right, you pull on the reins on the right side of the horse's head.

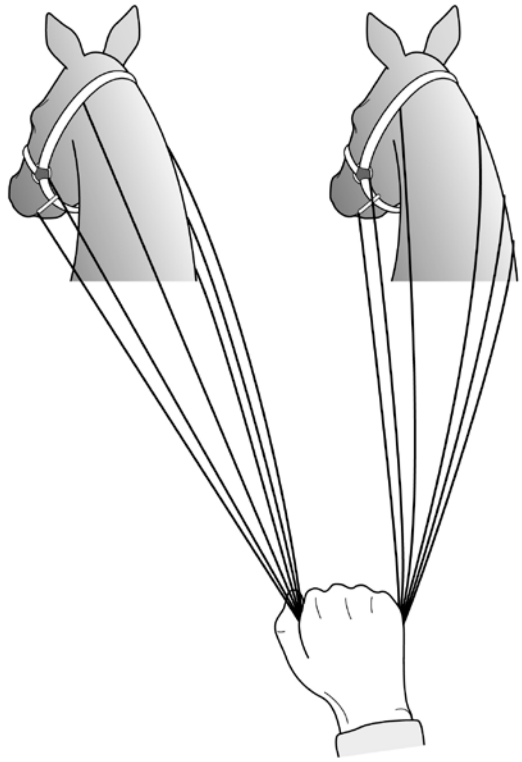


Fig 3-3 In this team of horses each horse has three reins running to each side of its head instead of the usual single rein. Keeping each horse facing exactly the same direction is difficult, because it is necessary to pull equally on the proper reins at the same time. Just as the reins turn the horses' heads, each eye is controlled by six extraocular muscles, which pull the eyes to turn them in specific directions. The very accurate ability of the eyes to team together seems even more remarkable when one realizes what a complicated mechanism is involved.

The six muscles attached to each eyeball move the eyes much as the reins turn the horse's head in Figure 3-3. One muscle moves each eye up and to the right, another moves it directly to the right, still another down and to the right, and so on. If someone wants to look straight up, two muscles in each eye must act to achieve the exact direction desired.

If we are to maintain *fusion*, the two eyes must move at exactly the same time, speed, and direction. *Fusion* is the tie that binds the lines of vision together and helps keep the eyes parallel. This is a very complicated process, so it is not surprising that it can sometimes go awry.

Convergence* and *Divergence

In addition to surveying the environment to the right, left, up, or down, the eyes can move quickly from far objects to near objects and back again. As we shift our gaze from a distant to a near object, our eyes, and consequently our line of sight, must come together if both eyes are to see the same object. This normal process is called *convergence*. Figure 2-4 on page 27 shows how the eyes must converge as they shift their gaze from a sailboat in the distance to a wristwatch close-up). In addition, if each eye individually is to see the object clearly it must change its focus from distance to near by *accommodating*. Recall the comparison of a camera that needs to have its focusing dial adjusted according to the distance to the subject. It turns out that because eyes need to both *accommodate* and *converge* as we look at near, nature has wisely connected those two processes. Whenever we *accommodate*, we *converge* our eyes just the right amount to have both eyes pointing at the object on which we are focusing. This is an automatic reflex that occurs without our thinking about it. In normal individuals, this reflex is helpful as it synchronizes the line of sight of the two eyes, and at the same time it ensures clear vision in each eye. But as we shall see later, the reflex can lead to problems in a child with a *crossed eye* (an eye that deviates inward toward the nose).

As we look from a near object to a distant one, the lines of vision must move apart. This normal process is called *divergence*. (See again Figure 2-4 on page 27). If gaze is shifted from the wristwatch close-up to the sailboat in the distance, the lines of sight would need to move apart — or diverge).

Suppression

Just as throwing a switch can turn off the ceiling light, the brain can shut off all or part of the image coming from one eye. This process is called *suppression* and occurs as a helpful means to prevent the annoying symptom of *diplopia* (the medical term for *double vision*). When an eye is being *suppressed*, there is no obvious external sign that *suppression* is occurring. *Suppression* takes place entirely within the brain. Although the ideal situation is to have both eyes seeing and *fusing* the same object, *suppression* may be a preferable alternative to *double vision*.

The Relationship between *Suppression* and *Fusion*

Having *fusion* is not an all-or-nothing situation; it is not that you either have it or you do not. There are different degrees or grades of *fusion*. For example, many people with *strabismus* have what is called peripheral *fusion*. The brain is able to *fuse* most of what they are looking at, but may shut off or *suppress* the central few degrees of the image from one eye. Imagine having two identical movies being projected on a screen, however on one there is a pinhead-sized black spot covering up the center of the projector’s lens. If you project these two movies at the same time, and line them up so the two images exactly superimpose, the movie showing on the screen would look normal. The center of the screen would not reveal the black dot from the spotted projector, because the image from the normal projector would fill in that area. This is analogous to peripheral *fusion*, where the image seen from the normal eye fills in the small area in the center of vision that is suppressed by the other eye. Even though peripheral *fusion* is not perfectly normal, having it is more helpful than completely suppressing one eye. For one thing, peripheral *fusion* expands our field of peripheral vision. You can appreciate this for yourself.

Try This Experiment. Look straight ahead at something on a wall or in a landscape. Keep looking at the same object but close your right eye. You will immediately observe that you do not see as far to the right (remember to keep looking at the original object), because you have shut off some of your peripheral vision. Now open both eyes while you continue to look at the straight ahead object. Notice how much further you can see in the right periphery. This is analogous to the day-to-day benefit of having peripheral *fusion*. In addition, having peripheral *fusion* helps keep eyes well aligned in individuals with *strabismus* as years pass.

Depth Perception

There are many mechanisms by which we judge depth. Some mechanisms require perfectly normal binocular *fusion,* and some can occur without any binocular *fusion*.

Try This Experiment. Close one eye and hold your hand at arm's length in front of you. It should be easy to tell that your hand is closer to you than the wall behind it. That is because your hand overlays the image of the wall and not the other way around. This is an example of a "monocular" (one-eyed) clue for judging depth, which does not require any *binocularity*.

The most complex form of depth perception, and the one that requires nearly normal binocular *fusion*, is *stereopsis* — the type of depth perception you can appreciate when wearing 3-D glasses. Looking at an object with two eyes is like taking two pictures of the same object at the same time with two cameras placed side by side. The two pictures are almost identical, but no matter how closely together the cameras are placed, the pictures will never be exactly alike. They are taken from slightly different angles. In the same way, the images of objects in the world around you are seen by your eyes from slightly different angles. When your brain receives these subtly different pictures, it not only *fuses* them, but gains information about their slight differences. This information conveys an appreciation of the relative distances of various objects through the process called *stereopsis*. *Stereopsis* is also not an all-or-nothing phenomenon. Your level of *stereopsis* can be graded by how subtle a difference in the distance between objects you can detect. In general, *stereopsis* is more useful for judging depth for very close objects — within several feet of us. It plays less of a role in judging depth for far distances such as are encountered while driving a car or for playing sports.

Myth: If your child does not have *stereopsis*, he does not have depth perception.
Fact: *Stereopsis* is only one of many mechanisms by which people judge depth. Even people who only have one eye, and hence have no *stereopsis*, may have excellent ability to perceive depth.

Question: My child does not have normal *stereopsis*. How will this limit her?
Answer: Practically speaking, she can engage in most activities and occupations successfully despite a lack of *stereopsis*. Many children without stereopsis excel in sports. In fact there are numerous world-class professional athletes who have no *stereopsis*. Also, there are many excellent surgeons who do not have *stereopsis*. There are however, certain occupations for which there are regulations preventing individuals without *stereopsis* from obtaining licensing or certification. These include flying a commercial airplane and professionally driving a truck on the interstate, to name a few. Many of these regulations are outdated and not backed up by sound reasoning. Hopefully they will be changed

in the future. For example, *stereopsis* mainly helps us when objects are within about 3 or 4 feet of us. If a pilot of an airplane had to wait until an oncoming airplane was that close to judge its distance, she would have waited too long!

Question: My daughter has no *stereopsis* but seems to have no difficulty in performing fine motor tasks. My own eyes are normal. In order to experience what she sees and how she judges depth, I tried covering one of my own eyes and performing tasks. I had a hard time judging depth. How does she function as well as she does?

Answer: It is true that individuals who have gone their whole life with normal *stereopsis* learn to rely on it and miss it if they lose it. A person who never had *stereopsis* from early childhood is entirely different. Because she began learning to judge depth using monocular clues from early in her development, she functions quite well without *stereopsis*.

Question: I am an adult with a misaligned eye. My doctor said I have little chance of obtaining *stereopsis* if I have my eyes straightened. Is the surgery "cosmetic only?"

Answer: In most cases, adults with longstanding *strabismus* have an excellent chance of obtaining some improvement in binocular function if their eyes are straightened. Just because it may not result in perfectly normal *binocularity* or *stereopsis*, that does not mean there is no functional benefit.

Question: My son's eye crosses intermittently. What does he see when that happens.

Answer: A person will experience one of several things when an eye deviates. If the problem is of recent onset, he may see double. He often compensates for this by closing one eye to eliminate the annoying second image. Alternatively he may *suppress* (or shut off) the second image. In children, *suppression* instead of *double vision* may be present at the onset of an eye muscle problem. Sometimes *double vision* is present initially and is replaced by *suppression* weeks to months later. The older the child, the longer it takes *suppression* to replace *double vision*. If the eye misalignment begins after about age 9 or 10, the child's brain may no longer have the flexibility to learn to *suppress*, and *double vision* may remain until the *strabismus* is corrected. Some older patients experience a "pulling" sensation, a feeling of eyestrain, or blurred vision when an eye deviates.

Question: Is *suppression* bad?

Answer: We can view *suppression* as nature's useful way of adapting to the abnormal situation of misaligned eyes. If the brain is perceiving the image from each eye as it normally should, and your eyes are seeing two different things, you would see double — which can be very annoying. So the development of *suppression* allows you to avoid this unpleasant experience. In this situation, although *suppression* represents an adaptation to an ocular misalignment, it is beneficial.

Advanced Information

More about Alternative Mechanisms for Depth Perception: "Parallax" is another mechanism we use for judging depth that does not require *fusion*. To understand parallax, again close one eye and hold your hand at arm's length in front of the other eye. If you move your head very slightly from side to side you will see that your hand appears to move across the wall behind it. This also allows us to know that our hand is closer than the wall. Other monocular clues for depth perception include the comparative size of objects, shadows and colors.

Chapter 4
About Strabismus and Why Eyes Are Sometimes Misaligned

Basic Information: The realization that your child has *crossed eyes*, or some other eye muscle imbalance, may come as quite a shock to you. Unfortunately, your hope that the *crossed eyes* will go away, or the belief that it is normal for a baby's eyes to cross may delay diagnosis and treatment of the problem. Also, *strabismus* is not always obvious in its early stages when it should ideally be diagnosed and treated.

The Development of Eye Muscle Control

A newborn baby lacks control over muscle function of many parts of the body. For example, a baby moves his legs at random, but he cannot coordinate their movements together sufficiently to walk. Similarly, although a newborn can move both eyes, he may not have good control over how they team together. Consequently, he may not always have perfect alignment of his eyes. Most commonly this is noticed when he changes his direction of gaze. One eye may momentarily overshoot or undershoot its intended position, and his eyes may seem momentarily misaligned. Because a newborn's vision is also not yet fully developed, he may have periods in which he is visually inattentive. During those times, his eyes are apt to be in a slightly divergent (wall-eyed) position. If an infant's eyes are misaligned for brief periods (several seconds at a time), are only slightly misaligned, and the problem appears to be improving, he may outgrow the problem.

An infant's vision and ability to control his eye muscles develop rapidly. Many babies can track objects smoothly with their eyes properly aligned by 3 or 4 months of age. If a child cannot do so by 6 months of age, parents should have him examined. Children who have even a slight or intermittent misalignment of an eye that continues past six months of age should visit an eye doctor as soon as possible. A misaligned eye may have some serious defect that prevents it from seeing clearly and staying properly aligned with the other eye. If a child does not have good and equal vision in each eye, he cannot fuse the two images and one eye may deviate. Early recognition of this difficulty may lead to prompt diagnosis of a disorder of the *retina*, *optic nerve*, or *crystalline lens*. Sometimes recognizing these problems as early as possible can be important for not only the child's visual health, but also for his general health. For example, prompt recognition of certain *retinal* tumors that can occur in babies may not only be vision-saving, but life saving. An *ophthalmologist*, who is a medical doctor specializing in diseases and treatment of the eye should be consulted because she is the most qualified person to recognize the specific nature of the problem, and has all the treatment modalities at her disposal. In my experience, most family doctors or pediatricians do not have the equipment or training necessary to adequately examine the inside of a baby's eyes to determine if such problems are present.

Pseudostrabismus

Many babies may appear to have a *crossed eye* when in fact no problem exists. This situation is called *pseudostrabismus*. (A false appearance of *strabismus* when in fact, the eyes are properly aligned). *Pseudostrabismus* is generally caused by a baby having rather narrow set eyes and a wide bridge of the nose. Normally when you look at someone, you see a substantial amount of white on each side of the colored part of the eye. In a child with *pseudostrabismus*, the small fold of skin in the inside corner of the eye covers much of the white of the eye. This alters our perception and makes it appear that the eye is turning in (see Fig 4-1).

A

B

Fig 4-1 A) A photograph of a baby with *pseudostrabismus*. Although in this picture it appears as though his left eye turning inward, it is in fact perfectly aligned with his right eye. This normal child is merely looking slightly to his right. His wide bridge of the nose covers most of the adjacent white of the left eye, giving the false appearance of *strabismus*. One way your doctor can tell that the eyes are properly aligned is by studying the reflection of a light in the pupils. If the eyes are pointing in the same direction, the light reflection (in the above photograph it is created by the camera flash) will be symmetrically positioned in the two eyes as seen in this photograph. B) A photograph of a baby with a crossed right eye. Note that the light reflections from the camera are not symmetrically located in the two eyes. The right eye is turned in.

Myth: All babies are normally *cross-eyed*.
Fact: Some babies have the appearance of *crossed eyes* due to their facial structure (*pseudostrabismus* — described above). But studies have shown that if a baby's eyes are truly and substantially crossed he almost never outgrows the problem.

Types of Strabismus

The word *strabismus* is an umbrella term to describe all types of eye misalignments. There are basically four ways eyes can be out of alignment with one another. If one eye turns in (crosses inward toward the nose), the *strabismus* is called *esotropia*. If one eye turns out ("wall-eyed", or pointing laterally toward the ear), the condition is called *exotropia*. If one eye turns up or down, the problem is named *hypertropia* or *hypotropia* respectively. Figure 4-2 illustrates these different conditions. Each of these types of *strabismus* may either be constantly present, or only present intermittently. In the latter, case they are called "intermittent *esotropia*, intermittent *exotropia*," etc.

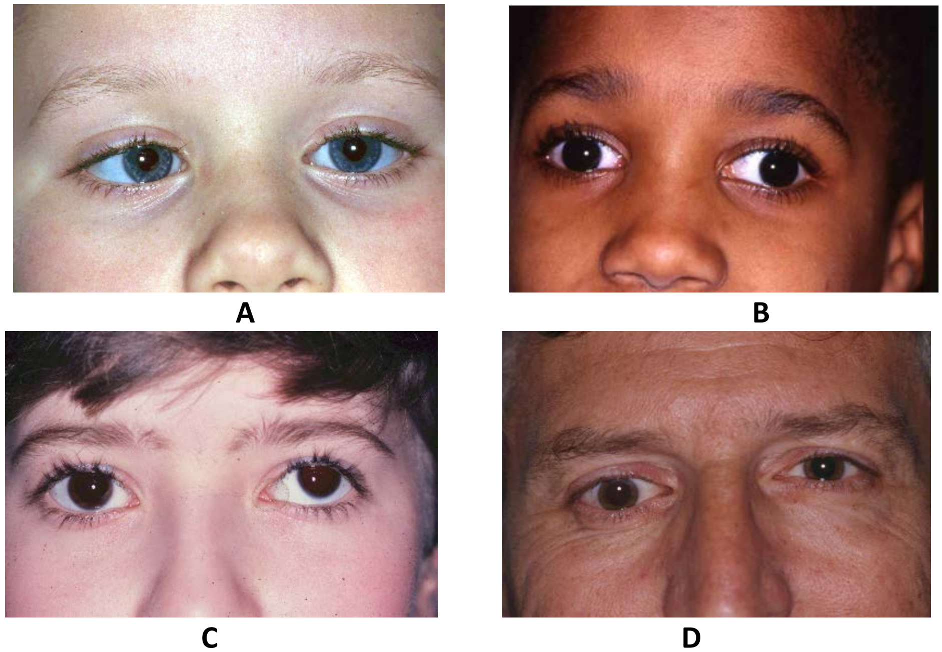


Fig 4-2 Types of *strabismus*. A) *Esotropia* (right eye is turned in towards nose). B) *Exotropia* (left eye is turned out toward ear) C) *Hypertropia* (left eye is turned upward). D) *Hypotropia* (right eye is turned downward).

Question: Only one of my child's eyes turns inward toward the nose. They do not both cross at once. Does she have *strabismus*?
Answer Typically when a child has *strabismus*, only one eye deviates at a time. In some children it is always the same eye, and in others the problem may alternate between the two eyes. Your child does have *strabismus*. Specifically she has *esotropia*.

Why Are My Child's Eyes Crossed?

There is no uniform answer to why a particular child's eyes are misaligned. The most common cause is heredity. That means the problem "runs in the family" and is inherited. In approximately half the children with strabismus, a similar problem is present in siblings, parents, or grandparents. Sometimes a child may inherit certain factors from their parents that may result in strabismus, even if both parents have normal eyes. (See Figure 4-3)

A **B**

Figure 4-3 A) These two girls are mirror image identical twins. The twin on your left in the photo has a right eye that is turned in. Her sister, on your right in the photo has a left eye that is turned in. B) Both girls required glasses which essentially had identical prescriptions. With their glasses on, their eyes were properly aligned.

Because control of the eye muscles is such a complicated task, it is common for *strabismus* to occur in children who have neurologic abnormalities. Similarly, certain illnesses during pregnancy such as German measles, the taking of certain medications, or the consumption of alcohol may affect the development of a baby's brain. In these cases *strabismus* does not occur as an isolated abnormality but is accompanied by other signs of brain dysfunction. When *strabismus* occurs in conjunction with other neurologic problems, it will take a skilled physician to determine the cause.

However, barring accidents, injuries, serious illness, or neurologic conditions, there is usually no specific reason known to explain the occurrence of *strabismus* in the half of cases in which *strabismus* is not hereditary. Fortunately, once the condition is recognized there is much that can and should be done to correct it.

Question: Is it our [the parents'] fault that our child's eyes are crossed, and is there anything we could have done to prevent it?
Answer In the vast majority of cases the answer to these questions is "no!"

Question: My 5-year-old son has a *lazy eye*. Is it important to have his 2-year-old sister examined? Her eyes appear normal.
Answer The tendency for a *lazy eye* frequently runs in families (is hereditary). Even though no person in your family except your son has been diagnosed as having a *lazy eye*, your other children are at increased risk for developing *strabismus* or *amblyopia*. Although your daughter appears normal, she may have *amblyopia* (poor vision in one eye only — see chapter 5). In that case, it would require an examination by an eye doctor to detect the problem.

Important Point: If you have one child with a *lazy eye*, your other children should have a complete examination by an eye doctor at 6 months of age even if you do not observe a problem.

Question: My baby's eye is crossing. What is the likelihood she has some kind of tumor?
Answer: Fortunately, brain tumors or tumors within the eye are very rarely the cause of eye muscle problems in children. Nevertheless, although the likelihood of a tumor causing *strabismus* is small, all children with a *lazy eye* should be examined by an eye doctor to determine if there is a specific medical cause for the eye problem.

Eyes That Cross During Infancy

In approximately one fourth of children who have *strabismus*, the problem appears at birth or by six months of age. The most common form of *strabismus* occurring in infancy is *crossed eyes* and is called “infantile” or “congenital” *esotropia*. Hereditary factors are the most common known causes of this disorder, however in many cases there is no obvious cause.

Important Point: Infants with an eye (or eyes) that are frequently turned in a large amount rarely outgrow the problem on their own. An *ophthalmologist* should be consulted as soon as possible. There is good evidence that better *fusion* is more likely to develop if the problem is corrected prior to 6-12 months of age.

Eyes Beginning to Cross After Six Months of Age

In about three fourths of children with *crossed eyes*, the problem develops after six months of age, typically between 2 and 3½ years of age. By this age a child has a stronger ability to focus (*accommodate*) and starts showing increased visual interest. At about this age a child begins to focus attentively on objects at different distances from him. As we will see in Chapter VI, this increase in visual focusing can cause the eyes to cross if a child is *hyperopic* (*farsighted*). Commonly *esotropia* is more noticeable when the child looks at something close up (such as coloring books, toys held in her hand, etc.,) because more focusing of the eyes is required for viewing near objects.

Eyes That Turn Out (exotropia)

Exotropia or eyes that turn out, is almost as common as *crossed eyes* (*esotropia*). In its early stages of development, *exotropia* is more likely to be present when a child is looking in the far distance and may not be present with near viewing. This makes it more difficult for parents and primary care doctors to detect the problem. *Exotropia* frequently begins between 2 and 5 years of age and usually is only present intermittently at first; it may be worse when a child is tired or ill. A child with an *exotropia* may tend to close one eye in bright sunlight. That behavior in a child may tip off that an *exotropia* is present. Although infantile *esotropia* is often characterized by a constant large angle of misalignment of the eyes by six months of age, it is less common for this to be the case with *exotropia*. A persistent and substantial *exotropia* in an infant is often a sign of neurologic problems or some structural birth defect within the eye that is adversely affecting vision.

Other than those cases for which there is a family history of similar problems, or when there is a specific underlying medical cause identified, there is usually no specific reason known for the development of *exotropia*.

Important Point: Particularly if the problem is getting worse, a constant large angle of *exotropia* in a baby should be evaluated promptly by an eye doctor. (Remember, occasional intermittent outward drifting of the eyes in a child under six months of age may be normal)

Eyes That Deviate Vertically

Vertical misalignments of the eyes are less common than eyes that cross (*esotropia*) or turn outward (*exotropia*). A child may have a vertical deviation of the eyes, *hypertropia* (upward drifting) or *hypotropia* (downward drifting), as the sole misalignment, or a vertical drift may occur in conjunction with *esotropia* or *exotropia*. When vertical strabismus occurs by itself, it is almost always due to an abnormality of the eye muscles themselves or their nerve supply. Although these abnormalities can develop as a result of medical problems, neurologic disorders, or accidents, in the majority of cases they are isolated birth defects that do not extend beyond the eyes. A child with vertical *strabismus* may tend to tilt his head to one side when he is visually attentive. This serves to compensate for the vertical misalignment of the eyes and helps avoid *double vision*.

Important Point: A child who always tends to tilt her head to one side when visually attentive may have vertical strabismus.

Eyes That Cross During or After Illness or Accident

Certain systemic diseases in adults, such as diabetes, high blood pressure, and thyroid disorders, can affect one or more of the muscles of the eyes or the parts of the brain that control eye movement. In children, this often occurs with infections of the sinuses or middle ear, both of which are situated close to the nerves that control the eye muscles. Similarly, head injuries such as can occur with motor vehicle accidents, or direct blows to the eye or eye socket, may result in temporary or permanent *strabismus*. When these systemic conditions result in an eye muscle disorder, the problem may be permanent or may be temporary (may heal itself). If it is destined to resolve on its own, the healing process can take 6-12 months. Fortunately, when permanent *strabismus* results from illness or accident, it can usually be helped with proper treatment.

Any disease that affects the entire body has a weakening effect on the ability to coordinate the two eyes as a team. Crossing of the eyes that begins between the ages of 2 and 4 is usually caused by the development of *hyperopia* (*farsightedness*) and an increase in visual attentiveness that occurs then. Since these are the same ages during which many childhood infectious diseases occur, it is common for *strabismus* to appear after a systemic childhood infectious illness. Parents may be apt to blame the eye muscle problem on chickenpox, measles or some other childhood infection, when in fact the infectious disease may have only hastened the time at which the inevitable eye crossing appeared.

Advanced Information

More about Types of *Strabismus*: You also may hear your doctor use the term *phoria* to describe your child's strabismus. A *phoria* is a type of *strabismus* that is characterized by a slight tendency for an eye to wander, which is compensated for by the brain's *fusion* mechanism. Although *phorias* are not cosmetically noticeable because *fusion* keeps them in check, they can at times cause symptoms of eye strain, eye fatigue, or intermittently blurred vision. Depending on whether the eye tends to drift in, out, up, or down, the condition is called esophoria, exophoria, hyperphoria, or hypophoria respectively.

Chapter 5
Amblyopia ("Lazy Vision")

What is *Amblyopia* and How Does It Develop?

Basic Information: *Amblyopia* means that the vision is decreased in one eye because the eye is not being used. Hence, the eye is described as being "lazy." With *amblyopia*, the decrease in sight is not immediately correctable with glasses alone. An important part of understanding eye muscle problems includes a familiarity with *amblyopia*, because they occur together so frequently.

Earlier we learned that when two eyes normally work together as a team, they are utilizing a process called *fusion*. The image of whatever a person is looking at falls on the center of the *retina* of each eye (the *fovea*). The two images of this object (one from each eye) are mentally blended together, and the person perceives one fused image.

There are two major obstacles to development of this normal process of *fusion*. One such barrier is the presence of *strabismus* (a misalignment of an eye). When *strabismus* occurs in a young child, he may immediately experience *double vision*. This happens because the two eyes are pointing in different directions, and the one image is perceived of as being in two different places at once. The brain can no longer blend these two images together into one and the child sees two objects — *double vision*. (see Figure 5-1A)

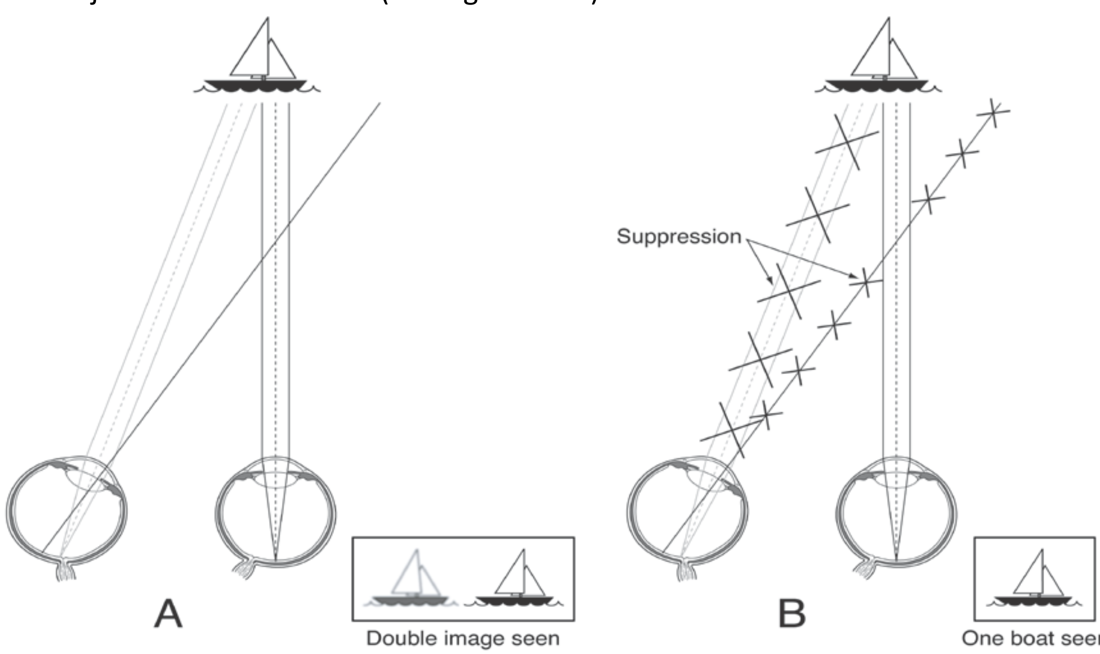


Fig 5-1 A) A person with a crossed left eye is looking at a boat. The right eye sees the boat as straight ahead, because it is looking with the fovea directed at the boat. The left is turned inward and is therefore not looking directly at the boat. The image of the boat does not fall on the center of the *retina* (the *fovea*) of the left eye, but instead strikes a peripheral point of the retina. As a result, the left eye perceives the boat as being off to the side, and a second image of the boat is seen (*double vision*). B) The same situation as in Fig 1-A, except that the brain is *suppressing* (shutting off) the image of the boat seen by the left eye. The person is only seeing with the right eye and sees single.

The child adapts to the annoying *double vision* by subconsciously shutting off, or *suppressing*, the eye that is deviated. Much as you can flip a switch and turn off the ceiling light, *suppression* involves the brain turning off the signals coming from the deviated eye. (see Figure 5-1B). While observing a child who is *suppressing* one eye, you will probably not be able to notice anything unusual about the way he appears to see (however you may notice a misalignment of his eye if one is present), and he will typically be unaware that *suppression* is occurring. Depending on the age of the child, the process of *suppression* can develop very rapidly after the onset of *strabismus*, often in a matter of days or weeks; it occurs more quickly in younger children than older children. After 7 to 9 years of age, his brain no longer is flexible enough for *suppression* to develop. For that reason, *strabismus* beginning after childhood is often accompanied by persistent *double vision*.

Some children with *strabismus* alternately use one eye or the other. In this situation, the vision from each eye is temporarily *suppressed* when it is the deviated eye. However, because each eye is used at least part of the time, the vision does not permanently deteriorate; each eye "wakes up" as soon as it is used. (see Figure 5-2)

Fig 5-2 Child with *esotropia* with alternating fixation. At times he looks with his right eye and the left eye crosses (left photo). At other times he looks with his left eye and the right eye crosses (right photo).

Many other children with *strabismus* always favor looking with one eye and only let the fellow eye deviate. In this situation, the vision begins to drop in the shut-off eye, and the vision becomes *amblyopic* (or "lazy"). This type of vision deficit is different than problems like *myopia* (*nearsightedness*) or *hyperopia* (*farsightedness*) or *astigmatism*. In these latter situations the eye is simply out of focus. Returning to our comparison of the eye and a camera, *myopia*, *hyperopia* and *astigmatism* are comparable to a perfectly good camera that is not focused properly. *Amblyopia* would be more comparable to improperly developing the film in a camera — the end product will be a poor quality picture no matter how well the camera is focused. In a child with *strabismus* or *amblyopia*, the affected eye may or may not be optically out of focus (*myopic, hyperopic,* or *astigmatic*). This is a separate issue. Eyes can be *myopic (nearsighted), hyperopic (farsighted)* or have *astigmatism*, irrespective of the presence of *amblyopia*. As we will see shortly, if any of those three optical abnormalities are present in a child with *amblyopia*, the use of glasses will be an important part of the treatment of *amblyopia*. However, glasses alone will not bring the vision up to normal. Spectacles will merely place the image that is being viewed in sharp focus on the *retina*. They will not make up for the fact the brain has been *suppressing* the eye; the *lazy eye* will have to be "awakened" or made to work.

Before I go on to discuss the actual treatment of *amblyopia*, I need to discuss a second important obstacle to fusion that accounts for many children with *amblyopia*. It is more insidious than a misalignment of the eye because it can easily escape our notice. When *suppression* and *amblyopia* occur because one eye is constantly misaligned, the problem may be obvious to parents and primary care doctors. However *suppression* and *amblyopia* can also occur when the eyes are not misaligned. In this case nothing will be obvious to untrained observers, and there will be no tip-off that the child has a problem. He will appear to see normally. This second cause of amblyopia occurs if there is a marked asymmetry of the optics of the eyes. Typically, if a child has a *refractive error* (*myopia*, *hyperopia*, or *astigmatism*) the condition is fairly symmetric between the two eyes. If one eye is a little out of focus, the other is also a little bit; if one eye is quite out of focus, so is the fellow eye. Although the images are not perfectly clear, the blur is equal between the two eyes so the brain does not favor one over the other. The equally blurred images can be *fused* by the brain. But in some situations, a child may be born with one eye much more out of focus than the other, and the more blurred image cannot be fused with the clearer one into a single image. Just as occurs with a misaligned eye, the brain *suppresses* the more out of focus eye and *amblyopia* develops. (see Figure 5-3)

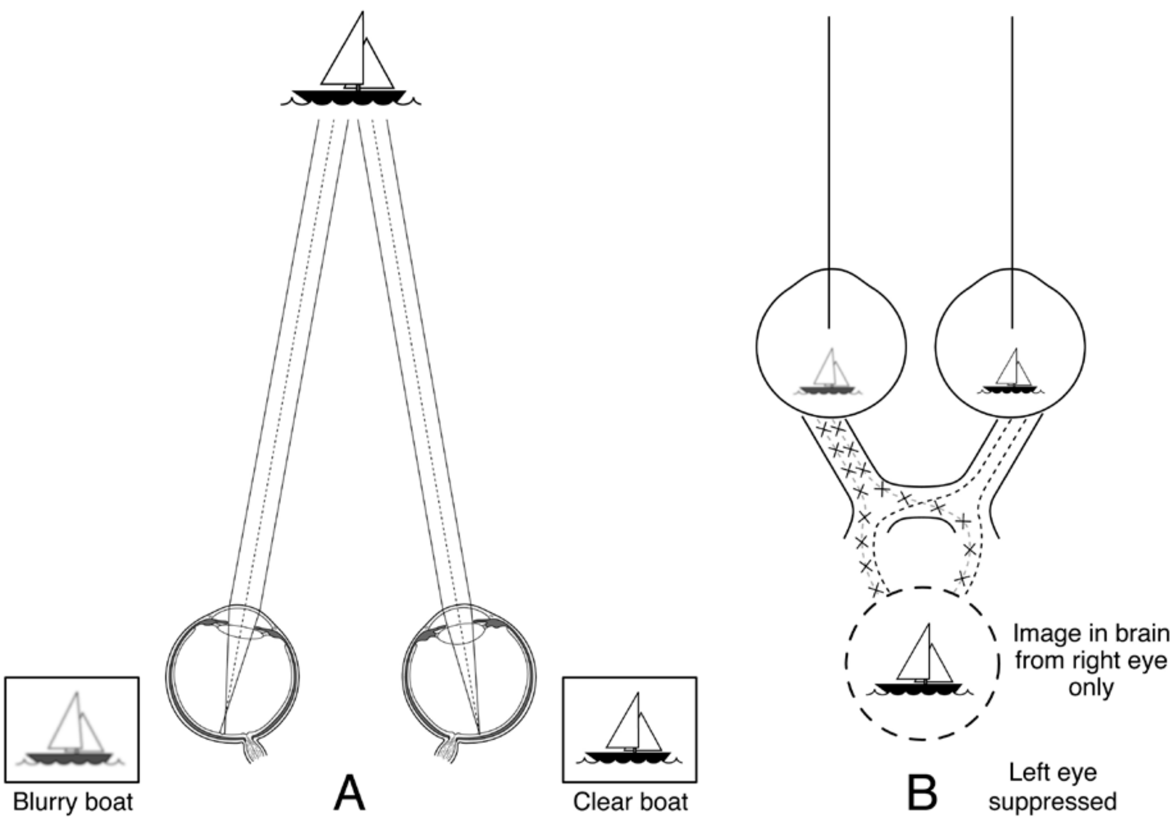


Fig 5-3 *Suppression* caused by asymmetric *refractive error*. A) The right eye is in proper focus for distance viewing and perceives a clear image of the sailboat. The left eye is quite *hyperopic* and sees a blurred image of the sailboat. B) The blurred image from the left eye prevents *fusion*, so the brain suppresses the image from that eye.

Merely putting glasses on the child to correct for the optical distortion does not in itself provide immediate improvement, because the eye is "lazy"; it needs to be "awakened" as was the case with the misaligned eye described earlier. Even though the eye tracks normally with the other eye and does not cross or wander, a serious vision problem is present. It can only be detected by testing the *visual acuity* of the child. This is the primary reason that vision screening programs are often conducted for preschool children. Fortunately, as we will soon learn, *amblyopia* is usually correctable if treated early enough. However, early detection is important.

Important Point: If your child is old enough to read letters or perform the *E test* (usually 3½ to 4 years of age), and your primary care doctor has not tested his vision, ask to have it tested even if you do not observe any eye problem. This is particularly important if there is a family history of *amblyopia* or *strabismus*.

How is *Amblyopia* Detected?

Amblyopia is detected by comparing the *visual acuity* in one eye to the other. If one eye sees substantially poorer than the other, and if the vision does not immediately improve with glasses alone (and if there are no other structural abnormalities to account for the problem such as a *cataract*, *retinal* scarring, etc.) then *amblyopia* is most likely present.

In a child who is too young to read the vision chart, *amblyopia* can be detected by her visual behavior. For example, if an eye muscle imbalance is present, and she is only looking with one eye at a time, the eye doctor can tell if she sometimes looks with her right eye, and other times with her left eye. If so, we can be fairly certain *amblyopia* is not present. A preliterate child would not choose to look with an eye that does not see as well as the other, if she is given a choice. If she has a strong preference for always looking with the same eye, and will not spontaneously look with the other, there is a good likelihood she has *amblyopia*. In a child who is too young to read, *amblyopia* can be detected by an eye doctor who is accustomed to examining small children using this technique and some of the special tests described on pages 12-13 and 17-18.

How is *Amblyopia* Treated?

Although there are some minor differences in how eye doctors treat *amblyopia*, all effective treatment programs include two important steps. The first is to correct any substantial optical problem (*myopia, hyperopia*, or *astigmatism*) if any is present, with appropriate glasses. The second step is to get the child to start using the *lazy eye*. Remember that a *lazy eye* may be aligned with and move with the normal eye. So when I say a child needs to "be made to use" the *lazy eye*, I am not merely referring to it tracking with the other eye. I mean we need to "wake up" the *suppressed* vision in the *lazy eye* and have the child start seeing with it. The most common treatment for *amblyopia* is to have the child wear a patch over the good eye to make her start seeing with the *lazy eye*. In some cases, if the *amblyopia* is severe, the good eye may need to be patched all day long, every day, until the vision has become normal in the *lazy eye*. Some parents have concern that patching the better eye may cause it to lose vision. This rare occurrence is called occlusion *amblyopia*, because it is caused by patching too long. Fortunately, in almost all cases, the vision in the good eye (the one that is being patched) does not slip or become *amblyopic* until after the vision has first become normal in the *lazy eye*. Consequently children undergoing patching therapy for *amblyopia* need to have regular visits to the eye doctor to guard against occlusion *amblyopia* by monitoring their patching program. Because vision improvement occurs more quickly in younger children with *amblyopia*, the frequency of office visits that are needed depends on the child's age. Typically the interval between examinations is one week per year of age until the rate of a child's improvement has been determined. Thus a one year old will need to be examined weekly, a two year old every 2 weeks, and so on up to age four, after which examinations should still be about every 4 weeks. Often, if *amblyopia* is not severe, children will improve on a program of patching only part of the day. Such a routine may allow for a longer time span between office visits. The exact program best for your child should be determined by taking into account her age, the severity of *amblyopia*, and ease with which you can make visits to the eye doctor's office. The patching will need to be continued until the *amblyopia* has been overcome, at which time it will be decreased or discontinued. In some children, *amblyopia* may recur after the patching has been stopped. If that happens, patching will need to be resumed until vision again improves, and discontinued more slowly. Sometimes slowly tapering off the patching (e.g. a month of patching ½ of the day, then a month of 3 hours /day etc.) may help prevent recurrence of the problem. After a child with *amblyopia* has been successfully treated, he will need to continue to have regular eye examinations throughout his childhood years. Once it is evident that *amblyopia* is not going to recur rapidly, the frequency of check-ups will gradually decrease and ultimately become once a year.

The most important measure to prevent the later return of *amblyopia* is to keep the child in proper glasses if they are needed. If a child begins developing *refractive error* (*myopia*, *hyperopia*, or *astigmatism*), or if there is an unrecognized change needed in a child's glasses, *amblyopia* is likely to recur.

When a child first begins patching his good eye to treat an *amblyopic* eye, he often does not like the experience and may protest by trying to remove the patch. This is not surprising! The treatment is causing him to see with an eye that does not see well. The poorer the vision, the more he may object to patching, yet the more he needs it! Patience and perseverance on the part of parents is essential for successful treatment of *amblyopia*. Fortunately, in most cases, vision in the *amblyopic* eye improves rapidly and the patching soon becomes less difficult. Often a child's resistance to wearing an eye patch can be overcome by allowing her to decorate the patch, or having her favorite toy animal wear a similar eye patch (see Figure 5-4). Your eye doctor, *orthoptist*, or the nurse working with your eye doctor can provide you with other pointers on how to deal with difficulty in patching.

Fig 5-4 Decorating the eye patch and placing a similar patch on a child's favorite toy animal may help overcome resistance to patching.

Although patching is the traditional and probably fastest method to overcome *amblyopia*, there are alternatives that may be acceptable in many situations. One of these involves blurring the good eye by using a dilating eye drop at home on a regular basis. This has the advantage of not relying on a child's compliance. A child may be able to remove an eye patch, however once the drop is instilled, it cannot be "pulled off." This treatment also may be less objectionable for older children who might be self-conscious about wearing an eye patch around friends. On the other hand, this treatment does have some disadvantages. It takes longer to work than patching, because simply blurring the eye may still permit its use a fair amount of the time. Also, some parents and children do not like the prospect of having to instill eye drops on a daily basis.

Another alternative to patching involves the use of special lenses in the glasses to blur the good eye. This treatment is effective for milder forms of *amblyopia*. It is also more useful in older children who are sufficiently cooperative to accept the blurring lens without peeking over it. Your eye doctor or *orthoptist* can discuss with you which treatment option is best for your child.

Important Point: If for any reason while your child is being treated for *amblyopia* (patching or blurring the good eye), you need to cancel a scheduled visit to the eye doctor, do not continue the *amblyopia* treatment without calling the eye doctor's office for instructions. If there will be a substantial amount of time until your re-scheduled examination, the treatment program may need to be modified to prevent occlusion *amblyopia*.

How Does Age Affect the Treatment of *Amblyopia*?

The younger a child is treated for *amblyopia*, the more successful the treatment, and the quicker it will work. The vast majority of children under three years of age can be successfully treated for *amblyopia*. By seven years of age, the success rate drops to about 75%, and by nine years of age it is somewhat less than 50%. Although many authorities feel that *amblyopia* cannot be successfully treated in children over 9 years of age, the issue is not that black and white. The less severe the amblyopia, the higher the likelihood of success. Some children even in their early teenage years can be successfully treated for *amblyopia*, particularly if it is relatively mild.

Amblyopia treatment is not only more likely to be successful in a younger child, a younger child also responds quicker to treatment. Many infants are successfully cured of *amblyopia* in several weeks. In a three-year-old it may take several months. In a seven-year-old, it can take many months. This is all the more reason for detecting *amblyopia* when a child is young.

Question: My child was being treated for *amblyopia*. The doctor said her vision has progressively improved, but her glasses prescription has not been made weaker. Does that make sense?

Answer: This frequently asked question addresses one of the most confusing things about *amblyopia*. When we talk about *amblyopia* "improving" we mean that the vision with the best glasses possible is now better than it had been before. In other words, the vision is no longer "lazy." However, the prescription needed in the glasses is solely a function of the shape and size of the eye. Depending on how an eye grows and changes shape, the lens needed to properly correct the *refractive error* of an *amblyopic* eye may not change (or possibly need to be made stronger), even though the best vision the eye is capable of may have improved. Let us think again about the analogy to a camera. The improvement in amblyopia would be like the photo processing lab now doing a better job in processing the film. That has nothing to do with how the camera needs to be focused to get the best possible picture.

Question: My child is now 12-years-old. When he was 5, he was successfully treated for amblyopia. Recently his amblyopia recurred, and the vision in his lazy eye slipped. Is he too old to treat?

Answer: No! All of the information described above regarding the age at which amblyopia can be treated relates to the age of first treatment. If amblyopia had been successfully treated in the past, and then recurs, the previous best vision can usually be recovered with patching at almost any age.

Question: I have an *amblyopic* eye and was not treated as a child. If I should have an accident and injure my good eye, what is the likelihood my lazy eye will improve?

Answer: One cannot be certain. There are reports of adults with *amblyopia* who injured their good eye, and experienced an improvement in the *lazy eye*. There are also many reports in which improvement did not occur. This is one of the major reasons it is so important to diagnose and treat *amblyopia* at as early an age as possible.

Question: I have an *amblyopic* eye that was not treated when I was young. My other eye is normal. My doctor recommended I wear plain glass spectacles for protection. Why?

Answer: Your doctor is to be commended for being appropriately cautious. It can be a real tragedy when someone with *amblyopia* injures his good eye. Most eye injuries do not necessarily occur in high risk situations such as while playing contact sports. Most occur as fluke accidents around the home. Glasses protect the eyes from injury. I realize that people who do not need to wear glasses in order to see more clearly often do not want to be bothered with spectacles. But wearing glasses for protection is a great idea.

Question: I have an *amblyopic* eye that was not treated when I was young. My better eye is *nearsighted*. What is the advisability of my wearing contact lenses or having refractive surgery in my better eye?

Answer: Although this is a matter of personal philosophy, there are compelling reasons for you to stay with glasses, and not wear contact lenses or have refractive surgery. As stated above, glasses afford protection to your good eye. In addition to the relatively small risk to the eye from the contact lens itself (infection or *corneal* scaring) or the surgical procedure, you would be losing the protection offered by glasses.

Question: My daughter has an amblyopic eye. I do not want my daughter to wear glasses. Can I just patch her? or

Question: My daughter has an amblyopic eye. I do not want to have to patch my daughter. Can I just use glasses? or

Question: My daughter has an amblyopic eye. I do not want glasses or patching for my daughter. Can they just do eye muscle surgery and get it over with?

Answer to all 3 questions: Glasses, patching, and eye muscle surgery address different aspects of your daughter's problem and cannot be substituted for one another. If there is a substantial *refractive error* (*myopia, hyperopia*, or *astigmatism*) patching without glasses will not work. That would be like forcing someone to look though a very dirty and smudged window, and expect them to see the landscape outside clearly. Similarly, using glasses alone, without patching, will not address the issue of *suppression*. If the child has shut the eye off, then merely correcting the optical distortion (glasses to put the image on sharp focus of the retina) may not cause the *lazy eye* to immediately "wake up." Eye muscle surgery, as we will learn about in chapter 7, will realign the eyes, but also will not cause the *lazy eye* to "turn on" its vision.

Question: Are there any exercises my son can do to treat his *amblyopia*?

Answer: Making him see with the *lazy eye* by patching or blurring the good eye (as described earlier in this chapter) is the best exercise. *Amblyopia* is not a problem with a muscle, but is a problem with vision due to *suppression*. So exercises, in the traditional sense of moving the eyes certain ways, will not help *amblyopia*.

Question: My child wears strong glasses and is undergoing patching for *amblyopia*. I am having a lot of difficulty getting him to leave the patch on. I have heard about refractive surgery to get rid of glasses. What about refractive surgery for my child?
Answer: Refractive surgery would not eliminate the need for patching. If successful, it would only eliminate or decrease the need for glasses. But if the vision is poor in one eye because of *amblyopia*, it would still be poor after refractive surgery. Patching would still be needed. Currently, most doctors who perform refractive surgery recommend waiting until after 18 or 20 years of age. At that time, the eye is usually finished growing and the *refractive error* has finished changing. Research is currently being conducted on the effectiveness of refractive surgery in children with *amblyopia*. At this time it is considered investigational.

Important Point: It is crucial to understand that refractive surgery would only be a substitute for glasses and **would not** eliminate the need of patching.

Question: For patching my child, I am using a black "pirate patch" that straps around his head. He keeps lifting the patch up and peeking. What should I do?
Answer: That type of patch usually does not work satisfactorily for the very reason you described. Similarly, taping or occluding one lens of his glasses is usually unsatisfactory because peeking is too easy. In most cases, the use of a specially made patch that has a sticky back (like a band aid) is preferred. It sticks on the skin and makes it harder for a child to sneak a peek with the eye that is being patched. There are several brands of these patches available in most pharmacies. Speak to your eye doctor or *orthoptist* about this.

Question: I was told my child has *amblyopia* because one of her eyes is quite out of focus, and the other is normal. The doctor prescribed glasses, however my child does not seem to like to wear them. If they were helping, would she not see better with them on and want to wear them?
Answer: In most cases, young children (even infants) will want to wear glasses if they provide an improvement in vision. Your child represents one of the few situations that can be an exception to this. Because your child has one normal eye, she sees perfectly well without glasses (but with one eye only.) People who are accustomed to seeing clearly with only one eye do not experience blurred vision as long as both eyes are open. When your daughter puts the glasses on, she is not aware of seeing better, because her vision with both eyes open was already normal without the glasses. However, if you cover the good eye, you will see a marked difference in how she sees with the *lazy eye* when the glasses are on versus when they are off. It is important that you are firm and insist she wear the glasses.

Advanced Information: I have heard about something called "photoscreening" to detect *amblyopia*. What is it, and is it accurate?

Answer: A lot of research is being done to develop a simple way to test large groups of children to detect *amblyopia*. Photoscreening devices are specially designed cameras that can be used to photograph infants. A trained expert can look at the reflections in a child's pupil in a photograph obtained with a photoscreener and may detect the presence of a misalignment of the eyes (*strabismus*) or a *refractive error* (*myopia*, *hyperopia*, or *astigmatism*). Although these devices seem useful in detecting many cases of *amblyopia* or *strabismus*, their accuracy is not 100%. So if your child has passed a photoscreening test, and there is either a family history of *amblyopia* or *strabismus*, or you suspect a problem, an examination by an eye doctor is still appropriate.

Chapter 6
The Treatment of Strabismus (Non-Surgical)

Basic Information

Now that you have an understanding of *amblyopia*, you have the background needed to learn about different types of eye muscle disorders, and how they are treated. You will learn the importance of glasses to correct *refractive errors* in the treatment of *strabismus*, the need to treat *amblyopia* (as was previously discussed) and the possible role of eye muscle surgery. We will investigate more thoroughly how a child's eyes focus, the important relationship between focusing (*accommodating*) and the alignment of eyes, and the manner in which certain glasses, bifocals, *prisms*, or even eye drops can correct an eye muscle problem and allow the eyes to work together as a team.

The basic goal of any *strabismus* treatment program is to have clear vision in each eye, and have eyes that are well aligned, to allow *fusion* to develop, if possible. Although perfect alignment is ideal, eyes that are within about 5 degrees of perfect alignment are close enough to straight to permit some *fusion* and to look properly aligned cosmetically (for reference, 90 degrees is a right angle). The treatment of all types of *strabismus* (*esotropia*, *exotropia*, or *hypertropia*) can be broken down into 3 basic steps: 1) If any significant *refractive error* is present (*myopia*, *hyperopia*, or *astigmatism*), then glasses must be the first step in treating the *strabismus*. 2) If *amblyopia* is present, it should be treated and overcome with patching or some alternative therapy. 3) After glasses (if needed) and patching (if needed), surgery to re-align the eyes is the third step. Surgery is the last step and should only be taken if the first two have either been completed or are not necessary for a particular child.

There is one important concept that is a bit confusing, but is essential to the understanding of all types of *strabismus*. In most cases eye muscle problems should not be thought of as being limited to one eye or the other. *Strabismus* means that the two eyes are not pointing in the same direction. Thus, at any specific moment, one eye will be looking at you (or whatever the child is looking at), and the other will be looking somewhere else. If it is always the same eye that deviates, parents naturally feel that the eye muscle problem is limited to the misaligned eye. However this is not usually the case. Let me try and explain this perplexing concept. It can be best understood by comparing eye alignment to the front wheels on a car. Just as both front wheels should point in the same direction and be parallel, our two eyes should similarly point in the same direction with the lines of sight from the two eyes being parallel. (see Figure 6-1)

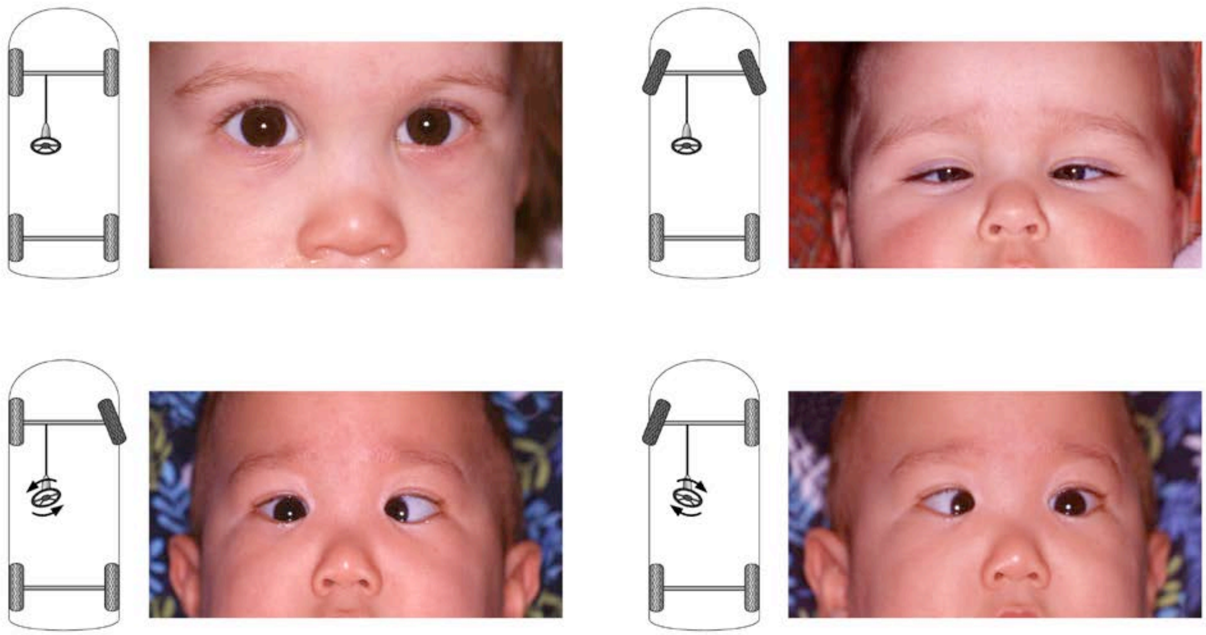


Figure 6-1 A) Straight eyes could be compared to the front wheels on a car. They should be pointing in the same direction and be parallel. B) Crossed eyes are analogous to the front wheel being knocked out of alignment, so they both turn in. C) Because the wheels can still be turned by rotating the steering wheel, turning the wheel to the left will straighten the left wheel. The right wheel will appear deviated inward. This is similar to the child in Fig 6-1-C, who is looking with his right eye. It has straightened and the left eye is deviated inward. D) If the steering wheel is turned to the right, the right wheel can be made straight. In this case the left wheel is deviated inward. Similarly, the children Fig 6-1-D can look with his left eye and straighten it. In that case the right eye is turned inward.

Having *crossed eyes* would be similar to knocking the automobile wheels out of alignment so they are both turned inward. The steering wheel can still turn them and make one or the other point straight ahead — but not both at the same time. When a child has a *crossed eye,* her eyes can be compared to the misaligned front wheels of the car as seen in Figure 6-1B-D. Because her eyes can still move, she has the choice of straightening either one or the other to look at you (or whatever she is looking at). However, her other eye will appear to deviate inward, because it is not lining up with the eye she is looking with. In most cases, if she just appears to have a problem in one eye, it is only because she always chooses to look with her other eye. This is what happens when one eye sees better than the other. She always chooses to look with the eye that sees better. All one needs to do is get her to look with the eye that appears lazy, and her “good eye” will cross. As a parent observing your child, you may never see this on your own, however, because she may never look spontaneously with that eye (see Figure 6-2) The converse would be true for *exotropia* — eyes that turn outward.

A B

Figure 6-2 A) This shows a girl with a crossed left eye. B) If you make her look with the left eye by occluding her right eye, her left eye straightens. If you peek behind whatever is occluding her right eye, you will see that it is turned in behind the occluder.

Important Point: Throughout this book, whenever I allude to an eye muscle problem such as crossed eyes, wall eyes, etc., I am almost always referring to the situation in which one eye is pointing in the proper direction, and the other is deviated or misaligned at any given time. It does **not** mean that **both** eyes are turning inward or outward at the same time. This is the same way your eye doctor will be using these terms.

* * *

This chapter will be divided into 3 sections. The first deals with eyes that cross (turn in, *esotropia*). The second describes eyes that turn out (wall-eyed, *exotropia*). The final section covers eyes that turn up or turn down (vertical misalignments, *hypertropia* or *hypotropia*). If you or someone you care about has one of those problems, you may wish to limit your reading to the appropriate section in this chapter. Each section, however will be designated as basic information for that particular type of *strabismus*

Eyes that Cross (*Esotropia*)

Basic Information

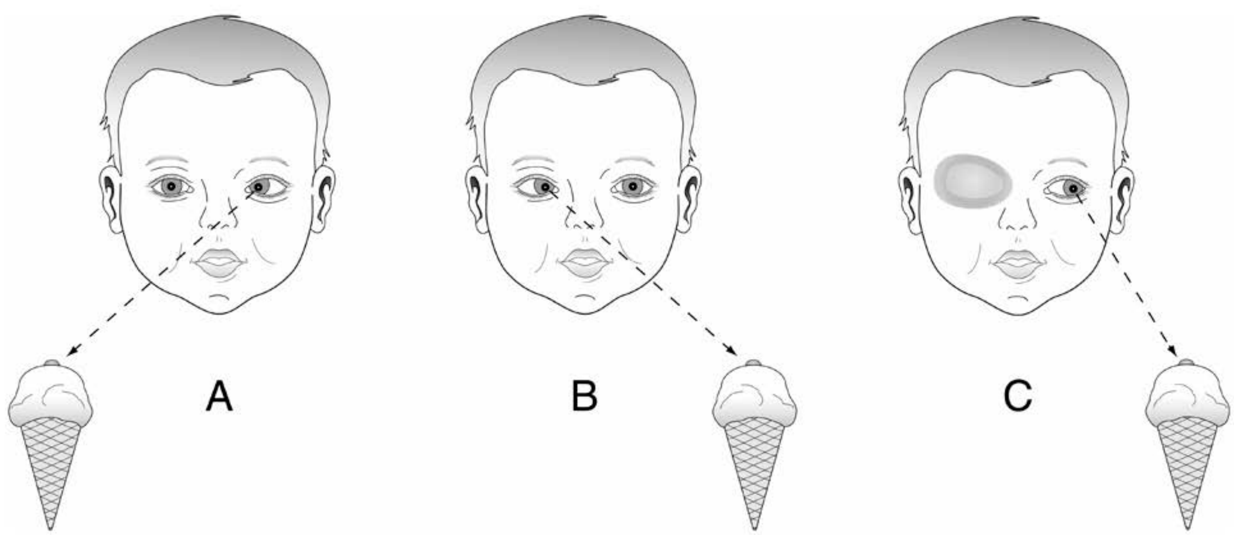
Esotropia in Infancy

When esotropia begins shortly after birth, or up to 6 months of age, the condition is called either “congenital” (means “born with”) *esotropia*, or “infantile” *esotropia* (because it occurs in infants). For many children with infantile *esotropia* the condition appears to be “hereditary.” That means that it is inherited, and other family members (siblings, parents, or grandparents) may also have *crossed eyes*. In approximately half of the children with infantile *esotropia*, no specific reason for the problem is found. Some experts feel a child with infantile *esotropia* is born without a normal *fusional* mechanism. They do not have the ability to see with the two eyes together as a normal team. Because they do not have *fusion*, the eyes tend to wander and *esotropia* results.

Because controlling the eye movements is one of the most complicated tasks the brain is required to do, infantile *esotropia* is also more likely to occur in an infant who has brain damage, cerebral palsy, or any other neurologic disorder. However, the vast majority of children with infantile *esotropia* are otherwise healthy and do not have any other neurological problems.

How Does Infantile *Esotropia* Behave?

Initially, the crossing may be variable in degree and only present intermittently. However, it develops fairly rapidly into a rather large angle of crossing that is constantly present. The majority of children with infantile *esotropia* tend to use one eye when they are looking to the right (because it is already pointing that way) and the other when looking to the left (because it is similarly pointing that way). This is called "cross-fixating" (see Figure 6-3). Because a child who cross-fixates tends to use each eye at least part of the time, they are less likely to develop *amblyopia* (lazy vision) than a child who always uses the same eye.



(Figure 6-3)

Figure 6-3 A) Boy with *esotropia* who demonstrates cross-fixation. When he wants to see something to his right, he uses his left eye, because it is already pointing in that direction. B) When he wishes to look to the left, he uses his right eye because it is already pointing in that relative direction. C) If his right eye is patched, he now will need to use his left eye to see something to the left. This loosens up the tight in-turning muscle in the left eye.

How Is Infantile *Esotropia* Treated?

The first step in treating infantile *esotropia* is to prescribe glasses if they are necessary. However, a great many children with infantile *esotropia* do not have a significant *refractive error*, and glasses are not needed. Secondly, if *amblyopia* is present, patching should be carried out to get the child to alternate fixation (use each eye equally frequently). Many eye doctors like to alternately patch a child with infantile *esotropia* (one eye one day; the other eye the next day, and so on) even if the child is not *amblyopic*. This treatment prevents cross fixation, (see again Figure 6-3). With a patch on the left eye, a child would need to use his right eye to look to the right. Similarly, with when his right eye is patched, he would need to use his left eye to look to the left. The goal of this treatment is to loosen up, or stretch out, the in-turning muscles in each eye and prevent *suppression*. The final step in treating infantile *esotropia* is eye muscle surgery, which is ultimately needed for the majority of children with *esotropia* that first appears prior to 6 months of age. Surgery will be discussed in detail in Chapter 7.

There is a lot of evidence that re-alignment of the eyes at an early age in a child with infantile *esotropia* is desirable. Because children with infantile *esotropia* are probably born without the normal ability for the eyes to work together, they usually do not develop perfectly normal *fusion* or *stereopsis* (3-D vision) after successful surgery to realign their eyes. Nevertheless, they can develop a reasonably high degree of *fusion* if the *strabismus* is treated early enough. It appears that proper alignment of the eyes prior to one year of age produces better *fusion* than if surgery is delayed until a later age. Consequently, many *ophthalmologists* prefer to perform surgery by 4-8 months of age, provided the other necessary steps have been taken first.

Important Point: After surgery is performed, your child will need to continue to see an eye doctor during her childhood years, even if her eyes look perfectly aligned. Children with infantile *esotropia* are still at risk for developing *amblyopia* at a later age, even if they did not have it before surgery. Also, the development of any significant *refractive error* may result in instability in the eye muscle control system, and cause the eyes to deviate again. Later on, many children with infantile *esotropia* develop a vertical (upward) misalignment of an eye which may require further treatment. Of all the children who undergo surgery for infantile esotropia, between 20% and 40% will ultimately require one or more additional surgical procedures. This can either be for a residual or recurrence of the *esotropia*, a later appearing outward drifting of an eye (*exotropia*), or for the aforementioned vertical *strabismus*.

Question: My 6-month-old son has infantile *esotropia* and initially only his right eye crossed. We have been patching his “good” left eye to strengthen his right eye. Now his good left eye is crossing some. Have we done it harm?

Answer: No! The goal of treatment is to get your child seeing equally well out of each eye. When that occurs, he will be just as happy looking with his right eye as his left — because his vision will be equally good in each eye. You will then note the crossing is 50/50, half of the time the right eye and half of the time the left eye. Even before you started patching, his right eye would have crossed if he chose to look with his left eye. He just never did that on his own, because he did not see well out of the right eye (refer again to Figure 6-2). So in other words, crossing each eye part of the time is better than only crossing one eye all of the time.

Question: My 5-month-old baby girl has a markedly crossed eye. What is the likelihood she will outgrow it? When should she be examined by an ophthalmologist?

Answer: It has been shown that if a child has a substantial eye muscle imbalance by 5-6 months of age, there is almost no chance the problem will go away on its own. In addition, your child needs to be examined to be sure there is no other serious disease causing the *strabismus*. This is the time to visit an eye doctor. You do not want to delay treatment.

Esotropia Beginning After Infancy

We just learned that a faulty *fusional* mechanism is a common cause of *esotropia* in infants. When eyes start to cross between 2 and 5 years of age, there is usually a different cause for the problem which relates to focusing (*accommodating*) and *hyperopia* (*far-sightedness*). These are the ages during which children often start really looking closely at small objects as they begin coloring, reading, and engaging in similar activities. If you are particularly interested in learning about eyes that begin to cross after 6 months of age, you will want to review the material on pages 27-30, 63-65, and in Figure 2-5 on *hyperopia* and *accommodation*, because it is crucial to understanding this subject.

As you learned earlier, a *hyperopic* (*far-sighted*) child can see clearly by *accommodating* (focusing) his eyes, even for viewing close-up objects. It is just more effort for him to see close-up than far away, but he can do so. Also, all people (even those with normal eyes) need to use the same process of *accommodation* to change focus from a distant image to a close up image. *Accommodating* is needed for clear vision close-up whether or not hyperopia is present. However, a person who is *hyperopic (farsighted)* must *accommodate* more than one who is not *hyperopic* to see clearly at near. With *hyperopia*, some *accommodation* is needed to compensate for the *hyperopia* and some for the fact that a near object is being viewed. Also, when we look at near objects, our eyes must *converge* (turn in slightly) if both eyes are to be seeing the same thing (see again Figure 2-5). It appears that Nature is wise. She has built in a reflex between *accommodation* and *convergence*. Whenever a normal sighted person looks at near objects (and hence *accommodates*) his eyes automatically and reflexly *converge* just the right amount for both eyes to be seeing the same thing. (see Figure 6-4)

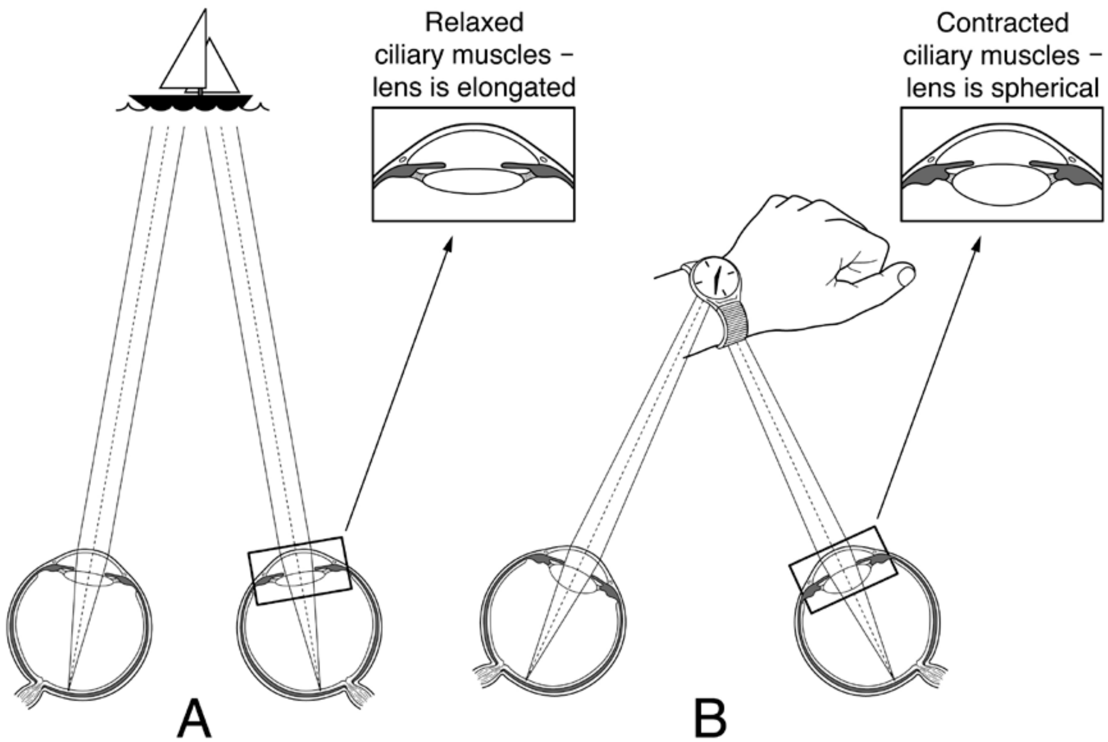


Figure 6-4 A) Normal eyes looking at a sailboat in the distance, and B) at a near object. The *ciliary muscle* (or focusing muscle) is thin and relaxed when looking at a distant object as shown in A. This muscle is noticeably thickened and contracted when looking at near objects as seen in B. By means of the *ciliary muscle*, the eye *accommodates* itself for objects at varying distances, hence the process is known as *accommodation*. In addition, when the eyes *accommodate* and look close up, they also *converge* (or turn in a bit) as seen in B so both eyes point toward the close up wristwatch.

This reflex is useful and helpful in normal children, but it can lead to problems when there is more than the average amount of *hyperopia*. Recall that most young children are a bit *far-sighted* by about 1-2 *diopters* (the unit by which *refractive errors* are measured). Children can compensate for this and see clearly without glasses by *accommodating*. But what happens if a child is more *hyperopic (farsighted)* than normal? He can still see clearly without glasses, but he needs to *accommodate* more than normal to clear up the vision. Because of the reflex that binds *accommodation* to *convergence*, his eyes cross. In a sense, this child has the subconscious choice between having everything blurred (because he is not *accommodating*) and his eyes straight, or clearing up the image (by *accommodating)* and having his eyes cross. That is why this problem, called accommodative *esotropia* or *refractive* esotropia, typically develops about the age a child becomes really interested in their visual environment (usually 2 to 4 years of age), although it occasionally occurs in young infants.

There is a second mechanism by which *accommodation* can cause esotropia. In the above example, we learned that *esotropia* can occur if a child is more *hyperopic (farsighted)* than normal. *Esotropia* can also occur even if a child has the normal amount of *hyperopia*, if the reflex that couples *accommodation* to *convergence* is hyperactive. Normally children *converge* about 3 degrees (90 degrees is a right angle) for each *diopter* they accommodate. If that relationship is greater, and a child converges more than the normal amount for each *diopter* they *accommodate*, there will be excessive *convergence*, and the eyes will be crossed. In this situation, also called accommodative *esotropia*, the eyes cross more as a child looks close up at a book than when he looks at a television across the room, because more *accommodation* is needed for closer viewing.

When *esotropia* is caused by *accommodation* in either of the ways described above, the condition is called *accommodative esotropia.*

How Does *Accommodative Esotropia* Behave?

In the early stages, *accommodative esotropia* is characterized by a variable and intermittent crossing of an eye. The crossing is more likely to occur when a child is focusing on small objects (especially at near), tired, or ill. Over a period of days to months, the crossing will become more frequent and ultimately become constantly present. Remember, the child is subconsciously choosing between blurred vision and straight eyes, or clear vision with crossed eyes. After a short period of time, given that choice, the child always chooses to see clearly. At that time the crossing will become constant, and *suppression* may develop to stop the *double vision*. If it is always the same eye that crosses, the child is likely to develop *amblyopia*. On occasion, an older child may complain of seeing double when their eye crosses, if they have not yet started to develop *suppression*. Sometimes, a high fever, infectious illness, or head injury may make it harder for a *hyperopic (farsighted)* child to compensate for the *hyperopia*, and an *accommodative esotropia* may develop. In that circumstance, the high fever, infectious illness, or head injury, did not actually cause the *esotropia* to occur. It just determined the time at which an inevitable problem became evident.

How Is *Accommodative Esotropia* Treated?

Now that we understand that *accommodative esotropia* is caused by a vision or focusing problem, the rationale behind its treatment should make sense. The first step in treating *accommodative esotropia* is to correct the underlying cause of the problem. This involves glasses to correct for the *hyperopia*. After glasses are prescribed, *amblyopia* (if present) must be treated in the previously described manner. In some children with *accommodative esotropia*, the eyes are well aligned with glasses, and nothing further needs to be done to treat the crossing. The eyes work well together when the glasses are on. They will continue to cross when glasses are off, however, because excessive *accommodation* is again needed to compensate for the *hyperopia*. The glasses have not eliminated the *hyperopia*, but merely focused the images for the eyes.

As explained above, some children with *accommodative esotropia* may have a normal amount of *hyperopia* but have a hyperactive reflex linking *accommodation* to *convergence*. As a result, their eyes cross more for near visual activities like coloring, reading a book, or looking closely at their parent’s face. Consequently, they need glasses that provide more correction for close up viewing (where the problem is greatest) than for far away — specifically they need *bifocals*. Although we often think of *bifocals* as something older people need, if you think about this, it should seem sensible. The eye crossing is greater at near, thus more correction is needed in the glasses for near vision. The lens that would correct the problem for close up viewing would be too strong for distance viewing. A pair of *bifocals* solves that problem.

A *hyperopic* child with *accommodative esotropia* needs to continue wearing glasses as long as she has substantial *hyperopia*, or an overactive reflex linking *accommodation* to *convergence*. Although the average *hyperopic* child loses about 1-2 *diopters* of *hyperopia* over their growth years — an average is just that — an average. Some children lose substantially more than 2 *diopters*, and some actually get more *hyperopic*. As a result, it is impossible to predict in a given child whether or not they will outgrow the need for glasses. I have cared for many children who started with a relatively low amount of *hyperopia* who never outgrew the problem, and I have seen occasional children with very large amounts of *hyperopia* who did outgrow the need for glasses.

Important Point: Many children actually get a bit more *hyperopic* between 2 and 7 years of age, and then begin to become less *hyperopic*. So it is not uncommon for a child with *accommodative esotropia* to need his glasses made stronger before they can be made weaker.

Important Point: We have seen how crucial the prescribing of proper glasses is to the management of *esotropia*. For this reason, all children with *esotropia* should undergo a dilated eye exam about once a year. If ever a previously well-controlled crossing problem gets worse a dilated exam should be performed, even if a year has not elapsed since the previous one, in order to determine if the *refractive error* has changed.

In many children, the glasses only straighten the eyes part way. When that occurs, eye muscle surgery will be needed to correct for the residual misalignment (see Chapter 7). Glasses will still typically be needed after surgery to correct for the misalignment that is caused by the *hyperopia* and *accommodation*. The surgery can only address the residual crossing that was not corrected by the glasses.

Advanced Information: On occasion, a special type of eye drop (or ophthalmic ointment) may be used to help straighten crossed eyes. This is a medication that makes the pupil small and is called a “miotic.” At first thought, it may be hard to imagine how a drop can straighten *crossed eyes*. This medication works by acting directly on the muscle that causes *accommodation* to occur. The medication allows the eye to *accommodate* without exerting as much **effort** to *accommodate*. Because it is the effort to *accommodate* that causes the crossing, less crossing occurs. The eyedrops are relatively free of side effects when used in proper dosage for relatively short periods of time (months). However, most doctors and patients do not like to use medication in children indefinitely, and the treatment of *accommodative esotropia* must continue throughout childhood. Consequently, miotics are often just used temporarily in order to help determine if a child’s eyes are crossing because of *accommodation*, or for short term use to fine tune the results of surgery or the response to glasses.

Basic Information

Other Causes of *Esotropia* Beginning after Infancy

Less commonly, a child's eye may begin crossing after infancy (more than one year of age), and it is not caused by *accommodation* and *hyperopia*. For this condition, called *non-accommodative* acquired *esotropia*, the reason for the crossing is not always apparent. It is treated similarly to the other two types of esotropia we have already discussed. If there is any significant *refractive error*, glasses are the first step.

After glasses (if needed) the second step is to treat *amblyopia* if it is present. Finally, eye muscle surgery should be performed to re-align the eyes after steps one and two.

Question: I was told my daughter has *accommodative esotropia*. Before she was put in glasses, her eye only crossed intermittently. Now it is always crossed when she takes her glasses off. Did the glasses make it worse?

Answer: No. Think of it this way. Your daughter has the subconscious choice of seeing an out of focus image and keeping her eye straight, or clearing up the image and having the eye cross. With glasses on, she has gotten accustomed to having clear vision and straight eyes. Now given the choice, she chooses clear vision all the time (being the smart girl she undoubtedly is). The consequence she pays for seeing clearly when she is not wearing glasses is crossing of the eye.

Question: My doctor prescribed glasses for my one and a half year old son for a crossed eye. How will I ever get my child to wear them?

Answer: In the vast majority of cases, children with *accommodative esotropia* love wearing glasses and leave the glasses on (frequently much to the surprise of parents). In a very small percentage of children, measures need to be taken to help a child in this regard. Some type of strap to help keep the glasses in place may be useful. In select cases a short course of a dilating drop will help a child get used his glasses.

Question: My daughter has an esotropia. I do not want her to wear glasses. Can I just patch her good eye? or

Question: My daughter has an esotropia. I do not want to patch her good eye. Can I just use glasses? or

Question: My daughter has an esotropia. I do not want glasses or patching for my child. Can her doctor just do eye muscle surgery and get it over with?

Answer to all 3 questions: Glasses, patching, and eye muscle surgery address different aspects of *strabismus* as you learned earlier. If the eyes are crossing because of a focusing problem (*hyperopia*), then patching or surgery will not address the cause of the eye crossing and will not cure the problem. If *amblyopia* is present, neither glasses alone or surgery will improve the vision.

Question: I have a friend whose daughter had crossed eyes. She had surgery at 7 months of age which corrected the problem. My son seems to have the exact same problem; however his doctor has recommended glasses. Why shouldn't my son have surgery?

Answer: Although your son's problem and that of your friend's daughter may seem identical to you, they probably are not the same. Most likely your friend's child was not significantly *hyperopic (farsighted)*, so glasses would not have been appropriate for her. If your son is *hyperopic*, glasses are the right treatment with which to start.

Question: I was told my child is very "farsighted." How is that possible when she can see and pick up tiny objects on the floor?

Answer: Recall that the term *"far-sighted"* is misleading when applied to a *hyperopic* child (see pages 22-23, and 27-29.) A *farsighted* child like your daughter can see perfectly clearly without glasses — even close up. She just needs to focus harder than normal to do so (but she is capable of doing so). This excessive focusing may cause an eye to cross.

Question: My son was put in *hyperopic* (farsighted) glasses to treat a crossed eye. The glasses seemed strong to me. I looked through them and could not see anything clearly across the room. How can he see with them?

Answer: Because he is *hyperopic (farsighted)*, he sees clearly with the glasses. Without glasses, and when he is not *accommodating* excessively, his vision is as blurred as yours when you looked through his glasses. Although it is natural to not want your son to wear strong glasses, it is important that the glasses be whatever strength is necessary to correct his *hyperopia*.

Question: I was told my 5 year old daughter is quite *hyperopic (farsighted)* and needs glasses to treat a crossed eye. My doctor said he did not want to prescribe her full prescription at the start, because she would have trouble adjusting to the glasses. He wanted to gradually build my daughter up to her proper prescription in stages. She has obtained the glasses and her eyes are still crossed, even when she wears them. What should I do next?

Answer: Almost all *hyperopic (farsighted)* children with esotropia adapt immediately to their full and proper *hyperopic* glasses. It is uncommon for a child to need to "build up" to their proper prescription. That approach should only be taken if a child does not adapt to the proper prescription initially. If your daughter's eyes are still crossed, she needs more of her *hyperopia* corrected with stronger glasses now.

Question: My son has been wearing *far-sighted* glasses to treat a *crossed eye* for over 5 years. His eyes are fine when he wears his glasses. When he takes the glasses off, his eye crosses as much as it did initially. I thought the glasses were to strengthen his weak eye muscles. Will they ever strengthen?

Answer: This is an excellent question that I am very frequently asked by parents. There is the common misperception that a *crossed eye (esotropia)* is caused by a weakness in the muscles. It sounds like your son has *accommodative esotropia*. If so, there is actually nothing "weak" about his eye muscles, and consequently nothing that should be expected to "strengthen." Think of his problem as being caused by a vision or focusing problem (*hyperopia*) — nothing more or different. As long as he is excessively *hyperopic*, he will need to focus harder than normal to see without glasses. This will cause his eye to turn in. If he outgrows the *hyperopia*, which he may (or may not) do, his eyes will then be straight without glasses.

Question: My daughter has been wearing glasses for years which has successfully treated her *crossed eye*. She is now a teenager. Can she wear contact lenses?

Answer: In general, if her eyes are well aligned with glasses, you can expect the same with contact lenses. An exception is if she needs a bifocal. Studies have shown that bifocal contact lenses do not work as well to treat a child with *accommodative esotropia* as they do in older people who are just having difficulty reading small print. Many children who need a bifocal for treating *esotropia* when they are younger do outgrow the need of a bifocal by the end of adolescence, even if they need to continue to wear glasses. This, however, is not true for all children.

Question: I was told my child would only need glasses for several years to treat a crossed eye. She has been wearing them for 5 years and still needs them. What went wrong?

Answer: Unfortunately, many doctors may tell parents that their child will only need glasses temporarily if the amount of their *hyperopia* is relatively small. They base this prediction on the assumption that the child will lose the average amount of *hyperopia* during their growth years. Alternatively, some parents are told their child "might" outgrow the need of glasses, but they interpret these words to mean "probably will." I personally feel one can never predict the future need of glasses for any particular child, and I never make predictions in this regard.

Question: My son's eye crossed markedly without glasses. His spectacles straighten his eye about half way leaving a residual amount of crossing. My doctor has recommended surgery, but says my son will still need glasses to have straight eyes afterwards. Why can she not operate for the full amount and eliminate the need of glasses?

Answer: This is an excellent and frequently asked question. The answer can be bit confusing to understand. Let us assume your son's eye crosses 30 degrees without glasses and only 10 degrees with glasses on. That means that 20 degrees of crossing is caused by the *accommodation* needed to compensate for his *hyperopia*, leaving 10 degrees of crossing caused by other unexplained reasons. When your son is not wearing glasses, if he is relaxing his focusing (not *accommodating)* he is only crossed 10 degrees, but his vision is blurred. He wants to see clearly, so he must *accommodate* (focus his eyes) to compensate for his *hyperopia*. But by doing so, his eyes cross the additional 20 degrees (to make a total of 30 degrees of crossing), because of the close linking of *accommodation* to *convergence.* What would happen if surgery was performed to correct the entire 30 degrees of crossing — the amount that is present when he is not wearing his glasses and *accommodating* — for the purpose of eliminating his need for glasses? After surgery, his eyes would not be crossed when he is not wearing glasses, as long as he was *accommodating* to overcome his *hyperopia*. However, *accommodating* continuously is fatiguing, and he would periodically need to relax his focusing. When he does so, his eyes would *diverge* the 20 degrees that was being controlled by *accommodation*, and he would appear 20 degrees *exotropic* (has an eye that deviates outward — "wall-eyed"). Being 20 degrees *exotropic* is no better than being 20 degrees *cross-eyed*! Similarly, if he ever did wear his glasses, which perhaps he may need to do to prevent eyestrain or blurred vision, the same thing would happen. The glasses would cause him to relax his *accommodation* and *exotropia* would result.

Important Point: Surgery is not a substitute for glasses if a child has a significant amount of *hyperopia* and *accommodative esotropia.* She may require surgery to correct for *eye crossing* that occurs with her glasses on. However, the surgery will not eliminate the crossing that is held in check by her glasses.

* * *

Eyes that Drift Outward (*Exotropia*)

Basic Information

A common eye muscle problem in children is called intermittent *exotropia*. It usually begins to appear between 2 and 4 years of age, however it can have its onset at younger or older ages. It gets its name from the fact that one eye deviates outward (is *exotropic* or wall-eyed) but only does so intermittently. Particularly in the early stages of intermittent *exotropia*, both eyes may be perfectly aligned with one another and may team together normally a large amount of the time. However occasionally, particularly with fatigue, illness, or while the child is daydreaming, one of his two eyes will drift outward as seen in Fig 4-2B on page 42. Unlike *esotropia*, intermittent *exotropia* tends to be worse with far distant viewing, for example while viewing a landscape as opposed to reading a book. Consequently, primary care doctors may be less likely to detect intermittent *exotropia*, because they typically perform their examinations in relatively small examination rooms. Often a child or adult with intermittent *exotropia* will not be aware of seeing differently when her eye deviates, because she *suppresses* the deviated eye. During the times her one eye is deviated, she is just seeing with one eye. Sometimes, however, she may notice *double vision* or experience that her deviated eye is more sensitive to light. In fact, a tendency to always close one eye in bright sunlight is often a sign a child has an intermittent *exotropia*. Slowly, over a period of years, the frequency with which the *exotropia* occurs may become greater. Ultimately, the eyes become constantly misaligned. Less commonly, however, the condition may not get worse and remains a mild or occasional problem over a lifetime.

When Should Intermittent *Exotropia* Be Treated?

Because a child with intermittent *exotropia* does use his eyes together normally much of the time, there is not the same urgency in treating him at a very young age, as there would be if his eyes were constantly misaligned. As long as his eyes are teaming together properly for a substantial amount of the time, fusion can be present and *amblyopia* is less likely to occur (although it can). There is less concern about him permanently losing the ability for his eyes to team together. Thus, the time to begin treating a child with intermittent *exotropia* varies with the frequency of the problem and whether it is getting worse.

How Does One Determine If Intermittent *Exotropia* is Getting Worse?

In deciding if intermittent *exotropia* has gotten “better” or “worse,” there are two issues that must be considered. The first is how **far** the eye may be misaligned (how many degrees the eye is turned), and the other is how **often** the deviation occurs. Sometimes the two do not go hand-in-hand. There are some people in whom an eye may occasionally drift very far — but rarely do so. In others, an eye may drift a small distance — but do so very often. Although it is the magnitude (number of degrees of misalignment) that determines whether the problem appears better or worse to family and friends, it is the frequency of the misalignment that is really most important. When the eyes are well aligned, a child may be using them together normally. When they are misaligned, she is only using one eye. Useful guidelines as to when to treat *exotropia* include 1) the misalignment occurs quite often (such as 50 % of the time) 2) the frequency of the problem is definitely getting worse or 3) the condition is causing symptoms such as *double vision*, eye strain, or blurring of vision.

How Is Intermittent *Exotropia* Treated?

The general steps in treating intermittent *exotropia* are similar to the ones described for treating all *strabismus*. In actuality, children with intermittent *exotropia* are less likely to have a significant *refractive error* (*myopia, hyperopia,* or *astigmatism)* as the cause of their *strabismus* than a patient with *esotropia*. Nevertheless, the most important first step in treating any wandering eye is to improve the vision to the best possible level. Consequently, if a child with intermittent *exotropia* has any significant *refractive error* glasses should be the first treatment prescribed. Also, correcting any *myopia* with glasses will stimulate a child to focus and *converge*, thus reducing the outward drifting of the eyes.

Occasionally, overcorrection of *nearsightedness* with glasses (providing glasses that have slightly more *nearsighted* correction than is actually needed to correct the *myopia*) and/or incorporating a small amount of *prism* in the glasses will have a beneficial effect in reducing the *exotropia*.

Some children with intermittent *exotropia* have the normal amount of *hyperopia* for their age, and many are *myopic*. If low or moderate degrees of *hyperopia* would be corrected with glasses, there would be less effort to *accommodate* and less resulting *convergence*. Thus the exotropia would be made worse, not better. For this reason, children with *intermittent exotropia* who have a small amount of *hyperopia* should not be given glasses to correct the *farsightedness*. However if an excessive amount of *hyperopia* is present, glasses that correct at least partially correct the *hyperopia* may be necessary to provide clear vision, and such glasses should be prescribed.

Important Point: Children with intermittent *exotropia*, and the normal amount of *hyperopia*, may not need glasses.

For relatively minor cases of *intermittent exotropia*, or patients with straight eyes but a weakness of the ability to *converge* the eyes (as is needed for reading) certain eye exercises to strengthen fusion may be helpful (see Chapter 9). Exercises are less likely to be successful if there is a large degree of *exotropia* or if there is a well-established pattern of *suppression*.

The final step in treating intermittent *exotropia* is eye muscle surgery (see Chapter 7). This is done if the problem is substantial and is getting worse, and if non-surgical means are ineffective or not appropriate.

Constant *Exotropia* in Infancy

A child who has an eye that is constantly misaligned in an outward direction has a constant *exotropia*. A constant *exotropia* in infancy is much less common than either a constant *esotropia* (*crossed eye*) in an infant, or an intermittent *exotropia* in a somewhat older child. As stated earlier, many babies' eyes are somewhat divergent in the first few months of life because they are not yet focusing and tracking objects with their eyes. A constant *exotropia* in an infant that persists beyond the first several months of life may be a sign of neurologic or developmental disorders, or may signify the presence of some other disease within the eye (such as a *cataract* or a tumor) that is preventing it from seeing well.

When an infant does have a constant *exotropia*, and there is no underlying medical or neurologic cause that needs treatment, the treatment program should follow the usual three steps — 1) glasses if needed, 2) treatment of *amblyopia* if present, and 3) eye muscle surgery if steps 1 and 2 do not correct the problem.

Advanced Information: Although *amblyopia* is less likely to occur in children with intermittent *exotropia*, than in those with a constantly misaligned eye, if *amblyopia* is present it must be treated with patching or some alternative method (see Chapter 5). There is another role that patching can play in the treatment of intermittent *exotropia*. As described earlier, when the eye drifts outward the brain *suppresses* (or shuts off) the eye. This makes it harder for the brain to know where the eye is pointing. A program of patching may break this habit of *suppressing* the deviated eye. When the eye is not *suppressed*, it appears easier for the brain to properly control its movements and bring it into correct alignment.

* * *

Eyes that Are Vertically Misaligned (*Hypertropia and Hypotropia*)

Basic Information: Vertical misalignments of the eyes, those that drift upward (*hypertropia*) or drift downward (*hypotropia*) are less common than horizontal deviations. There are two main situations in which vertical eye muscle problems occur. 1) those that occur as the sole eye muscle problem, and 2) those that occur in conjunction with *esotropia* or *exotropia*.

In the course of normal daily activity, we frequently make more horizontal adjustments in position of our two eyes than we do vertically. For example, just the change in focusing on a distant object seen through a window, to a page in a book close-up, and then to the clock on the wall requires us to *converge* and *diverge* our eyes. There is no normal up and down eye movement that is the equivalent of this. Consequently, humans have developed much stronger abilities to compensate for horizontal misalignments of their eyes than for vertical ones. Also, as we have already discussed, focusing and *accommodation* will cause eyes to *converge* or *diverge*. Again, there is no vertical equivalent of this. As a result, vertical eye muscle problems are less likely to respond to eye exercises or simple glasses. If vertical *strabismus* is significant, it is more likely to require surgery. However, a small *hypertropia* or *hypotropia* may respond to treatment with *prisms* in spectacles (see chapter 10). This is more likely to be the case with vertical eye muscle problems that develop after childhood and are causing *double vision*, headaches, or eye strain.

Vertical *Strabismus* Accompanying Horizontal Strabismus

A large percentage of people with *esotropia* or *exotropia* also develop a vertical misalignment of the eyes as an accompanying problem. Sometimes the vertical misalignment develops at the same time as the horizontal *strabismus*, and sometimes it occurs years later. Vertical *strabismus* that accompanies horizontal *strabismus* is usually caused by either excessive action or inadequate action of one or more of the vertical muscles in each eye (see again, Fig 3-2 on page 34). Most commonly this is characterized by either eye drifting up or downward when the child is looking to the side (see Fig 6-5). If this upward or downward drifting is significant, it usually requires eye muscle surgery for correction.

Figure 6-5 Child with vertical misalignment of her left eye that is only present when she looks to her side. In the photo on your right, she is looking straight ahead and her eyes are properly aligned. When she looks to her right as seen in the left-hand photo, her left eye has drifted upward and is vertically misaligned.

Another common form of vertical *strabismus* that accompanies horizontal *strabismus* is called “dissociated vertical divergence” and is abbreviated DVD. It occurs quite frequently in children who have *infantile esotropia* but often does not appear until after a year of age. It is characterized by an intermittent upward drifting of one (or either) eye, particularly when a child is fatigued. Sometimes it is more evident with visual effort such as reading small print. It also requires surgery if the upward drifting is of sufficient magnitude to warrant treatment.

Vertical *Strabismus* as the Sole Eye Muscle Imbalance

When a *hypotropia* or *hypertropia* occurs as the sole eye muscle imbalance, it is often caused by a weakness (paresis) of one of the vertical eye muscles. Alternatively it can be caused be a muscle that is abnormally tight due to a loss of its normal elasticity. The tight muscle can restrict the eye from moving vertically — as though the eye is tethered by a leash.

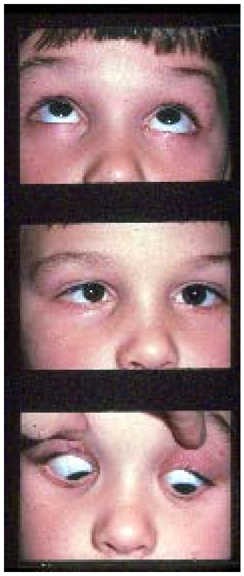
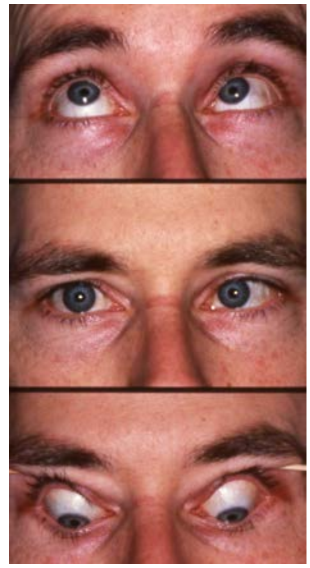
When vertical *strabismus* becomes evident in children or young adults, it is usually caused by a birth defect affecting the nerve to the eye muscle. It can also occur as result of head injury or (less commonly) neurologic disease that can affect the nerves to the muscles. When it occurs after young adulthood, medical problems such as diabetes or thyroid disorders are sometimes the cause (see Chapter 11). If a *hypertropia* or *hypotropia* is small, it can sometimes be treated with *prisms* in spectacles. When larger, or if *prisms* are not successful, surgery is necessary.

Advanced Information: Your brain derives a great deal of information for controlling the vertical position of your eyes from the balance mechanism that is located in your middle ears. Tilting your head to the right or left sends different signals to your vertical eye muscles to relax or contract, thus adjusting the vertical position of your eyes. Because of this, a person with a weakness of one of the vertical eye muscles may compensate by tilting his head to one shoulder. This puts his head in a position in which the weak muscle is not normally called upon to act. Head tilting is a means of compensating for the *hypertropia*, because doing so makes the eye misalignment smaller and easier to control. Many infants with vertical eye muscle problems are thought to have a congenitally stiff neck called “torticollis” and receive unnecessary physical therapy to the neck muscles before the eye muscle problem is diagnosed.

Important Point: A child who always tilts her head toward one shoulder may have a vertical eye muscle problem instead of a stiff neck.

Changes in Horizontal Alignment When Looking Up Or Down

In about 1/3 of people with *esotropia* or *exotropia*, the problem may be worse when they look up than down, or conversely worse when looking down than up (see Fig 6-6). If the eyes are more divergent when looking up (in other words less *cross-eyed* or more *wall-eyed*) it is called a “V-pattern.” It is so-called because the shape of the letter “V” mimics the position of the eyes — more spread apart at the top (or when the eyes are both looking up), and closer together at the bottom (or when the both eyes are looking down). Conversely, if eyes are more converged when looking up than down (in other words more *cross-eyed* or less *wall-eyed*) it is called a “A-pattern” because the letter “A” has that shape — closer together at the top and more spread apart at the bottom.

A B

Figure 6-6 A) Child with V pattern *esotropia*. Eyes are more crossed looking down and less crossed looking up. B) Man with an A pattern *esotropia*. Eyes are properly aligned looking down and more crossed looking up.

A and V patterns are often caused by excessive or deficient action of some of the vertical muscles. If surgery is being performed to treat the *esotropia* or *exotropia*, surgery is often also performed on the vertical muscles at the same time to correct the A or V Pattern.

Chapter 7
Surgical Treatment of Strabismus

Basic Information: Many people with *strabismus* ultimately require surgery to realign their eyes. The purpose of surgery is to achieve satisfactory alignment of the eyes in order to permit *fusion* to occur, eliminate *double vision* (if it is present), and improve the person's appearance. This chapter will explain the principles of eye muscle surgery, address very common questions, and dispel some myths.

Although the thought of surgery can evoke fear and concern for many parents and patients, I hope after you read this chapter your apprehensions will be eased. We will see that *strabismus* surgery has a high likelihood of being successful and carries quite a low risk.

Basic Principles of Surgery

You learned earlier that most *strabismus* is not caused by a weakness in the eye muscles (although in some cases it can be). The cause of the problem usually lies in the eye movement steering mechanism that is located in the brain, or in a weak *fusional* mechanism. How then can operating on the eye muscles help correct this problem? To answer this, it is useful to think of the eye muscles like rubber bands. If you stretch a rubber band, it pulls harder; if you relax it, the rubber band pulls less hard. Similarly, eye muscle surgery involves either relaxing (or shortening) the eye muscles to make them pull less effectively, or by putting them on stretch to make them pull harder. Even though *strabismus* may not have been caused by an abnormality of the length or tightness of the muscles, moving the muscles in this manner will alter the alignment of the eyes.

How Is Strabismus Surgery Performed?

All of the eye muscles lie on the surface of the eyeball, under the thin white outer layer called the *conjunctiva.* (see again, Figure 3-2 on page 34) Consequently, *strabismus* surgery does not involve operating inside the eyeball itself, as is the case with *cataract* surgery.

For children, and for many adults, strabismus surgery is done under general anesthesia. That means the person is completely asleep. In some circumstances, *strabismus* surgery can be performed using local anesthesia (numbing medication around the eye). In either case, the surgery itself is pain free! After anesthesia has been applied (either general anesthesia or local anesthesia) a speculum is put in place to hold the eyelids apart. Next an incision is made through the conjunctiva to permit the *ophthalmologist* to view the muscle(s) that are undergoing surgery. (See Fig 7-1).

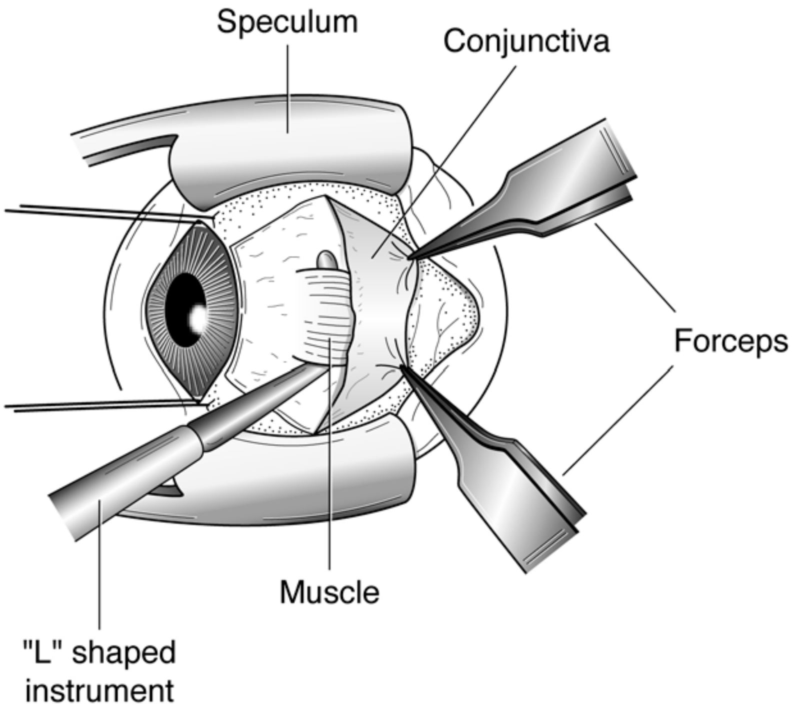


Fig 7-1 This view of a right eye is very similar to what an *ophthalmologist* would see during *strabismus* surgery. The eyelids are gently held apart by a speculum. The muscles lie on the outside of the eyeball, just underneath the conjunctiva, which is a thin membrane covering the eyeball. In this drawing, the *conjunctiva* is reflected to the side and held by two forceps in order to expose *the medial rectus muscle*. There is an “L-shaped” surgical instrument (called a “muscle hook”) under the muscle. The other *extraocular muscles* cannot be seen in this drawing, because they are covered by the *conjunctiva* and are in different locations.

The *ophthalmologist* then locates the muscle and proceeds to either loosen or tighten it. For most *strabismus* surgery, the stitches used to secure the muscle dissolve on their own about 6 weeks after surgery and do not need to be removed.

Myth: Eye muscle surgery requires removing the eye from the eye socket.
Fact: The eye is never removed from the eye socket, nor would it even be possible to safely do so!

Myth: Eye muscle surgery is performed with lasers.
Fact: Although lasers are used quite extensively in other types of eye surgery, they are not used and would be of no benefit for *strabismus* surgery.

Loosening a Muscle

The surgery to loosen a muscle, or decrease its pulling strength is called a “recession” (because the attachment of the muscle to the eye is moved backwards — or “recessed”). After the surgeon locates the muscle, she places sutures in it near its attachment to the eye. This attachment is then separated, and the muscle is re-attached to the eye using the previously placed sutures. (see Fig 7-2).

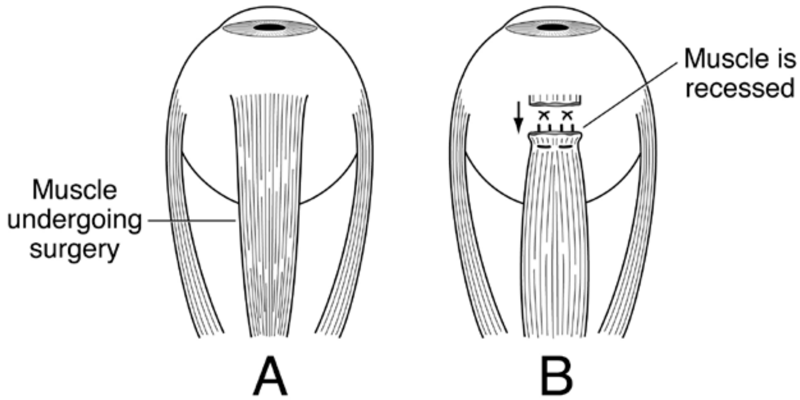


Fig 7-2 In a recession operation, sutures are placed in the muscle, the muscle is detached from the eye, and is re-attached to a new location behind the original one.

The new attachment site of the muscle is typically 3 to 11 millimeters behind the original attachment, the exact distance being determined by how many degrees the eye was misaligned. The further the muscle is “recessed” (moved back), the greater the change in the position of the eye.

Tightening a Muscle

The surgery to tighten a muscle, or increase its pulling strength is called a “resection” (because the part of the muscle is cut away — or “resected”). After the surgeon locates the muscle, the amount of muscle to be removed is measured with a ruler. Sutures are placed in the muscle just behind the tissue that is to be removed. Next, the section of muscle that will be resected is cut away. The sutures are then placed in the original attachment location and tied, thus putting the muscle on stretch. (see Fig 7-3).

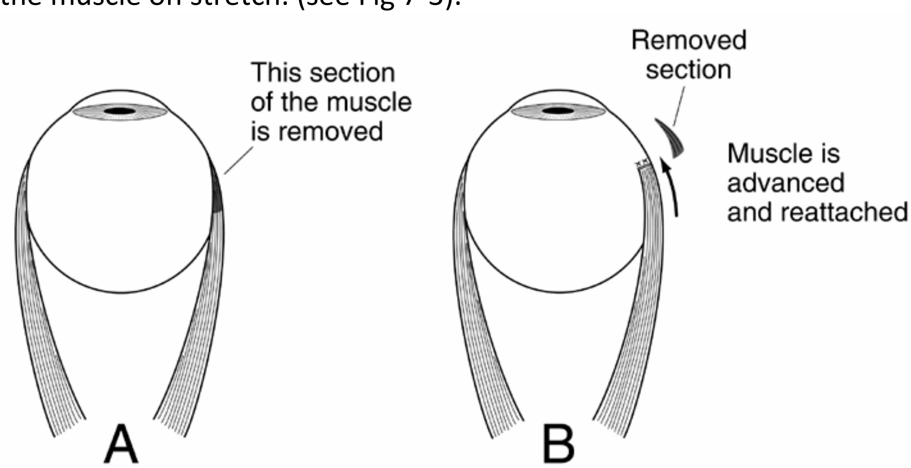


Fig 7-3 In a resection operation A) the segment of muscle to be resected is measured with a ruler. Sutures will be placed in the muscle just behind the segment that is to be resected. B) The segment to be removed is cut away and the front

edge of the remaining muscle is attached to original attachment site, thus placing the muscle on stretch.

Planning Strabismus Surgery

The amount of realignment that occurs with surgery is a related to how many millimeters the muscles are recessed or resected, and there are practical limits as to how much surgery can be performed on a given muscle. Let us return to the comparison of the muscles to rubber bands. If you stretch a rubber band too much, it will no longer feel elastic and no longer have any "give." If you relax its stretch too much, it will become very lax and not pull at all. Similarly, an eye muscle that is resected too much may become stiff and inelastic, and tether the eye from moving. If it is recessed too much, it will be too weak and ineffective in moving the eye. Consequently the number of degrees of correction that is needed not only determines the number of millimeters the muscle(s) should be moved, it also determines the number of muscles that need to undergo surgery. For example, if an eye is a little bit crossed (*esotropic*), the in-turning muscle in that eye can be recessed (loosened). But if there is a larger amount of crossing, more surgery may be needed than can safely be performed on only one muscle. In that situation, the surgeon can also resect (tighten) the out-turning muscle in same eye at the same time (see Figure 7-4)

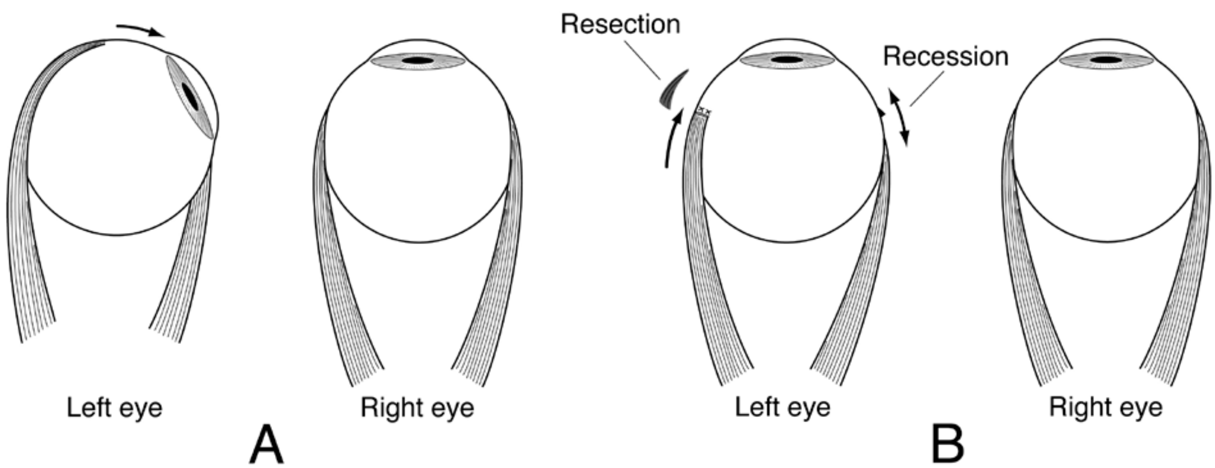


Fig 7-4 A) Esotropia with the left eye turned inward. B) Recession of the in-turning muscle and resecting the out-turning muscle in the left eye will correct the strabismus.

Alternatively, he might simultaneously loosen the interning muscle in both eyes. (see Figure 7-5)

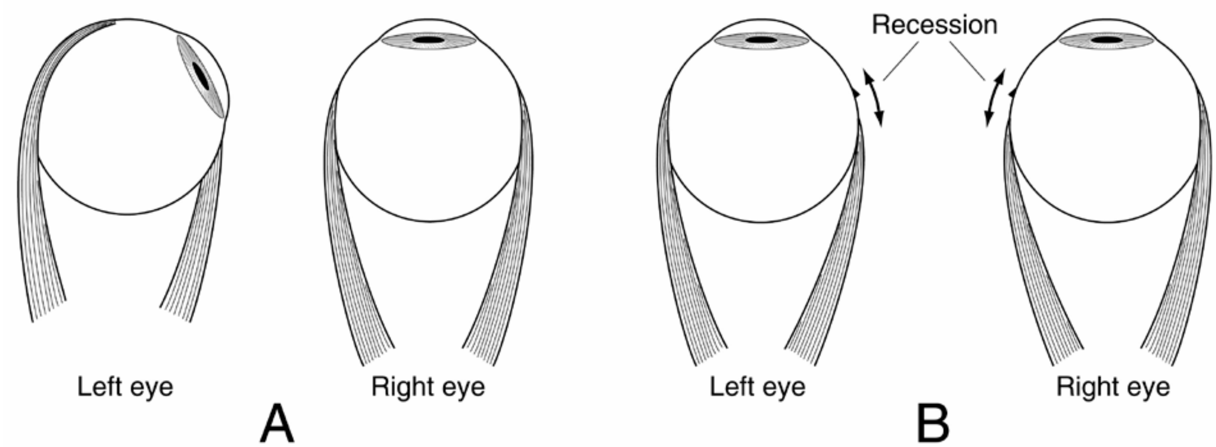


Fig 7-5 A) Esotropia with left eye turned inward. B) Recession of the in-turning muscle in each eye will correct the strabismus.

If eyes are *exotropic* (*wall-eyed*), surgery might involve recessing the out-turning muscle in each (see Figure 7-6), or loosening the out-turning and tightening the in-turning muscle in the same (see Figure 7-7).

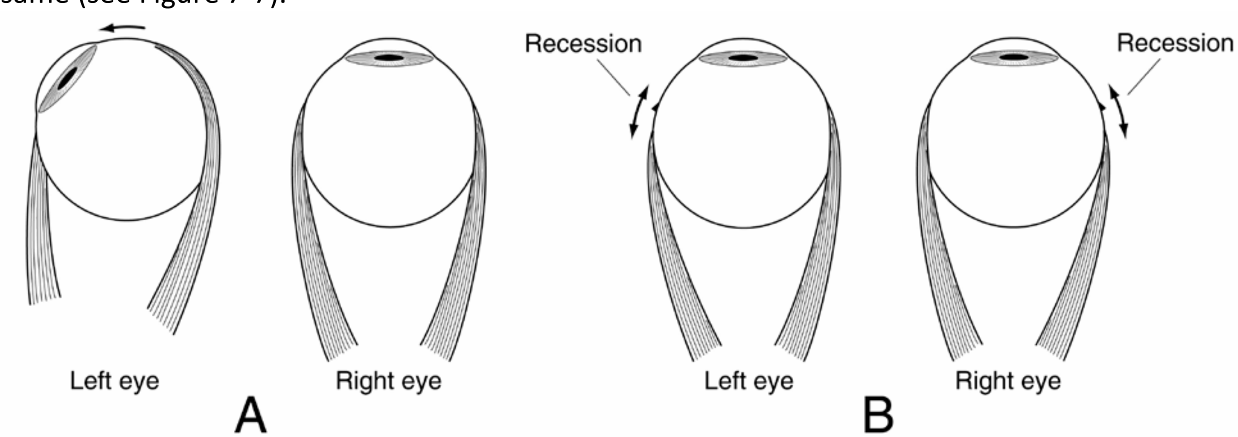


Fig 7-6 A) Exotropia with the left eye turned outward. B) Recession of the out-turning muscle in each eye will correct the strabismus.

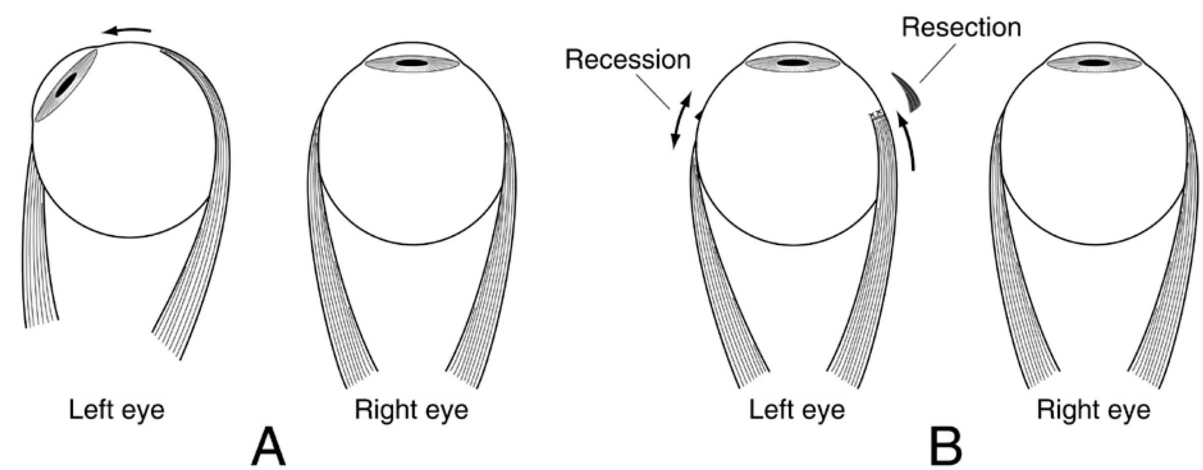


Fig 7-7 A) Exotropia with the left eye turned outward. B) Recession of the out-turning muscle and resection of the in-turning muscle in the left eye will correct the strabismus.

In fact, when *strabismus* is significant enough to warrant surgery, it is more common for two eye muscles to need surgery than only one. It is often of great concern and confusion to patients and parents when the surgeon recommends operating on both eyes, when the problem only appears to be in one eye. Similarly, it may seem equally perplexing if surgery is only recommended on one eye, when both eyes appear to have a problem. It may seem obvious to you that the decision whether to operate on one or both eyes should be made based on which eye or eyes seem to deviate on their own. In reality, it is made based on a combination of factors which may not intuitively seem important to you as a parent or patient. These include whether the *strabismus* is worse looking far away versus near, if it is worse looking to right versus the left, and what (if any) muscles may have had prior surgery. Recall the comparison of misaligned eyes to misalignment of the front wheels of a car (see again page 58). We learned how the crooked car wheels can be made parallel by aligning either one with the other. Similarly, misaligned eyes can be corrected to team together normally if **either** eye is operated upon to be made parallel with its mate.

Important Point: If the recommendation you have received regarding which eye, or the number of eyes (one or two) that should undergo surgery is of concern to you, then ask your eye doctor to explain his reasoning.

Eye Alignment Immediately After Surgery

There are certain eye muscle problems for which the alignment of the eyes changes in a fairly predictable manner during the healing period. For example, when a child undergoes surgery to correct an *exotropia* the eyes tend to drift back outward (*diverge*) an average of about 5 degrees during the healing period. For that reason, the ideal alignment for some children immediately after surgery to correct *exotropia* is to be a few degrees “overcorrected” (*esotropic* or *cross-eyed*), so that when the eyes *diverge* a bit during healing, they will then be straight. For a person with *exotropia,* his brain is accustomed to his eyes being *divergent* (*wall-eyed*) and he learns to *suppress* the deviated eye. He is not accustomed to the eye being turned in (*cross-eyed)* and does not know how to *suppress* an eye in the *cross-eyed* position. Consequently, if and when the eye is turned inward after surgery, temporary *double vision* is common. This typically lasts several days or weeks. If *double vision* persists, it may need to be treated with eyedrops, glasses, prisms, or further surgery. In most cases, temporary *double vision* after *strabismus* surgery is predictable and no cause for undo concern or alarm.

Question: My daughter has an *exotropia*. When she looks at me, I only see the left eye looking off center and have never seen any problem with her right eye. Her doctor wants to perform surgery on both eyes. Why?

Answer: Your doctor’s recommendation may be entirely appropriate. Do not think of your daughter’s *exotropia* as being in the left eye only. Think of her problem as though both eyes are not pointing in the same direction but are divergent. But, when she looks at you, she either must look with her right eye, or her left eye. Otherwise, she would not be looking at you. If her right eye is her dominant eye (just as your right hand may be more coordinated than your left), when given a choice, she always chooses to look with the right eye. So you only see the left eye off center. All you need do is make her look with her left eye (perhaps by covering her right eye), and probably the right eye will be just as far off center as was her left eye. (see again, Fig 6-2 on page 59) You never see her left eye deviate on its own, because she doesn't look with her left eye when she has to choose one eye or the other.

Question: Years ago I had surgery on my left eye for *exotropia*. The problem has returned and I again have an *exotropia* of my left eye. My doctor wants to operate on my right eye only. Why would he do that when there is no problem with the right eye?

Answer: As described in the answer to the above question, *strabismus* surgery can actually be performed on either eye to get the two eyes to team together. In your case, the previous surgery was also to correct an *exotropia* of the left eye. Probably the out-turning muscle was recessed (loosened) and the in-turning muscle resected (tightened). If further surgery was done on the left eye to correct an *exotropia* the out-turning muscle would need to be recessed further and the in-turning muscle resected more. This may involve tightening or loosening the muscles beyond the maximum limits that they can be moved. Depending upon what was done in your prior operation, surgery on your "normal" and previously unoperated right eye may be the correct approach.

Question: I had surgery on my eye muscles many years ago as a child. Records from that surgery are no longer available. I need *strabismus* surgery again. My doctor says he will decide what specific surgery he will perform (and even which eye or eyes he will operate on) at the time of the surgery. I am concerned he does not have a clear plan in mind. Should I be concerned?

Answer: With *strabismus* surgery, the exact surgical plan may often be determined or modified at the time of surgery. When a patient is asleep (under anesthesia) the surgeon can feel the amount of tightness in the different muscles, in a manner that cannot be done as easily or painlessly in the office while a person is awake. The results of this testing will often alter the surgical plan. Also, when someone has had prior surgery, the best plan for subsequent surgery is often influenced by what was done before. If that information is not available, the decision making is often deferred to the time of the subsequent surgery. At that time the surgeon can examine the muscles and see where they were previously re-positioned. This is the reason it is very helpful if patients can provide their eye doctor with records describing any eye muscle surgery they may have previously had.

The Logistics of Strabismus Surgery

Strabismus surgery is typically an outpatient procedure. That means there are no nights spent in the hospital. The eye doctor may need to repeat measuring the misalignment of your eyes some time shortly prior to the date of your surgery, because the amount the muscles are surgically moved will be based on the amount of misalignment at the time the surgery is performed. Therefore you may have an additional visit to the *ophthalmologist* on a day shortly prior to the surgery.

In children, *strabismus* surgery is performed using general anesthesia. Your child will be completely asleep during the operation, so he will not move around during the operation and not feel any discomfort. In adults, *strabismus* surgery is sometimes performed with general anesthesia and sometimes with local anesthesia (numbing medicine around the eye). The choice depends on the nature of the surgery that needs to be done, whether it involves one or both eyes (local anesthesia may be less practical for some patients when the surgery is being performed in both eyes) and individual preferences of the patient and *ophthalmologist*.

Many hospitals or ambulatory surgery centers allow a parent to be in the operating room until a child is asleep, and again to be in the recovery room around the time a child is starting to wake up. The length of the surgery depends on how many muscles are being operated on (operating on four muscles takes about four times as long as operating on one muscle). Questions about the type of anesthesia and length of surgery for you or your child should be asked of your eye doctor. Depending on the nature of the surgery, **one** eye may be patched immediately after surgery; however doctors do not patch both eyes. Patients are able to see as soon as they wake up. After surgery, a patient will go to a recovery room to wake up if the surgery was performed with them asleep. The time spent in the recovery room varies from one half to several hours. Once sufficiently awake, the patient is then brought back to her initial room. Usually the ophthalmologist will want to see a patient within several days after surgery, and then several times in the 2 months afterwards, until the eyes are finally healed. The white of the eye(s) that had surgery will be red immediately after surgery, and will gradually clear up over the subsequent month and half. Restrictions on activity after eye muscle surgery do vary somewhat with individual *ophthalmologist's* preferences and technique. However, restrictions tend to be minimal. Most children are back at school within a few days after surgery and most adults are back to work (depending on the nature of the job) within a week. This varies somewhat depending on the exact nature of the surgery being performed and should be discussed with your *ophthalmologist*. Often there is a short term restriction placed on swimming, contact sports, contact lens wear, and the use of eye make-up immediately after *strabismus* surgery.

Preparing a Child for Strabismus Surgery

The ideal way to prepare a child for upcoming *strabismus* surgery varies with the child's age and level of understanding. However, some guidelines apply to all ages. Children tend to sense apprehension if it is present in their parents. If you, as a parent, can quiet your own anxiety about the upcoming surgery, your sense of confidence will likely translate to your child. It is helpful for children to see their parents taking things as a "matter of course." For a young child, a simple explanation in the days prior to the surgery that he "is going to the hospital (or doctor's office) to have his eyes "fixed" is sufficient. Older children will want more of an explanation and more time to prepare. If your child asks specific questions they should be answered honestly and without evidence of concern. "Will you be there?" "Yes, I will." "Will it hurt?" "Very little." "Will I be asleep?" "Yes." The most effective method of reassuring a child is to convey the sense that you feel everything is in order and under control. There are many excellent books available, designed for children of different ages, to prepare them for surgery. Your local reference librarian, *ophthalmologist*, her nurse or *orthoptist*, should be able to guide you in finding one that is good for your child's age level. Many hospitals and outpatient surgery centers allow you and your child to visit the facility in advance of the surgery date, take a tour, and walk through the steps that will occur when your child later returns for the actually surgery procedure. This type of advance preparation is quite helpful in reducing pre-operative anxiety. Children who are prepared in this way don't make false assumptions about what will happen, because they actually know what to expect. If your hospital or surgery center does allow such pre-operative visits, I encourage you to take advantage of it.

Risks of Strabismus Surgery

Fortunately, the actual risks of *strabismus* surgery are quite small, though not non-existent. The tremendous advances in general anesthesia have now reduced the risk of serious complication (including death) to less than the risk of a 2-hour automobile ride on the freeway. Similarly, serious risk to vision or eyesight is extremely remote. Although an unforeseen infection, hemorrhage, or damage to important parts of the eye can occur and result in vision loss, the likelihood of these happening are also less than the risk of serious injury while crossing a busy street — something people do everyday without giving it much thought.

The biggest downside with *strabismus* surgery is more a limitation than a risk. It relates to the variability or unpredictability of the response. Eye muscle surgery is based on averages. We know that in the average eye, moving a muscle a certain number of millimeters will change its alignment by a given number of degrees. Each individual patient may not experience this same average response. Some eyes may change their alignment more and some less for the same amount of surgery. Consequently some eyes may under-respond to surgery (straightening less than the average amount). If this happens the *strabismus* would be improved after surgery but still be present to a lesser degree. Alternatively some eyes may occasionally over-respond to surgery. This would result in the eye "going the other way"; an *esotropic* eye might be *exotropic*, an *exotropic* eye might be *esotropic* after surgery. The bottom line is that a small percentage of patients may need additional surgery to obtain the desired result.

Question: What is the likelihood of my child needing more than one *strabismus* operation?

Answer: There is no uniform answer to this question, because it varies based on the specific type of *strabismus* your child has, his age (for some conditions like infantile esotropia — younger is better), whether the deviation is constant and if so, for how long has it been so (shorter is better), and if your child has good vision in each eye (good vision is also better). Depending on the answer to these questions, the need of additional strabismus surgery may vary from between 15% to 35%. Proper timing of surgery and treatment of *amblyopia* will work in your favor. You should ask your *ophthalmologist* for meaningful figures for your child's specific problem.

Question: If my daughter needs additional surgery, when will it be done?

Answer: That also depends on the situation. On occasion, if the results from her first operation are clearly not satisfactory, and non-surgical means (glasses, patching, medication) do not improve the results, she may need additional surgery as soon as 6-8 weeks after the first operation. Alternatively, her eyes may be straight for years after surgery and then may drift again. In that case she may need additional surgery when the problem recurs.

Question: If surgery is not 100% guaranteed, why should I do it?

Answer: Just because more than one operation is sometimes needed to achieve the desired result, that is no reason a child or adult should not receive the benefit of properly aligned eyes. The possibility of needing more than one surgical procedure does not cause most patients to ignore the problem. It is merely something parents and patients need to be aware of in advance.

Question: My daughter needs strong *farsighted* glasses. Will *strabismus* surgery improve her vision?

Answer: No. Strabismus surgery is done only on the muscles on the outside of the eye and does involve the inner structures that affect *refractive error* or *visual acuity*. Although sometimes *strabismus* surgery may result in a slight change in the glasses prescription, your child will still probably need strong glasses after surgery.

Question: If strabismus surgery will not improve vision, is it "cosmetic only?"

Answer: No. Although strabismus surgery does not improve *visual acuity*, in most cases it does improve the way people see, by improving *fusion* to some degree. Most people with *esotropia* will have an improvement in their peripheral field of vision after surgery (see experiment on page 36). Many people will develop peripheral *fusion* (see again, page 36) regardless of their age at the time of surgery, and they have the awareness they are "seeing with both eyes together" after their eyes are straightened. Many patients — even adults — will show improved *stereopsis* (3-D vision) after their eyes are straightened.

Question: My son had surgery for *esotropia*. His eyes are now straight with his far-sighted glasses on, but they still cross with the glasses off. Was the surgery unsuccessful?

Answer: No, in fact it was a success. The purpose of *strabismus* surgery is to correct the amount of crossing that is not corrected by the glasses. The crossing caused by *far-sightedness* will still be seen when he is not wearing his *hyperopic* glasses (see pages 64-65).

Question: How much pain is there after *strabismus* surgery?
Answer: Individuals vary a lot in their threshold for pain, so this question can only be answered based on what most patients experience. In general, the discomfort after *strabismus* surgery is primarily foreign body sensation. It feels like when you get something in your eye, rather than the deep discomfort that follows an appendix or tonsil removal. Most children do not require any pain medication after *strabismus* surgery. For those that do need medication, it is usually limited to over-the-counter pain-relief products. Adults typically have similar needs, unless their problem is more complex requiring more extensive surgery.

Question: I heard that nausea is common after *strabismus* surgery. Is that true?
Answer: Recent advances in anesthetic technique have made this much less a problem than it was even a short time ago. However, there is something about operating on the eye muscles that sometimes causes more nausea immediately afterward than with surgery on other parts of the body. Nevertheless, if nausea occurs, it is usually controlled with medication. It is rare for nausea to last more than one day after the operation.

Advanced Information
Adjustable Suture Strabismus Surgery
As stated above, the biggest limitation to *strabismus* surgery relates to the variability of the response. The use of adjustable sutures is a technique that in some circumstances may decrease the variability of *strabismus* surgery and improve results. The principle of adjustable sutures is to do the *strabismus* surgery in the usual manner with the patient asleep, or with the eye numbed with local anesthesia. However, at the end of the surgery, one or more of the muscles is tied in place with a type of temporary knot. When the patient is awake (either later the same day or the next morning) the temporary knot can be loosened, and the position of the eye can be adjusted. The muscle can be allowed to slip backward or be pulled forward, if the eye alignment is not satisfactory. This is usually done at bedside in the hospital or surgery center, or in the doctor's office. Numbing eye-drops (Novacaine) are used to minimize discomfort during the time of muscle re-positioning. After any adjustment is made, a permanent knot is tied in the suture, which will dissolve approximately 6 weeks later.

Adjustable suture surgery does require some cooperation on the part of the patient, and consequently is not suitable for most children. Many *ophthalmologists* limit their use of adjustable sutures to cooperative older teenagers and adults. Although for certain types of *strabismus* surgical procedures the use of adjustable sutures does appear to improve results, they still do not provide a 100% guarantee of a good outcome. Adjustable sutures only permit improvement of the alignment of the eyes immediately after surgery. The *ophthalmologist* cannot re-adjust the muscle's position once the final knot is tied. If the alignment of the eyes is unstable during the subsequent weeks, adjustable sutures will not provide further help. Also, some of the eye muscles, because of their location on the eyeball, do not lend themselves to the use of adjustable sutures. In addition, for certain types of eye muscle problems, they appear less helpful than others. You might wish to discuss with your *ophthalmologist* the pros and cons of adjustable sutures for your specific type of *strabismus*.

Botox® (Botulinum Toxin) To Treat Strabismus

In select circumstances, your doctor may recommend the use of Botox® as an alternative to standard *strabismus* surgery. This treatment involves the injection of a very dilute solution of a muscle relaxant (specifically botulinum toxin) directly into one of the eye muscles. This is a short procedure that can be done in the eye doctor's office for cooperative patients (usually adults). The medication causes a temporary paralysis of the muscle, which lasts about 1-2 months. The principle behind the use of Botox® is as follows: Assume someone has an eye that turns inward (*esotropia*). If the in-turning muscle is injected with Botox®, it will be completely (but temporarily) paralyzed. During this time, the out-turning muscle is unopposed, so it will pull the eye into an outward (*exotropic*) position. Over the course of a month or so, this out-turning muscle may tighten or strengthen, because it is unopposed. Ultimately, when the effect of the Botox® on the in-turning muscles has worn off, the balance of forces will have changed and the eye is straighter. In general, the advantages with Botox® are that it does not require a trip to the operating room (for adults). The disadvantages are that for many conditions, its effect is temporary and needs to be done repeatedly. For children, general anesthesia or sedation is needed to safely perform the injection. Many *ophthalmologists* feel that as long as a child has to be put to sleep, standard surgery should be performed, because it may be more predictable. Finally, for 1-2 months after receiving Botox® to treat strabismus, the eye will be in an overcorrected position (a *crossed-eye* will become *wall-eyed*; a *wall-eye* will be *crossed*). During this time, the person may be more bothered by *double vision* and the alignment of their eyes may appear even less satisfactory than it was prior to the injection. *Ophthalmologists* differ in their enthusiasm for this treatment; some report good success with it and others not so good. Not all *ophthalmologists* offer this procedure. If Botox® is of interest to you, you should discuss it with your *ophthalmologist*.

Chapter 8
Eye Muscle Problems in Adults

Basic Information: *Strabismus* in an adult and *strabismus* in a child are somewhat different. In a child, the problem is usually caused by a congenital fault in the *fusion* mechanism or from her having a substantial focusing problem (*hyperopia*). In an adult, *strabismus* is more often an acquired problem resulting from some underlying systemic condition causing a weakness of an eye muscle. A list of such conditions includes diabetes, stroke, thyroid disorders, or an injury to the head or eye socket as often occurs in motor vehicle accidents, to name a few. Alternatively, *strabismus* in an adult may be the result of an untreated eye muscle problem left over from childhood, or a recurrence of a previously treated condition.

Adults with Acquired *Strabismus*

When an adult who had previously normal eye muscle control develops *strabismus*, he usually has *double vision*. This occurs because his two eyes are pointing in two different directions and his adult brain is not able to learn to *suppress* the second image. When *strabismus* occurs as a result of a specific event such as an injury or stroke, the problem will often heal itself, however this can take 6 to 12 months. During that time, he can manage the *double vision* by either closing one eye (which will always eliminate the second image), or by occluding (patching) one eye. In many cases, temporary *prisms* placed on his glasses will eliminate *double vision*. If the problem does not get better on its own, or if *prisms* are not a satisfactory long term solution, then eye muscle surgery will be needed to correct the problem. Although *strabismus* caused by actual damage to the nerves to the eye muscles, or abnormalities in the eye muscles themselves are more complicated to treat surgically than routine *strabismus*, the vast majority of people with such problems can be helped, and the *double vision* reduced or eliminated.

Adults with Residual or Recurrent *Strabismus* from Childhood

When an adult has *strabismus* that is left over or recurrent from childhood, the treatment has some similarities to that used in children. Specifically, the first step is to provide optimum vision with proper glasses, if needed. Unlike in a child, however, patching to treat *amblyopia* is not effective in adults and is not done. *Strabismus* surgery is likely to be needed if the problem is significant enough to warrant treatment. If prior *strabismus* surgery had been performed, it is important to provide your new eye doctor with records of that surgery to help in planning any subsequent *strabismus* operation. *Strabismus* surgery on muscles that have been previously operated upon is somewhat more complicated than on muscles that have not had prior surgery, because there is more unpredictability in their response. The good news, however, is that most adults with residual or recurrent *strabismus* can be helped.

There are many misconceptions about the actual benefit of *strabismus* surgery in adults who have misaligned eyes and do not appear to have *fusion*. I believe some misconceptions result from a lack of current information on the part of some doctors (both eye doctors and primary care doctors). Others stem from the desires by insurance companies and managed care gatekeepers to restrict care and thus save cost. Depending on the exact nature of the *strabismus* (whether it is intermittent or constant, developed in young childhood versus infancy, *esotropia* versus *exotropia*) many adults with longstanding *strabismus* may develop good fusion (including *stereopsis*) if their eyes are successfully realigned. Equally important, even those adults who have a low likelihood of developing high degrees of *fusion* after eye muscle surgery almost invariably show some improvement in *fusion* after successful *strabismus* surgery. Recall from chapter 3 that *fusion* is not an "all or nothing" phenomenon. Most adults with *esotropia* will show a widening of their range of peripheral vision (see experiment on pages 36-37) after successful *strabismus* surgery, and will be able to tell on their own that they are seeing with both eyes together. This latter statement is also true for most adults with *exotropia*.

Myth: *Strabismus* surgery in adults is usually just "cosmetic surgery."
Fact: Although one of the most obvious benefits of *strabismus* surgery will be an improvement in a person's appearance, almost all adults do obtain some improvement in the way their eyes work together after successful *strabismus* surgery. If your insurance carrier is denying coverage for *strabismus* surgery on the grounds it is only "cosmetic," you may have reason to appeal that ruling depending on your particular condition. In addition, there is a difference between the terms "cosmetic surgery" and "restorative surgery." A "cosmetic" operation is surgery to improve the beauty of something that is perfectly normal — for example a large nose. On the other hand, a "restorative" operation is one that makes an abnormal situation more "normal." It is not "normal" to have misaligned eyes, and surgery to correct them is "restorative."

Double Vision after *Strabismus* Surgery in Adults

When adults undergo *strabismus* surgery for a residual or recurrent childhood problem, a common concern is the possible development of new and bothersome *double vision* afterwards. If an adult has a longstanding *strabismus*, her brain may become accustomed to the misaligned position of her eyes and learns to adapt by *suppressing*. If the alignment of her eyes is changed (even if it is made more normal) her brain may not be accustomed to the new position and will not continue to *suppress* the deviating eye. She may then see double. The likelihood of this occurring is dependent on several factors. First, the situation is different whether the surgery is successful versus unsuccessful in re-aligning her eyes. For example, *double vision* after surgery may predictably occur if someone with an intermittent *exotropia* experiences a persistent overcorrection from surgery and is now *esotropic*. In this situation, additional surgery or *prisms* in glasses may be necessary, because the alignment after surgery was not satisfactory. However, on rare occasion, an adult may achieve the desired outcome from surgery with respect to the eye alignment and she may see double. When this does occur, it is usually temporary and short lived (days to weeks). However, very infrequently it can persist and be annoying. When that occurs, glasses with a *prism*, or with a lens to blur one eye and make the second image less bothersome, can often minimize *double vision*. Very rarely, additional surgery may be needed. Your *ophthalmologist* or *orthoptist* can do some testing before surgery to determine what your particular risk is for developing *double vision* if you undergo surgery. Although this testing is not 100% accurate in predicting who will develop this problem, it can help identify individuals who are more likely to be at risk. Fortunately, persistent *double vision* of this type is very rare.

Question: I am 45 years old and have an *exotropia*. I also have poor vision in my left eye due to *amblyopia*. If I have surgery to straighten my eye, how long will it continue to stay well aligned?

Answer: This is obviously an important question for which there is no simple answer. Many adults with longstanding *strabismus* may experience improvement from eye muscle surgery that lasts a lifetime. However, in others, the results may last a shorter time. The problem may recur after several years. How long the good results will last is not as predictable as buying a set of tires that are good for a specified number of miles and then need to be replaced. Some specific factors affect the answer. If good *fusion* develops after surgery, your eyes may stay aligned longer. Good vision in each eye (with proper glasses) promotes *fusion*, while *amblyopia* is an obstacle to *fusion*. Also, if the *strabismus* began in infancy, a lower level of *fusion* is expected than if the problem first appeared after infancy. Your *ophthalmologist* should be able to give you some specific estimates based on your own problem.

Chapter 9
Eye Exercises (*Orthoptic* Treatment)

"*Orthoptics*" is the term to describe eye exercises designed to improve the way the eyes work together as a team. The Greek word *orthoptic* means "straight eyes." "Ortho" means straight as in orthopedics — straight bones, or orthodontics — straight teeth; and "optics" refers to the eyes. One goal of *orthoptic* treatment is just that — having straight eyes. The other goals are to obtain best possible vision in each eye, *binocular vision* (eyes working together as a team), the absence of *double vision*, all with comfort and flexibility. An *orthoptist* is usually the person who directs the eye exercises. She is a therapist who has had extensive training in this field, and has been certified after taking both a written and oral examination by the American Orthoptic Council. Some *optometrists* also administer eye exercises.

Myth: Eye exercises strengthen the eye muscles.
Fact: The muscles that control eye movement have over 100 times the amount of strength they need for eye movements. The reason *strabismus* occurs in many cases is because of an imbalance between the two eyes and their inability to work together as a team. In some cases, the *fusion* mechanism is faulty. To have comfortable and flexible *binocularity* a person must have good *convergence* and *divergence* no *suppression* and equal vision in each eye. Effective eye exercises are designed to improve those factors, not actually strengthen the muscles. Eye exercises are of little benefit when the *fusion* mechanism has failed to develop normally.

In many situations, the best "eye exercise" is simply to cause the eye to be used, as is done with patching for treating *amblyopia*. More involved types of exercises require a child to be old enough and sufficiently cooperative to follow instructions of the eye doctor or *orthoptist*. Exercises are more likely to be effective in treating an eye muscle imbalance if the deviation is slight, *fusion* is present, and the vision is good in both eyes. For example, individuals with normal, or nearly normal eye alignment, but have difficulty *converging* the eyes for close up viewing (such as reading a book) may experience *double vision* and eye strain with reading. This situation, called "*convergence* insufficiency," responds quite well to *orthoptic* exercises. On the other hand, if there is a substantial misalignment of the eyes, particularly if it is present constantly and accompanied by *suppression*, eye exercises alone are, in my experience, usually not helpful. They may sometimes be of benefit when combined with other forms of treatment such as surgery.

Most commonly *orthoptic* exercises are done at home between visits to the eye doctor that are spaced 3 to 4 weeks apart. If eye exercises are deemed helpful for a young child (under 5 years of age), a program of more frequent office sessions may be beneficial until the child and her parents fully understand what is expected of them, and improvement begins to occur. However, continued office visits to use special machines or techniques are seldom any more effective than a home exercise program with monthly supervision, and they are certainly more expensive. It is generally preferable to exercise frequently for brief periods daily than during occasional prolonged office sessions.

Not every child with *strabismus* should be treated with *orthoptic* exercises, but in appropriately selected cases they may hasten the day when comfortable *fusion* is obtained.

Chapter 10
Glasses in the Management of *Strabismus*

Basic Information

Glasses for Young Children: You have learned how the use of glasses is an important part of the treatment of *strabismus*. As a parent, you may be surprised to learn your small child needs glasses and, you may not have experience in picking out glasses for someone who is young. This chapter is designed to give you some tips in that regard.

For glasses to work properly in a young child, it is particularly important that the frames fit properly and stay in place. Some optical shops are not accustomed to fitting glasses on small children and do not carry frames in small enough sizes. If the optical shop you go to does not have a frame that fits your child properly, you should go elsewhere. Ask your eye doctor for suggestions. To help ensure that the glasses stay in place properly, you should get the type with temple pieces that wrap around the ears. Often an elastic strap (available at drugstores and optical shops) that goes behind the head will help keep the glasses on, however it is not a substitute for correctly fitting glasses.

The design and fit of the frame should be such that the child's pupil is located near the center of the lens, both vertically and horizontally (see Fig 10-1).

Fig 10-1 A good frame choice for a young child. The child’s pupil is near the center of the lens.

If your child needs a bifocal to treat *esotropia*, it is important that the bifocal be positioned sufficiently high to encourage its use. An adult who needs a bifocal to see clearly for reading, will automatically look through the bifocal segment, or they will not see clearly close up. A child who is wearing a bifocal to straighten an *esotropia* will be able to see clearly close up even if they do not look through the bifocal, because they have strong *accommodation*. Consequently a bifocal in a child is usually positioned higher than for an adult. It is typically level with the middle of the pupil (see Fig 10-2).

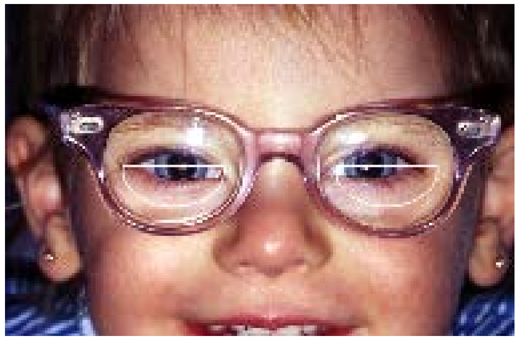


Fig 10-2 Proper positioning of a bifocal for a child with esotropia. The bifocal line is level with the mid-pupil.

Question: My doctor just prescribed a bifocal for my 3-year-old daughter to treat an *esotropia*. Can I get a "no-line" bifocal?
Answer: Generally that is not advisable at the start, at least until your child has developed good *fusion*. A no-line bifocal is made with a gradual transition zone (about 1/2 inch high) between the distance and near correction in the lens. Consequently, the proper near correction is near the bottom of the lens. Because your child can see clearly at near without looking through the bifocal (it is just that her eye crosses at near), she would probably look over the bifocal segment for close work and her eye would still cross.

Question: My doctor just prescribed a bifocal for my 4-year-old son to treat an *esotropia*. Can he get contact lenses instead?
Answer: This is probably not a good idea. Bifocal contact lenses do not appear to work well for children with *esotropia*. The eyes still cross at near viewing despite the bifocal in the contact lens. When your son gets older, he may outgrow the need of a bifocal and can wear single vision (not bifocal) glasses. In that case, contact lenses would work the same as his glasses.

Question: I do not want my child (who has an *esotropia*) to wear glasses. Can she have laser surgery to eliminate the need of glasses?
Answer: There is yet a lot we do not know about how eyes change with growth and what effect that may have on *refractive errors (myopia, hyperopia,* and *astigmatism*). Most specialists agree that it is not wise to perform refractive surgery until a child is about 20 years of age and her eyes have finished growing. If your daughter still needs glasses to control her *strabismus* at that age, refractive surgery might be an option. It would not be successful if she needed a bifocal or *prisms* in her glasses.

Advanced Information: A *prism* is a special type of lens that can be used to treat certain eye muscle disorders. When you look at something through a *prism*, the image of what you look at will be shifted (see Fig 10-3). Consider the situation where the two eyes are pointing in different directions. By placing a *prism* before the deviated eye, the image of what the other eye is looking at can be shifted so the deviated eye sees the same thing.

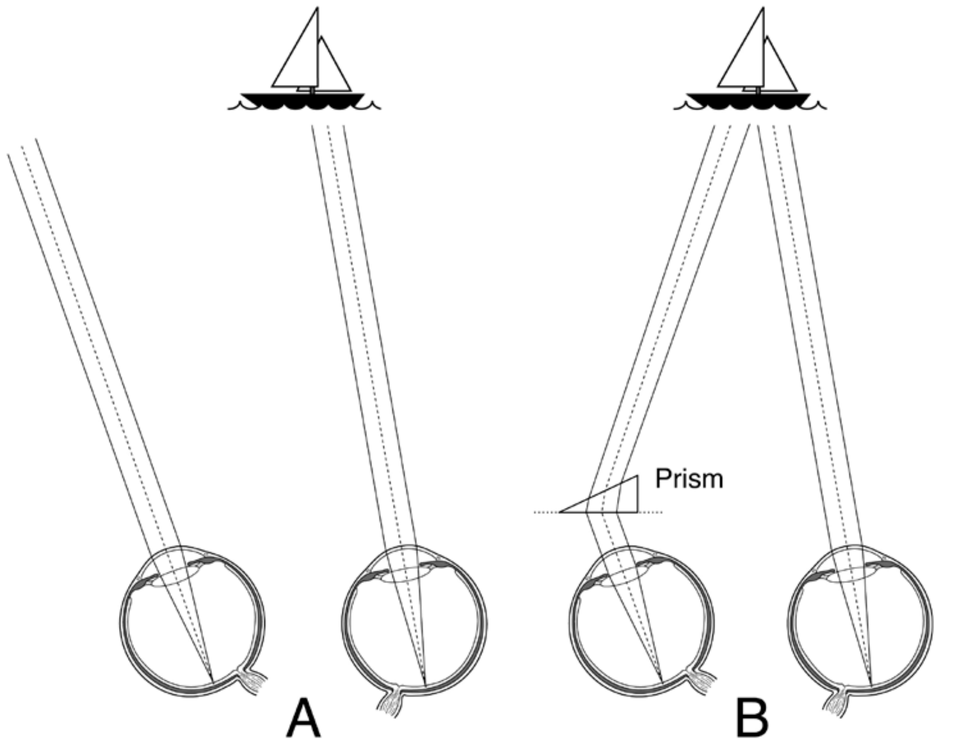


Fig 10-3 A) Person looking at a boat with his right eye. His left eye is looking off to the side (*exotropic*). B) By placing a *prism* over the left eye, the image of the boat is shifted to where the left eye is looking and both eyes see the boat.

There are two different types of *prism* that are used to treat *strabismus*. If the amount of prism needed is relatively small, it can be ground into a persons spectacle lenses. This is called a “ground in” *prism* which has the clarity of regular glasses. However, if a strong *prism* is needed, “ground in” prisms cause a substantial increase in the thickness and weight of the glasses. Practically speaking, this type of *prism* is useful if someone needs less than 4 degrees of *prism* in for each eye (8 *prism diopters*). When larger amounts of *prism* are needed, a type called a “paste-on” or “Fresnel *prism*” can be used. This is a thin plastic membrane than can be applied to a person’s regular spectacle lens, much like a sheet of cellophane. The advantage with a Fresnel *prism* is that it does not add significant weight or thickness to the glasses, is less expensive than ground-in *prism*, and can be changed easily as the amount of *prism* needed is changing. The disadvantage is that it blurs vision somewhat, depending on its strength.

Monovision

We discussed earlier that when people enter their 40s, the decrease in their ability to *accommodate* will result in blurred vision for reading. It is for this reason that people typically obtain bifocals. A popular alternative to bifocals is called "monovision." This involves providing optical correction (glasses, contact lenses, refractive surgery) so that one eye is always in focus for distance (like for watching a movie) and the other eye for near viewing (like while reading a book). With monovision, only one eye is ever clearly in focus at a time. Although this treatment option appears satisfactory for many people who do not wish to wear bifocals, it can be problematic for people with *strabismus*. Throughout this book I have discussed the importance of good and equally clear vision from both eyes for people with *strabismus*. Some adults with a history of *strabismus* that may have been satisfactorily treated in the past may experience a recurrence of their eye muscle problem if they try monovision.

Chapter 11
The Psychological Effects of Strabismus

Basic Information: Eyes that are misaligned are not only working improperly, they also look different. To other children, a playmate with *strabismus* may look "funny." A child with *strabismus* may be laughed at, teased, or called names, any of which can have an unsettling effect on his self-image. After exposure to such experiences, a child with *strabismus* may learn to look down or away from people in order to cover his defect. His personality may consequently develop so he becomes shy and self-conscious. By the time he enters kindergarten, his behavior pattern may already be affected, and by the time he reaches first grade, personality problems may be well entrenched and difficult to undo. Parents who delay treating *strabismus* in an infant in hopes that the problem will correct itself are not only decreasing the likelihood obtaining good fusion, they also risk subjecting their child to emotional distress. These are important reasons for the early treatment of *strabismus*.

Science does not fully understand the degree to which *strabismus* may hinder an infant's development. We know that the vast majority of infants with *strabismus* have normal development and grow up to have normal intelligence. But most *ophthalmologists* hear individual reports of infants who show a sudden spurt in their developmental milestones immediately after their eyes are surgically straightened.

Try This Experiment. One possible reason for the developmental advances that may occur after *strabismus* surgery can be appreciated if you do this simple experiment. Keep your left eye closed or covered while you look at an object on the wall in front of you. A picture or clock will do. Then, while still looking at the object and keeping the left eye closed, turn your head to the right, so that your right eye is seeing the object by looking across your nose. You will immediately notice how limited your peripheral vision off to the left becomes, because your nose blocks that area from your right eye. This is the way that many infants with *esotropia* see the world. Now open both eyes and note how much further in left periphery you can see. Most infants with *esotropia* shut off, or *suppress* one eye. When they do so, they are just seeing with one eye at time. Because they have been "cross fixating" (see Figure 6-3, page 60**)** they have difficulty moving either eye to the center position. They tend to turn their head to keep the "seeing eye" in toward the nose, just as you did in the above experiment. It is easy to understand why an infant with such limited peripheral vision may be reluctant to explore her surroundings, and why this would improve as soon as her eyes are straightened.

The Psychological Effects of *Strabismus* on Adults

Artists and photographers know that the eyes are one of the first features we notice when we look at someone, and they are the most revealing of one's inner nature. Studies have shown that people with misaligned eyes are subjectively viewed as being less trustworthy and less honest. In one experiment, photographs of people with normal eyes were altered by a computer, to show the same people as having *strabismus*. The normal and doctored photographs were then shown to personnel managers as part of otherwise identical job applications. In the study, the personnel managers were consistently less likely to hire the applicant if shown one of the doctored photographs depicting the applicant with misaligned eyes. Many adults with *strabismus* report that when they are engaged in conversation, people frequently do not know if they are the one being spoken to; they do not know who the speaker is looking at. This is particularly problematic for individuals with *strabismus* who frequently interact with the public, such as teachers and salespeople.

Given the current high success rate in the treatment of adult *strabismus*, it is usually unnecessary for adults to have to put up with these distressing situations.

Chapter 12
The Eye as it Relates to Reading Disabilities

Basic Information: It is said that we are living in the "age of information." Throughout the day we need to rely on our ability to read to acquire much of that information. The use of computers, the Internet, understanding a map, and determining which brand of canned food to buy in the supermarket all require our being able to read. It is no surprise that when a child is having difficulty learning to read, his parents are very concerned. Because the first step in reading involves being able to see the printed word, it is natural to suspect that eye problems may be the cause of reading difficulties. Although eye problems may cause trouble seeing the printed word, eye strain, fatigue, headaches, or *double vision* with reading, these problems rarely result in difficulty learning to read. They may, however, cause individuals to tend to avoid reading, or not like reading. Consequently, eye conditions should be checked for as part of an eye examination when reading problems are suspected.

Myth: Eye problems are a common cause of reading disabilities, and eye exercises will improve reading skill.
Fact: Many frustrated parents spend large sums of money on vision training programs to improve their child's ability to track objects in hopes that reading skills will improve. Recommendations for these programs are often based on the observations that the eyes of poor readers do not track smoothly across a page. The false assumption is that the reading is poor because the tracking is poor. In fact, it is the other way around. If a person with normal reading skills is shown printed material that is more complex than he can understand, or is in an unfamiliar language, his eyes will also make frequent stops, starts, and back-up movements as he tries to read the difficult material. The reason a poor reader does not track smoothly is because he is having trouble reading the material, not the other way around.

Some children who have difficulty with reading are told they have the "Scotopic Sensitivity Syndrome" and are advised to obtain specially tinted lenses for reading. In my opinion, there is no rational basis for this often costly treatment. More importantly a clinical study found they are of no benefit in treating reading disabilities.

Important Point: If you have been advised to enroll your child in a costly vision training program or obtain special tinted lenses because he is a poor reader, you may wish to get another opinion.

Similarly, many children with poor reading ability are prescribed very mild *farsighted* glasses (usually under 1 *diopter*) on the premise that they will make things easier to see. Although these glasses are not harmful, and children can see clearly with them for reading because they magnify print slightly, they will not help a child with a reading problem to read better.

Important Point: If your child was prescribed a pair of mild reading glasses because she is a poor reader, and if you and she do not think the glasses are helping, they may likely be unnecessary. You may wish to get another opinion.

Dyslexia

Dyslexia is a relatively uncommon problem that can account for difficulty with learning to read. It is often hereditary (runs in families). People with dyslexia often reverse letters when reading or writing, and sometimes write backwards (as would be seen in a mirror). Recent studies have confirmed that Dyslexia is a language-based learning disability. It refers to a cluster of symptoms, which result in people having difficulties with specific language skills, particularly reading. Dyslexia is characterized by difficulties with accurate and / or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language. Most people with dyslexia have been found to have problems with identifying the separate speech sounds within a word and/or learning how letters represent those sounds, a key factor in their reading difficulties. Dyslexia is not actually an eye problem and cannot be helped with vision therapy. Consequently exercising eye muscles, vision therapy, or the use of special tinted lenses will not help a child with dyslexia learn to read.

Question: My three-year-old child reverses letters. For example she calls a “b” a “d.” Does she have dyslexia?
Answer: Not necessarily. Reversals of letters for reading and writing are very common when children are first starting to read and write.

Question: My son reverses letters when reading and writing. Is he seeing things backwards?
Answer No. Even people with dyslexia do not actually see things backwards.

Question: Is there any resource to help me understand my son’s reading problem?
Answer: An excellent resource for parents of children with reading difficulties is the International Dyslexia Association. It is an international organization devoted to providing information about dyslexia and reading disabilities. They can be contacted at:

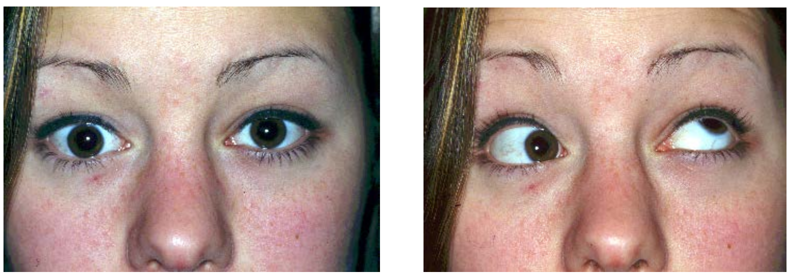
The International Dyslexia Association
40 York Rd., 4th Floor
Baltimore, MD 21204
Office Telephone: (410) 296-0232
http://www.interdys.org

Chapter 13
Special Forms of Strabismus

Advanced Information: This entire chapter is devoted to the less common forms of *strabismus*. It is intended to provide an overview for individuals with an interest in specific selected subjects. Unless you have a particular interest in one of the conditions mentioned in this chapter, you may wish to skip reading this chapter.

Brown Syndrome

Brown Syndrome is an eye muscle disorder named after Dr. Harold Brown, who was the first to describe it. It is an abnormality of one of the vertical muscles of the eyes, specifically the "superior oblique" (see again, Figure 3-2 on page 34).



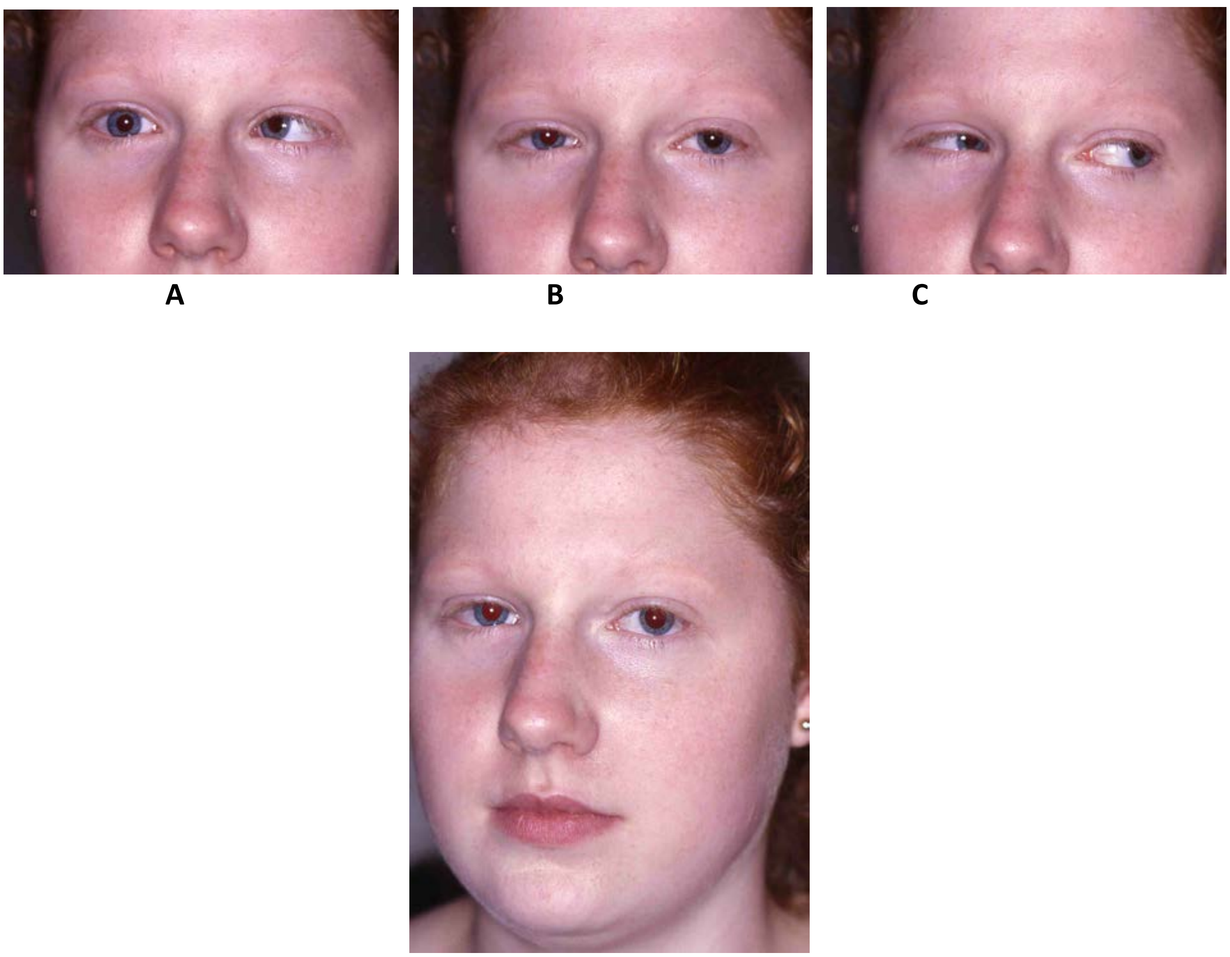
A **B**

Figure 13-1 This girl has Brown Syndrome of her right eye. When she looks straight ahead (13-1A) her eyes are properly aligned. Her left eye is unable to move up and to the left, so when she looks in that direction, her eyes are vertically misaligned. (13-1B)

Often the problem is only present in one eye, however sometimes both eyes may be affected. It is characterized by an abnormal tightness of the superior oblique muscle, which cannot not relax or stretch out when it should. People with Brown Syndrome cannot look up and inward (toward the nose) with the affected eye.(see Figure 13-1) Often parents feel the problem is in the other (normal) eye, which may appear to be too high when their child looks up. Brown Syndrome is often a birth defect, but can also develop after trauma or inflammation to the muscle's tendon. It can be treated with surgery if there is an eye misalignment in the straight ahead position. If abnormal alignment only occurs when the child looks up, Brown Syndrome can often be left untreated.

Duane Syndrome

Duane Syndrome is an eye muscle problem named after Dr. Thomas Duane, who described this condition over 100 years ago. It is a birth defect characterized by abnormal connections of the nerves to the eye muscles in one or both eyes. With Duane Syndrome, different muscles may be affected to varying degrees in different patients. Hence, not all patients with Duane Syndrome appear to have identical problems. In the most common form of Duane Syndrome, the out-turning muscle does not receive the normal nerve signal to tighten when the person looks to the side (toward the ear on the side of the eye with Duane Syndrome), so his eye stops at the midline. (See Figure 13-2) His other eye, which may move normally, appears to overshoot the eye with Duane Syndrome, and can thus appear crossed. When a person with Duane Syndrome looks to the other side (toward his nose) his in-turning muscle tightens as it should, and his out-turning muscle tightens a bit (when it shouldn't) and his eye is pulled backward slightly in his eye socket. This may cause the opening of the eye to appear to get a bit smaller. Sometimes these opposing forces on the eye can cause it to rotate upward or downward on attempted side gaze as is seen in Figure 13-2.



A B C

D

Figure 13-2 This girl has Duane Syndrome of her right eye. When she looks straight ahead B) her eyes are properly aligned. When she looks to her right, her right eye does not move past the midline position. A) Sometimes parents feel this situation is an abnormal crossing of the left eye, when in fact the problem is that the right eye cannot rotate to the right. When she looks to her left, the right eye is pulled back in the eye socket causing the opening of the eyelids to narrow and the eye look smaller; the eye also rotates downward. C)

Many people with Duane Syndrome have perfectly aligned eyes when they look straight ahead, and the problem is only evident when they look to the side. For them, no treatment may be needed. In others, even with straight ahead gaze their eyes do not line up properly. Such an individual will turn his head to one side to get his eyes to line up to allow fusion. For him, eye muscle surgery is often effective in eliminating the abnormal head turning. It is not possible, however, to change the abnormal pattern of nerve connections.

Thyroid Disorders

In some adults with thyroid problems, the eye muscles may become inflamed, which causes them to become swollen, inelastic, and tight. Instead of being normally stretchable like rubber bands, these tight muscles can pull the eye out of its normal position and restrict its movement, just as though the muscle was a leash or a tether. When this happens, *double vision* often results. The problem can occur in one or multiple muscles in one or both eyes. Many adults with this problem also develop a retraction of the eyelids resulting in a “stare” or widening of the opened eyelids. The eyes may also become more prominent.

The exact relationship between thyroid gland problems and this eye disorder is a bit confusing. Sometimes the eye problem occurs when the thyroid gland is overactive and occasionally when it is underactive. More perplexing, sometimes the eye problem does not occur while the thyroid gland is malfunctioning, and then the eye problem appears after the thyroid problem has been successfully treated. A simplified explanation is that an abnormal thyroid gland (overactive or underactive) makes some protein (antigen) against which the body makes an antibody. This antibody cross-reacts with something in the eye muscles, and causes the problem. Some patients need to undergo surgery (an “orbital decompression) to make more room in the eye socket so the swollen muscles do not press on and damage the nerve of vision. Sometimes radiation to the eye socket or steroid medication is helpful. If *double vision* persists, and it cannot be eliminated with *prisms*, then eye muscle surgery will be needed. Although this type of *strabismus* can be a frustrating problem for patients to deal with, ultimately most can get relief from their symptoms. One must wait until the condition has stabilized and is no longer changing before surgery can be performed.

Myasthenia

Myasthenia is a neurologic disorder that can cause *double vision*. People with myasthenia are missing a chemical in their blood that is necessary for nerves to transmit messages to eye muscles to contract. Someone with myasthenia appears to have progressively weakening muscles that may be worse with fatigue or repeated use. Myasthenia has two forms. One is a systemic disorder in which there is weakness of multiple body muscles (arms, legs, etc.) This is called myasthenia gravis. The other form, called ocular myasthenia, is limited to the muscles that move the eyes. People with myasthenia may have *double vision* that may vary throughout the day, or from day-to-day, and is often accompanied by droopy eyelids. There are various tests that can confirm the presence of myasthenia. The ocular symptoms can sometimes be treated with *prisms*. When symptoms affect other muscles in the body, myasthenia is usually treated with medication.

***Strabismus* Associated With Neurologic Impairment In Children**

Controlling the eye muscles is one of the more complicated tasks the brain must carry out. It is not surprising that children with neurologic problems such as cerebral palsy and microcephaly, to name a two, will have eye muscle problems. Depending on the severity of the neurologic problem, *strabismus* can still be treated in a similar fashion as in children who are neurologically normal. If brain damage is severe, good fusion may be less likely to occur.

***Strabismus* Associated With Structural Vision Loss**

As you have learned, one of the most important factors in preventing eyes from wandering in the first place is the presence of good vision in each eye. It is not surprising that children with either birth defects or acquired problems that severely affect vision in one or both eyes will have strabismus, because good *fusion* is not possible. Examples of these structural problems include congenital underdevelopment of the nerves of vision, *cataract*, *retinal* scar, internal ocular malformation, or damage from injury. In these situations, attempts should first be made to improve vision if that can be accomplished. In some children, good vision may be obtainable despite the underlying problem. After the best possible vision has been obtained, *strabismus* surgery may still be necessary depending on the nature of the problem. If it does not appear that good *fusion* is possible because of the vision deficit, it may be prudent to delay surgery until a child is 3-5 years of age. This is around the time children start interacting more with peers and they may become more self-conscious of their different appearance.

Ptosis (Droopy Eyelid)

Ptosis, pronounced "toe-sis" (the "P" is silent), is when the muscle in the upper eyelid is weak and the eyelid droops. (see Figure 13-3)

Figure 13-3 This boy has *ptosis* of the his left upper eyelid. The eyelid is droopy. This is not to be confused with *lazy eye*.

Ptosis in a child is most commonly an isolated birth defect affecting the eyelid muscle. Although *ptosis* is often confused with a "*lazy eye,*" it is a different condition. In many cases, *ptosis* only affects a child's appearance and it does not cause any vision problem. Sometimes, however, a droopy eyelid can cause *amblyopia* by either of two different mechanisms. If the eyelid droops so much that it blocks off the *pupil* and the eye cannot see, *amblyopia* may develop. Also, the pressure of the droopy eyelid against the eyeball can mold or distort the front surface of the eye (the *cornea*) and cause *astigmatism*. In that situation, *amblyopia* may also develop. Finally, *ptosis* may sometimes occur in conjunction with *strabismus*. Any child with ptosis should be examined by an eye doctor by 6 months of age to determine if her vision is being adversely affected. This examination should include a *refraction* performed after the instillation of dilating drops. If vision is not being affected, surgery to raise the eyelid is usually deferred until the child is 3 or 4 years old. When *ptosis* affects vision, surgery is sometimes performed earlier. If *amblyopia* is also present, it is treated in the manner described in Chapter 5.

Nystagmus

Nystagmus is the term to describe a rhythmic back and forth "jiggling" of the eyes. The word "*nystagmus*" sounds similar to *astigmatism* but they are not the same and should not be confused. There are two common causes of *nystagmus* in children. The first occurs if there is any abnormality within both eyes that affects vision development. Smooth and steady eye movements require good vision in order to develop. If vision is limited or fails to develop, *nystagmus* may occur. There are a number of conditions in which the *retina* (remember — the *retina* is the light sensitive tissue in the eye that acts like the film in a camera) may not be capable of working properly, even though it may look normal to the eye doctor. Having one of these disorders would be comparable to having a good camera in which the film is defective. Special testing can be done to diagnose these *retinal* disorders, if they are suspected. These *retinal* abnormalities include a number of fairly rare disorders of the *retina* such as achromatopsia, rod and cone dystrophies, albinism, and Leber's amaurosis to name a few.

The second major cause of nystagmus in children is a condition simply called "congenital motor nystagmus." In that disorder, the eyes are perfectly capable of seeing well. However there is instability in the part of the brain that controls eye movements and the eyes are unsteady. A child with this type of *nystagmus* may note that when she looks in certain directions (right, left, up or down), the *nystagmus* is less, her eyes are steadier, and she sees better. She will tend to turn or tilt her head when she wishes to look carefully at things, so as to put her eyes in the position in which her vision is improved. If this abnormal head positioning is marked and persistent, eye muscle surgery can be done to shift this "quiet zone" toward the straight ahead position and decrease the abnormal head posture.

Question: My child has *nystagmus*. He always turns his face to his right when he looks at things. It appears he is doing this so he can favor using his left eye. Should I be worried about the vision in his right eye? It appears he is neglecting it.

Answer: Probably not. The reason he is turning his head is because he sees better with both eyes when he looks to the left, because his eyes are steadier. In fact, he is most likely using both eyes equally well when he turns his head. Turning his head to the side does not mean he is using one eye.

Try This Experiment. Look at an object on the wall straight ahead. Next, keep looking at the object while you turn your head about 30 degrees to the right as is done by the child described in the above question. Now close your left eye. Unless you turned your head so far that your nose blocked the vision, you will note that you can still see the object with your right eye. The child described in the preceding question is probably using his right eye.

Chapter 14
Glossary: Some Important Terms to Understand

AAPOS**:** American Association for Pediatric Ophthalmology and Strabismus. It is the official association for *pediatric ophthalmologists* and eye muscle specialists in North America. To become a regular member, an *ophthalmologist* must complete a minimum of a one year fellowship in an *AAPOS* approved training program. That year is devoted solely to diagnosing and treating eye diseases in children (including *strabismus*) as well as adults with *strabismus*. For more information visit their website at www.aapos.org

AACO**:** The American Association of Certified Orthoptists (*AACO*) is the official association of *orthoptists* in the United States. To become a member, an *orthoptist* must first complete training in an *AACO* approved training program, and then pass both a written and an oral examination.

Accommodation**:** The process by which an eye changes focus from distance to near viewing. It is also the process by which a *hyperopic* child can overcome and compensate for *hyperopia*.

Accommodative Esotropia: Crossing of the eyes (see *esotropia*) caused by focusing (*accommodation*) and *hyperopia* (*farsightedness*).

Amblyopia: Decreased vision, usually in one eye only, that does not immediately improve with glasses, yet in the absence of there being something structurally wrong with the eye, such as a *cataract*, internal scarring, etc., that accounts for the decreased vision. In lay terms the eye is said to be "lazy" because the vision is decreased as a result of the eye not being used.

Astigmatism**:** An optical aberration of an eye that will distort vision at both near and far distance.

Binocularity: The normal process of seeing with both eyes simultaneously.

Cataract: A loss of clarity, or cloudiness of the *crystalline lens* of the eye,

Ciliary Muscle**:** A muscle that is located behind the *iris* and is responsible for our ability to change the focus of our eyes.

Conjunctiva: The thin layer of tissue that covers the white of the eyes.

Convergence**:** The normal slight turning in of both eyes that is necessary for viewing a close-up object.

Cornea: The very front most part of the eye, which overlies the *pupil* and *iris*. The *cornea* covers the eye much like the crystal on a watch.

Cross-eyed**:** A slang term to describe *esotropia* — the situation when one eye turns in towards the nose.

Crystalline Lens**:** One of the two lenses within the eye. It is the only one of the two that can change its shape to alter the focus of the eye. The *crystalline lens* is located just behind the *pupil.*

Diopter**:** Much as inches are a unit for measuring length, and pounds for measuring weight, a *diopter* is the unit for measuring the strength of a lens. The more *diopters* of power in a lens, the stronger it is. By convention, *hyperopic* (*farsighted*) lenses are considered described as having plus (+) power, and *myopic* (*nearsighted*) lenses have minus (-) power. The term *diopter* is different than *prism diopter*.

Diplopia**:** *Double vision*. Seeing two of the same object when only one is actually present.

Divergence**:** The two eyes moving away from each other and toward the ears.

Double Vision: see *diplopia*
E-Chart**:** A *visual acuity* chart that consists of capital letter Es, in different sizes and orientations. (See Figure 1-1)
Emmetropic**:** An eye that has no *refractive error* (has no *hyperopia, myopia,* or *astigmatism* is said to be neutral or *emmetropic.*
Esotropia: A type of eye muscle imbalance in which one eye is crossed, or turned in toward the nose.
Extraocular Muscles: The muscles that are attached to the outside of the eye under the *conjunctiva*. They are responsible for moving the eyes right, left, up or down. There are six *extraocular muscles* for each eye.
Far-Sighted**:** A slang term to describe *hyperopia*. (see *hyperopia)*
Fovea**:** A pin head sized area in the very center of the *macula* that is responsible for our sharpest vision.
Fusion: The process by which the brain blends the two images, one coming from each eye, into a single image.
HOTV Test**:** A test of *visual acuity* that consists of the letters H,O,T, and V.
Hyperopia**:** In lay terms this is what is referred to as "*farsighted*," which is very misleading when applied to children. An adult who is *hyperopic* may see better at far distance than close-up (and hence has "far sight") provided there is nothing else wrong with the eye that may affect vision (such as a *cataract, retina* abnormality, etc.). However, a child who is *hyperopic* has a much stronger ability than an adult to compensate for, and overcome *hyperopia*. Depending on the amount of *hyperopia*, a *hyperopic* child can see equally clearly at far distance and close up, however looking close-up may take more effort or work.
Infantile Esotropia**:** *Esotropia (crossed eyes)* that develops in infancy — usually prior to six months of age.
Iris: The doughnut shaped part of our eyes that we normally think of as containing our eye color (blue eyes, brown eyes, etc.).
Lazy Eye**:** A slang term for *amblyopia*. It is also frequently used inappropriately to describe a misaligned eye (one with *strabismus*). Contrary to popular belief, the term *lazy eye* does not directly refer to an eye that has a weak muscle, although eye muscle disorders are the most common cause of "lazy vision."
Legally Blind**:** *Visual acuity* that is 20/200 or poorer, even when the person is wearing the optical correction (glasses or contact lenses) that provide the best vision each eye is capable of. *Legal blindness* is a very confusing and unfortunate term. It often implies to lay people that vision is so poor that there has been a legal declaration an individual is blind. Actually, *legal blindness* is merely the level of vision deficit at which people qualify for benefits available to the visually impaired by the Internal Revenue Service, Social Security Administration, and other public service agencies. In fact, people who have a best corrected vision of 20/200 often function quite well and may not appear to have a vision problem for many day-to-day activities, although they may have difficulty reading the size of print normally used in books and newspapers. For an understanding of what 20/200 vision is like, see the experiment described on page 25.
Macula**:** An area in the center of the *retina*, about 1/4 inch in diameter, that is responsible for our sharper vision.

Myopia**:** In lay terms this is what is referred to as "*nearsightedness*." If there is nothing else wrong with a *myopic* eye, it will see better at near than distance (and hence has "near sight"). A *myopic* person will have more difficulty reading traffic signs (distance vision) than a book (near vision) with his glasses off. The expression "*nearsighted*" may be misleading when applied to a *myopic* eye that has other abnormalities such as *amblyopia*. Such an eye may have decreased vision at all viewing distances.

Nystagmus: A rhythmic back and forth "jiggling" of the eyes.

Ophthalmologist: Someone who has completed medical school, is a physician, and also completed at least 3 years of additional training as a resident to specialize in disorders of the eyes. An *ophthalmologist* is the only specialist trained and qualified to provide comprehensive care of ocular disorders. This includes diagnosing abnormalities of the eyes, prescribing of glasses or contact lenses, medical therapy, or eye exercises for ocular conditions, and performing eye surgery.

Optician**:** Much as a pharmacist fills a doctor's prescription for medicine, an *optician* is someone who fits spectacle frames and dispenses glasses based on an eye doctor's prescription. An *optician* does not determine the prescription for glasses.

Optic Nerve**:** A large nerve in the back of the eye that carries vision back to the brain.

Optometrist**:** Someone who has spent four years studying the prescribing of glasses and contact lenses. Many *optometrists* have training in diagnosing and treating various eye diseases. An *optometrist* is not a physician and cannot perform surgery.

Orthoptist**:** An individual who has trained for two years after college in an accredited program learning the diagnosis and treatment of *amblyopia* and *strabismus*. *Orthoptists* can prescribe and supervise eye muscle exercises. They are not physicians and work in conjunction with an *ophthalmologist* rather than independently.

Orthoptics**:** Eye exercises that are designed to create straight eyes with comfortable *binocularity*.

Pediatric Ophthalmologist: Someone who has completed residency training and is certified as an ophthalmologist, and also has spent at least one additional year in subspecialty training in the treatment of eye disorders that occur in children (including eye muscle problems). This extra year also includes learning about the management of eye muscle problems in adults (although the title, "*pediatric ophthalmologist*" does not suggest that).

Phoria**:** A tendency for an eye misalignment that is held in check by *fusion*.

Prism**:** A block of plastic or glass which, in cross-section, is shaped like a triangle. If you look at something through a *prism*, it will appear as though the object has moved to the right, left, up or down, depending on how the *prism* is oriented. The stronger the *prism*, the more it will displace the image. *Prisms* are used to measure the amount of deviation of a misaligned eye.

Prism Diopter**:** The unit in which the strength of a *prism* is described. One *prism diopter* is approximately $^{1}/2$ of a degree. Thus if your child's eye is 30 *prism diopters* crossed, it is turned in by approximately 15 degrees (with 90 degrees being a right angle). As stated earlier, in the examples given throughout this book, I described the amount of misalignment of eyes in terms of degrees, rather than *prism diopters*, because most readers are more familiar with the concept of degrees. The term *prism diopter* is different than, and should not be confused with the simple term *diopter* as described earlier.

***Pseudostrabimsus*:** The appearance of crossed eyes, when in fact the eyes are properly aligned.
***Pupil*:** The *pupil* is a hole in the *iris* and appears as a small black circle in the center of the colored part of our eyes. It enlarges in the dark and constricts in bright light.
***Refraction*:** The process the eye doctor goes through to determine the *refractive error* of an eye. A skilled eye doctor can very accurately determine the *refractive error* of a young child — even a newborn, however the child needs to be able to read letters or symbols before the *visual acuity* (what the child actually sees with the proper glasses) can be accurately measured, unless special laboratory tests are used.
Refractive Correction: The exact lens power needed (combination of *myopic*, *hyperopic*, or *astigmatic* correction) needed to put a far distant image in sharp focus on the *retina* — the light sensitive tissue that lines the inside of the eye.
***Refractive Error*:** The situation in which an eye is out of focus. *Hyperopia, myopia,* or *astigmatism* is present.
***Retina*:** The light-sensitive layer of tissue that lines the inside of the eyeball. When comparing the eye to a camera, the *retina* would be comparable to the film in the camera.
***Snellen Letter Chart*:** A chart consisting of different sized letters of the alphabet that is used to test *visual acuity*.
***Stereopsis*:** The ability to see things in 3-D. *Stereopsis* is only one of the several methods by which we can judge depth.
***Strabismus*:** The umbrella term to describe all types of misalignments of the two eyes. It includes eye that cross (*esotropia*), drift outward (*exotropia*) or deviate vertically (*hypertropia* or *hypotropia*).
***Suppression*:** The shutting off of the image from one eye by the brain.
***Visual Acuity*:** The description of how well an eye actually sees. It can be determined with or without glasses. *Visual acuity* is denoted as a fraction, in the familiar notation 20/20, 20/70, etc. For technical reasons, vision testing for far away viewing is typically done at a distance of 20 feet and is indicated by the top number in the fraction. The bottom number represents a comparison to what an average normal eye can see. For example, 20/70 means that when tested at 20 feet, the eye can see what an average normal eye can see from as far as 70 feet away. *Visual acuity* of 20/20 is said to be normal because it implies an eye can see at 20 feet what an average normal eye can see at 20 feet. *Visual acuity* can be better than the average normal. For example, a person who can read letters at a distance of 20 feet, that an average normal person could only decipher from the closer distance of 15 feet, would be said to have 20/15 *visual acuity*.
***Zonules*:** Thread-like structures inside the eye that connect the *crystalline lens* to the *ciliary muscle*.

X

U T

O

H A

V

X

U T

O

H A

V

Instructions: Cut on dotted lines. You hold one set of letters and the child holds the other. Stand close enough to the child that you are certain she can see the letters. Point to different letters and have the child point the same one.

E

E

Instructions: Cut on dotted lines. Cut on dotted lines. You hold one of the Es and the child holds the other. Stand close enough to the child that you are certain she can see the E. Hold the E in different orientations so that the 3 parallel lines (like legs on a table) point up, down, right, or left. The child is then to either match the direction with his E, indicate the direction by pointing his fingers, or name the direction.

About the Author

Burton Kushner, MD is currently the John W. and Helen Doolittle Professor of Ophthalmology in the Department of Ophthalmology and Visual Sciences, Madison, WI, where he also serves as director of the Pediatric Ophthalmology and Adult Strabismus Clinic.

Dr. Kushner is an internationally known authority on the cause and treatment of amblyopia and strabismus (eye muscle problems and lazy eye). He has authored over 190 scientific articles that have been published in peer-reviewed medical journals as well as 39 textbook chapters, and has edited three books. In addition, he has been invited to lecture in almost every state in the Union, and to every continent. Dr. Kushner has frequently appeared on local radio and television shows speaking as an expert on Pediatric Ophthalmology and adult eye muscle disorders. He has delivered twenty-three prestigious named lectures, all dealing with aspects of amblyopia and strabismus. Dr. Kushner has been a member of the American Association for Pediatric Ophthalmology and Strabismus (AAPOS) since 1975, for which he has served as Secretary for the Scientific Program. This job entails selecting papers for presentation at, and organizing the Annual Scientific Meeting of the AAPOS. This meeting is attended by 600-700 Pediatric Ophthalmologists annually. Also, he has served as Editor-in-Chief of the official scientific journal of that association, and was the Founding Editor of the *Journal of AAPOS.* He has also served on the Editorial Board of *Strabismus and Binocular Vision Quarterly.* From the inception of that journal in 1985 until 2002, Dr. Kushner edited the popular Grand Round Section, in which he selects five or six specialists from around the world to discuss the management of a patient with a difficult strabismus problem. Dr. Kushner has been the recipient of the Lifetime Honor Award and Senior Honor Award the American Academy of Ophthalmology and the AAPOS, respectively. In 1999 he was awarded the esteemed HEED Award for distinguished lifetime achievement, and in 2005 was honored with the prestigious Alfred W. Bressler Prize in Vision Science. The ophthalmology residents in his department have recognized Dr. Kushner's skills as an educator, and his ability to present complex material in an understandable manner, by repeatedly awarding him the Outstanding Teaching Award. In the course of his career of nearly 40 years, Dr. Kushner has performed close to 8,000 eye muscle operations and, and many times that number of patients have trusted him with their eye care, or that of their children.

While introducing Dr. Kushner prior to his presentation of a named lecture in 2007, a colleague said:

> Dr. Kushner is one of the most respected authorities in the world in the field of *strabismus*. His contributions to our subspecialty have been prodigious and important. Not only have his ideas been instrumental in formulating the way all of us think about this field, but also he has a unique ability to make complex material seem simple and understandable.