Objective Refraction: 
Retinoscopy

The *retinoscope* objectively determine:
- the spherocylindrical refractive error
- astigmatism is regular or irregular
- opacities and irregularities.

- The majority of retinoscopes in use today employ the streak projection system
- The illumination of the retinoscope is provided by a special bulb that has a straight filament that forms a streak in its projection.
Objective Refraction: Retinoscopy

- The filament can be moved in relation to a convex lens in the system.
- **Plano mirror setting**: the distance between the convex lens and the filament decreased by moving the sleeve on the handle, thus allowing divergent light to be emitted. The image of the filament should be behind the examiner.
- **Concave mirror setting**: the distance between the convex lens and the filament increased by moving the sleeve on the handle, thus allowing converging light to be emitted, the image of the filament would be between the examiner and the patient.
Figure 4-1  Observation system: light path from patient’s pupil, through mirror, to observer’s retina. (Modified from Corboy JM. The Retinoscopy Book: A Manual for Beginners. Thorofare, NJ: Slack; 1979:13.)
Figure 4-2  Illumination system: position of source with plano mirror effect.
**Retinoscopy**

**Positioning and Alignment**

- Ordinarily, the examiner uses the right eye to perform retinoscopy on the patient's right eye, and the left eye for the patient's left eye.
- If the examiner looks directly through the optical centers of the trial lenses.
- If the examiner is too far off-axis, unwanted spherical and cylindrical errors can occur.
- The optimum alignment is just off-center, where the lens reflections can still be seen between the center of the pupil and the lateral edge of the lens.
Retinoscopy

Fixation and Fogging
• Retinoscopy should be performed with the patient's accommodation relaxed.
• The patient should fixate at a distance on a nonaccommodative target.

The Retinal Reflex
• The projected streak, forming a blurred image of the filament on the patient's retina, can be considered as a new light source returning to the examiner's eye.
• If the patient is emmetropic, the light rays will emerge parallel.
• If the patient is myopic, they will be convergent.
• If the patient is hyperopic, the rays will be divergent.
Retinoscopy

Figure 4-2  Illumination system: position of source with plano mirror effect.
Figure 4-2  Illumination system: position of source with plano mirror effect.

Figure 4-3  Illumination system: position of source with concave mirror effect.
Retinoscopy

- If the examiner is at the patient's far point, all the light enters the examiner's pupil and illumination is uniform.

- **Against motion**: If the far point is between the examiner and the patient, the rays will have met and will be diverging again.

- **With motion**: If the far point is not between the examiner and the patient (hyperopia), the light will move in the same direction as the sweep.

- When the light fills the pupil and does not move—either because the eye is **emmetropic** or because the appropriate correcting lens has been placed before it—the condition is known as **neutrality**.

- Examiner moved forward, *with* motion would be seen.

  - Examiner moved backward, the light the far point and begun to diverge again, *against* motion would be seen.
Retinoscopy

Figure 4-4  Observation system for myopia.
Retinoscopy

Figure 4-5  Neutrality reflex. Far point of the eye is conjugate with the peephole of the retinoscope. 
Retinal reflex movement

**Figure 4-6**  Retinal reflex movement. Note movement of the streak from face and from retina in *with* versus *against* motion. (*Modified from Corboy JM. The Retinoscopy Book. A Manual for Beginners. Thorofare, NJ: Slack; 1979:32.*)
Retinoscopy

**Characteristics of the reflex**

The moving retinoscopic reflex has 3 main characteristics

- **1. Speed.** The reflex moves slowest when the examiner is far from the focal point and becomes more rapid as the focal point is approached.

- **2. Brilliance.** The reflex is dull when the examiner is far from the focal point, becoming brighter as neutrality is approached. *Against* reflexes are usually dimmer than *with* reflexes.

- **3. Width.** The streak is narrow when the examiner is far from the focal point. It broadens approaching the focal point and, fills the entire pupil at the focal point itself.
Retinoscopy

The Correcting lens

- When the examiner uses the appropriate correcting lenses, retinoscopic reflexes can be neutralized.

- When the examiner brings the patient's far point to the peephole, the patient's entire pupil is illuminated and the reflex will not move.

- The power of the correcting lenses that neutralizes the reflex provides a measure of the patient's refractive error.

- The examiner is determining the refractive error for the distance at which he or she is working.

- The dioptric equivalent of the working distance should be subtracted from the correcting lens to obtain the patient's actual distance correction.
Retinoscopy

Figure 4-7  Characteristics of the moving retinal reflex on both sides of neutrality. The vertical arrows indicate the position of the retinoscope with regard to the point of neutrality. *(Modified from Corboy JM. The Retinoscopy Book: A Manual for Beginners. Thorofare, NJ: Slack; 1979:38.)*
Retinoscopy

**Figure 4-8** Observation system at neutralization.
Retinoscopy

Finding Neutrality

- In *against movement*, the far point is between the examiner and the patient., to bring the far point to the examiner's pupil, minus lenses should be placed
- In *with movement*, plus lenses should be placed
- If you see *with* motion, add plus power (or subtract minus)
- If you see *against* motion, add minus power (or subtract plus).
- It is considered easier to work with the brighter, sharper *with image*, it is preferable to over minus the eye and obtain a *with* reflex and then reduce the minus (add plus) until neutrality is reached.
Figure 4-9  Approaching neutrality. Change in width of the reflex as neutrality is approached. Note that working distance remains constant, and the far point (FP) is pulled in with plus lenses.  (Modified from Corboy JM. The Retinoscopy Book: A Manual for Beginners. Thorofare, NJ: Slack; 1979:41.)
Retinoscopy

- slow, dull reflexes of high refractive errors may be confused with the pupil-filling neutrality reflex or with dull reflexes (as seen in patients with hazy media).
- Place a high-power plus and minus lens over the eye and look again
Retinoscopy of Regular Astigmatism

- Light is refracted differently by the 2 principal astigmatic meridians.
- If we move the retinoscope from side to side (with the streak oriented at 90°), we are measuring the optical power in the 180° meridian.
- Power in this meridian is provided by a cylinder at axis 90°.
- The extremely convenient result is that the streak of the retinoscope is aligned at the same axis as the axis of the correcting cylinder being tested.
Retinoscopy of Regular Astigmatism

Finding the cylinder axis

• Before measure the powers in each of the principal meridians, the axes of the meridians must be determined.

• Four characteristics of the streak reflex:

  1. **Break.** A break is seen when the streak is not parallel to one of the meridians.

  2. **Width.** The width of the streak varies as it is rotated around the correct axis.

  3. **Intensity.** The intensity of the line is brighter when the streak is on the correct axis.

  4. **Skew.** Skew (oblique motion of the streak reflex) may be used to refine the axis in small cylinders.
**Figure 4-10**  Break. The retinal reflex is discontinuous with the intercept when the streak is off the correct axis. *(Modified from Corboy JM. The Retinoscopy Book: A Manual for Beginners. Thorofare, NJ: Slack; 1979:90.)*
Figure 4-11  Width, or thickness, of the retinal reflex. We locate the axis where the reflex is thinnest. *(Modified from Corboy JM. The Retinoscopy Book: A Manual for Beginners. Thorofare, NJ: Slack; 1979:90.)*
Figure 4-12  Skew (oblique motion). The arrows indicate that movements of the reflex and intercept are not parallel. The reflex and intercept do not move in the same direction but are skewed when the streak is off-axis. (Modified from Corboy JM. The Retinoscopy Book: A Manual for Beginners. Thorofare, NJ: Slack; 1979:91.)
Retinoscopy of Regular Astigmatism

Finding the cylinder axis

• if the streak is off-axis, it will move in a slightly different direction from the pupillary reflex

• The reflex and streak move in the same direction (both at right angles to the orientation of the streak) when the streak is aligned with one of the principal meridians
Retinoscopy of Regular Astigmatism

Finding the cylinder axis

Figure 4-13  Locating axis on the protractor. **A**, First determine the astigmatic axis. **B**, Then lower the sleeve to enhance the intercept until the filament is seen as a fine line pinpointing the axis. (*Modified from* Corboy JM. *The Retinoscopy Book: A Manual for Beginners.* Thorofare, NJ: Slack; 1979:92.*)
Retinoscopy of Regular Astigmatism

**Straddling**

- This axis can be confirmed through a technique known as *straddling*, which is performed with the estimated correcting cylinder.
- The retinoscope streak is turned 45° off-axis in both directions, and if the axis is correct, the width of the reflex should be equal in both off-axis positions.
- If the axis is incorrect, the widths will be unequal in the 2 positions.
- The axis of the correcting cylinder should be moved toward the narrower reflex and the straddling performed again until the width is equal
Retinoscopy of Regular Astigmatism

**straddling**

![Diagram of straddling](image)

**Figure 4-14** Straddling. The straddling meridians are 45° off the correcting cylinder axis, at roughly 35° and 125°. As you move back from the eye while comparing meridians, the reflex at 125° remains narrow (A) at the same distance that the reflex at 35° has become wide (B). This dissimilarity indicates an axis error; the narrow reflex (A) is the guide toward which we must turn the correcting cylinder axis. *(Modified from Corboy JM. The Retinoscopy Book: A Manual for Beginners. Thorofare, NJ: Slack; 1979:95.)*
Retinoscopy of Regular Astigmatism

**Finding the cylinder power**

- Once the 2 principal meridians are identified, we can follow the previously explained spherical techniques,
  
  **With 2 spheres**: Neutralize one axis with one spherical lens. If the 90° axis is neutralized with a + 1.50 sphere and the 180° axis is neutralized with a +2.25 sphere, the gross retinoscopy would be + 1.50 +0.75 x 180.

- **With a sphere and cylinder**: Neutralize 1 axis with a spherical lens. To, neutralize the *less plus* axis first. Then, with this spherical lens in place, neutralize the axis 90° away by adding a plus cylindrical lens.

- **With 2 cylinders at right angles to each other**: this variant does not seem to provide any advantages over the other methods.
Aberrations of the Retinoscopic Reflex

- Spherical aberrations tend to increase the brightness at the center or periphery of the pupil.
- As neutrality is approached, one part of the reflex may be myopic, whereas the other is hyperopic, producing the so-called *scissors reflex.*
- Marked irregular astigmatism or optical opacity produces confusing, distorted shadows, subjective refraction used.
- All of these aberrant reflexes become more noticeable with larger pupillary diameters.

- In these cases, considering the central portion of the light reflex yields the best approximation.
Summary of Retinoscopy

- Hold the sleeve of the retinoscope in the position that produces a **divergent beam** of light.
- Sweep the streak of light (the intercept) across the pupil perpendicular to the long axis of the intercept.
- Sweep in several different meridians.
- Add minus sphere until the retinoscopic reflex shows *with* motion in all meridians.
- If the reflexes are dim or indistinct, consider high refractive errors and make large changes in sphere (-3 D, -6 D, -9 D, and so on).
- Add plus sphere until the retinoscopic reflex neutralizes or shows a small amount of residual *with* motion.
Summary of Retinoscopy

- If all meridians neutralize simultaneously, the patient's refractive error is spherical.
- Rotate the streak 90° and set the axis of the correcting plus cylinder parallel to the streak.
- Sweep this meridian to reveal additional with motion.
- Add plus cylinder power until the remaining with motion is neutralized.
- Refine the correcting cylinder axis by sweeping 45° to either side of it.
- Move in slightly closer to the patient to pick up with motion.
Summary of Retinoscopy

Refine

• Rotate the axis of the correcting plus cylinder a couple of degrees toward the "guide" line, the brighter and narrower reflex.

• Repeat until both reflexes are equal Refine the cylinder power by moving in closer to the patient to pick up with motion in all directions.

• Back away slowly, observing how the reflexes neutralize.

• Change sphere or cylinder power as appropriate to make all meridians neutralize simultaneously.

• Subtract the working distance.
Subjective Refraction Techniques

- Astigmatic Dial Technique with minus cylinder
- Astigmatic Dial Technique with plus cylinder
- Cross-Cylinder Technique
Subjective Refraction Techniques

- Subjective refraction techniques rely on the patient's responses to obtain the refractive correction that gives the best visual acuity.
- If all refractive errors were simply spherical, subjective refraction would be easy.
- Determining the astigmatic portion of the correction is more complex.
- The Jackson cross cylinder is the most common instrument for determining the astigmatic correction.
Subjective Refraction Techniques

Astigmatic Dial Technique

• The pencil of light from every point on the astigmatic dial is imaged by an astigmatic eye as a conoid of Sturm.

• Those spokes of the dial that are parallel to the principal meridians of the eye's astigmatism will be imaged as sharp lines corresponding to the focal lines of the conoid of Sturm.
Astigmatic Dial Technique

Figure 4-15  Astigmatic dial technique. A, Conoid of Sturm and retinal image of an astigmatic dial as viewed by an eye with compound hyperopic astigmatism. B, Fogging to produce compound myopic astigmatism. C, The conoid of Sturm is collapsed to a single point. D, Minus sphere is added (or plus sphere subtracted) to produce a sharp image.
Astigmatic Dial Technique

with minus cylinder

• 1. Obtain best visual acuity using spheres only.
• 2. Fog the eye to about 20/50 by adding plus sphere.
• 3. Note the blackest and sharpest line of the astigmatic dial.
• 4. Add minus cylinder with axis perpendicular to the blackest and sharpest line until all lines appear equal.
• 5. Reduce plus sphere (or add minus) until best acuity is obtained with the visual acuity chart.
Astigmatic Dial Technique with plus cylinder

1. Obtain best visual acuity using spheres only.
2. Fog the eye to about 20/50 by adding plus sphere.
3. Note the blackest and sharpest line of the astigmatic dial
   - Add plus cylinder with axis parallel to the blackest and sharpest line. As each 0.25 D of plus cylinder power is added, change the sphere simultaneously 0.25 D in the minus direction.
Subjective Refraction Techniques

Cross-Cylinder Technique

- adjusting the sphere to yield best visual acuity
- Fog the eye to be examined with plus sphere.
- First refinement of cylinder axis and then refinement of cylinder power.
- If no cylindrical correction is present initially, the cross cylinder may still be used placed arbitrarily at 90° and 180°, to check for the presence of astigmatism.
- If a preferred flip position is found, cylinder is added with axis parallel to the respective plus or minus axis of the cross cylinder until the 2 flip choices are equal.
- If no preference is found with the cross-cylinder axes at 90° and 180°, then 45° and 135° should always be checked before assuming that no astigmatism is present.
Subjective Refraction Techniques

Cross-Cylinder Technique

- Cylinder axis is always refined first.
- Refinement of cylinder axis involves the combination of cylinders at oblique axes.
- To refine the axis, therefore, place the cross cylinder with its principal meridians $45^\circ$ away from the principal meridians of the correcting cylinder.
- Present the patient with alternative flip choices, inquiring which is "blackest and sharpest;' and rotate the axis of the correcting cylinder toward the corresponding plus or minus axis of the cross cylinder.
Subjective Refraction Techniques

Cross-Cylinder Technique

• To refine cylinder power, align the cross-cylinder axes with the principal meridians of the correcting lens, as illustrated.
• As the examiner changes cylinder power according to the patient's responses, the spherical equivalent of the refractive correction should remain constant to keep the circle of least confusion on the retina.
• One achieves this by changing the sphere half as much in the opposite direction as the cylinder power is changed.
• For every 0.50 D of cylinder power change, the sphere is changed 0.25 D in the opposite direction.
Subjective Refraction Techniques

Cross-Cylinder Technique

- Continue to refine cylinder power until both flip choices appear "about the same" to the patient.
- This is the correct endpoint, for the 2 flip choices now produce equal and opposite mixed astigmatism, blurring the visual acuity chart equally.
- Remember always to use the proper-power cross cylinder for the patient's visual acuity level.
- 0.25 D cross cylinder is commonly used with visual acuity levels of 20/30 and better.
- A high-power cross cylinder (:to.50 D or :t 1.00 D) should be used with poorer vision.
Figure 4-16  Cross-cylinder refinement of cylinder power. The cross cylinder is flipped between positions 1 and 2 as the patient is asked, “Which is better, one or two?” In position 1, the astigmatism is increased; in position 2, it is decreased. Position 2 is chosen because it yields a clearer image. In position 2, the plus axis of the cross cylinder is parallel to the plus cylinder axis, indicating that the plus cylinder should be increased in power.
Subjective Refraction Techniques

Cross-Cylinder Technique

Figure 4-17 Correct endpoint for cross-cylinder refinement of cylinder power. Equal and opposite mixed astigmatism is provided by the 2 flip choices.
Subjective Refraction Techniques

Refining the Sphere

- the final step in monocular refraction is to refine the sphere.
- The endpoint in the refraction is the strongest plus, or weakest minus.
- Once the cross-cylinder technique has been used to determine the cylinder power and axis, the conoid of Sturm is presumed to be collapsed to a point on the retina.
- Add plus sphere, +0.25 at a time, until the patient reports a decrease in vision.
- If no plus sphere is accepted, add minus sphere, -0.25 D at a time, until the patient reaches maximum acuity.
Subjective Refraction Techniques

**duochrome (red-green or bichrome) test**

- The eye is not corrected for chromatic aberration, the shorter wavelengths (green) will be focused in front of the longer red wavelengths of the spectrum.
- The eye generally focuses at some midpoint in the color spectrum, the letters on the red and green halves of the chart will appear equally clear when read through the correct sphere.
- With the commercial filters used in the duochrome test, the chromatic interval is about 0.50 D between the red and the green.
- When the image is clearly focused in white light, the eye will be 0.25 D myopic for the green symbols and 0.25 D hyperopic for the red symbols.
Subjective Refraction Techniques

- **duochrome (red-green or bichrome) test**
- With the duochrome test, each eye is tested separately.
- The duochrome test should always be started with the eye slightly fogged (by 0.5 D to relax accommodation).
- In this situation, the letters on the red side should appear clearer, and **minus sphere** should be added until the 2 halves are equal.
- If the patient responds that the symbols on the green side are **sharper**, the patient is **over minused** and more plus power must be added to bring the chromatic interval forward.
- The duochrome test is not useful for patients with visual acuities worse than 6/9 (20/30), for the 0.50 D difference between the 2 sides is too subtle for them to distinguish.
Subjective Refraction Techniques

**Binocular Balance**

- As the final step in subjective refraction, it is important to be sure that accommodation has been relaxed equally in the 2 eyes.
- Several methods of binocular balance are commonly used.
- Most require correctable visual acuity to be essentially equal in the 2 eyes.
Subjective Refraction Techniques

Binocular Balance

Fogging

- When the endpoint refraction is fogged using a +2.00 sphere, the visual acuity should be reduced to (20/200-20/100).
- Place a -0.25 D sphere first before one eye and then the other, and rapidly alternate cover; the patient should then be able to identify the eye with the -0.25 D sphere before it as having the clearer image at the 6/30 (20/100) or 6/20 (20/70) level.
- If the eyes are not in balance, sphere should be added or subtracted in 0.25 steps until balance is achieved.
- If either eye is over minused or under plussed, the patient will read farther down the chart, as far as 6/20 (20/70), 6/15 (20/50), or even 6/12 (20/40) with the +2.00 fogging spheres in place.
Subjective Refraction Techniques

Binocular Balance

Prism dissociation

• The most sensitive test of binocular balance is performed by fogging the refractive endpoints with +1.00 spheres, placing vertical prisms of 4 or 5 prism.
• A single line, usually 6/12 (20/40), is projected.
• Differences between the fogged image in the 2 eyes of 0.25 D sphere or even less can be identified readily.
• +0.25 D sphere is placed before 1 eye and then before the other.
• If the eyes are balanced, the patient will report that the image corresponding to the eye with the additional +0.25 0 sphere is more blurred.
• After a balance is established, remove the prism and reduce the fog binocularly until maximum visual acuity is obtained with the highest plus or lowest minus.
Subjective Refraction Techniques

Binocular Balance

Cycloplegic and Noncycloplegic (Manifest) Refraction.

• The amount of habitual accommodative tone varies from person to person, and even within individuals it varies at different times and ages.

• The indication and appropriate dosage for a specific cycloplegic agent depend on the patient's age, accommodative amplitude, and refractive error.

• A practical approach to satisfactory refraction is to perform a careful manifest refraction, relaxing accommodation by fogging.

• If results are inconsistent or variable, a cycloplegic refraction should be performed.

• If the 2 refractions are similar, the prescription can be based on the initial refraction findings.
Subjective Refraction Techniques

Binocular Balance

Cycloplegic and Noncycloplegic (Manifest) Refraction

• Cycloplegic agents can be classified on the basis of their intensity and duration of action.
• Cycloplegia lasts somewhat longer than mydriasis.
• Side effects may occur because of an idiosyncratic reaction but more commonly because of rapid systemic absorption through the nasolacrimal mucosa.
• Atropine can produce dryness, flushing, high fever, and delirium.
### Cycloplegic agents

#### Table 4-1 Commonly Used Cycloplegic Agents

<table>
<thead>
<tr>
<th>Drug</th>
<th>Concentration (%)</th>
<th>Dosage</th>
<th>Onset of Maximum Cycloplegia</th>
<th>Total Duration of Cycloplegia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atropine sulfate¹</td>
<td>0.5, 1.0, 2.0</td>
<td>2–3 times/day for 3 days</td>
<td>6–24 hr</td>
<td>10–15 days</td>
</tr>
<tr>
<td>Scopolamine HBr²</td>
<td>0.25</td>
<td>2 drops separated by 5 min</td>
<td>30–60 min</td>
<td>3–4 days</td>
</tr>
<tr>
<td>Homatropine HBr³</td>
<td>2.0, 5.0</td>
<td></td>
<td>1 hr</td>
<td>1–2 days</td>
</tr>
<tr>
<td>Cyclopentolate³</td>
<td>0.5, 1.0, 2.0</td>
<td></td>
<td>20–45 min</td>
<td>12–24 hr</td>
</tr>
<tr>
<td>Tropicamide</td>
<td>0.5, 1.0, 2.0</td>
<td></td>
<td>20–30 min</td>
<td>4–10 hr</td>
</tr>
</tbody>
</table>

¹ Usually reserved for young children. May be prescribed in ointment or drop form. Side effects, such as flushing and fever, may be avoided by applying pressure over the puncta and canaliculi for 1–2 minutes after instilling atropine drops. The same precautions should be used for all cycloplegic-mydriatic drops.

² Rarely used for refraction but clinically useful in case of atropine allergy.

³ The concentration needed will vary with the clinical problem. Higher concentrations of the agents are associated with an increased incidence of undesired side effects.
Overrefraction

- For a +12.00 D sphere spectacle lens, each millimeter change of vertex distance creates about 0.12 D sphere error.
- 10 degrees of pantoscopic tilt introduces about +0.37 D of cylinder error at an axis of 180 and increases the sphere by 0.12 D.
- There is no guarantee that the optician will heed the vertex distance notation on the prescription.
Overrefraction

- If the patient is wearing spherical lenses, the new prescription calculated by combining the old spherical correction with the spherocylindrical overrefraction.
- If the old lenses are spherocylindrical and the cylinder axis of the new refraction is not at 0° or 90° to the old correction, other methods are used to determine the resultant refraction.
- Such lens combinations were often determined with a lensmeter used to read the resultant lens power through the combinations of the old glasses and the overrefraction correction.
- This procedure is prone to error, however, because the lenses may rotate with respect to each other or transfer to the lensmeter.
Overrefraction

- Over refraction has other uses:
  - A patient wearing a soft toric contact lens may undergo overrefraction for the purpose of ordering new lenses.
  - Retinoscopic examination of children.
  - The examiner can quickly judge whether enough refractive change has occurred to warrant a more careful refraction and prescription of new lenses.
Spectacle Correction of Ametropias

Spherical Correcting Lenses and the Far Point Concept

• The far point plane of the non accommodated eye is conjugate with the retina.
• For any simple lens, distant objects (those at optical infinity) come into sharp focus at the secondary focal point of the lens.
• A correcting lens must place the image it forms at the eye's far point.
• The correct diverging lens forms a virtual image of distant objects at its secondary focal point, coincident with the far point of the eye.
• The far point plane of a hyperopic eye is behind the retina, a converging lens must be chosen in the appropriate
Near point of farsighted eye

Object

Tensed lens

Sharp image behind retina

(a)

Near point of farsighted eye

Object

Converging lens

Sharp image on retina

(b)

Virtual image formed by converging lens

Near point of farsighted eye

Object

Converging lens

(c)
Distant object

Far point of nearsighted eye

Relaxed lens

(a)

Distant object

Far point of nearsighted eye

Diverging lens

Image formed in front of retina

(b)

Distant object

Virtual image formed by diverging lens

Far point of nearsighted eye

(c)
Spectacle Correction of Ametropias

Vertex Distance

- The distance from the back surface of the lens to the cornea is called the lens vertex distance.
- With refractive errors greater than is D, the vertex distance must be accounted for in prescribing the power of the spectacle lens.
- The opposite is true for minus lenses.
- Moving a plus correcting lens closer to the eye reduces its effective plus power, whereas moving it farther from the eye increases its effective power.

.
Spectacle Correction of Ametropias

Vertex Distance

- for any spherical correcting lens, the distance from the lens to its focal point is constant.
- Changing the position of the correcting lens relative to the cornea will also change the relationship between the secondary focal point of the correcting lens and the far point plane of the eye.
- With high-power lenses, as used in the spectacle correction of aphakia or high myopia, a small change in the placement of the lens produces considerable blurring of vision.
Spectacle Correction of Ametropias

- The +10 D lens placed 10 mm from the cornea provides sharp retinal image.

- By definition, the secondary focal plane of the correcting lens is identical to the far point plane of the eye and because this lens is placed 1 cm in front of the eye, the far point plane of the eye must be 9 cm behind the cornea.

- If the correcting lens is moved to a new position 20 mm in front of the eye and the far point plane of the eye is 9 cm, the secondary focal plane of the new lens must be 11 cm, requiring a +9.1 D lens for correction.

- This example demonstrates the significance of vertex distance in spectacle correction of large refractive errors.
Spectacle Correction of Ametropias

Figure 4-18  A diverging lens is used to correct myopia.
Figure 4-19  The importance of vertex distance in the correction of high refractive errors.
Spectacle Correction of Ametropias

Cylindrical Correcting Lenses and the FarPoint Concept

- the conoid of Sturm is collapsed to a point focus on the retina.
- instead of the correct spherocylindrical combination, an equivalent sphere were used, result would be a blurred retinal image representing the circle of least confusion.
- The primary cause is meridional aniseikonia—that is, unequal magnification of retinal images
- Although aniseikonia may be corrected by iseikonic spectacles, such corrections may be complicated and expensive; and most practitioners prefer to prescribe cylinders according to their "clinical judgment."
- adult patients vary in their ability to tolerate distortion
- children always adapt to their cylindrical corrections.
Spectacle Correction of Ametropias

- **Children:** prescribe the full astigmatic correction
- **Adults:** try the full correction initially. Give the patient a "walking-around" trial with trial frames before prescribing, if appropriate. Inform the patient about the need for adaptation.

- use minus cylinder lenses (most lenses dispensed today are minus cylinder) and minimize vertex distance.

- reduce distortion:
  - by rotating the axis of the cylinder axis toward 180 or 90 degree
  - toward the old axis)
  - reduce the cylinder power.
  - Adjust the sphere to maintain spherical equivalent

- If distortion cannot be reduced sufficiently, consider contact lenses or iseikonic corrections.
Prescribing for Children

- The correction of ametropia in children presents several special and challenging problems.
- In adults, the correction of refractive errors has one measurable endpoint: the best-corrected visual acuity.
- Prescribing visual correction for children often has 2 goals:
  - providing a focused retinal image
  - achieving the optimal balance between accommodation and convergence.
Prescribing for Children

• *Subjective refraction* may be impossible or inappropriate

• the optimal refraction in an infant or a small child (particularly with esotropia) requires the *paralysis of accommodation* with complete cycloplegia.

• *Objective techniques* such as retinoscopy are the best way to determine the refractive correction.
Myopia

Childhood myopia falls into 2 groups

• *congenital* (usually high) myopia
• *developmental* myopia, usually manifesting itself between ages 7 and 10 years.

• The latter type of myopia is less severe and easier to manage, as the patients are older and refraction is less difficult.

• both forms of myopia are progressive; frequent refractions (every 6-12 months) and periodic prescription changes are necessary.
Myopia

- Cycloplegic refractions are mandatory.
- In infants, esotropic children, and children with very high myopia (> 10 D), atropine refraction may be necessary if the full refractive error should be corrected.
- Prolonged accommodation hastens or increases the development of myopia.
- Intentional undercorrection of a child with myopic esotropia to decrease the angle of deviation is rarely tolerated.
- Intentional overcorrection of a myopic error (or undercorrection of a hyperopic error) has some value in intermittent exodeviation.
- Contact lenses may be desirable in older children to avoid the problem of image minification found with high-minus lenses.
Hyperopia

- The appropriate correction of childhood hyperopia is more complex than that of myopia.
- Children who are significantly hyperopic (>5 D) are more visually impaired.
- Childhood hyperopia is more frequently associated with strabismus and abnormalities of the accommodative convergence/accommodation (AC/A) ratio.
- There is esodeviation or evidence of reduced vision, it is not necessary to correct low hyperopia.
- Significant astigmatic errors should be fully corrected.
Hyperopia

When hyperopia and esotropia coexist:

- full correction of the cycloplegic refractive error.
- reductions in the amount of correction may be appropriate, based on the amount of esotropia and level of stereopsis at near and at distance with the full cycloplegic correction in place.
- In a school-age child, the full refractive correction may cause blurring of distance vision because of the inability to relax accommodation fully.
- The amount of correction may have to be reduced for the child to accept the glasses.
Anisometropia

• An anisometropic child or infant should be given the full cycloplegic refractive difference between the 2 eyes, regardless of:
  - age
  - presence or amount of strabismus
  - degree of anisometropia.

• Anisometropic amblyopia is frequently present and may require occlusion therapy.

• Amblyopia is more common in conjunction with anisohyperopia than with either anisomyopia or antimetropia.
Clinical Accommodative Problems

Presbyopia

- Presbyopia is the gradual loss of accommodative response resulting from loss of elasticity of the lens.
- Accommodative amplitude diminishes with age.
- It becomes a clinical problem when the remaining accommodative amplitude is insufficient for the patient.
- Convex lenses can compensate for the waning of accommodative power.
- Symptoms of presbyopia usually begin after age 40 years.
- The age of onset depends on:
  - preexisting refractive error
  - depth of focus (pupil size)
  - the patient's visual tasks
  - other variables.
Clinical Accommodative Problems

Accommodative Insufficiency

• Accommodative insufficiency is the *premature* loss of accommodative amplitude.

• This problem may manifest itself by blurring of near visual objects (as in presbyopia) or by the inability to sustain accommodative effort.

• The onset may be heralded by the development of asthenopic symptoms, with the ultimate development of blurred near vision.

• "premature presbyopia"

✓ concurrent or past debilitating illness
✓ medications such as the parasympatholytics
✓ tranquilizing drugs.

• permanent accommodative insufficiency may be associated with neurogenic disorders such as encephalitis or closed head trauma.
<table>
<thead>
<tr>
<th>Age</th>
<th>Average Accommodative Amplitude*</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>14.0 (±2 D)</td>
</tr>
<tr>
<td>12</td>
<td>13.0 (±2 D)</td>
</tr>
<tr>
<td>16</td>
<td>12.0 (±2 D)</td>
</tr>
<tr>
<td>20</td>
<td>11.0 (±2 D)</td>
</tr>
<tr>
<td>24</td>
<td>10.0 (±2 D)</td>
</tr>
<tr>
<td>28</td>
<td>9.0 (±2 D)</td>
</tr>
<tr>
<td>32</td>
<td>8.0 (±2 D)</td>
</tr>
<tr>
<td>36</td>
<td>7.0 (±2 D)</td>
</tr>
<tr>
<td>40</td>
<td>6.0 (±2 D)</td>
</tr>
<tr>
<td>44</td>
<td>4.5 (±1.5 D)</td>
</tr>
<tr>
<td>48</td>
<td>3.0 (±1.5 D)</td>
</tr>
<tr>
<td>52</td>
<td>2.5 (±1.5 D)</td>
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<tr>
<td>56</td>
<td>2.0 (±1.0 D)</td>
</tr>
<tr>
<td>60</td>
<td>1.5 (±1.0 D)</td>
</tr>
<tr>
<td>64</td>
<td>1.0 (±0.5 D)</td>
</tr>
<tr>
<td>68</td>
<td>0.5 (±0.5 D)</td>
</tr>
</tbody>
</table>

*Under age 40, accommodation decreases by 1 D for each 4 years. Over age 40, accommodation decreases more rapidly. From age 48 on, 0.5 D is lost every 4 years. Thus, one can recall the entire table by remembering the amplitudes at age 40 and age 48.
Clinical Accommodative Problems

Accommodative Excess

- Ciliary muscle spasm, often incorrectly termed *spasm of accommodation*, causes accommodative excess.
- A ciliary spasm has characteristic symptoms:
  ✓ Headache
  ✓ brow ache
  ✓ variable blurring of distance vision
  ✓ close near point.
- Ciliary spasm may occur:
  - Iridocyclitis
  - anticholinesterases used in the treatment of glaucoma
  - uncorrected refractive errors, usually hyperopia but also astigmatism.
  - after prolonged and intense periods of near work.
Clinical Accommodative Problems

- *Spasm of the near reflex*
  - (1) excess accommodation
  - (2) excess convergence,
  - (3) miosis.
Clinical Accommodative Problems

Accommodative Convergence/Accommodation Ratio

• Normally, accommodative effort is accompanied by a corresponding convergence effort (expressed in terms of meter angles).
• Thus, 1 D of accommodation would be accompanied by a 1-m angle of convergence.
• For practical purposes, the AC/A ratio is ordinarily expressed in terms of prism diopters of deviation per diopter of accommodation.
• Using this type of expression, the normal AC/A ratio is 3:1-5:1.
• Conversely, a patient with uncorrected myopia must converge without accommodative effort in order to see clearly at the far point of the eye.
• The AC/A ratio can be measured by varying the stimulus to accommodation in several ways.
**Accommodative Convergence/Accommodation Ratio**

*Heterophoria method (moving the fixation target)*

The heterophoria is measured at 6 m and again at 0.33 m.

\[ AC/A = PD + \frac{\Delta n - \Delta d}{D} \]

where

- \( PD \) = interpupillary distance in centimeters
- \( \Delta n \) = near deviation in prism diopters
- \( \Delta d \) = distance deviation in prism diopters
- \( D \) = diopters of accommodation

Sign convention:
- Esodeviations +
- Exodeviations −
Accommodative Convergence/Accommodation Ratio

Gradient method

- The AC/A ratio can be measured in 1 of 2 ways using the gradient method.

✓ **stimulating accommodation.**
- Measure the heterophoria with the target distance fixed at 6 m.
- Then remeasure the induced phoria after interposing a -1.0 sphere in front of both eyes.
- The AC/A ratio is the difference between the 2 measurements.

✓ **relaxing accommodation.**
- With the target distance fixed at 0.33 m, measure the phoria before and after interposing +3.0 spheres.
- The phoria difference divided by 3 is the AC/A ratio.
- An abnormal AC/A ratio can place stress on the patient's fusional mechanisms at one distance or another, leading to asthenopia or manifest strabismus.
- Abnormal AC/A ratios should be accounted for when prescribing corrective lenses.