Subjective Refraction and Prescribing Glasses

The Number One (or Number Two) Guide to Practical Techniques and Principles

Richard J. Kolker, MD

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Initial Reviews

"Wow, a fantastic resource! Giants like you and David Guyton who can make refraction understandable and enjoyable are key. This book will make it so much easier for our residents."

—Tara A. Uhler, MD
Director, Resident Education
Wills Eye Hospital

"Subjective Refraction and Prescribing Glasses: Guide to Practical Techniques and Principles is really awesome."

—Jean R. Hausheer, MD, FACS
Clinical Professor
Dean McGee Eye Institute

Many thanks for volunteering your time and expertise for the benefit of resident education.

—Richard Zorab
Vice President of Clinical Education
American Academy of Ophthalmology

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Dedicated with love to my wife, Susie, and my children, Andy, David, Jon, and Abby.

Foreword

I believe it was Dr. Frank Newell who said that unless one knows how to obtain best corrected vision, one has no business calling oneself an ophthalmologist. I agree. The process of clinical refraction is the first skill that we teach our residents, and it is the procedure that they are required to repeat more than any other procedure during their training. Best corrected vision, obtained via skillfully performed retinoscopy and subjective refraction, is the primary measure that guides much of our treatment and our surgery. There is no substitute for it.

And yet our patients need more: refractive errors must be corrected. But the practical guidelines and tricks for prescribing glasses, in my experience, are taught neither frequently enough nor well enough. The beginning ophthalmologist is often left to learn these practical points by trial and error, with not enough time, or not enough interest, to engage older colleagues to learn from their wisdom and teaching. Dr. Richard Kolker's text provides simple and elegant exposure to the practical points of subjective refraction and prescribing glasses. He begins with basic terminology and then includes such important topics as the most efficient phrases to use during subjective refraction, the advisability of comparing the new refraction back and forth with the old glasses, the problems patients have adjusting to new glasses, and how to deal with "glasses bounces." An appendix even covers proper use of the lensmeter.

The latter half of the text teaches by case examples, an entertaining method of embellishing upon, and adding to, the principles previously presented, in real-world patient situations. The reader is briefly presented with the problem case, has a chance to consider the best solution, and then is taught why the best solution is optimal and why other approaches will likely fail.

The young ophthalmologist will enjoy this text on first reading it and will learn all the more by revisiting it after years of experience. Dr. Kolker has provided our field with a most valuable resource, one that will benefit us and thereby our patients. I heartily recommend it, not only to the beginning ophthalmologist, but to the seasoned ophthalmologist as well.

David L. Guyton, MD
Professor of Ophthalmology
The Wilmer Ophthalmological Institute

Preface

A journey of a thousand miles begins with a single step.

—Lao-tzu, *The Way of Lao-tzu*

It is easy to see that medical and surgical eye care benefit patients in a profound way, at times improving vision in a dramatic fashion. In contrast, it can be easy to overlook that when our patients put on their eyeglasses each morning, vision is improved dramatically. And this improvement is made possible through the process of refraction.

The goal of this guide is to present the first steps along the journey of mastering the art of subjective refraction and prescribing glasses. It is an attempt to present this introduction in a clear and accessible manner, with emphasis on the practical.

Subjective refraction can be viewed as simply asking the patient a monotonous series of questions, "Which is better, number one or number two?" However, when the refractionist understands what is happening optically with each step, the process becomes interesting and can be, at times, quite intellectually challenging. Even after excellently performed retinoscopy or measurement with an autorefractor, subjective refinement is necessary to find the patient's best correction.

Deciding what will be the best glasses prescription for a patient is also an art. The decision is based upon the patient's presenting visual complaint, the result of subjective refraction, and a determination of the reason for the patient's difficulty. This is exactly the same approach with which medical problems are addressed — history, examination, diagnosis and treatment decisions.

Therefore, it can be seen that subjective refraction and prescribing glasses involve not only measurement, but problem solving. They are the means by which a patient's visual needs are met, as well as determining the best corrected visual acuity. The process, when undertaken with an appreciation of the art and the benefit to the patient, is inherently an enjoyable one.

This book is written to share with the beginning refractionist what I have learned from my teachers, colleagues, students, and patients over thirty-five years in the practice of ophthalmology. It is my hope that it will be helpful at the beginning of a long and successful career of helping patients with their visual needs.

Richard J. Kolker, MD

Introduction

Neither college nor medical school nor anything else prior to entering the field of eye care exposes one to the techniques and principles of refraction. Beginning residents and technicians can, understandably, feel insecure as they begin their journey toward mastery of the art of prescribing glasses. The material presented in this guide is to provide help in taking those first steps.

Part 1 presents the basic optics necessary to understand the correction of refractive errors and presbyopia. Two important formulas are described, and various types of optical correction are discussed.

Part 2 provides the standard method of performing subjective refraction, tips to help with the process, and important considerations before writing the glasses prescription.

Part 3 consists of cases in a question-and-answer format. The cases are based on real situations and problems that present to the refractionist, with answers containing techniques and principles important to understand.

The plus cylinder method is used throughout.

The emphasis throughout is on the practical, and main points are in boldface.

It is my hope that the beginning refractionist will find this guide helpful in understanding, and enjoying, the process of helping patients see more clearly.

Part 1: Practical Optics

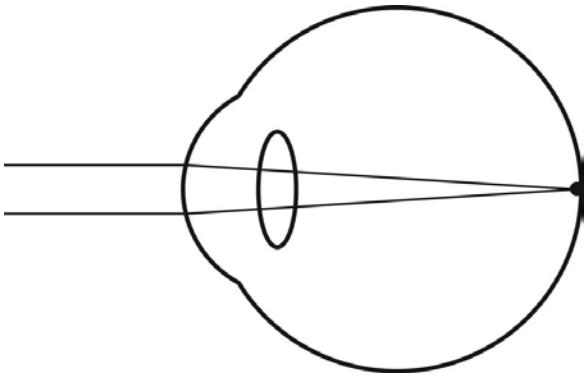
Goal of Refraction

The ideal refractive state of the eye is **emmetropia (Figure 1)**. In an **emmetropic** eye the refractive powers of the cornea and the crystalline lens combine to precisely focus parallel rays of light from a distant object **onto the retina as a single point**. The cornea plays the greater role in achieving this.

An eye whose refractive power does not produce this precise focus is **ametropic**, and is described as having a **refractive error**.

The goal of **clinical refraction** is to determine the strength of the corrective lens that will achieve this precise focus when placed in front of the eye.

Figure 1. Emmetropia: Parallel rays of light from optical infinity focused as a single point on the retina.



Six Principles of Refraction

1. Refraction is the art of improving vision without medicine or surgery.
2. Refraction and prescribing glasses are best approached as problem solving.
3. The process is more than measurement, and what we measure is not necessarily what we give.
4. History, examination, diagnosis, and treatment decisions are necessary. Just as with medical problems, history plays a large role in determining what will best help the patient.
5. The goal is to give the simplest system that satisfies that individual patient's visual needs.
6. The appropriate prescription is decided upon for and with each patient. Explain and always show the patient, binocularly, what you will be prescribing for them.

Snellen Visual Acuity

What does 20/20 vision mean?

Twenty feet is used for measuring visual acuity because that distance approaches and approximates optical infinity. Thus, light rays from twenty feet away are essentially parallel as they come into the eye. The Snellen, or other, visual acuity chart is placed twenty feet from the patient either literally or by way of mirrors. Alternatively, the size of the letters on the chart can be adjusted to achieve essentially the same effect.

The 20/20 designation is based on what the "normal" individual is able to see. That individual is able to read letters of a given size at twenty feet. Their visual acuity is 20/20 because, by definition, they can read at twenty feet what the normal individual can read at twenty feet.

What does 20/80 vision indicate?

If someone has 20/80 vision, that means they have to be twenty feet away to see clearly what the normal person can see clearly from eighty feet away.

Can vision be better than 20/20?

Yes, some individuals have better than 20/20 visual acuity. If, for example, someone has 20/15 acuity, they can read from twenty feet away what the normal person would need to be fifteen feet away from to be able to read.

Spherical Refractive Errors

There are two types of spherical refractive errors, myopia and hyperopia.

In **myopia,** parallel rays of light from optical infinity, bent by the cornea and the crystalline lens, come to **a focal point in front of the retina**. The eye is "**too long**" relative to its inherent plus power. The patient is described as being **myopic** or **nearsighted**. This is corrected with a concave lens — a **minus (red) lens** — which diverges the rays of light so that the focal point moves posteriorly and is focused on the retina (**Figure 2**).

In **hyperopia**, parallel rays of light from optical infinity, bent by the cornea and the crystalline lens, come to **a focal point behind the retina**. The eye is "**too short**" relative to its inherent plus power. The patient is described as being **hyperopic** or **farsighted**. This is corrected with a convex lens — a **plus (black) lens** — which converges the rays of light so that the focal point moves anteriorly and is focused on the retina (**Figure 3**).

Myopia and hyperopia are corrected by a **"sphere"** of a specific power.

Figure 2. Myopia:

A. Parallel rays of light from optical infinity focused as a single point in front of the retina. The eye is "too long."
B. A biconcave lens diverges rays of light.
C. A minus (red) lens corrects myopia.

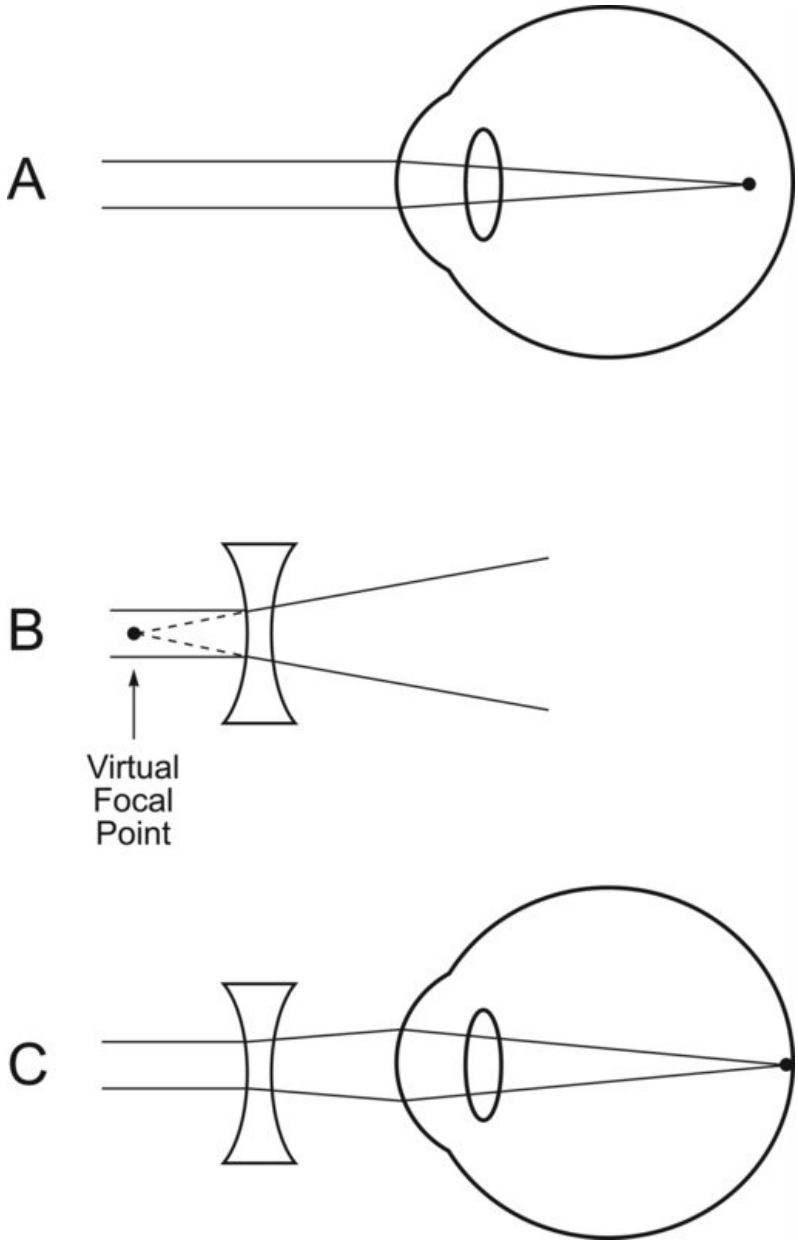
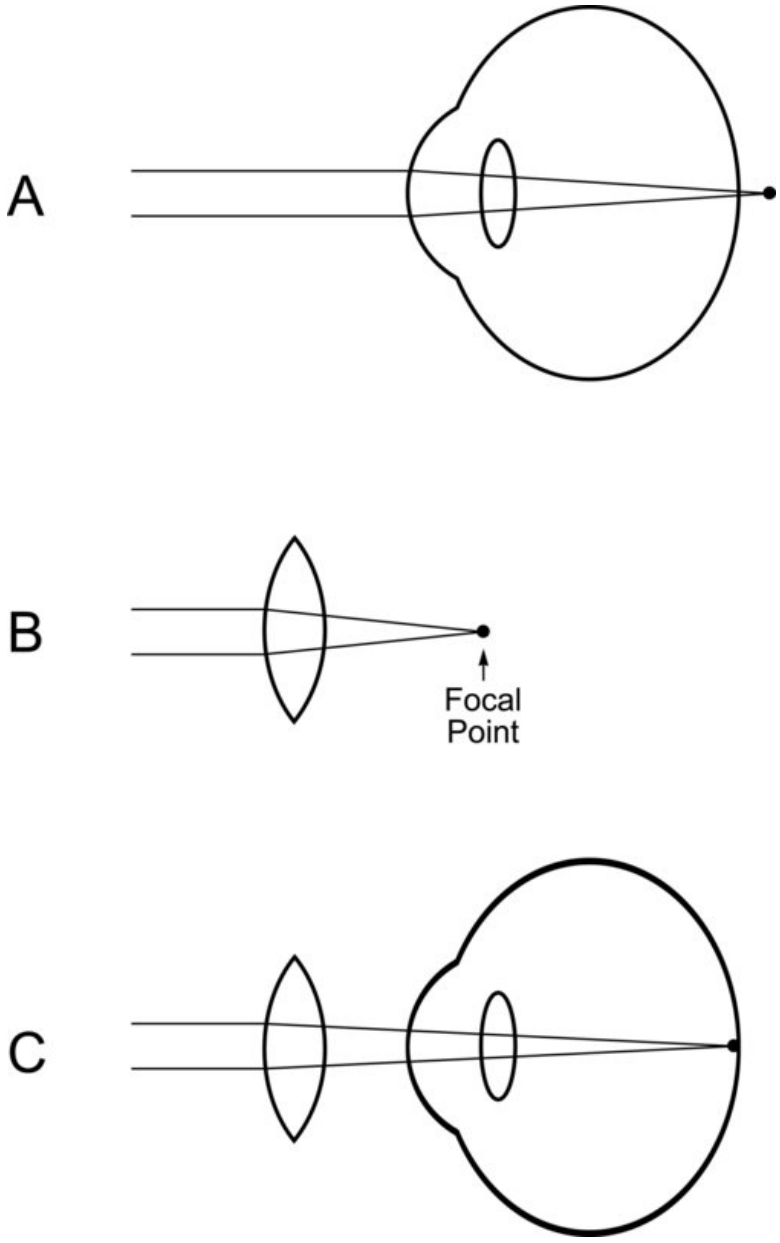


Figure 3. Hyperopia:
A. Parallel rays of light from optical infinity focused as a single point behind the retina. The eye is "too short."
B. A biconvex lens converges rays of light.
C. A plus (black) lens corrects hyperopia.



Fallacy Alert

There is an interesting fallacy in the seemingly straightforward term **"farsighted."** When not wearing corrective glasses, a moderately "nearsighted" person has blurred vision at distance but can see clearly at near, thus they can be called "near-sighted." The term nearsighted works: one can see clearly at near, but not at far.

One might then logically conclude that, for a "farsighted" person, the opposite would be the case: the individual would have blurred vision at near but be able to see clearly at distance. But this is not so. A moderately farsighted person has blurred vision at distance! Thus, the term "farsighted" is a fallacy because the individual cannot see clearly at far without correction.

The reason this seemingly simple terminology breaks down is that the nearsighted/farsighted designations do not properly describe what is happening with these refractive errors. A camera analogy demonstrates what is occurring in myopia and hyperopia. If a camera is in focus at distance, the image becomes equally blurred if the focusing lens is turned to the right or the left, that is, if the image is defocused anteriorly or posteriorly. Similarly for the eye, a distant image will be blurred if the focal point is in front of (myopia) or behind (hyperopia) the retina.

So, should the terms "nearsighted" and "farsighted" be replaced with "like a camera whose image is blurred because it is displaced too far anteriorly" and "like a camera whose image is blurred because it is displaced too far posteriorly?" Probably not!

Astigmatism

Astigmatism is a Greek term meaning "**without a point**." It is most often used to describe a type of **curvature of the cornea**, although the crystalline lens can also contribute. An easy way to understand astigmatism is to consider the difference between a **basketball** and an American **football**. We know that they have different shapes, but we usually don't stop to think about exactly how they are different.

A **basketball** has one curvature. Wherever you look the curvature is the same. A single curvature equates to an optical system that is spherical.

An American **football** looks different. This is because it has two curvatures. If we put the football on a table and hold it so that its tip is pointing upward, we can see that it has a gradual curve from top to bottom, and a steeper curve from side to side. Two different curvatures equates to an optical system that is astigmatic.

Thus, a basketball-shaped cornea has no astigmatism, in contrast to a football-shaped cornea which is astigmatic.

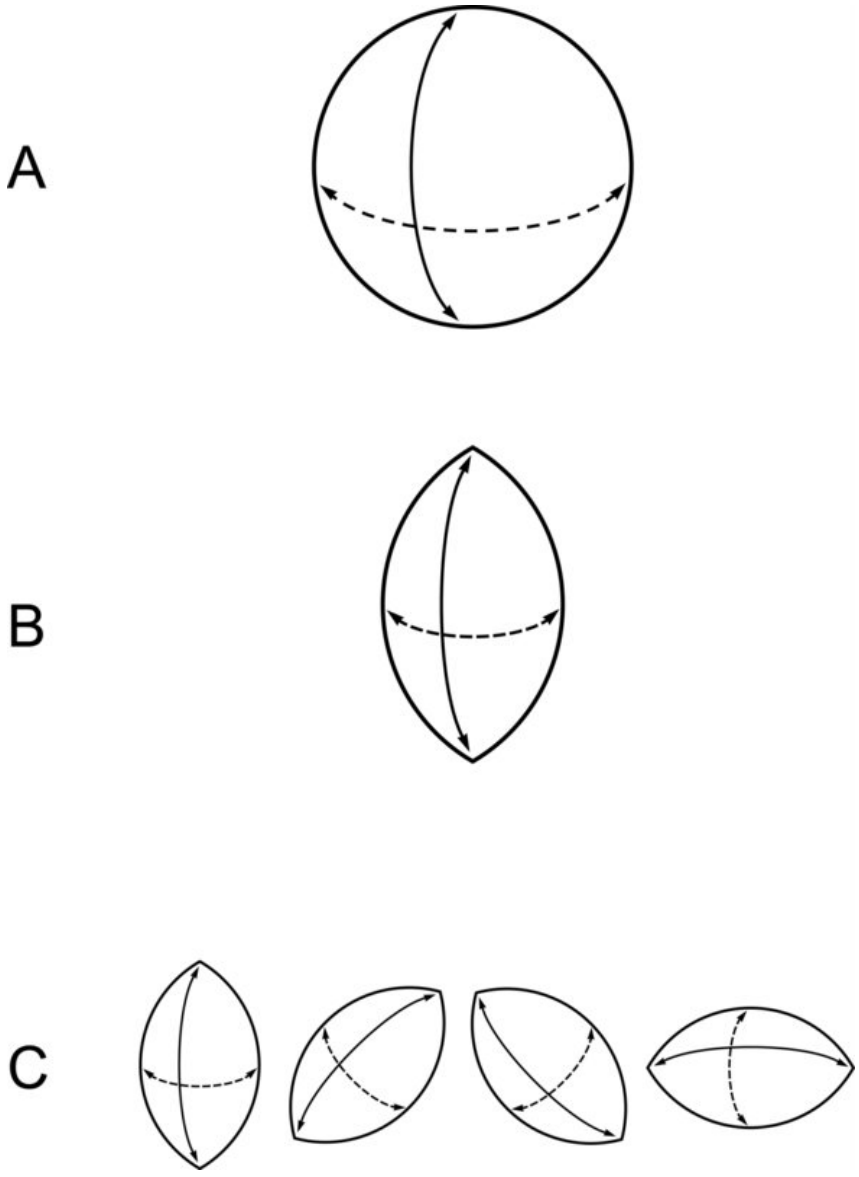
Astigmatism is corrected by a **"cylinder"** of a specific power and axis.

Note

In contact lens and intraocular lens terminology, the term **toric** is used to describe the curvature of an astigmatic surface.

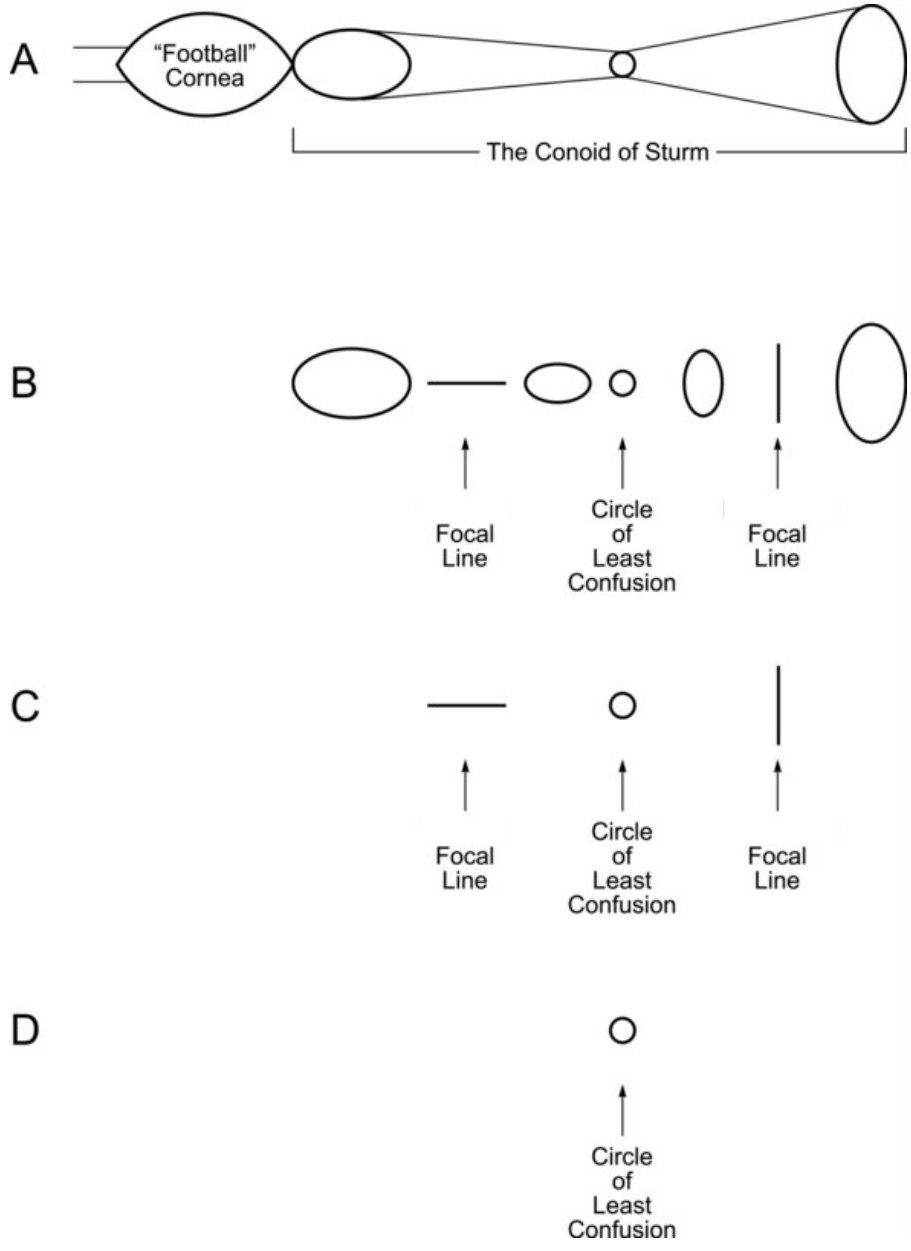
Axis is another aspect of astigmatism that must also be taken into account. We have described the two curvatures of the football while it is held with the tip pointing upward, but a football can also be held in a variety of tilted positions to the left or the right. It can even lie on a table in a horizontal position. The slant of the football can be considered its axis, which can range from zero to 180 degrees. An astigmatic cornea is described in the same manner (**Figure 4**).

Figure 4. Astigmatism:
A. A "basketball" cornea has no astigmatism. The curvature of the solid line and the broken line are the same.
B. A "football" cornea has astigmatism. The curvature of the solid line (more gradual) and the broken line (more steep) are not the same.
C. The angle of the football determines its axis.



In addition, it is necessary to understand the **conoid of Sturm (Figure 5)**.

Figure 5. The conoid of Sturm:
A. The conoid of Sturm.
B. Cross sections through the conoid of Sturm.
C. One simplification: The interval of Sturm equals the distance between the two focal lines.
D. Another: The circle of least confusion. It is always dioptrically midway between the two focal lines. Also referred to as "the blur circle" and "the spherical equivalent."



When parallel rays of light from an object pass through a spherical refracting system, a single point of focus is the result. However, when parallel light rays pass through a **spherocylindrical system**, a single point of focus is not achieved. The result is a unique appearing cone-like shape, which can be visualized as two squashed ice cream cones joined at their tips, with one cone squashed horizontally and the other vertically. This configuration was first described by J.F.C. Sturm in 1838 and is called the conoid of Sturm (**Figure 5A**).

If one cuts cross-sections sequentially through the cones, the result is a series of elliptical images, two focal lines, and a central circle (**Figure 5B**).

The most important parts of the conoid of Sturm are the two focal lines and the circle, the latter always located dioptrically halfway between the two lines.

If the spherocylindrical refracting system mimics a football held with its tip pointing up, the vertical curvature produces a horizontal focal line, and the horizontal curvature produces a vertical focal line.

If, to simplify the conoid of Sturm, one ignores the ellipses and looks simply at the two focal lines with the circle in the center, this is called the **interval of Sturm (Figure 5C)**.

If, further simplifying the conoid of Sturm, one eliminates the ellipses and the two focal lines, only the circle remains. The circle is called the **circle of least confusion (Figure 5D)**.

Thus, the circle of least confusion can be used to represent the conoid of Sturm, the result of light rays passing through a spherocylindrical system. The circle of least confusion is also referred to as **the blur circle**. The blur circle is produced by an astigmatic refracting system, in contrast to a point of focus produced by a spherical system.

When refracting a patient, the blur circle is referred to as the **spherical equivalent**. That is, it is not yet a point of focus, but it can be moved anteriorly and posteriorly like a spherical point of focus, and in that sense is equivalent to one. During the refraction process, the blur circle/spherical equivalent is reduced to a focal point.

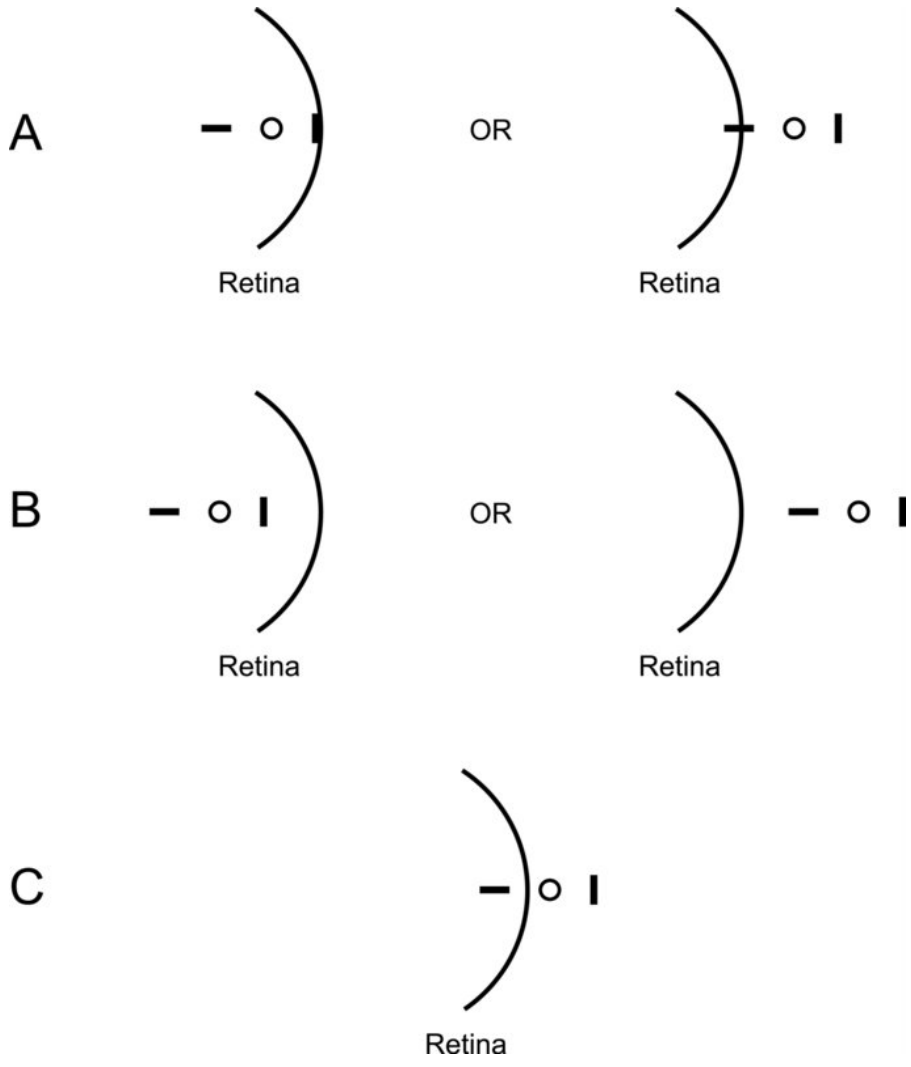
Notes

- **A cylinder's power (its meridian) is 90 degrees from its axis**. **A cylinder correcting lens moves the focal line parallel to its axis.**
- Some beginning optics students jokingly call the center of the conoid of Sturm "the circle of most confusion." It need not be!

Types of Astigmatism

The three types of astigmatism are **simple, compound, and mixed. Figure 6** contains a definition and diagram of each type.

Figure 6. Types of Astigmatism demonstrated by the interval of Sturm:
A. Simple astigmatism: One meridian is emmetropic; the other is either myopic or hyperopic.
B. Compound astigmatism: Both meridians are myopic or hyperopic.
C. Mixed astigmatism: One meridian is myopic; the other is hyperopic.



With-the-Rule, Against-the-Rule, and Oblique Astigmatism

- **With-the-rule astigmatism**: corrected with **plus axis at 90 degrees**.
- **Against-the-rule astigmatism**: corrected with **plus axis at 180 degrees**. **Note:** 180 degrees equals 0 degrees.
- **Oblique astigmatism**: axes other than 90 or 180 degrees; often symmetrical. **Note: When perfectly symmetrical, cylinder axes add to 180 degrees**.

Presbyopia

The term **presbyopia** comes from the Greek *presbyteros,* which means "old-age vision." It is probably best to refrain from mentioning this derivation to patients!

The understanding of presbyopia begins with an analogy to a camera (as do many aspects of the functioning of the eye). When a camera is in focus to take a picture of an object in the distance, and subsequently needs to take a picture of something up close, a change in focus needs to occur.

In their resting state, after the correction of any refractive error, our eyes are like a camera set for distance. To view nearer objects clearly, some **focusing** is necessary. The nearer the object, the more focusing is required.

The focusing performed by our eyes for near viewing is called **accommodation**. Accommodation is achieved by an increase in the plus power of our natural crystalline lens. When we are looking at distance, the ciliary muscle is relaxed and the taut zonular fibers pull on the crystalline lens. Near viewing is accomplished by contracture of the ciliary muscle which loosens the pull of the zonular fibers. This results in the crystalline lens reverting to a more convex shape, thus increasing its plus power.

Presbyopia is **the age-related decrease in accommodative ability** that occurs inevitability in everyone — **whether one is nearsighted, farsighted or emmetropic**. In childhood we have a large amount of accommodative ability, but this gradually decreases over our lifetime. However, it is typically not until after age 40 that enough has been lost to make near tasks, reading and other close viewing, more difficult. By age 45 help for seeing clearly at near is usually needed in the form of **reading glasses** (for emmetropes) or the addition of a **bifocal or progressive addition lens** (for those wearing a distance correction).

Presbyopia is treated with plus power in these ways to make up for the inability of the natural crystalline lens to become more convex and thus increase its plus power. The plus corrective lenses supplement the remaining accommodative ability. The added plus power is referred to as the **Reading Addition** or more commonly as the **Add.** The Add is an addition to the lower portion of the distance correction, and its efficacy depends on a **correct distance prescription.**

Another way to understand presbyopia is with an extension of the above camera analogy. When we are young, our camera can focus very rapidly, essentially instantaneously, from distance to

near. However, let's say we take our camera to the beach each summer and it gets more and more sand in it. Over the years, as the sand accumulates in the camera, it can make some of the turns to focus from distance to near, but it loses the ability to make those last few turns for focusing up close. When an insufficient amount of accommodation remains for reading at near, our patients complain that their **"arms aren't long enough."** They have to push their reading material farther away to see clearly because their loss of accommodative ability (sand in the camera) has not left them with enough plus power to focus at their normal reading distance (the camera cannot make those last few turns).

Fallacy Alert

It is sometimes stated that **"one gets more farsighted as one gets older."** This is incorrect and results from a misunderstanding of presbyopia. With the onset of presbyopia, one is able to see reading material more clearly by pushing it farther away to a position where less accommodation is needed. However, this is not the same as becoming more farsighted, which is a description of refractive error at distance. The mid-forties difficulty reading is the result of the onset of presbyopia, not farsightedness.

Five Points About Correcting Presbyopia with an Add

1. As a general guideline, the following **rule of thumb** for Add strength is often helpful:
   - **At age 45**, the typical Add that is needed is **+1.50 diopters.**
   - **At age 50**, the typical Add that is needed is **+2.00 diopters**.
   - **At age 55**, the typical Add that is needed is **+2.50 diopters** (the typical maximal strength Add).

   ### Notes

   - Although we retain some accommodative ability into our early seventies, the maximal strength Add is usually needed by our mid-fifties.
   - At any age, if **cataract surgery** has been performed with a monofocal intraocular lens implant that rendered the eye **emmetropic**, an Add of **+2.50 diopters** is typically needed.
2. For practical purposes, when determining the proper Add to prescribe, have the patient hold the near card at their **usual reading distance rather than at 14 inches** as described on certain near acuity cards. Some individuals read closer than 14 inches as their preference and others read farther than 14 inches as their ideal reading distance. The determination of the proper strength Add should be made at the individual patient's preferred reading distance. Make sure that when the patient is asked to hold the card at their normal reading distance, it is their ideal reading distance and not the distance at which they can see most clearly.

Note

The 14-inch designation on the near card is the distance at which the Jaeger and distance equivalent acuity designations are determined.

3. When testing the patient to find which Add to prescribe, it is important to ensure that the lens strength they prefer is making the letters/numbers on the near card **clearer rather than larger**. This distinction is necessary because if the patient is comparing two choices that give equal clarity, they may respond that the choice producing the larger figures is "better." However, the goal of a presbyopic correction is to supplement or replace the accommodative ability that has been lost over time. Before the patient became presbyopic, their accommodative ability brought the reading material into focus but did not magnify it. The purpose of a presbyopic Add is to do the same. Magnification is an indication that the Add is overly strong and will produce a reading range that is closer and narrower than necessary.

Fallacy Alert

Thus, although it is common for over-the-counter reading glasses to be referred to as "magnifiers," they should really be called "focusers." Prior to the onset of presbyopia, the patient's accommodative ability was used to focus, not magnify.

4. When prescribing an Add, testing the **range** in which the vision remains clear can be very helpful. The purpose is to make sure that the Add not only provides clear vision at the patient's ideal reading position, but also nearer and farther than that position. The reading range is tested by having the patient hold the near card at their preferred reading distance, and then asking them to move the card toward them until the numbers blur. The point at which the numbers blur is the near point of the range. Next the patient is asked to push the card away until the numbers blur, and the point at which that occurs is the far point of the range. An ideal reading range has the preferred reading distance midway between these two points.

Note

Increasing the plus power of an Add results in a **closer and narrower reading range**. Interestingly, an Add that is too strong can produce more difficulty for the patient than an Add that is too weak. Patients are often more distressed about having to hold their reading material too close than they are about having to push it farther away.

5. **Stronger Adds** of +3.00, +3.50 or higher can be given for individuals who prefer an unusually close reading distance or as a low vision aid given with the intention of producing magnification.

Bifocals

The bifocal was invented by **Benjamin Franklin** in the eighteenth century. At that time, when someone wearing glasses became presbyopic, a separate pair of reading glasses was prescribed. When Ben Franklin found himself in that situation, he felt it was inefficient to have to change glasses when alternating his vision from distance to near and vice versa. Franklin realized that when viewing at distance through his distance glasses he was using the top portion of the lenses, and when reading at near with the reading glasses he was using the bottom portion of the lenses. (As is the case with many brilliant observations, they seem quite obvious once made.) Therefore, he decided to cut each distance and reading lens in half and glue them to each other, with the distance lens at the top and the reading lens at the bottom. Thus, he had **two pairs of glasses in one** — and the bifocal was invented!

The top part of a bifocal lens corrects the patient's distance refractive error, and the bottom part of the lens contains that distance correction **combined with additional plus power** for focusing at near. Thus, the lower section in a bifocal is dependent upon and is **an addition to the distance prescription.** The additional plus power is referred to as the "**Add**," and its strength is determined by the amount of focusing power needed by the patient.

Example: For the distance prescription: -4.50 +0.75 × 10, and the need for a +2.50 Add

- The bifocal prescription would be written as -4.50 +0.75 × 10 (+2.50).
- When the patient is looking at near, the power that they are reading with is determined by **the algebraic sum** of the sphere and the Add: -2.00 +0.75 × 10 .

The bifocal segment can be made in several configurations:

- **Flat-top or "standard" bifocal:** The top of the bifocal is a flat line and the segment occupies a portion of the lower part of the lens. Most bifocals "with a line" are of this type.
- **Round or half-moon crescent:** The segment is circular and is often cut off at the bottom of the lens resulting in a half moon shape.
- **Executive®:** The line and bifocal segment extend across the entire lower lens.
- **Blended:** No easily visible separation line, but not a progressive addition lens.

Note

When using the bifocal segment, the patient is looking through a combination of the distance prescription and the Add. Therefore, the **bifocal segment is dependent upon a distance prescription that is correct**.

Reading Glasses

At times it is appropriate, based on the patient's needs or preference, to prescribe a separate pair of reading glasses. The reading glasses prescription is determined by **algebraically adding the distance prescription sphere and the reading Add**, leaving any astigmatic correction unchanged.

Example: For a bifocal prescription of: -4.50 +0.75 × 10 (+2.50):

- The distance prescription is -4.50 +0.75 × 10
- The reading glasses prescription is -2.00 +0.75 × 10

Note

This is, and should be, the same power the patient is looking through when using the bifocal segment.

Misnomer Alert

Of interest is that a patient will sometimes be surprised to find, "I now need my reading glasses when I'm eating!" The term reading glasses is, in a sense, a misnomer. Reading glasses are really "**near glasses**." They are making up for the focusing that we are no longer able to do — for any near task, not only reading.

Trifocals

Trifocals are an extension of Ben Franklin's concept for the bifocal, incorporating a third lens for correction of **the intermediate distance**. The standard bifocal, with a line separating the distance and the near portions of the lens, allows for clear vision both at distance and at near. Objects in the intermediate distance — the area beyond the normal reading distance and less than 20 feet away — are not seen clearly through either the top or bottom of the bifocal. (Thus, to view something at the intermediate distance when using a standard bifocal, one must either come closer and use the bifocal segment or back away and use the distance portion of the lens.) The trifocal adds **a third lens** between the distance and the near portions of the standard bifocal to correct for the intermediate distance — there are three lenses combined into one, with two lines separating the three segments.

The power written for the trifocal is typically **one-half the strength of the bifocal Add,** although other strengths can be designated.

Example: For the bifocal prescription: -4.50 +0.75 × 10 (+2.50):

- One-half the bifocal Add is +1.25.
- The trifocal prescription would be written as: -4.50 +0.75 × 10 (+1.25) (+2.50)

Note

Since the advent of the progressive addition lens, trifocals are prescribed much less frequently as the solution to viewing in the intermediate distance.

Progressive Addition Lenses (PALs)

The standard bifocal works well for far and close viewing, but it does not provide for clear vision in the intermediate area between distance and near. The trifocal has a third lens which allows for clarity at the intermediate distance, but there are still gaps — one between the distance and intermediate area, and another between the intermediate and near area. The **progressive addition lens (PAL)** is an extension of the bifocal and trifocal concepts. It can be thought of as **a graduated multifocal. With the distance correction at the top of the lens, plus power increases "progressively" in the lower portion of the lens until the prescribed Add power is reached.** Thus, one can focus clearly from distance to near, with gaze directed lower in the lens for intermediate and near viewing. There are no gaps.

Notes

- The progressive addition lens is sometimes called a "no-line bifocal," and some patients refer to it incorrectly as a "trifocal."
- Many patients consider the "no line" a cosmetic benefit.

When the progressive lens is working properly, distance vision is corrected with the normal straight-ahead head position, near is corrected with the normal eyes-down reading position, and the intermediate distance is corrected with varying amounts of chin-up positioning depending on how far away the object is. The closer the object in the intermediate distance, the more elevated the chin needs to be. When patients are using the PAL successfully, their functioning should be similar to how it was before they became presbyopic. They are able to see clearly at distance and near, as well as all points between, seamlessly.

Note

With a desktop computer, the monitor screen is often in the intermediate distance, and this is brought into clear focus with **a slight chin-up position**.

The PAL does have a special consideration resulting from how the graduation is achieved in the grinding of the lens: there is **an inherent blur at the sides**. One must be looking straight ahead for clear viewing. However, as progressive lenses manufacturing has improved, the clear central channel, and reading area, have been widened. This has made adjustment to, and functioning with, this lens much easier. The introduction of **free-form progressive lenses** has been a significant advance in this regard.

Note

Many individuals were taught in school to move their eyes across the line of print when reading. With the PAL, one must move one's head when reading so that one continues to look through the central part of the lens. It is surprising how easily most people are able to make this change — and especially surprising after all those years of moving only their eyes! Most individuals are able to adjust to the progressive lens right away, although for some it can take up to two weeks. It is quite helpful to explain this to the patient when prescribing the first PAL.

Computer Glasses

With both a trifocal and progressive addition lens it is necessary to adopt a slightly chin-up position to view a desktop computer screen, for it is typically located at the intermediate distance. Some individuals cannot or prefer not to work in that position; in these situations, separate computer glasses may be given.

The top portion of computer glasses corrects, not for 20 feet and beyond as in a normal bifocal, trifocal, or PAL, but for the intermediate distance. The bottom portion of computer glasses can have a correction for near, given either as a bifocal segment or a PAL, the latter having the advantage of allowing clear vision from the intermediate distance to near. **A bifocal or PAL** is often preferable to a single vision intermediate lens, for without the correction for near there can be difficulty reading something printed from the computer or other reading material.

The computer glasses prescription is calculated by **splitting the patient's normal Add in half**. One-half of the Add is incorporated into the top part of the lens, leaving the remaining half of the Add at the bottom part of the lens. This will result in **an odd-looking Add power** when the prescription is written.

The calculation: To have the intermediate distance correction at the top of the lens, the Add is divided in half. **One-half of the strength of the full Add is added to the distance sphere algebraically;** this will determine the top portion of the computer glasses. **The remaining one-half of the strength of the full Add is written as the Add for the computer glasses;** this will result in the bottom portion of the computer glasses containing the full Add.

Note

One can check that this calculation has been done correctly by being certain the reading power is correct.

Example: If the bifocal prescription is -4.50 +0.75 × 10 (+2.50):

- The power for the top half of the computer glasses is obtained by adding half of the bifocal strength, +1.25, to the distance prescription: -3.25 +0.75 × 10
- The remainder of the bifocal strength, +1.25, becomes the Add for the computer glasses, resulting in a prescription of: -3.25 +0.75 × 10 (+1.25).

Note

It is only the top portion of the computer glasses that differs in total power from the patient's regular bifocal. The reading portion in the computer glasses has the same power as the regular bifocal: -2.00 +0.75 × 10.

Two Formulas: Spherical Equivalent and Plus-Minus Cylinder Conversion

For everyday clinical practice, it is necessary to know the following two formulas:

1. The Spherical Equivalent of an Astigmatic Prescription

An astigmatic eye requires a prescription with spherical power, cylinder power and cylinder axis; this combination results in a focal point positioned on the retina. The cylinder axis and power are correcting the astigmatic part of the refractive error.

If an astigmatic eye were to be corrected with a spherical lens alone, the result would be a blur circle — circle of least confusion — on the retina. The spherical lens power that places the circle of least confusion on the retina is called the spherical equivalent.

Rule for finding the spherical equivalent: Add one-half of the cylinder power to the sphere algebraically (that is, keeping in mind the plus and minus signs).

Example 1: What is the spherical equivalent for: -6.00 +2.00 × 90?

Applying the rule: One-half of the cylinder power is +1.00; +1.00 added algebraically to -6.00 = -5.00

Answer: -5.00

Note

When writing a glasses prescription, the spherical equivalent calculation is used if one decides to give less cylinder power than was measured. If it was decided to reduce the cylinder power in this example by half a diopter, the resulting prescription would be: -5.75 +1.50 × 90. This calculation can and should be checked by making sure the original and the modified prescriptions have **the same spherical equivalent.**

Example 2: What is the spherical equivalent for +3.50 +0.50 × 180?

Applying the rule: +0.25 added algebraically to +3.50 = +3.75

Answer: +3.75

2. Plus-Minus Cylinder Conversion

There are two conventions for writing eyeglass prescriptions: the plus cylinder and minus cylinder methods. In the United States, most ophthalmologists use the plus cylinder method. It is necessary to know how to convert one to the other.

There are three steps:

1. **Add the cylinder power to the sphere algebraically, i.e., taking into account the plus and minus signs.**
2. **Change the sign of the cylinder from plus to minus or from minus to plus.**
3. **Change the axis by 90 degrees: Add or subtract 90 degrees.**

Example 1: -4.00 -2.00 × 65

In plus cylinder form it equals -6.00 +2.00 × 155.

Example 2: +3.50 -1.50 × 115

In plus cylinder form it equals +2.00 +1.50 × 25.

Example 3: -4.25 +1.25 × 90

In minus cylinder form it equals: -3.00 -1.25 × 180

Note

It is always good to check the correctness of a conversion by reconverting to the original cylinder sign.

Part 2: Subjective Refraction and Lens Prescription

The Phoropter

The starting point for subjective refraction can be the measurement found by retinoscopy or the autorefractor. The patient's current glasses prescription can also be used. The patient's refinement of the starting point is necessary to arrive at the best correction for the refractive error. Most patients are able to perform this process successfully, with the subjective end-point being superior to an objective measurement.

The starting prescription is typically placed in the refractor, usually referred to as a phoropter or by the trade name, Phoroptor®. Loose lenses or lenses put in a trial frame can also be used.

When using the phoropter, it is important to **position the patient correctly.**

It is often helpful to extend the **forehead rest** to its maximal position initially, telling the patient, "I'll bring the machine to you." Extending the forehead rest prevents the patient from being too close to the phoropter lenses, with the possibility that their lashes might rub against them. Bringing the phoropter toward the patient, rather than having them lean forward at the start, allows you to move the forehead rest (with the patient's head gently against it) to the proper position without the patient ending up leaning forward excessively.

The patient's working position should be such that the phoropter lenses are at the **glasses plane,** and this is best checked by looking at the position of the lashes. The checking can be accomplished either by glancing around the side of the phoropter or using the mirrors located at its sides. Additionally, the phoropter should be adjusted so that the patient's **pupils** are centered in the lenses and the **leveling bubble** is centered. An exception to centering the leveling bubble occurs if the patient has a chronic head tilt which will result in the glasses frames being tilted. In that situation, the phoropter should have a matching tilt.

It is helpful to become familiar with the features of the phoropter, which include a **pinhole** aperture and a dial that allows one to move the spherical lenses in **three-diopter steps.**

Terms

The refractionist should know the following terms:

- **Manifest refraction:** A refraction without cycloplegic drops (which dilate the pupils and prevent accommodation); it is also called a "dry" refraction.

- **Cycloplegic refraction:** A refraction done with cycloplegic drops given to dilate the pupils and prevent accommodation; it is also called a "wet" refraction.

- **Post-cycloplegic refraction:** A "dry" refraction performed on a visit at least several days after a "wet" refraction. The purpose is to see how much of the full cycloplegic refraction found on the previous visit can be tolerated.

Notes

- It is not necessary to have all the lights off in the examining room when the subjective refraction is being performed. Most modern projection charts have sufficient luminosity to permit some ambient light. The projection chart should be approximately thirty times as luminous as the ambient light. Having dim illumination in the room allows the refractionist to see the numbers while changing power and axis.
- It is preferable to try to always use the same level of illumination during subjective refraction so that it is not a variable when comparing visual acuity from one visit to the next.

Sequence for Subjective Refraction

To begin subjective refraction, dial into the phoropter the prescription to be refined. This starting point can be the result from retinoscopy, autorefraction, or the patient's current glasses.

Subjective refinement is necessary to arrive at the best end-point of refraction, even when retinoscopy is performed expertly or a modern autorefractor is used.

Subjective refraction consists of **four sequential refinements** performed in the following order: **sphere**, **cylinder axis, cylinder power,** and **sphere**. During each of the four steps, the patient is given a series of choices and asked to make a comparison, letting you know which of the two choices you are showing them is clearer, or whether they appear to be the same in clarity.

Classically the **Snellen chart** has been used for testing visual acuity. The **ETDRS acuity chart** has also been used since the commencement of the Early Treatment Diabetic Retinopathy Study in 1979.

Have the patient work with the smallest line they can read. This will allow them to make the finest discrimination between the choices you will be giving them.

The discussion below uses **the plus cylinder method**.

The Four Steps of Subjective Refraction

Step 1: Sphere

The **large spherical dial** at the side of the phoropter is used to show the patient a series of **two choices** to compare. The patient is asked to compare the two and tell you **which is more clear**, or that they appear the same in clarity.

With the sphere power to be refined in place, choices are given in the plus and minus direction, changing the sphere based on the patient's preferences. Begin with choices 0.50 diopter apart before further refining in 0.25-diopter increments. **Always checking in the plus direction first** is helpful in trying to avoid stimulating accommodation, and it keeps the method consistent.

End-point: the spherical lens that is reported by the patient to yield **the clearest** view of the letters on the acuity chart. If the patient reports the clarity between two choices to be **the same**, **always favor less minus**.

Notes

- In step 1, the refinement of the spherical part of the prescription **for an astigmatic eye places the circle of least confusion, or blur circle, onto the retina**.
- If the patient has no astigmatism, step 1 places the focal point onto the retina; it is the same as step 4.

Step 2: Cylinder Axis

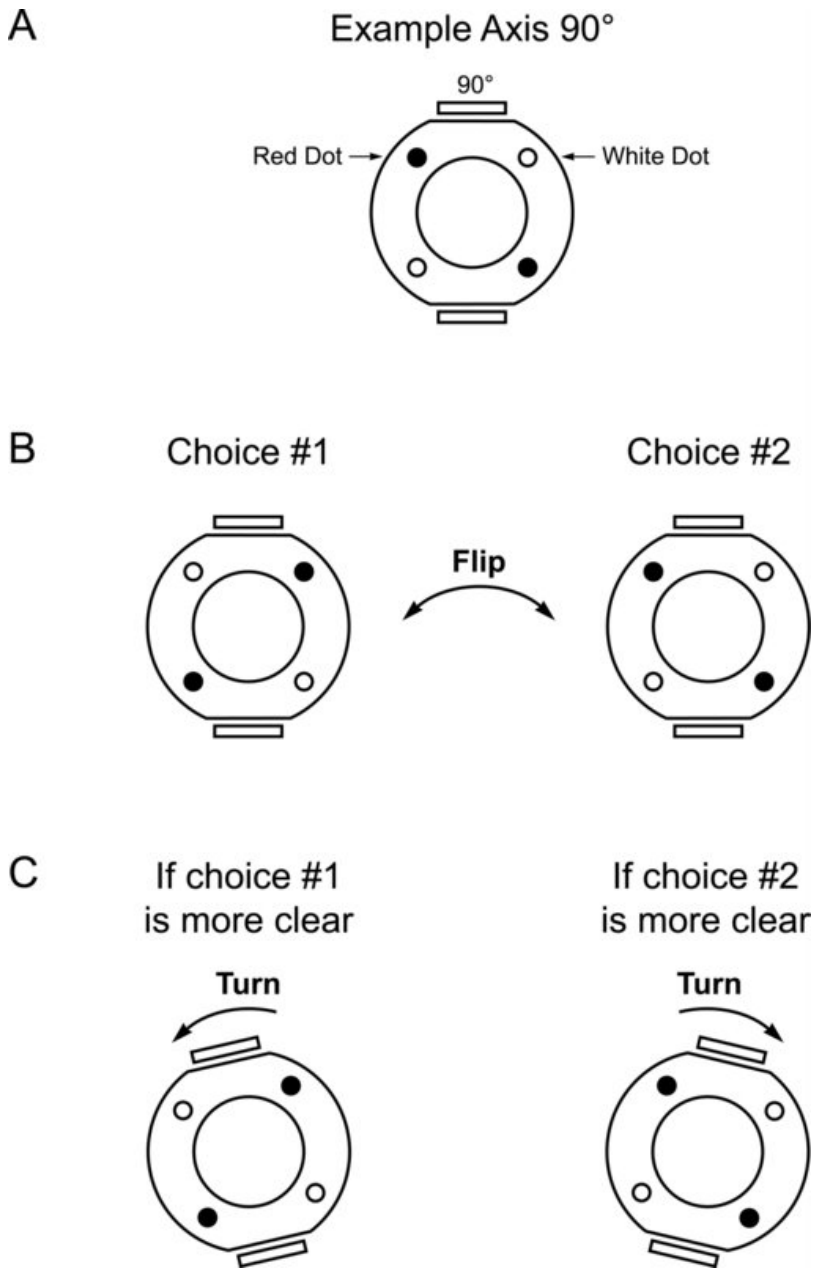
The **Jackson cross cylinder (JCC)** is used to refine the cylinder axis. During this step it is used **straddling the axis.** The JCC is positioned so that **the white and red dots are on either side of the axis** to be refined. The JCC is then flipped, thereby giving a first and second choice to compare, and the patient indicates which of the two choices they have seen is more clear.

When the patient indicates which position of the JCC is more clear, t**he axis is rotated in the direction of the white dot** for that choice (**Figure 7**). Begin with larger steps, typically 10-degree changes; then as the correct axis is approached, make 5-degree shifts.

Figure 7. Refining the cylinder axis using the Jackson cross cylinder (JCC):

A. Position the Jackson cross cylinder so that the red and white dots **straddle** the not-yet-refined axis. Example axis 90 degrees.
B. Flip the cross cylinder to give the patient two choices, asking which is more clear.
C. Rotate the axis in the direction of the white dot.
   If choice 1 is clearer, the white dot is on the left, therefore turn the axis to the left.
   If choice 2 is clearer, the white dot is on the right, therefore turn the axis to the right.

   The correct cylinder axis has been located when the cross cylinder is flipped and the two choices are equally clear.



End-point when refining cylinder axis: The two choices given the patient are reported to be **the same** in clarity. At this point **the correct axis is being bracketed**.

Notes

- When positioning the Jackson cross cylinder in front of the patient's eye with **the axis straddled**, it is helpful to let the patient know that **the letters on the acuity chart will become more blurred**. They should not be concerned that neither of the choices you are giving them to compare will be completely clear, and they should simply let you know which of the choices presented is **more** clear.
- **It may be necessary to move up one line on the acuity chart** for the patient to see the letters well enough to compare when choices are given.
- **Locating the cylinder axis precedes measuring the cylinder power** because the correct cylinder power can only be determined at the proper axis.

Step 3: Cylinder Power

The Jackson cross cylinder (JCC) is also used to refine the cylinder power. The JCC is rotated so that **the red or white dot is aligned with the axis** determined in step 2. The JCC is now **on axis**. Choices are given by flipping the JCC, and the patient indicates which of the two choices you have shown is clearer.

If the patient responds that the letters appear to be more clear **when the white dot is positioned on axis, then plus power is added** to the cylinder. If the letters are more clear **when the red dot is positioned on axis, then plus power is subtracted** from the cylinder (**Figure 8**).

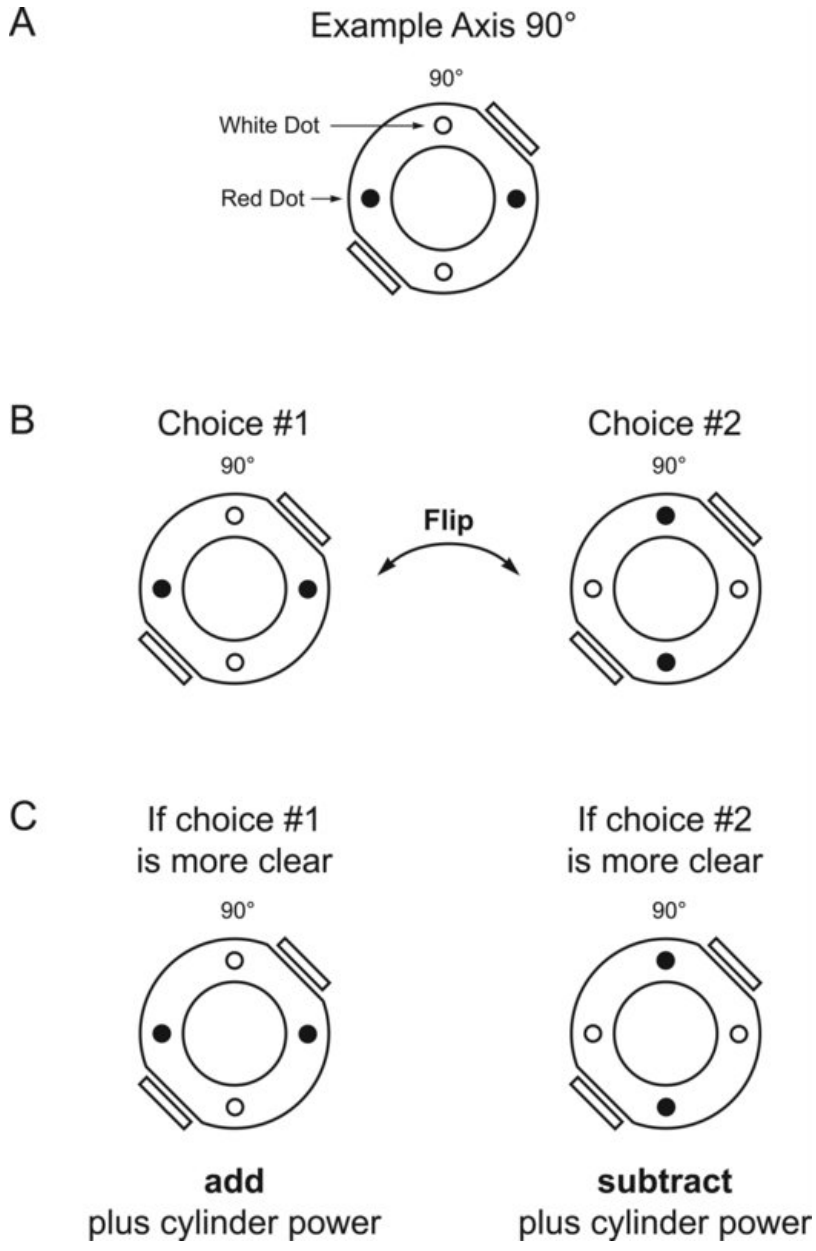
Cylinder power is usually modified by 0.25-diopter changes from the start. During the process of refining the cylinder power, **an adjustment to spherical power** must be made whenever the cylinder power has been modified by a half diopter. The adjustment is necessary to reposition the circle of least confusion onto the retina. **The JCC is now "on axis."**

Figure 8. Refining the cylinder power using the JCC:

A. Turn the Jackson cross cylinder so that the red or white dot is **"on axis,"** i.e., aligned with the axis determined by the previous step. Example axis 90 degrees.

B. Flip the cross cylinder to give the patient two choices – asking which is more clear.

C. Add or subtract cylinder power.
If choice 1 is clearer, the white dot is chosen, therefore add plus cylinder power.
If choice 2 is clearer, the red dot is chosen, therefore subtract plus cylinder power.
(See The Adjustment, pages 32 and 33.)
The correct cylinder power has been determined when the cross cylinder is flipped and the two choices are equally clear.



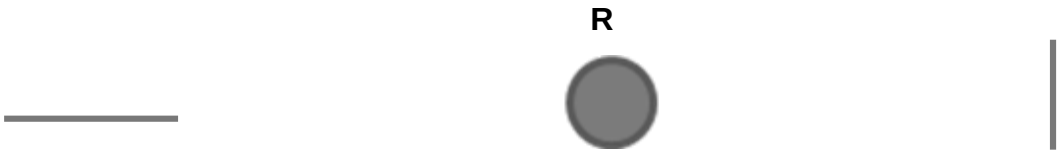
The Adjustment

An adjustment to the **spherical power** (determined in step 1) must be made for every half-diopter change in **cylinder power**. The adjustment is necessary to reposition the blur circle onto the retina, which will then enable the patient to make the best discriminations going forward. The spherical equivalent is used to make the adjustment.

The rule when **adding** plus cylinder power:
For every +0.50 diopter of cylinder power added, remove +0.25 diopter from the sphere.

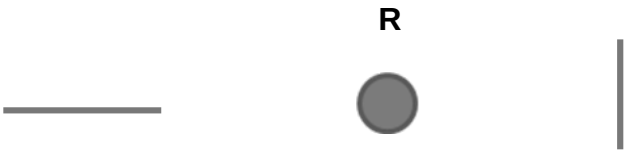
Optically, the following is occurring (click here for animation):

1. The circle of least confusion (the blur circle) has been placed on the retina (R) in step 1. It is always dioptrically midway between the two focal lines.

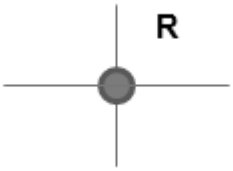


2. **0.50 of plus cylinder power is added at 90 degrees.** A cylinder affects the focal line that is parallel to its axis. The addition of plus cylinder power has moved the vertical focal line forward and the conoid of Sturm is collapsing. The blur circle has become smaller and has moved to the left, midway between the two focal lines.

3. **The adjustment: 0.25 of plus spherical power is removed.** The spherical lens change has moved both focal lines posteriorly, and the blur circle is located at its mid-position. This adjustment has repositioned the blur circle onto the retina.



4. The above two steps are repeated as necessary until the two focal lines meet. When they meet, the conoid of Sturm is fully collapsed and only a focal point remains. (The position of the focal point is refined in step 4.)



The rule when **subtracting** plus cylinder power:
For every +0.50 diopter of cylinder power removed, add + 0.25 diopter to the sphere.

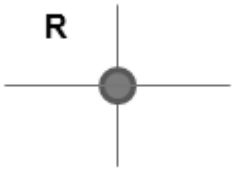
Optically, the following is occurring:

1. The circle of least confusion (the blur circle) has been placed on the retina (R) in step 1. It is always dioptrically midway between the two focal lines.

2. **0.50 of plus cylinder power is subtracted at 90 degrees.** A cylinder affects the focal line that is parallel to its axis. The subtraction of plus cylinder power has moved the vertical focal line posteriorly and the conoid of Sturm is collapsing. The blur circle has become smaller and moved to the right, midway between the two focal lines.

3. **The adjustment: 0.25 of plus spherical power is added.** The spherical lens change has moved both focal lines anteriorly, and the blur circle is located at its mid-position. This adjustment has repositioned the blur circle onto the retina.

4. The above two steps are repeated as necessary until the two focal lines meet. When they meet, the conoid of Sturm is fully collapsed and only a focal point remains. (The position of the focal point is refined in step 4.)



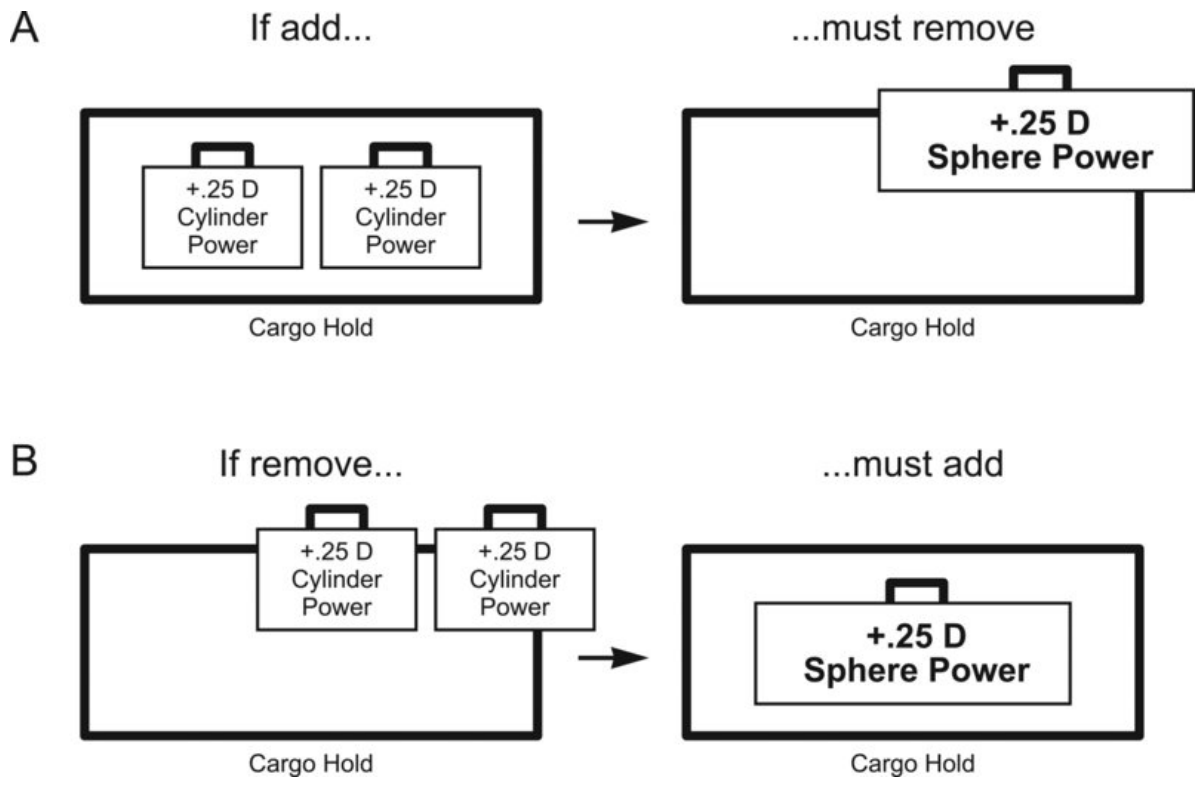
End-point when refining cylinder power: The two choices given the patient are **the same** in clarity. At this point **the correct cylinder power is being bracketed**.

Notes

- For step 3, remember to **return to a smaller line** if a larger one had to be used during axis location in step 2.
- **If the cylinder power increases significantly in step 3, recheck the axis because the greater the cylinder power, the easier it is to locate the correct axis.**
- **Steps 2 and 3 are collapsing the conoid of Sturm to a single focal point.**
- An **airplane luggage analogy** can be helpful in conceptualizing the adjustment technique (**Figure 9**, click here for animation).

Figure 9. Airplane luggage analogy for maintaining spherical equivalent:
- Small pieces of luggage equal cylinder power.
- Large pieces of luggage equal sphere power.
- The cargo hold is, and must always be, filled to capacity.
- Exchanges cannot involve the same size bags.
- In size, two small bags equal one large bag.

Therefore:
A. If two small pieces of luggage are added, one large piece must be removed.
B. If two small pieces of luggage are removed, one large piece must be added



Step 4: Sphere

As in step 1, the **large spherical dial** at the side of the phoropter is used to show the patient a series of **two choices** to compare. The patient is asked to compare the two and tell you **which is more clear**, or that they appear the same in clarity.

Choices are given in the plus and minus direction, changing the sphere based on the patient's preferences. **Always checking in the plus direction first** is helpful in trying to avoid stimulating accommodation, and it keeps the method consistent.

Initially 0.50-diopter changes can be made, changing to 0.25-diopter shifts as the final end-point of refraction is approached.

End-point: the spherical lens that is reported by the patient to yield **the clearest** view of the letters on the acuity chart. If the patient reports the clarity between two choices to be **the same**, **always favor less minus**.

Notes

The spherical refinement in step 4 places **the single focal point onto the retina.**

If the sphere changes significantly during this step, repeat steps 3 and 4.

During step 4, the following **additional tests** can be used:

- **The red-green duochrome test:** if red is more clear, add minus; if green is more clear, add plus = mnemonic RAMGAP (red add minus, green add plus)
- **Fogging:** refining sphere after dialing in extra plus spherical power to avoid over-minusing. One method, called **binocular balancing,** uses the prism dials on the phoropter to split the binocular image vertically into separate images and fogs each eye to make sure neither is over-minused.

(See Instructing Patients, below, and 16 Tips for Accurate Subjective Refraction Results, page 39, for more detail and tips for performing the above 4 Steps of Subjective Refraction.)

Instructing Patients

The efficiency and final result of subjective refraction can be maximized by guiding the patient through the process with the proper instructions. There is no one right way to do this, and each refractionist will arrive at a method that best suits them. The following is one method.

With the patient looking through the phoroptor or trial frame, tell them:

"I'm going to give you some choices. I will show you sets of two lenses to compare, and I want you to tell me which is more clear, the first way or the second way. And if they seem 'about the same,' that is always a good answer."

After the initial instructions, describing the choice for the patient as "**the first way or the second way**" can be abbreviated to "**first or second,**" "**number one or number two,**" or "**one or two.**" Since you are always giving the patient a choice between two lenses for comparison, using the numbers "one" and "two" is all that is necessary. Because of its numerical simplicity, it can also be less confusing for the patient. However, some refractionists prefer to number subsequent choices "three or four," "five or six," "seven or eight," etc. This is perfectly fine and a matter of personal preference.

To be most efficient, it is generally best to steer the patient toward responding only with the number or "same." **A "no conversation" approach** often is a big help in making the process go smoothly, quickly, and correctly. (This is in contrast to taking a medical history, when it is often beneficial to expand the narrative.) If patients are asked more open-ended questions such as "Which do you like?" or "Is this better?" some will want to describe various aspects of what they are seeing. A descriptive response tends to slow things down considerably and is usually not helpful.

A Note on "About the Same"

If the patient says the two choices you have given them are **"the same" or "about the same":**

- **When measuring spherical power (steps 1 and 4), the end-point is the less minus of the two choices.** This prevents over-minusing.
- **When locating cylinder axis with the Jackson cross cylinder (step 2), you have arrived at the correct end-point.** Each choice is moving equally away from the correct axis, thus they are "the same."
- **When testing cylinder power with the Jackson cross cylinder (step 3), you have arrived at the correct end-point.** Each choice is moving equally away from the correct power, thus they are "the same."

Managing Pauses

It is important to properly manage the pauses that can often occur after the patient has been shown two choices to compare. A pause is usually due to uncertainty on the patient's part, and it is best not to simply wait for a response. Once you detect the pause, immediately show the patient the choice once again, saying, "**Let me show you again**." Giving the choice a second time often helps the patient decide, and greatly expedites the refraction. (And many times it is the patient who will request you give the choice again!) Subjective refraction is **a test of first impression**, and it works best when the patient does not "study" the choices. If there is continued uncertainty on the patient's part, it suggests the two choices are about the same.

When Straddling the Axis

When beginning the refinement of the patient's astigmatism correction (step 2), the Jackson cross cylinder (JCC) is positioned to straddle the axis. When the JCC is placed in this position, the patient will notice that their vision is less clear than it was at the end of step 1. It is therefore helpful to tell the patient, before moving the cross cylinder into place, that **you will be making things a little more blurred**. During the testing, the patient can be told, **"Neither of these choices will be great, but tell me which one is clearer."**

Notes

- Because of the slight blurring induced at the beginning of this step, **it is sometimes necessary to move one line higher on the Snellen chart** to be working on a line the patient can read**.**
- To determine if you should work with a higher line, once the cross cylinder has been moved into place, ask the patient if they can still read the line you were using at the end of step 1. If they cannot, move one line higher.
- **And remember to move back to a lower Snellen line when, in step 3, the cross cylinder is positioned on axis.**

Over-Minusing

If, at the conclusion of a refraction, **the measurement contains more minus spherical correction than the true refractive error,** the patient has been **"over-minused."**

Over-minusing results from the patient **accommodating during the refraction.** When the patient is accommodating, more internal plus power is added to the eye, thus requiring additional minus correction externally to offset it. Thus, the extra minus correction is not correcting the basic refractive error; it is only offsetting the accommodation.

If a patient were to be prescribed the "over-minused" measurement in a pair of glasses when looking in the distance, they would need to continually accommodate for the focal point to remain on the retina. The internally added plus power would be needed to offset the extra minus power in the prescribed lens. This chronic accommodative tone would be likely to cause eye fatigue. In addition, it would leave less accommodation available for focusing at near, often resulting in a complaint of eye strain with reading.

There are four ways to avoid over-minusing during subjective refraction: **instructing the patient properly, cycloplegia, fogging techniques, and the duochrome test.**

1. If subjective refraction is performed without cycloplegia, it is important to **instruct the patient properly** when measuring sphere to prevent over-minusing. During steps 1 and 4, the patient should be told, **"Compare only clarity. If one of the choices makes the letters smaller and darker, ignore that."** The smaller and darker phenomenon results from a reverse Galilean telescope effect, and it is a sign of over-minusing. The reason this

instruction needs to be emphasized is that the patient may "like" the appearance of the smaller and darker letters.

2. A **cycloplegic refraction** eliminates the concern about over-minusing, as the patient is unable to accommodate.

3. The purpose of **fogging techniques** is to avoid extra minus spherical correction by starting the refraction from a position of extra plus spherical power. Plus power is then removed, stopping as soon as the letters on the acuity chart are read correctly. One method of fogging, termed **binocular balancing,** fogs each eye separately. This separation can be achieved by using the prism dials on the phoropter.

4. The **duochrome test** uses the differing wavelengths of colors and the chromatic aberration within the eye. The red and green sides of the screen should appear equally clear, and if they do not, this indicates that additional plus or minus spherical power is needed. If the **red side** of the screen appears to the patient to be clearer, more **minus power** is needed. If the **green side** of the screen is more clear, the eye is **over-minused** and more **plus power** is necessary. Remember red add minus, green add plus with the mnemonic **RAMGAP**.

Encouragement

C**omparing visual acuity from visit to visit** is an integral part of monitoring the status of a patient's medical eye problem, e.g., diabetic macular edema. To make proper comparisons from visit to visit, the amount of effort the patient makes when reading the letters on the acuity chart must be kept consistent. **It is not unusual for a patient to state that a line is too difficult to read, but then be able to read it when encouraged.**

Phrases such as **"Give it a try" or "Do the best you can"** are very helpful in this regard.

It is preferable to **avoid using the phrase "Guess."** as it can give the patient an improper impression of the importance of determining visual acuity.

Three Patient Concerns

There are three concerns often expressed by patients during the process of subjective refraction:

1. The choices are being given **too fast.**

2. The patient is worried that they are **not being consistent** in their responses.

3. They are not naming the letters correctly, thus **not getting the answers "right."**

The following are possible ways to allay these patient apprehensions:

1. If the patient feels the choices are being presented too fast, it is helpful to explain that the comparison of lenses in subjective refraction is **a test of first impression**.

2. Patients who are concerned about consistency are usually reassured if you explain, **"That is for me to worry about. You are doing fine."**

3. The concern about getting **"the right answer"** is understandable. (Isn't that what everyone tried to do in school?) So what should you do if the patient asks, "Is that a B?" As a general rule, **it is best not to tell the patient what the letter is.** One way to respond is, "You know, we are sworn to secrecy." The patient will enjoy the humor and it is usually effective in indicating that it is not necessary, and in fact not the purpose of this test, to get every letter right. The purpose of the test is to determine the level of the patient's visual acuity, and from that perspective, they can be told, **"This is a test that everyone passes."** In fact, everyone's score is perfect, even if answers are wrong, because the level of their visual acuity has been determined.

16 Tips for Accurate Subjective Refraction Results

1. **Move through the four steps expeditiously**. This makes the process more efficient, more precise and easier for the patient and the examiner. Comparing different lenses during subjective refraction is **a test of first impression**. A good rule of thumb is to not wait for a delayed response, i.e., have **a "no pauses" policy**. A pause is the result of the patient being uncertain which of the two lenses is better. Therefore, once a pause occurs, show the patient the choice again and remind them that "same is always a good answer." If there is still a pause, consider it identical to a response of "**the same**." Keep moving!!

2. When initially measuring a patient's visual acuity, there is **no need to start with the largest letters** on the visual acuity chart, unless you have an indication that visual acuity is reduced. The goal is to find the smallest line the patient can read, and you want to get there as efficiently as possible.

3. During subjective refraction **work with the smallest line that the patient can read**, going further down as acuity is improving. The patient is able to make finer discriminations on the smaller lines.

4. Watch to make sure the patient is **not squinting**, as this will give an unwanted pinhole effect.

5. Run through The Sequence again **if there is a large change in any of the steps**.

6. **When working with the white dot** on the Jackson cross cylinder while checking cylinder axis and power, there are two strategies that can be employed **if the patient selects choice 1**. If the patient chooses choice 2, one can directly visualize where the white dot is located.

   If the patient says choice 1 was more clear, you can either **flip back** to the first choice to see where the white dot is or **not flip back** but know that choice 1 was the opposite of what is now visualized. This strategy saves one flip.

One reasonable approach is for the novice refractionist to flip back to choice 1 if it is chosen to lessen the chance for confusion. With experience that extra flip may be abandoned.

7. When refining sphere, if the patient prefers choice 2 (that is, the lens they are currently looking through), two different methods may be employed with regard to the lens to be shown as the first of the next two choices.

   The first lens presented for the next set of choices can be either a new lens or the lens the patient is currently looking through.

   Some refractionists feel it is important to show the patient a new lens at the start of each series. Others find it is not necessary to do so, and using the lens already in place from the previous set of choices does save an additional step.

8. **If the patient has reduced vision due to an eye disease**, use large steps throughout. If it is available, a handheld +/-0.50 or +/- 1.00 diopter cross cylinder can be helpful.

9. If retinoscopy, autorefraction, or the old glasses suggest there is a spherical refractive error without astigmatism, **it is still necessary to determine if astigmatism is present** (unless the vision is a crisp 20/20 with the spherical correction). **Two methods that can be used to make this determination are as follows**:

   - One method **uses the Jackson cross cylinder** (JCC) — with no cylinder power dialed into the phoropter. The JCC is positioned at the 90 and 180 degree position, and it is then flipped so that the white dot is alternatively **at 90 or 180 degrees**. The patient is asked which of the two choices is more clear.

     If one of the choices is clearer, then 0.50 diopter of plus cylinder power is dialed into the phoropter at the axis where the white dot was located, and 0.25 diopter of plus sphere is removed. The subjective refraction continues from that point with refinement of cylinder axis and power.

     If the choices at 90 and 180 degrees are reported to be the same in clarity, the JCC is then turned so that the patient is shown a new set of choices at **45 and 135 degrees**. **If one of the choices is clearer**, then 0.50 diopter of plus cylinder power is dialed into the phoropter at the axis where the white dot was located, and 0.25 diopter of plus sphere is removed. The subjective refraction continues from that point with refinement of cylinder axis and power.

     It can be concluded that no astigmatism is likely to be present if the patient finds no difference during each set of comparisons.

   - An alternative method does not use the JCC. **Dial in, and then out, 0.50 diopter of plus cylinder power at each of the 4 axes (90, 180, 45 and 135 degrees).** It is not necessary to adjust the sphere when doing this. If 1 of the 4 choices results in the letters becoming clearer, from that starting point, and after removing 0.25 diopter of plus sphere, begin refinement of cylinder axis and power.

10. **It is sometimes the case that a patient's subjective responses are inconsistent or unreliable**. In this situation, **do not let yourself get frustrated or angry**, a sometimes tempting response. It is important to keep in mind that the patient came, not to cause you difficulty, but for care for their eyes. When visual field testing yields unreliable responses, we glean whatever information we can from it and move on. An unreliable subjective refraction can be thought of the same way.

    It is important to understand that some patients can give a very precise and repeatable end-point, and others cannot. Sometimes there is a medical explanation for those that cannot. Cataracts, macular edema, dry eyes, age-related macular degeneration and other conditions can cause vision to fluctuate.

    You can **use visual acuity** to make sure you are moving to the correct end-point. If the acuity is worsening following the patient's choices, this indicates the responses have been unreliable.

    If you find the patient is not progressively moving to a correct end-point, but in fact deviating from it, **you can deviate from the normal sequence either during or after the normal subjective refraction steps**. You can make **larger jumps** in spherical power, cylinder axis, and cylinder power than you would normally, and the axis dial can even be turned freehand without use of the JCC**.**

    It is also important to **"know when to quit."** It is appropriate to end the subjective refraction if it seems that the responses are not reliable enough to be helpful. In that situation, it should be noted on the patient's chart that the refraction resulted in a **"poor end-point."** By doing so, you will know to be cautious about prescribing from that result.

11. During subjective refraction we are giving the patient choices and asking for their preferences. However, **we as refractionists also have preferences:**

    - **Less minus in the sphere** — to avoid over-minusing.
    - **Less power in the cylinder** — to make adjustment to the glasses easier for the patient.
    - **Axis at 90 or 180 degrees** — to lessen the chance that the patient will have tilting of viewed objects.
    - **Oblique axes adding to 180 degrees** — the axes are then symmetrical, which suggests that they are correct.

12. If, during the spherical measurement, the patient keeps choosing lenses moving in the minus direction (this can be called "the minus march") and then begins to progressively choose less minus, continue to allow the patient to move in the plus direction. This pattern can occur if accommodation is at first increasing, but subsequently relaxing, as the refraction proceeds. **(See Over-Minusing, page 37, and Myopia Case 1, page 49.)**

13. **When there is only +0.25 diopter of cylinder power**, it can be difficult to correctly position the axis.

14. **When refracting a child**, at the completion of the refraction, allow the patient to view the chart binocularly. Add + 0.25 diopter of sphere to each eye and determine whether the child's ability to read the chart is unchanged. If it is unchanged, continue to remove minus binocularly until the visual acuity is affected. This additional step will **decrease the likelihood that a child will be over-minused** as a consequence of their very strong accommodative ability.

15. **When prescribing aphakic glasses**, **the vertex distance** must be specified. This is measured with a special caliper called a **distometer**.

16. It may be helpful to occasionally use **Halberg clips, supplemental cylinder power inserts, or the 0.0 power lens in the trial lens set**.

    A **Halberg clip** is placed over the existing lens in the patient's glasses. The clips are made to hold trial lenses that are placed in front of the patient's glasses.

    A **supplemental cylinder power insert** is intended for use when the power of the patient's cylinder exceeds 6.00 diopters.

    The **0.0 power lens** can be helpful in several situations. It can be used to have consistency of lens additivity when one eye has a purely cylindrical correction. It can also be helpful as a "magic lens" for a patient whom you suspect of malingering or wanting glasses only because a sibling or friend has them.

Before Writing a Glasses Prescription

- **Show What You Plan to Give**

  This is an essential ending for the refraction process, and its importance cannot be overemphasized. Despite this, it is often omitted.

  After the subjective refraction has been completed for each eye, **show** the patient what you plan to give them binocularly. **It is essential that the patient be part of the decision-making process; the refractionist should not make the decision unilaterally.**

  If the patient is currently wearing glasses, ask them to compare what has just been measured to their glasses — the measurement in the phoropter versus their glasses. If the patient responds that they are seeing more clearly with the just completed refraction, and if they think it is a worthwhile improvement, then it may be prescribed. If the patient responds that the glasses are better than the refraction, then a change in prescription should not be made (or the refraction should be reworked).

Note

If there is uncertainty about whether the planned change is **an improvement for each eye**, the comparison between the measured and present prescription can be performed **monocularly**.

When performing either monocular or binocular comparisons, the prescriptions can be shown sequentially using the phoropter alone, or they can be compared by alternating between the phoropter and the current glasses.

The refractionist should not feel that they have done anything wrong if the subjective responses do not lead to an improved prescription. This can be the case even after a meticulously performed refraction.

If the patient is presbyopic, they should similarly be shown the potential change binocularly at near to again make certain it is an improvement.

So, why is this step so important? It avoids the patient coming back, after having purchased an expensive pair of glasses, telling you that their old glasses are better than the new ones.

- ## Factors to Consider When Changing a Prescription

  - Does the patient report any difficulty functioning with their present glasses?

  - The **magnitude and type of the measured change** — any large change or a change in cylinder power or axis (**especially axis**) can be difficult to adjust to.

  - Does the patient want to get new glasses because of scratches on the lenses or to have new frames? In these situations, there is no need to worry that a change is "too small to make."

  - How long the patient has been wearing the present glasses — **the longer one has worn a given prescription, the more difficult it may be to adjust to a new prescription.**

  - Cost considerations must also be taken into account, as purchasing a pair of glasses is not an insignificant expense.

- ## Trial Run

  In several situations it is important to **put the contemplated prescription in a trial frame** and have the patient **take a short walk** before writing the prescription. The planned change may be well tolerated sitting in the exam chair, but walking with the prescription is more likely to identify a problem.

  The trial run can be presented to the patient as a "**test drive**," and should be done when:

- There is a **large change in the patient's spherical correction**
- There is a **change in cylinder power or axis**
- This is the patient's **first pair of glasses**
- Cylinder is being prescribed for the **first time**
- The patient does not have their previous glasses and therefore the amount of change cannot be determined
- There is any other concern about the new prescription.

After walking with the new prescription in place, if the patient reports experiencing eyestrain, "pulling," nausea, things looking slanted, an alteration of depth perception ("the floor is coming up to me"), or poorer vision than with their current glasses, you do not want to give them that prescription!

When the intended prescription is not tolerated on the trial run, it is very unlikely the patient will adjust to it over time. It is best to try another trial run with a modified prescription in place. The prescription can continue to be modified until the patient feels comfortable with it.

- **A New Presbyope**

If a patient is **a new presbyope**, discuss with them the pros and cons of the possible methods of correction:

- Over-the-counter reading glasses — if the patient has an insignificant distance correction, don't hesitate to recommend these (the quality is fine).
- Using two pairs of glasses — one pair for distance, one pair for near
- Bifocals — flat-top versus progressive-addition lenses

Notes

- Although this discussion can be left for the patient to have with the optician, you know your patient and their needs, and it is best if you make the decision with your patient. The type of presbyopic correction decided upon can then be **specified on the glasses prescription.**
- **If an older individual is doing well with a flat-top bifocal**, it is often best to have them continue with that type.

- ## Instructing the Patient

  When prescribing a patient's **first pair of glasses**, discuss with them **how often the glasses should be worn**, for this will be a concern of theirs.

  It is often helpful to begin by discussing two conflicting myths:

  Myth 1: "You should wear the glasses all the time for, if you don't, you are straining your eyes."

  Myth 2: "Don't start wearing glasses because your eyes will become weak and dependent on them."

  Neither is correct!

  Glasses, when worn, are simply helping the individual see better. There are exceptions to this, for example, when the glasses are being used for protection or in the treatment of accommodative esotropia, amblyopia, or for other medical reasons.

  Thus, the proper instruction is that **the glasses should be worn when the patient finds they would like to see more clearly**. This may mean that the glasses are worn all the time or only for specific tasks such as night driving. Visual need should determine the wearing schedule**, without any concern about hurting or affecting the eyes.**

  The "**winter coat analogy**" is one way to clarify this concept for the patient. One knows when they want to wear their winter coat and, conversely, when they don't feel they need it.

  If one is prescribing glasses for a child or teenager, **it is important to give these instructions to both the child and the parent.**

- ## Special Situations

  - If a patient has **prism** in their glasses that you would like to continue unchanged in their new prescription, but you are not completely confident in your measurement, write **"duplicate prism"** on the prescription and the optician will be able to do so.

  - To provide extra **safety, polycarbonate lenses** have traditionally been preferred **for children and monocular patients**. **Trivex lenses** are a newer alternative, having less chromatic aberration than polycarbonate. Fortunately, modern standard plastic lenses also provide a good amount of protection.

- ## Final Considerations

  - When a change in the prescription is being made, it is good to instruct the patient to **purchase only one pair of glasses initially**. If the prescription should need to be modified for whatever reason, only one pair of glasses will then need to be remade. Once

the new prescription is successfully worn, the patient can order one or more additional pairs of glasses if they would like.

- If you are **prescribing a progressive addition lens for a patient who has never used this type of correction**, explain that a slight tilt up of their chin, i.e. head tilted slightly back, will usually provide optimal focus for a desktop computer monitor. Some patients do not discover this on their own.

- If you are prescribing glasses for a child**, direct your discussion and give the glasses prescription to the child rather than the parent**. The parent will, of course, be listening to every word you say, but the child is your patient — and has just cooperated the best they could for the exam. Although it will probably not be acknowledged, both the child and the parent will appreciate the consideration and respect inherent in doing so. The child will often immediately give the prescription to the parent, and that is fine.

- Instruct the patient to **call you after a few days** if they are having any difficulty with the new glasses. The standard optical industry policy is that the optician will change the glasses at no additional cost within the first month of wear.

Subjective Refraction over Current Lenses (Spherical Over-Refraction)

- Subjective spherical **over-refraction** is performed **with the patient wearing their current glasses**, presenting choices "over" each lens while the other side is occluded. The patient is shown spherical lenses in the same manner as step 4 **(see page 35)** to determine if a change in the spherical part of the correction needs to be made.

- Over-refraction can be performed **when a change in the cylinder power and axis is not indicated**. This might be the case if a meticulous refraction was performed one year earlier and a change in the astigmatism portion of the prescription is not likely to have occurred or be needed.

- One can use **trial lenses** or lenses mounted on a handle, the latter called a "**confirmation test.**" For a patient with reasonably good vision, begin by showing them a +0.25 diopter lens and a -0.25 diopter lens to compare. If the two choices are of equal clarity, no change in the spherical correction is indicated. If either the choice on the plus side or the minus side is more clear, continue the subjective refraction with lenses on the chosen side.

- When working with the patient's glasses, one can occlude the eye not being tested with a **hand-held occluder** or a **clip-on occluder**. If the patient holds the occluder, make sure the glasses are in their normal position and are not being pushed closer to the eye. This is especially important with larger prescriptions where a change in vertex distance affects the measurement. The clip-on occluder will not alter the patient's vertex distance.

- When over-refracting, try to make sure the patient is looking through **the optical center** of the lens in their glasses.

- When testing distance vision over **a progressive addition lens**, it is very important to make certain the patient's **chin is not elevated**. If the patient is looking through the intermediate channel, this will prevent determination of the correct distance measurement.

- Over-refraction can be used to evaluate **the reading prescription** as well as the distance prescription.

- When refracting for near vision over reading glasses, make sure the glasses are **positioned** where they are usually worn. A change in position alters **the effective power of the lenses.**

- Over-refraction can also be used when measuring for **computer glasses**. One technique is to **place the near card on the slit lamp chin rest**, with the position of the slit lamp adjusted to simulate the distance and height of the patient's desktop computer monitor.

Note

As a screening method to determine if astigmatism might be present, a +0.50-diopter cylindrical lens can be held up, at varying axes, **over a spherical correction**.

Near Vision

- When determining the proper correction needed for reading, **ask the patient to hold the near card at their ideal reading distance.** Clarify that you are not asking them to hold the card at the distance where things seem most clear with their current glasses. Ideal reading distance is used (rather than the 14 inches specified on some near cards) because this is where the patient will be doing most of their reading. It is, however, at 14 inches that the Snellen equivalent designations are valid.

- **The Jaeger system of notation** (e.g., J1+, J2, J10) is used for near to readily differentiate it from distance acuity.

- When testing near vision, it is usually best to measure **each eye** individually. This is helpful even though the prescribed Add will almost always be the same for each eye.

Note

If an asymmetric Add is measured, this suggests that the distance prescription that is it being added to may be incorrect.

- The goal of near refraction is to find the correction which makes the numbers or letters on the near card **more clear, not larger**. The correction for near is simply supplementing or replacing the individual's diminished accommodative ability – an ability which, when it was functioning fully, focused but did not enlarge small print.

- **An Add that magnifies is overly strong. This is not desirable because as the Add increases, the closer and narrower the reading range becomes**.

- Before prescribing an Add or reading glasses, it is very helpful to evaluate **the range of clear near vision** with the planned correction. The range is determined by asking the patient to bring the near card toward them, stopping when the numbers or letters blur. They are then asked to push the card away, stopping when blurring occurs. The reading range is optimal when the patient's ideal reading position is halfway between these near and far positions.

Using the Trial Frame

- Adjust the trial frame so it is **sitting properly** on the patient's face with the lenses centered on each pupil.

- Place the **spherical correction** in the clip at the back of the trial frame, and place the **cylinder** in the front of the trial frame so the axis can be adjusted.

- Keep the trial lenses **organized** in the trial lens drawer**.** The best way to do this is to **place each lens in its correct slot immediately after use**.

- Keep the trial lenses **clean**.

Part 2 Summary

- As with the medical problems that present to us**, refraction and prescribing glasses involve history, examination, diagnosis and treatment decisions.**

- The process is **not only measurement, but problem-solving.**

- Often the diagnosis can be made from the **history.**

- The **goal** is to give **the simplest system that satisfies that individual patient's visual needs.**

- **Show and discuss with the patient** any change you are considering giving them. Give the change **if they would like to have it.**

Part 3: Case Studies

Myopia

Myopia Case 1

A 24-year-old myope who, although seeing reasonably well at distance without correction, is **"soaking up" minus spherical power during subjective refraction.** Why is this happening, and what can be done to determine if it is needed?

Answer: It is important, when performing subjective refraction, to be concerned about giving the patient too much minus spherical correction. **Over-minusing** occurs as a result of the patient accommodating during the refraction. This is especially a concern with a younger patient, for they have a great deal of accommodative ability. There is a tendency for the extra minus power to be preferred by the patient because, when offset by accommodation, the letters on the acuity chart will look smaller and darker, and thus "better."

There are several techniques that can be employed to try to prevent over-minusing during subjective refraction:

- The patient should be instructed, and reminded, to compare only the clarity of the choices being shown. It should be emphasize that if a given choice makes the letters smaller and darker, it should be considered "the same."
- The refractionist should make certain the additional minus is resulting in improved ability to read the acuity chart.
- Fogging techniques can be employed so that the patient begins from a position of extra plus. **(See Over-Minusing, page 37.)**
- The red-green duochrome test can be used. **(See Over-Minusing, page 37.)**
- A cycloplegic refraction can be performed. **(See Terms, page 26.)**

Myopia Case 2

A 75-year-old patient is found to have a -1.00 diopter change in refractive error in each eye from their prescription of one year ago. What are the possible etiologies of this **myopic shift**? What are the considerations before giving the patient a prescription for a new pair of glasses incorporating this myopic shift?

Answer: Possible etiologies include **a nuclear sclerotic cataract, the onset or worsening of control of diabetes mellitus, a recent scleral buckle, some medications (e.g., Tetracycline), and hyperbaric oxygen treatment.**

If it is determined that the myopic shift is due to cataract, it should be explained to the patient that the change in prescription will offset, but not overcome, their cataract (unless it is very mild).

The change in prescription measured should be shown to the patient binocularly at distance and near. (If the myopic shift worsens near vision, the Add may need to be increased.) A decision will have to be made, with the patient, whether the change will allow them to satisfactorily carry out activities of daily living. If it appears that it will, give the prescription. If not, discuss cataract surgery with the patient.

Note

If, after discussion, it is unclear whether the vision will or will not be satisfactory with the new prescription, it is sometimes best to make the change. That way both you and the patient will know, if they find they are still having difficulty while wearing the new prescription, that cataract surgery is indeed indicated.

If it is determined the myopic shift has resulted from diabetes, it is usually best to remeasure once the patient's glucose level is stabilized.

If a systemic medication is considered to be the etiology of the myopic shift, a decision about changing the patient's glasses will depend upon the length of time they are expected to be on the medication. Discussion with the prescribing doctor is at times very helpful.

Myopia Case 3

A 48-year-old patient who, without reading glasses or a bifocal, is having no trouble reading. Why? They are certainly at the age one would expect them to have symptomatic presbyopia.

Answer: If the patient is wearing glasses for myopia, almost certainly their **myopic refractive error is not fully corrected**. They can read at near because of the myopia that remains uncorrected.

In this situation, if the patient feels they are seeing satisfactorily at distance and near, it is often best not to give the additional minus to fully correct the distance refractive error. Keeping them "under-minused" allows them to defer moving to a bifocal or progressive addition lens for a little while. If the patient were to be given the full myopic prescription, almost certainly a bifocal or progressive addition lens would be needed.

If the patient is not functioning satisfactorily at distance, then the full myopic prescription can be given, with the addition of a bifocal or progressive addition lens. The decision about when to no longer use a single vision lens is best made with the patient.

Note

An extension of this concept can be seen in the individual with myopia who takes their glasses off to read — they are reading with what can be termed **natural nearsightedness.**

Myopia Case 4

A 37-year-old myope seeing well at distance with their glasses is having trouble reading. Is this presbyopia?

Answer: For someone 37 years of age, presbyopia is not the most likely diagnosis. It is much more likely the patient is **over-minused** at distance. Their trouble reading is, most probably, the result of having to use their accommodative ability to offset the excessive minus in their glasses. They therefore do not have enough accommodation left to use for reading.

Note

Let the patient know that the new glasses you will be giving them, with less minus sphere, may require a little adjustment period for seeing clearly at distance, as their accommodative tone may take a little time to relax.

Myopia Case 5

A 55-year-old high myope presents for routine examination. You determine that they do not need a change in glasses and that their eyes are in excellent health. When discussing those results, **what else should you tell them?**

Answer: Because an individual with **high myopia** has an increased risk of a retinal tear and subsequent detachment, it is important to instruct every such patient to **call immediately should they have the onset of new floaters, flashes, or a change in their side vision**. This reminder should be repeated and reinforced when you see the patient in the future.

Myopia Case 6

A 30-year-old patient who has never worn glasses is examined and found to have **a small amount of myopia**. The patient says they do not feel they need distance glasses. Should you prescribe them?

Answer: If the patient feels they are seeing satisfactorily at distance, and you have found only a small myopic correction, it is usually fine for the patient to continue to function without distance glasses.

Were you to prescribe the glasses for the patient, the proper instructions would be that they do not need to be worn all the time, only when the patient wants their help. The patient has indicated it is unlikely they would be worn, so it would most likely be a wasted expense.

Myopia Case 7

A 35-year-old wearing glasses for myopia is examined, and you measure **a very slight increase in their myopic correction. Should you make it?**

Answer: The best way to determine if this change should be made is to show it to the patient, and let them decide whether they feel it is a significant enough improvement to warrant the purchase of a new pair of glasses.

Note

This is a good rule-of-thumb to follow for any anticipated change in prescription.

Hyperopia

Hyperopia Case 1

A 37-year-old with a single vision hyperopic correction in their glasses is seeing well at distance, but is having difficulty reading. Is this presbyopia?

Answer: The patient most likely has hyperopia that is not being fully corrected by their glasses. They are therefore using their accommodative ability to correct the **latent hyperopia**, leaving an insufficient amount of accommodation for reading.

When measuring to uncover latent hyperopia, one may perform a **cycloplegic refraction** or **"push plus,"** that is, during a noncycloplegic refraction, give as much plus spherical power as the patient will tolerate without causing blurring or discomfort.

If a large amount of latent hyperopia is found with a cycloplegic refraction, it is often best for the patient to return for a **post-cycloplegic refraction** to make sure they can tolerate the additional plus. It may be necessary to give them the full hyperopic correction in stages if the

accommodative tone, probably present for many years to correct the latent hyperopia, is not able to relax readily.

Note

Latent hyperopia can, not uncommonly, be present in individuals who see well at distance without glasses and are not known to be hyperopic.

Hyperopia Case 2

A 50-year-old who is successfully using over-the-counter reading glasses is **now beginning to have trouble with distance vision**. Why, and what might you recommend?

Answer: The patient's difficulty at distance is almost certainly due to **latent hyperopia that has now become manifest**. Prior to age 50 they were able to use their accommodative ability to correct their distance vision, but now there is not enough accommodation left to do so.

If the patient does not want a bifocal or progressive addition lenses and does not mind having two pairs of glasses, there is an inexpensive way to correct their vision for distance and near. If they have a low and symmetrical amount of hyperopia, and no astigmatism, they can use over-the-counter "reading glasses" for distance. For example, they may do well using a +1.25 pair for distance and +3.25 pair for near.

Hyperopia Case 3

A 25-year-old patient found to have **latent hyperopia** was recently given a glasses prescription following a **cycloplegic refraction**. They are now complaining that they **cannot tolerate the new glasses**. What should be done?

Answer: The patient should return for a **post-cycloplegic refraction**.

If a significant amount of plus sphere, not previously worn, is found on a cycloplegic refraction, it is best to bring the patient back for a post-cycloplegic refraction before writing the final prescription. The purpose is to determine how much of the full cycloplegic refraction they can tolerate.

A lesser amount than the full hyperopic correction may need to be prescribed because the long-standing **accommodative tone**, which has been present to self-correct the latent hyperopia, can be quite resistant to relaxation. Over time, this tone will decrease and, subsequently, additional plus can be added until the full hyperopic correction is accepted.

Hyperopia Case 4

A 64-year-old patient whom you find has had a **hyperopic shift** in their prescription since the last visit. What are two possible etiologies?

Answer:
1. Macular edema
2. Recent initiation of treatment, or treatment change, for diabetes mellitus

Hyperopia Case 5

A 6-year-old patient is examined and found to have a refractive error of +1.25 in each eye. **Should glasses be given?**

Answer: Because of the patient's young age, and if strabismus is not a factor, glasses should not be given for this refractive error. The patient has ample accommodation to correct the hyperopia, and it will be invoked without any conscious effort by the patient.

Note

It is also not necessary to give a correction for a small amount of astigmatism at this age.

Astigmatism

Astigmatism Case 1

A 35-year-old patient calls having just begun wearing the new glasses you prescribed.

Previous prescription: OU -1.75 + 1.00 × 90.

The prescription you gave: OD -2.00 + 1.25 × 75, OS -1.75 + 1.50 × 105.

They say that with their new glasses, **the top of their desk looks slanted, and when walking they have some nausea and the floor seems to be coming up at them**.

What is the most likely cause of these symptoms?

Answer: Their symptoms are the result of **the change made in the astigmatism correction** in their new prescription.

The astigmatic portion of a glasses prescription is the most prone to cause difficulty. A change in cylinder axis, especially with higher cylinder powers, is always a concern. A "**trial run**" prior to prescribing may very well have avoided this patient's problem. **(See Trial Run, page 43.)**

Astigmatism Case 2

A 26-year-old patient who has never worn glasses presents complaining of decreased distance vision. If retinoscopy is not performed, and an autorefractor is not available, **how do you determine if cylinder is present?**

Answer: See 16 Tips for Accurate Subjective Refraction Results, tip 9, page 40.

Astigmatism Case 3

A 34-year-old patient, after completion of retinoscopy, begins subjective refraction with the following prescription: -3.50 + 0.50 × 180.

Using the phoropter, the spherical correction in step 1 **(see The Four Steps of Subjective Refraction, page 28)** is determined to be -3.00, and in step 2, the axis remains unchanged.

You begin modifying the cylinder power of +0.50 × 180 with the Jackson cross cylinder , and the patent chooses the red dot. Therefore, you lessen the cylinder power to +0.25 × 180.

The patient then chooses the red dot again and you to lessen the cylinder power to 0.00 × 180, and add +0.25 power to the sphere.

On the next sequence of choices the patient once again chooses the red dot, but **you are working with plus cylinders and cannot go any lower. What can you do?**

Answer: The patient, when choosing more minus cylinder power power at -2.75 + 0.00 × 180 degrees, is choosing plus cylinder power at 90 degrees. To proceed, dial in +0.25 diopter of cylinder power at 90 degrees, and then begin again to refine cylinder axis and power.

Astigmatism Case 4

A 25-year-old myope, who previously had a small amount of astigmatism, is **choosing a large amount of cylinder power during subjective refraction**. Why?

Answer: It may be that there has simply been an increase in the astigmatism. However, it is important to make sure this is not the result of **over-minusing the sphere**, which will necessitate an increase in cylinder power.

For every half diopter the patient is over-minused, the cylinder plus power needs to be increased by one diopter to maintain the spherical equivalent and keep the circle of least

confusion on the retina. (See The Spherical Equivalent of an Astigmatic Prescription, page 24).

For example, if a patient has a true refractive error of: -3.50 +0.50 × 180:

- They have a spherical equivalent of -3.25
- If the sphere is over-minused by -0.50 diopter, the cylinder power needs to be increased by +1.00 diopter. This results in a correction of -4.00 +1.50 × 180 which is necessary to order to maintain the spherical equivalent of -3.25 and keep the circle of least confusion on the retina.
- And if the sphere is over-minused by -1.00 diopter, the cylinder power needs to be increased by +2.00 diopters. This results in a correction of -4.50 +2.50 × 180, again necessary to maintain the spherical equivalent of -3.25.

Astigmatism Case 5

A 45-year-old new presbyope is examined and found to have, in each eye, a distance refractive correction of plano +0.50 × 90 and a near correction of +1.50 +0.50 × 90. They have never had distance glasses and their only difficulty is with reading. **What should you give?**

Answer: If the patient is seeing fine at distance and would simply like help with reading, they may do quite well with over-the-counter reading glasses. A strength of +1.75 would be recommended based on the spherical equivalent of the near measurement. It is not necessary to give them a prescription incorporating the astigmatism correction unless their reading or distance acuity is significantly improved with the addition of the cylinder and they prefer it.

Astigmatism Case 6

A 14-year-old patient, who has not had a previous refraction, complains of trouble seeing at distance. Subjective refraction results in the following prescription:

Right eye: -1.75 + 0.50 × 100 = 20/20

Left eye: -1.50 = 20/25 (pinhole 20/20)

No organic etiology is found to explain the lesser acuity in the left eye.

What should be the next step?

Answer: Because the astigmatic correction for a patient is often **symmetrical**, a helpful next step would be to look for that possibility. Complete symmetry would indicate a refractive error for the left eye of -1.75 + 0.50 × 80. When symmetrical, the axes add to 180 degrees. Repeat subjective refraction for the left eye could begin with that prescription, and note that the correction originally found is the spherical equivalent of the new starting point.

Presbyopia

Presbyopia Case 1

A 45-year-old patient presents with the complaint that when trying to read, "**My arms aren't long enough**."

What is the diagnosis and what should you prescribe?

Answer: The patient's symptom is the result of **presbyopia**.

Note

The patient's age is 45. This is usually when the initial correction of presbyopia is necessary, not age 40 as is often stated. If presbyopic symptoms occur before age 45, make certain the patient is not overminused or a latent hyperope. These may be the cause of the earlier than usual onset of presbyopic symptoms. And conversely, if a patient is reading satisfactorily without correction in their late forties, it is very likely some uncorrected myopia is present.

The treatment would seem to be very straightforward, but surprisingly there are ***four*** **categories of solutions for a patient with presbyopic symptoms and additional choices within the categories.**

The **four categories** are as follows:

1. **Give nothing:** If a patient has **mild to moderate myopia and has been taking their distance glasses off for reading**, it is fine to have them continue to do so. When their glasses are off, they are reading with their natural nearsightedness.

2. **Give reading glasses:** A patient can be given a **prescription for reading glasses** or, when appropriate, instructed to purchase **over-the-counter (OTC) reading glasses**.

   Three things to consider with regard to OTC reading glasses:

   (1) OTC reading glasses are sometimes referred to as "drugstore reading glasses," "readers," "cheaters," or "magnifiers." Although OTC reading glasses are sometimes called "magnifies," their purpose is **not magnification**. Their function is to **supplement** the patient's diminished focusing ability. That focusing ability, before it was lost, focused the print but did not enlarge it. Therefore, the proper strength for OTC reading glasses is determined by finding the **amount of plus power that best focuses the reading material without magnifying it**. The reason to refrain from giving additional plus power, which would produce magnification, is that it would result in an **unnecessarily closer and narrower reading range**. An exception to this is for a patient with low vision where magnification may help.

(2) OTC reading glasses are appropriate when **three criteria** are met:

- The patient must be **essentially emmetropic at distance**. (If glasses are worn to correct a distance refractive error, an Add is typically prescribed.)
- The two eyes must be reasonably **symmetrical** in their refractive status. (OTC reading glasses have the same strength lens for each eye.)
- The patient must have **no astigmatism or an insignificant amount**. (OTC reading glasses have only spherical plus power.)

Note

When these **three criteria** are met, OTC reading glasses can be recommended with confidence. The strength designation found on the glasses can be relied upon, the quality of the lenses is good, and there is a significant cost saving for the patient.

(3) **Three types of OTC reading** glasses are made, and it is helpful to discuss with the patient the pros and cons of each type to determine which is likely to work best for them:

- Half-glasses:
  Pro: Allow for distance viewing over the top of the glasses.
  Con: Some individuals prefer to not have this "look."
- Full reading glasses:
  Pro: Gives the patient a larger reading area than the half-glass.
  Con: The glasses need to be removed for distance viewing.
- Plano bifocals (plano at top; flat-top bifocal at bottom):
  Pro: Allow the patient to alternate between distance and near.
  Con: Some patients prefer to not have bifocals.

Note

It is helpful to **write down** for the patient the **strength and type** of reading glasses decided upon. When doing so, if a glasses prescription pad is used, it is best to write OTC clearly on the prescription to avoid confusion if it is taken to an optical shop.

3. **Give two pairs of glasses, one for distance and one for near:** This choice may be especially appropriate if the patient uses distance glasses only for certain tasks, such as driving. They may then prefer to carry two pairs of glasses, using each pair when appropriate. This choice is probably not best if someone, at work or home, has a need to frequently alternate vision from distance to near and vice versa.

   Two pairs of glasses can also be preferred by a patient who is overly concerned about using a bifocal. A new presbyope may sometimes chose to begin with separate reading glasses for this reason, knowing they can always change to a bifocal or PAL if they find that switching back and forth between the two pairs of glasses is a nuisance.

4. **Give bifocal or multifocal glasses:** This choice works best for most people, as it is the simplest and most efficient way for the presbyope to have best corrected vision both at distance and near. In daily life, we are constantly alternating our gaze from far to near, as well as in-between. Teachers are a prime example, for they often have to read and look out at a classroom of students in the same setting. Also, some individuals like to sit and simultaneously read or knit while watching TV.

Note

It is good to be aware that, for some patients, the initial prescription of a bifocal is a cause for worry or even mild distress. Some are concerned they will have difficulty adjusting to them, while others consider it an unpleasant indication they are getting older. If these concerns are detected, gentle reassurance can be quite helpful.

It is important to discuss with the patient that there are three primary ways a presbyopic Add can be given. It can be given as a **standard bifocal, a trifocal, or a progressive addition lens (PAL)**, the latter sometimes referred to as a "no-line bifocal." It is best to discuss the pros and cons of each of these options with the patient to determine which is most appropriate for them.

- The **standard bifocal** may be given as a **flat top segment** or, less often, as an **executive bifocal**. In the latter, the bifocal segment occupies the entire lower portion of the lens. The intermediate distance is not corrected by a standard bifocal.

- The **trifocal** has three distinct segments, with two lines. The additional (middle) third lens corrects **the intermediate distance**. Gaps between the distance and intermediate areas, as well as between the intermediate and near areas, still exist. The trifocal is prescribed with much less frequency now that the PAL is available.

- The **PAL** is a graduated multifocal. Plus power increases from the distance portion at the top of the lens to the full strength Add at the bottom. This lens allows one to focus from distance to near, without any gaps, by looking further down the lens.

Notes about the PAL Lens

- It is important to let the patient known that, when a progressive lens is working properly, distance vision should be clear when they are looking straight ahead, near vision should be clear when they are looking down in the usual reading position, and it is only in the intermediate area where some adjustment with chin-up positioning needs to be made. The closer the object, the higher the chin needs to be. After a short while, positioning for the intermediate distance should happen essentially automatically.

- The great advantage of the PAL is that it allows clear vision at all distances, allowing one to **function very similarly to how one did prior to the onset of presbyopia**!

- It needs to be mentioned to the patient that there is an **inherent blur at the sides** with the PAL. This does necessitate straight ahead viewing for most things, especially for reading.

Most patients are able to adjust to this quite easily — surprisingly easily, as now **movement of the head** is necessary as one reads across a page rather than moving only one's eyes. Of note, the recently developed **free-form progressive lens** has greatly improve side vision in the PAL.

Note

Bifocal or multifocal glasses do not usually work well for a patient who watches TV while lying in bed. They will have difficulty seeing the TV screen clearly because, when in the supine position, they will be looking through the Add rather than the distance portion of the lens.

In summary, it is very helpful to determine, **with the patient**, which of these options will most simply and effectively meet their visual needs.

Presbyopia Case 2

A 45-year-old patient for whom you have just recommended over-the-counter reading glasses asks, "**Will using reading glasses weaken my eyes?**"

Answer: No, it will not. There will be a normal decrease in accommodative ability over time, and this will occur at the same rate whether or not reading glasses are used. It is expected that, in the future, the patient will become more dependent on reading glasses. This is simply the result of presbyopia's normal progression.

Note

Because of this unfounded concern, an occasional patient will report that, despite difficulty reading, they have avoided using the recommended reading glasses to "keep my eyes strong."

Presbyopia Case 3

A 50-year-old patient who received reading glasses several years earlier complains that they **now need their reading glasses to see their food clearly when eating**. Why is this happening?

Answer: The patient can be reassured that what they are experiencing is normal. In a sense, reading glasses are misnamed. They should be called **"near glasses,"** for their purpose is to help with focusing up close, whatever the near task. The glasses are simply making up for the accommodative ability that has been lost, and that accommodative ability was used to bring everything at near into focus, including food.

Presbyopia Case 4

A 50-year-old presbyope is examined, and it is found that they need an increase in the strength of their over-the-counter reading glasses. The patient asks, "**Can I still use my old reading glasses which are less strong, or will that hurt my eyes?**"

Answer: The patient **can** continue to use the older reading glasses as long as they find that the glasses are providing satisfactory vision for reading and not causing eyestrain. They are not doing any harm by using them.

Presbyopia Case 5

A 55-year-old moderately high myope, successfully using progressive addition lenses for normal reading, finds they are having **difficulty threading a needle**. What might you recommend?

Answer: The simplest solution to enable them to thread a needle would be to **take off the glasses**. In doing so, they are using their natural nearsightedness to see up close and no accommodation or supplemental plus power is needed.

This strategy will also be beneficial when trying to read very small print, or when it's necessary to read while looking up. The reading material will need to be held closer than the normal reading distance.

This situation is somewhat analogous to overdrive in a car. Pressing the gas pedal all the way down for extra pick-up is something that is needed only occasionally. For day-in and day-out driving it is not necessary.

Presbyopia Case 6

A 45-year-old emmetrope presents with three complaints:

1. "I am having trouble reading the menu in a dimly lit restaurant."
2. "I have some difficulty reading early in the morning and late at night."
3. "I cannot see clearly when reading in bed at night."

What is the diagnosis and how should the patient be managed?

Answer: These are common symptoms of diminished accommodative ability at the **onset of presbyopia**. They occur because:

1. **In dim illumination**, the pupils will dilate, resulting in a loss of the **pinhole effect of miosis**. (With diminished accommodative ability, the pinhole effect aids the ability to read clearly.)

Note

The corollary: **In bright light,** reading is much easier for a presbyope because of the pinhole effect.

2. Accommodation — accomplished by contracture of the ciliary muscle relaxing the zonules and allowing the crystalline lens to become more convex — tends to function as we often do: There can be a little **sluggishness** in the morning and **fatigue** late at night!

3. When reading in bed at night, one tends to hold the reading material **closer** than when sitting up during the day. Closer requires more accommodation.

For an emmetrope at age 45, usually a +1.50 pair of over-the-counter reading glasses will work quite well.

Presbyopia Case 7

A 44-year-old emmetrope complains that it **takes a few seconds for their vision to become clear when looking across the room after reading**. What is the etiology, and should glasses be given for this?

Answer: This symptom is due to **early presbyopia**. Their remaining accommodation is working very hard to allow them to read and, because of this extra effort, it takes a few seconds for it to relax when they look up.

If this symptom is something the patient has simply noticed but it is not causing any inconvenience or difficulty, reading glasses can be **deferred**. However, if the patient has also noticed some difficulty with small print or would like to eliminate this problem, then over-the-counter reading glasses can be **recommended**.

Presbyopia Case 8

A 50-year-old emmetropic presbyope who uses over-the-counter reading glasses asks, **"Why was I able to read without my reading glasses when I was at the beach?"** Why were they able to do so?

Answer: The patient was experiencing the **pinhole effect** — without using the pinhole occluder! In bright sunlight, the pupil reaches a level of miosis that produces the pinhole effect**.** Through a pinhole, only the central rays from an object being viewed are able to enter the eye. These central rays, unlike more peripheral ones, do not require refraction.

Note

Squinting is another method of producing the pinhole effect.

Presbyopia Correction

Presbyopia Correction Case 1

A 60-year-old **flat-top bifocal wearer** is having **difficulty reading** with the recent prescription you have given them. The distance vision is fine. What should you do?

Answer: Additional information is needed, and will be likely to indicate where the problem lies. Three potential problems can be the cause:

1. The patient should be asked whether **pushing the reading material farther away** (a too weak bifocal) or **bringing it closer** (a too strong bifocal) has been helpful.

2. The line for the flat-top bifocal segment should typically be **positioned at the lower lid margin**. If it appears on your examination that the segment is too low, the patient should be asked whether they have noticed that pushing the glasses up or tilting the chin up has helped them read more easily.

   Note

   Because glasses, in some individuals, have a tendency to slide down the nose, the working position of the bifocal may be lower than intended.

3. It is also important to check that the bottom portion of the lenses are angled inwardly — the **pantoscopic tilt**. The lack of a proper pantoscopic tilt can make reading more difficult, and correcting it can significantly enhance the ability to read comfortably.

   Note

   It is always important to remember that a bifocal Add is literally added to the distance prescription. **If the distance prescription is incorrect, the reading portion of the bifocal will be incorrect.**

Presbyopia Correction Case 2

A 70-year-old presbyope whom you have **changed from a flat-top bifocal to PAL** is not doing well. How should this problem be approached?

Answer: The first consideration is whether the patient should have been changed from a standard bifocal to a PAL. In general, if a patient is doing perfectly well and has no complaints in a standard bifocal, it may be best to continue with that type. However, if there is a need to correct the intermediate distance, for example for computer work, it is very reasonable to make the change.

It is important to determine the nature of the patient's difficulty with the new prescription:

- Are they bothered by the inherent **blur at the sides** of a PAL?
- Do they need to assume an abnormal **head position** for distance viewing or when reading?
- Is there a proper **pantoscopic tilt**?
- How long have they had the new glasses? There is an **adjustment period** for a progressive bifocal, in some individuals up to two weeks.
- And, of course, the new lenses should be measured in the lensmeter to be certain the prescription was **filled correctly**.

If the problem cannot be identified, or if it is determined that the patient cannot tolerate a PAL, it is best to change back to a standard bifocal. The optician will typically remake the glasses with a flat-top bifocal — **without an additional charge** to the patient. However, they will have paid a premium price for the PAL, which they will no longer be using.

Presbyopia Correction Case 3

A 55-year-old flat-top bifocal wearer is having **difficulty at their desktop computer**. What are some possible solutions?

Answer: The monitor for a desktop computer is usually located beyond the normal reading distance. This area is referred to as the "**intermediate distance**" and is not able to be viewed clearly with either the top (for distance) or bottom (for near) of the standard bifocal.

Three possible solutions to view this area with clarity are as follows:

1. A **trifocal** can be prescribed. The middle segment will allow the intermediate distance to be viewed clearly. A slight chin-up position is necessary when using the middle segment.

2. The **most-often** used solution is to change to a progressive addition lens. The patient needs to be instructed to elevate their chin slightly so that they are viewing the monitor through the graduated portion of the lens.

   ### Note

   If a patient has a problem with their neck, so that the **chin-up position** poses difficulties for them, neither the trifocal nor the PAL will be the best choice.

3. If neither of the above two solutions is preferred by the patient, a separate pair of **"computer glasses"** should be prescribed. Computer glasses have **the intermediate correction at the top of the lens** and the reading correction at the bottom. The computer monitor will be seen clearly when looking straight ahead, without the necessity of elevating the chin.

Four notes about prescribing computer glasses:

1. It is often **best to not give a single-vision prescription** that corrects the intermediate distance only. Although this will function well for the computer screen, if the patient should print some material, they will not have a near correction that will allow them to easily read it

2. It is usually best to give computer glasses as a **PAL or standard bifocal**. A progressive bifocal has the advantage of having no gaps from the computer screen to the reading distance.

3. If the computer glasses prescription contains an Add, it will be an **odd-looking Add.** It will be, typically, half of the patient's normal Add. This is because half the patient's full Add has been incorporated into the top part of the prescription, leaving the other half as the Add for the computer glasses.

4. A helpful technique to help decide how strong to make the top portion of the computer glasses (for the intermediate distance) is to use a near card propped on the chin rest of the slit lamp. The slit lamp, with the near card on it, can be positioned to simulate the distance and height of the patient's computer monitor. With this simulation, a measurement of the optimal intermediate correction needed can be made.

Presbyopia Correction Case 4

A 45-year-old emmetrope, who is using +1.50 over-the-counter reading glasses very successfully for reading, finds that they are having **difficulty threading a needle**. What are the possible solutions?

Answer: 3 possible solutions:

1. Have the patient purchase a separate pair of stronger OTC reading glasses.
2. Have the patient thread the needle with the current reading glasses under a very strong light.
3. If the need to thread a needle is a very occasional occurrence, and the patient has several pairs of +1.50 readers at home, a creative solution is for them to use two pairs of reading glasses at the same time (and some patients make this discovery on their own!).

Presbyopia Correction Case 5

A 60-year-old priest, when he is preaching, is having **difficulty reading his sermons** while wearing his flat-top bifocal. What should you do?

Answer: The most likely cause of his difficulty is that the podium he is using is positioned at the **intermediate distance**, beyond the normal near reading distance.

Two possible solutions:

1. Change to a **PAL** (or a trifocal) so that the intermediate distance can be viewed clearly.
2. If preferred by the patient, a separate pair of "sermon glasses" can be given. This pair will have the full distance correction at the top so the congregation can be seen clearly. The Add will be half the strength of the Add in his regular glasses so he can see his sermon on the podium clearly.

Note

These same strategies can be beneficial for **a musician** whose music stand is positioned at the intermediate distance.

Presbyopia Correction Case 6

A 50-year-old musician who plays the **French horn** is having difficulty seeing the sheet music which is positioned on top of the instrument. They are currently wearing a flat-top bifocal. How might you help them?

Answer: When a bifocal Add is incorporated into a lens, it is placed at the bottom portion of the lens because that is the position through which reading material is usually viewed. However, for special needs, the location of the bifocal can be changed.

The French-horn player would benefit by having **the bifocal at the top of their lenses**. In past years, meter readers often required this location for a bifocal. These special glasses are termed "**occupational bifocals**." Interestingly, the French-horn player and the meter reader can also continue to have a bifocal at the bottom of the lenses as well.

An altered location can also be helpful for those individuals who play golf. A bifocal located in one corner of the lens will not interfere with seeing the golf ball when looking straight down, but will allow viewing of the scorecard when looking to the side.

Presbyopia Correction Case 7

Which is more likely to cause a problem for the patient, a bifocal that is **too weak or one that is too strong**?

Answer: An overly strong bifocal is more likely to be bothersome to a patient than a bifocal that is too weak. A closer and narrower reading range (a stronger bifocal) is typically tolerated less well than a farther and wider range (a weaker bifocal).

Note

OTC reading glasses that are being used successfully for both reading and desktop computing may not function as well for the computer if they are strengthened because the reading range will become closer and narrower.

Presbyopia Correction Case 8

A new bifocal wearer reports that their bifocals are working very well for most of their activities. However, they found that their vision was not clear in two situations: viewing the stage from their theater balcony seat, and watching TV while lying in bed at night. What is the most likely cause of these difficulties? What are possible solutions?

Answer: In both situations, the blurring is the result of gaze being directed through the bottom portion of the lens, the area designed for near vision.

Two techniques, neither an ideal solution, can be used to redirect gaze through the top portion of the lens. The patient can adopt a chin-down position or move the glasses further down on their nose. For prolonged viewing, both may be uncomfortable — and moving the glasses lower on the nose increases the vertex distance, itself a cause of blurring with stronger prescriptions.

If the patient will be engaging in these activities with some frequency, it would be best to prescribe an additional distance-only pair of glasses.

Refraction

Refraction Case 1

A 68-year-old patient gives **frustratingly inconsistent responses during subjective refraction**. What should you do?

Answer: See 16 Tips for Accurate Subjective Refraction Results, tip 10, page 41.

Refraction Case 2

A 55-year-old patient, for whom you performed a meticulous refraction two weeks ago, calls on the phone and says, "**The new glasses you gave me are not good. I can't see well with them**." What should you do?

- **Answer: First, obtain a good history.**
  - Is their difficulty at distance, at near, or both?
  - Have they checked to see whether the problem is in one eye or both?
  - What are the symptoms they are experiencing: eye strain, things slanting, nausea, etc?
  - How long have they had the new pair?
  - Where were the glasses made?
- It is usually necessary to have the patient **return to the office** to be re-evaluated.
- Ask the patient to **bring their old and the new glasses with them and measure both**.
- If the complaint is that the old glasses were better, have the patient compare the two pairs in the office. Occasionally you and the patient will find that the new glasses are indeed better, and only some reassurance was needed.
- **A repeat refraction** is usually necessary.
- If you identify the problem and determine that the glasses need to be re-made, there will traditionally be **no additional charge to the patient by the optician if it is within the first 30 days after purchase**.

Notes

Some opticians may extend the 30-day time-frame depending on the individual circumstances.

It is also customary for there to be no charge by you to the patient for this type of return visit.

- If you find that the optician has made an error, which is quite rare, it is important to handle this **kindly** and **respectfully**.
- If you are **unable to identify what the problem is** after re-refraction, it is often best to **default back to the old glasses prescription**. This is especially good to do if the complaint is, "My old glasses are better than the new ones." **(See Show What You Plan to Give, page 42.)**

Refraction Case 3

A 23-year-old patient returns one year after an excellent refraction by you with the complaint of recently noting slight difficulty with distance vision. What **type of refraction might you do** this year?

Answer: It may not be necessary to change the cylinder power and axis determined a year earlier. The refraction can begin with a spherical **over-refraction**. **(See Subjective Refraction**

over Current Lenses, page 46.) If this results in excellent vision, only a change in the sphere need be made.

As a general rule, leaving the astigmatic part of a prescription unchanged lessens the chance there will be difficulty adjusting to the new prescription

And the corollary is also true; changing the cylinder power or, especially, the axis increases the chance the patient will have difficulty adjusting to the new prescription.

Note

Another advantage of over-refraction is that the **vertex distance** — the distance between the lens and cornea — is unlikely to be a factor with the new prescription, for the new glasses will most likely sit in the same plane as the present glasses. The stronger the prescription, the more relevant vertex distance becomes.

Refraction Case 4

An 83-year-old patient presents with 20/100 vision in each eye secondary to age-related macular degeneration. **Should the normal subjective refraction technique be modified when testing this patient?**

Answer: Yes. Large steps should be used when giving choices to a patient with low vision. When measuring power, both sphere and cylindrical, comparisons with a difference of 0.50 or 1.00 diopter can be shown, and axis choices can be followed by shifts of 15 degrees or greater.

Refraction Case 5

Two 70-year-old patients present with the following best corrected visual acuity:

Patient 1: Distance vision of 20/30 with near vision of J1+ in each eye

Patient 2: Distance vision of 20/30 with near vision of J2 in each eye.

Which patient is more likely to have age-related macular degeneration, and which is more likely to have a cataract?

Answer: Patient 1 is more likely to have a **cataract**. With an early to moderate cataract, there is often a disparity between distance and near acuity, with near better than distance.

Patient 2 is more likely to have **age-related macular degeneration**. With age-related macular degeneration, distance and near acuity tend to be comparable.

Note

If a patient with decreased vision has both cataract and macular degeneration, this distinction can be helpful in determining which is more responsible for the decrease.

Refraction Case 6

A 78-year-old patient is bothered by scratches on their lenses, and your refraction reveals that their measurements are unchanged. **You write a prescription that is identical to the previous one, but the patient finds that they cannot tolerate the new glasses**. When they return, you put each pair of glasses in the lensmeter and find that the measurement is the same. What should you do?

Answer: The most likely explanation for this problem is that **the base curve** of the new lenses is different from that of the old pair. Often, the best way to resolve this is to have the patient take the old glasses to the optician along with your written request for the optician to "**duplicate the previous prescription, including duplication of the base curve**."

Note

In a similar fashion, if you would like to duplicate a patient's existing prism, but are not completely sure you have measured it correctly in their present glasses, you can ask the optician to "**duplicate the prism**."

Refraction Case 7

A 27-year-old who does not wear glasses is having difficulty reading. What are the considerations?

Answer: Reading difficulty in a 27-year-old is not due to presbyopia. Three primary considerations are:

1. If the patient has a significant amount of **latent hyperopia**, their accommodative ability is being used to correct their hyperopic refractive error, leaving an insufficient amount for reading.

2. **Convergence insufficiency:** The near point of convergence should be no farther away than 8 cm. Patients with convergence insufficiency typically complain of **headache** and eye strain (**asthenopia**) which occur very soon after they begin reading. Often **words will begin to swim together**, and they should be asked whether they have observed this, for this symptom is quite diagnostic. **Convergence exercises** are a very effective treatment for these patients, with great success in eliminating their symptoms.

3. **Medication:** Medicines used for colds, motion sickness, and some central nervous system diseases are among those that can make reading more difficult by their effect on the pupils and accommodation. History is important in identifying this etiology.

Refraction Case 8

A 39-year-old patient who has a -3.00 spherical myopic correction in each eye inquires about refractive surgery. When discussing the risks, benefits and alternatives to surgery, what factors related to near vision should not be overlooked?

Answer: Presbyopia should be explained to, and discussed with, the patient. They should understand that in several years they will need to use reading glasses if refractive surgery completely eliminates the nearsightedness in each eye. If they were to not have the surgery, they would retain the ability to read and see things at near while not wearing glasses. Some presbyopic individuals find that ability valuable when doing various near tasks such as shaving and applying makeup.

Refraction Case 9

A 55-year-old flat-top bifocal wearer inquires about refractive surgery. What should you discuss with them?

Answer: Remind the patient that there are "two prescriptions" in the bifocal glasses they are now wearing, a distance and a near component. Discuss with them that if their distance vision is fully corrected in each eye they will still need glasses for reading. An alternative would be to have a monovision laser correction, fully correcting one eye for distance while leaving the second eye with some nearsightedness for reading and near activities.

Refraction Case 10

An 80-year-old patient comes into the examination room carrying a brown paper bag, which they hand to you, saying, "Here are my glasses." Inside the bag, you find **seven pairs of glasses**. What do you do?

Answer: The goal is to **simplify** things for the patient (and this will also simplify things for you!). It is helpful to ask:

- Is there one pair that you prefer?
- When do you use the other glasses?
- How old are the various pairs?

If the patient has a different pair of glasses for a variety of activities, it may be appropriate to continue that way, but it is worthwhile to try to decrease the number. **The goal is to find the simplest system that that satisfies the patient's visual needs.**

If most of the glasses are older prescriptions and are not being used, the patient should be encouraged to donate them to **The Lions Club** or other resource for distribution to the needy.

Refraction Case 11

A 75-year-old patient who has needed over-the-counter reading glasses for many years is surprised to find that they can now read without them. **Why are reading glasses no longer needed, and what is this phenomenon called?**

Answer: The improvement in the patient's ability to read up close is, of course, not the result of regained accommodative ability. It is due to an increase in myopia, **a myopic shift**. Their newly acquired nearsightedness is allowing them to read unaided. The most common cause of a myopic shift is a **developing nuclear sclerotic cataract**, and another frequent etiology is an **elevated blood glucose** level in diabetes mellitus. When due to a cataract, this phenomenon has been called "**second sight**."

Note

As a patient's near vision improves secondary to a myopic shift, there is a corresponding greater difficulty with distance vision.

Refraction Case 12

When fitting a contact lenses patient for monovision, it is necessary to know which is a patient's **dominant eye. How can this be determined?**

Answer: There are a number of techniques for determining which is the dominant eye. One easy method is for the patient to fully extend their arms with one hand on top of the other, leaving a small opening above the thumbs.

The patient should then be asked, while keeping both eyes open and arm outstretched, to look at an object across the room through the small opening.

While the patient maintains this position, the examiner occludes one of the patient's eyes and then the other. One eye will be able to see the object, and the other will not. The eye that sees the object is the dominant eye.

Refraction Case 13

A 12-year-old patient is examined and found to be emmetropic. **At what age should they next be examined?**

Answer: It is during the teenage years that myopia is most likely to develop. Because the change occurs gradually, teenagers may not be aware that they are not seeing as well at distance. An examination every one or two years during this period is recommended.

Refraction Case 14

A 50-year-old patient wearing a spherocylindrical correction in each eye complains of **double vision**. When measuring their acuity, it becomes apparent that they have **monocular diplopia** in their left eye. Could refractive error be the etiology of their double vision?

Answer: Yes. Uncorrected refractive error usually results in a complaint of blurred vision, but occasionally can present as monocular diplopia. This symptom can occur when the sphere, cylinder, or axis is incorrect. It can also result from irregular astigmatism. When a patient presents with monocular diplopia, a refraction should be performed. If the new refractive result eliminates the double vision, the etiology has been determined.

Note

If **the pinhole test** eliminates the monocular diplopia, the most likely cause is refractive error or cataract.

Special Considerations When Prescribing Glasses

Special Considerations Case 1

A 55-year-old myope is examined and found to have a small change in their bifocal glasses prescription. They are planning to have it filled, but have **many questions**. How would you answer each?

1. Should my sunglasses also be updated?
2. If I get new sunglasses, I am going to get them without a bifocal. Can I use the same prescription?
3. What color should my sunglasses be?
4. Should I get the type of sunglasses that darken when I go outside?
5. Should I get an anti-glare coating on the new regular glasses?
6. Should my spare pair of glasses be updated?
7. I am going to be fit for contact lenses soon. Do I even need glasses?
8. Can I use the glasses prescription to get contact lenses?
9. Will you write me a prescription for contact lenses?

Answers:

1. Should my sunglasses also be updated?

With any change of glasses prescription, it is good to advise the patient to have only one pair of glasses made initially. Once the new pair of glasses is worn and found to be working well, then additional glasses can be made, if desired.

The best way to determine if the sunglasses should be updated is for the patient to wait until they receive their new glasses. If their vision with the existing sunglasses seems satisfactory **compared to the new prescription**, then it is not essential that the sunglasses be changed. If, on the other hand, they find that their vision is unsatisfactory by comparison, then the sunglasses should be updated.

2. If I get new sunglasses, I am going to get them without a bifocal. Can I use the same prescription?

   A cautionary yes: The same prescription can be used, but **it is usually a good idea to get the bifocal or PAL in the sunglasses**. Although many activities outdoors do not require reading, it is beneficial to have the Add in sunglasses for activities such as looking at a map when traveling, reading at the beach, and many other outdoor situations.

3. What color should my sunglasses be?

   Grey, as it is best in preserving natural colors.

4. Should I get the type of sunglasses that darken when I go outside?

   In the past, a concern with photosensitive glasses was that they got neither light enough indoors nor dark enough in the sun. Improvement in the lenses has greatly lessened these concerns. However, some patients still complain that the glasses do not get dark enough when driving. This is because the windshield absorbs a large percentage of the ultraviolet rays needed to cause the photochemical change.

5. Should I get an anti-glare coating on the new regular glasses?

   Many patients find that the two primary advantages of an anti-glare coating are:

   - When talking with another individual, their own eyes are able to be seen clearly by that person, without reflections from the lenses.

   - If a flash photograph is being taken, unless an anti-glare coating is present, their eyes are usually obscured by reflections.

6. Should my spare pair of glasses be updated?

   Initially only one pair of glasses should be made. The patient should then compare how they are seeing with the spare pair of glasses compared to the new glasses. If they feel they will still be able to **function satisfactorily** (despite the acuity not being as sharp as with the new prescription), then it is not necessary to update the spare pair unless they wish to do so.

Note

It may be helpful to the patient to suggest that they **keep their spare pair of glasses in their travel kit**. By doing so, they do not have to remember to pack them for traveling, and they will know where the glasses are should they be needed when at home.

7. I am going to be fit for contact lenses soon. Do I even need glasses?

   It is essential that all contact lens wearers have back-up glasses.

   Contact lenses are reasonably safe in eyes that are healthy. However, if a contact lens wearer develops conjunctivitis, a sty, or other infection, the contact lenses must be discontinued. If the patient has back-up glasses, then they can be substituted without significant inconvenience. If there are no back-up glasses, often the individual will, with potentially serious consequences, continue to wear their contact lenses because of the lack of an alternative.

Alert

Infection and contact lenses do not mix; it is the ophthalmologic equivalent to drinking and driving.

8. Can I use the glasses prescription to get contact lenses?

   No, a glasses prescription is only a starting point for a contact lens fitting and cannot be used in lieu of it.

9. Will you write me a prescription for contact lenses?

   A proper contact lens prescription can be written **only after a contact lens fitting**.

Special Considerations Case 2

A 27-year-old patient has **no light perception (NLP) in one eye due to an old injury and is emmetropic in their remaining eye**. What are your recommendations?

Answer: Because this patient is functioning monocularly it is important to maximally **protect their useful eye**. They should be encouraged to wear clear (plano) glasses with **polycarbonate** or **Trevex lenses**. When playing any contact or racquet sport, **sports goggles** must be worn. Also, it should be recommended that they have **a yearly eye examination**. **(See Special Situations, page 45.)**

Special Considerations Case 3

A 57-year-old patient is **NLP in one eye and refraction of their seeing eye results in a measurement of -3.25 + 0.50 × 180 with a +2.50 Add**. How should you write the prescription?

Answer: For cosmetic purposes, it is desirable that the lens in front of the nonseeing eye be **similar in appearance** to the lens prescribed for the seeing eye. This is accomplished by writing the word "**balance**" on the prescription pad in the block where the spherical designation would normally be written. The optician will then place a lens in the glasses for the blind eye that will match the prescribed lens in thickness and style, i.e., **a balance lens**.

Additionally, to protect their only useful eye, **polycarbonate** or **Trivex lenses** should be specified on the glasses prescription, and they must wear **sports goggles** when playing any contact or racquet sport. Also, **yearly eye examinations** are recommended. **(See Special Situations, page 45.)**

Special Considerations Case 4

A 19-year-old patient who has never worn glasses complains of slight difficulty seeing at distance. Refraction reveals a **myopic correction in the right eye of -1.50 and in the left eye of -7.50. What is this called? What should you prescribe?**

Answer: A significant difference in refractive error between the two eyes is called **anisometropia**.

If the refractive error in each eye were to be fully corrected, it would result in **aniseikonia**, a difference in image size. In this patient, the left eye would have a smaller image.

In general, a difference in refractive error between the two eyes of **greater than 3.00 diopters** is not able to be fused, although the exact amount varies depending on the individual. The **"trial run" (see Trial Run, page 43)** can be very helpful in determining whether a worrisomely asymmetric prescription will be tolerated.

There are three ways to handle this patient's very large asymmetry:

1. The left eye may be less than fully corrected, thus continuing to function as a "spare tire."
2. A contact lens, if used for the left eye, will eliminate the aniseikonia. It will do so because of the elimination of vertex distance as a factor.
3. Once the myopia is stable, refractive surgery could be considered.

Special Considerations Case 5

An 80-year-old patient with 20/40 vision in each eye secondary to **dry age-related macular degeneration** complains of **difficulty reading with their bifocal, which has a +2.50 Add**. What might you consider?

Answer: An Add of +2.50 (or +3.00) is typically the maximal strength prescribed for a patient with normal visual acuity. However, a stronger Add than the norm can function as a low vision aid.

This patient can be given a **+3.50 or a +4.00 Add** if they do not mind holding they reading material somewhat closer than they normally would. The increase in plus power results in a closer and narrower reading range.

If **an Add higher than +4.00** is decided upon, it is often best to give a separate pair of single vision reading glasses. Again, the reading material would need to be held quite close.

If these measures do not work satisfactorily for this patient, or if their vision deteriorates further, **a low vision consultation** should be considered.

Special Considerations Case 6

A 30-year-old patient is refracted and has 20/20 vision in each eye with a measurement of **plano in the right eye and -2.50 in the left eye. What will you prescribe?**

Answer: This decision will depend on the patient's preference.

Without wearing any correction, the patient will see clearly at distance when viewing binocularly because the right eye is emmetropic **(see Emmetropia, page 8)**. In general, one sees as well as their better eye. Thus, some individuals find that correcting the other eye does not add to their distance clarity, and they are happy to continue not using glasses. Others, however, find that correction of the refractive error in the second eye gives them a subjective improvement in acuity, and they prefer to have that eye corrected.

Note

The 2.50 diopter difference between the eyes should not result in aniseikonia and, therefore, glasses can be prescribed for this asymmetric prescription.

In summary, some patients find there is subjective improvement in their acuity if their second eye is fully corrected, and others feel they see just as well with it remaining uncorrected. The patient's preference should determine what is done.

Special Considerations Case 7

A 55-year-old new patient is refracted for distance and measures **plano in the right eye and -2.50 in the left eye. At present they are not wearing glasses. What will you prescribe?**

Answer: Unless the patient prefers to have each eye fully corrected at distance and near, they will continue to do exceedingly well without glasses. They have natural monovision, using the right eye for distance and the left eye at near.

If they would prefer to have the distance correction for the left eye, a bifocal or PAL would then be needed because they are in the presbyopic age range.

In summary, if the patient is functioning well without glasses, it is best to do nothing.

Special Considerations Case 8

A 41-year-old patient has only one pair of glasses. Your refraction determines that they need a change in each lens and you give them a prescription. The patient states that **they want to use the same frames they now have**, but they cannot function without glasses and therefore cannot leave them with the optician. What might you recommend?

Answer: If the new prescription can be filled at an optical shop that can do so while the patient waits, that would be a satisfactory solution.

If the patient prefers to have the glasses made at an optical shop that will take several days for the lenses to be ground, or if the prescription requires that several days are needed, the patient can continue to wear their present glasses once the optician has determined the size of the lenses to be ordered. After the lab delivers the lenses to the optical shop, the patient can then return and have the old lenses removed and the new lenses inserted.

Thus, there should not be a time when the patient would have to go without their glasses.

Special Considerations Case 9

A 75-year-old patient can no longer satisfactorily perform their activities of daily living secondary to **bilateral cataracts**. Best corrected visual acuities are right eye 20/40 and left eye 20/50. Their cataracts have not caused a myopic shift, and their long-standing refractive correction is right eye -3.00 and left eye -3.00 +0.75 × 180, with a +2.50 Add bilaterally.

They would like to have **cataract surgery** for the left eye initially, with subsequent surgery for the right eye. **What considerations are important to discuss** with regard to postoperative refractive status?

Answer: The discussion prior to the initial surgery should include the following considerations:

- If the patient chooses to have a **monofocal intraocular lens implant** for their left eye, their preference for the implant to correct **for distance or for near** must be determined. If for distance, reading glasses will be needed; if for near, distance glasses will be needed. If they choose the former, it must be emphasized that they will no longer be able to read, as they now can, without reading glasses.

  Notes

  - For the left eye, a **toric lens** (if the astigmatism is corneal rather than lenticular) can also be considered.
  - Another alternative for this patient is a **monovision** option (one eye set for distance, the other set for near), but a contact lens trial would be necessary prior to deciding about this.

- If the patient chooses to have a **multifocal or accommodating intraocular lens implant** for their left eye, they will not have to decide between near or distance vision. However, the possibility of glare and a decrease in contrast sensitivity are factors to be considered with the current generation of multifocal lenses. With the accommodating lenses, the amount of accommodation achievable is also a consideration.

- If the patient chooses an implant that will eliminate the myopia in their left eye, **anisometropia (see Special Considerations Case 4, page 76)** will be a consideration for the interval between the first and second surgeries. If they are unable to tolerate their asymmetric refractive error during this period, a contact lens can be used in the right eye to eliminate the disparity in image size.

In summary, a variety of considerations may be present in the pre-op period based on an individual's refractive error and personal preferences.

Special Considerations Case 10

Two 60-year-old patients are refracted and found to have, in one eye, **a recent change in spherical power, cylinder power and axis measurements.** Other findings in the same eye are a **chalazion** of the upper lid, and in the second patient, a **ptosis**. Could either of these, a chalazion or ptosis, be responsible for the change in refractive error?

Answer: Yes, each can be responsible for the measured change.

A chalazion, because of its bulk, can push on and distort the cornea, thereby altering its curvature. If irregular astigmatism is produced, best corrected visual acuity may be decreased until the chalazion is excised.

Ptosis, likewise, may indent the superior portion of the cornea, resulting in a change in refractive error. In each patient, the cornea would be expected to eventually return to its original curvature after the problem is corrected.

Appendix

How to Use the Manual Lensmeter (Lensometer®): Plus Cylinder Method

Prior to Measuring

1. Place the glasses, with the arms pointing away, flat on the adjustable shelf. (The axis measurement will be incorrect if the glasses are not level.)

2. Make sure the prism knob is positioned at zero.

3. Look through the ocular and turn it so the numbers/circles are in focus.

4. The intersection of the lines, the optical center of the lens, should be positioned within the central circle.

Note

For a PAL, which should be measured at the top of the lens, the prism knob can be used to accomplish the centering.

Steps for Measuring the Prescription

1. Begin to focus the single line, but while doing so check to make sure the three lines are going to be in focus in the plus direction — with the knob turning counterclockwise. If the three lines are coming into focus moving in the clockwise direction, change the axis of the single line by 90 degrees.

2. Focus and align the single line — this measures the **spherical power** and the **cylinder axis** respectively.

3. Focus the three lines by turning the knob counterclockwise. When the three lines are in focus, determine the dioptric difference between the measurement of the single line and the three lines — this is the amount of **plus cylinder power.**

   When an Add is present, there is a fourth step:

4. Elevate the shelf and focus the single line in the Add segment. The dioptric difference between the measurement of the single line in the distance portion of the lens and in the Add segment is the amount of the **Add.**

Notes

- In a progressive addition lens, there is almost always a laser marking located at the outer third of the lens, often below the manufacturer's insignia. This can be read with the help of background illumination provided by an overhead room light.
- When measuring a high plus or high minus lens, the other side of the lens must be used when measuring the Add. The glasses are repositioned in the lensmeter with the arms pointing toward you, and the single line is measured both above and below, with the difference being the strength of the Add.
- When learning to read prism, practice with known prisms in the trial lens set.

Retinoscopy Primer: Plus Cylinder Method

Preparation

- Dim the room lights.
- Dot as distance fixation target.
- Working distance = arm's length from patient (66 cm).
- Your right eye aligned with patient's right eye, and vice versa for left.

The Retinoscope

- Right hand for right eye, and vice versa for left.
- Use the widest streak (beam), thumb slide up or down depending on model.
- Two maneuvers:
  - Turning sleeve to view reflexes at perpendicular axes
  - Sweeping side to side (streak vertical) and up and down (streak horizontal) to observe movement of reflex
    Note: If oblique cylinder, can sweep in diagonal positions (ninety degrees apart).
- Movement of reflex (streak) seen within pupil when sweeping can be
  - "With": Reflex moves in same direction as sweep.
  - "Against": Reflex moves in opposite direction of sweep.
  - No movement (the reflex fills the pupil) = neutralization

Procedure

- The goal of retinoscopy: neutralization of the two reflexes which are ninety degrees apart.
- The sequence is identical to that of subjective refraction: **sphere, cylinder axis, cylinder power**, and then **final sphere**!

After obtaining red reflex:

1. Move sphere dial in minus direction until you see "with" movement at 90 and 180 degrees.
2. Sweep, alternating at 90 and 180 degrees, while adding plus sphere power until the first axis is neutralized. (The other axis will still have "with" movement.)
   = **sphere**
3. Turn the axis dial on the phoropter to the remaining ("other") axis.
   = **cylinder axis**
4. Add plus cylinder power until the remaining axis is neutralized.
   = **cylinder power**
5. Subtract 1.50 diopters (for the working distance) from the sphere found in step 2.
   = **final sphere**

Notes

- Retinoscopy after cycloplegia is a good way to begin learning.
- When neutralizing "with" reflexes, move in larger diopter steps initially, then smaller ones.
- Oblique cylinder will tilt the reflex away from 90 and 180 degrees. Narrowing the streak briefly can help localize an oblique axis. Work with axes 90 degrees apart.
- Record your retinoscopy findings for comparison with the final subjective refraction.
- Practice.