

MASTERS PAPER

**Taking the Mystery Out of
Refraction**

"A Basic Overview"

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TAKING THE MYSTERY OUT OF REFRACTION

“A Basic Overview”

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The basic goal of refraction is to focus light rays from optical infinity on the retina through the application of corrective lenses placed in front of the eye. To restate that in functional terms, one could say that the refractionist's main goal is to provide lenses that will allow not only clear, but comfortable vision. That simply means allowing one to see everything he or she wants and needs to see comfortably without discomfort or eyestrain.

“the term refraction refers to the sum total of refractometry (measuring the refractive error of an eye), assessing the visual needs of an individual, and arriving at a clinical judgment as to which prescription to provide.” (Ophthalmic Terminology, H. A. Stein, B. J. Slatt, R. M. Stein, Pg 85)

The overall process of refraction can be divided into three parts. Part one is called the "starting point." The refractionist collects basic information about the visual conditions of the customer. This includes a technique called static retinoscopy. This determines the refractive condition of the customer's distance vision by objective means. Objective refraction requires no verbal response from the customer.

The second part is often referred to as the "refinement" phase of the process. In this section, the refractionist would normally use a phoropter. This would involve the customer looking at some type of eye chart or screen while the refractionist makes changes in the corrective lenses in the phoropter while the customer verbally responds to each change. This refinement portion is generally called the "subjective refraction." "After retinoscopy has been completed for both eyes, the subjective refinement begins. A phoropter, an adjustable refractor with a series of discs containing plus and minus spheres and cylinders in 0.25 D increments, a cross cylinder, and a pupillary distance setting, is an instrument commonly used for refinement.” (Fundamentals for Ophthalmic Technical Personnel, B. Cassin, Pg 189)

The third part of the refraction is usually referred to as the "end point." This part of the refraction is perhaps the most critical portion. The refractionist

must evaluate all the available information to solve the customer's refractive problems. This process involves a variety of techniques to be addressed later.

The refractionist must consider the information obtained in the first two steps to determine a single prescription that will provide the customer with corrected vision that will allow he or she to perform visual functions with comfort and clarity. "Visual acuity is defined as the resolving..power of the eye, or the ability to see two separate objects as separate. It is often referred to as the minimum separable (as opposed to the minimum visible). It may be thought of as the ability to see a gap." (Primary Care Optometry, T. P. Grosvenor, Pg 11)

The eye conditions that can be corrected through refraction are:

"Myopia, the myopic eye has excessive refractive power; that is, too much plus power. Parallel rays from infinity come to a focus in front of the retina. The conjugate focus is a point in front of the retina." (Handbook of Refraction, George E. Garcia, M.D., Pg 29)

"Hyperopia, the hyperopic eye is deficient in refractive power. The rays from infinity are not refracted enough; thus the point of focus is behind the retina. The eye lacks plus power." (Handbook of Refraction, George E. Garcia, M.D., Pg 23)

"Presbyopia is a normal condition associated with age. Accommodation available falls short of the demand made upon it for the usual reading range. It is due to a physiological decrease in the amplitude of accommodation. Its appearance varies with the individual, particularly his or her occupation and refractive error." (Handbook of Refraction, George E. Garcia, M.D., Pg 78) An interesting "clinical point" concerning presbyopes is that, "most early presbyopes not only experience blurring for near tasks, they also have difficulty *unfocusing* when they look up from a new task. Their distance vision may remain blurred for several seconds, even minutes. This inability to relax accommodation quickly is as much a manifestation of the loss of lens elasticity as is the loss of

accommodation itself." (The Fine Art of Prescribing Glasses Without Making a Spectacle of Yourself, B. Milder,

L. Melvin, @ Pg 120)

'Astigmatism is a condition in which rays of light are not refracted equally in all meridians. For the purpose of classification, an astigmatic eye is assumed to have two principle meridians that are usually at right angles to each other. The term astigmatism is derived from the Greek and means, literally, without a point." (Handbook of Refraction,

George E. Garcia, M.D., Pg 35)

As the customer enters the examination room, the refractionist can observe many things. For example, the customer may be of large or small stature, overweight or underweight, calm or nervous, etc. These observations should be noted while taking the customer case history.

A large, vigorous, able-bodied person many times will accept a full refractive correction. The fragile or high-strung, sensitive person may be unable to adapt to large changes in his or her prescription, but many appreciate small, subtle changes that would be undetected by a more hearty individual.

The customer's posture and head position should be noted for future reference should multifocals be required. Other observations worth noting are an asymmetrical face that could suggest anisometropia. Large eyes may indicate myopia, whereas small eyes may indicate hyperopia. Individuals with brown eyes usually require more cycloplegia than a blue-eyed person, and are more prone to becoming presbyopic at an earlier age. Many other objective clues can be easily observed and noted such as staring, frowning, excessive blinking, tearing, and squinting.

Neutralize the customer's current eyewear and record the Rx on the customer's record. The customer's actual PD should be compared with the PD obtained from the eyewear along with the base curves of the lenses and the lens thickness. This information should be recorded as well.

It is always a good practice to ask the customer to explain the main purpose of their visit. This may be as simple as asking the customer are your eyes giving you any visual problems or is it simply time for an "eye exam?" In some cases, the customer may have lost or broken their eyewear. By recording the customer's "main complaint," the refractionist can later determine whether or not the prescription will provide relief for their "main complaint." Frequently, it is determined that the discomfort that bothers the customer, such as eyestrain or headaches, are not caused by the use of the eyes, but the customer "hopes" the new prescription will relieve them.

The customer's visual symptoms can be classified as blurring, double vision, and distance or near vision that seems out of focus. These symptoms may be of great concern to the customer, but do not cause any pain or discomfort. Other symptoms described by the customer may include eye fatigue, tearing, a pulling sensation, tired eyes, and a number of other symptoms which may be referred to simply as "eyestrain."

Headaches seem to be the most common symptom to be associated with a customer who has an outdated or undercorrected Rx that provides inadequate refractive power.

Taking a careful history of the customer with the refractionist's attention focused on the main visual complaints of the customer is extremely important. The refractionist needs to develop the ability to evaluate and analyze the customer's symptoms and determine how to evaluate their significance.

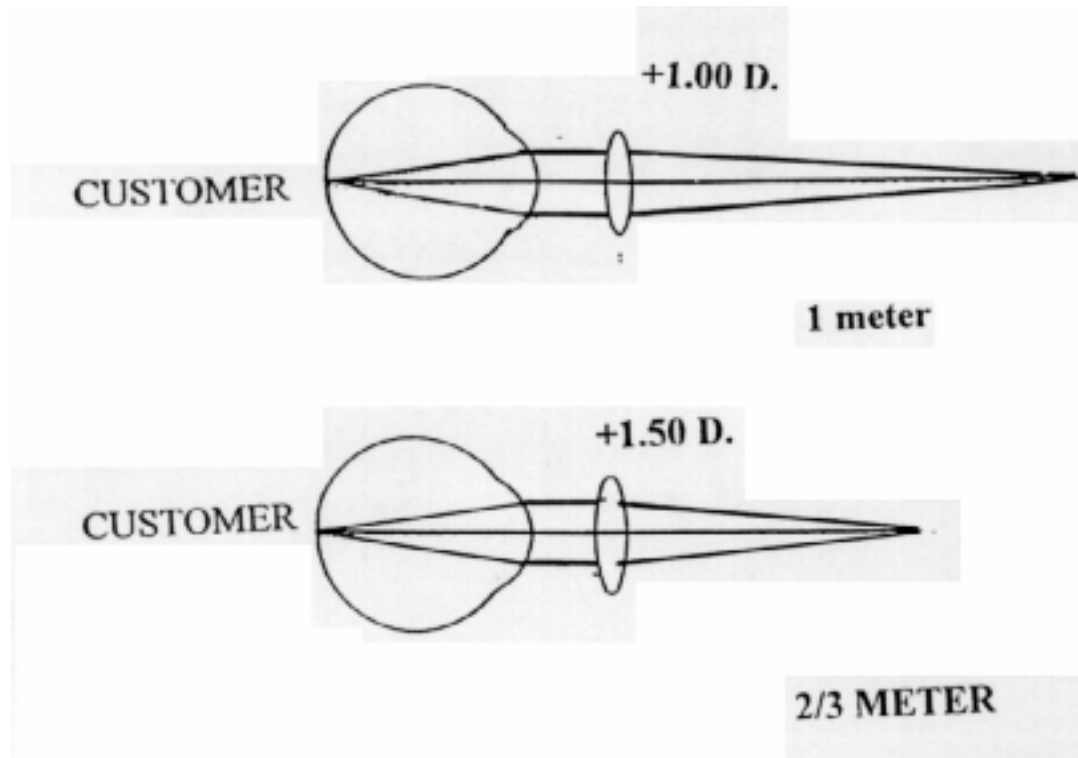
Retinoscopy is a technique used by refractionists for objective refraction of the eye. This requires no verbal response from the customer. Retinoscopy is an "objective method of determining the refractive error of the eye by observing the movements of light reflected from the back of the eye." (Manual of Ophthalmic Terminology," H. A. Stein, B. J. Slatt, P. Cook, Pg 46) Basically, there are two types of retinoscopy. Static retinoscopy is performed while the customer focuses on a spot or image at a distance of 20 feet (or more). Dynamic retinoscopy is

performed while the customer is focusing at near position or normal working distance for close vision. This technique performed by an experienced refractionist can result in a very accurate determination of the customer's refractive error.

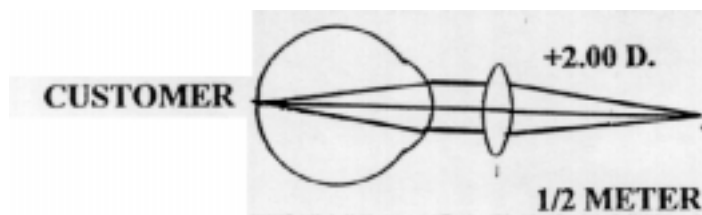
Retinoscopes come in several basic styles. The most widely-used scope is called the streak retinoscope and for the most part, has replaced the spot retinoscope, an older design seldom used today. In performing retinoscopy, the scope itself is a battery-charged or electric-powered hand-held light which directs a beam of parallel or slightly divergent beam of light into the customer's eye. The light illuminates the customer's retina and is reflected back causing a reflex in the customer's pupil. The refractionist while observing the reflex in the customer's pupil can determine the refractive condition of the customer's eye by using trial lenses on a phoropter. The trial or corrective lenses placed in front of the customer's eye cause the reflected light to focus or conjugate to the pupil of the examiner's eye. The reflected light from the customer's retina is known as the "fundus reflex." However, it appears to be located in the plane of the customer's pupil. To clearly see the fundus reflex, the refractionist must be within one meter (40 inches) or less from the customer's eye.

The distance at which the refractionist observes the fundus reflex is called the "working distance." The necessary lens power placed in front of the customer's eye in order to compensate for this distance is called the "retinoscopy lens" or "working lens."

Here is how it works. Rays of light from a normal (emmetropic) eye are reflected off the retina (from the retinoscope) and exit the pupil as parallel rays.



If the retinoscope is held at a distance of one meter from the customer's eye, then a +1.00 D spherical ('working lens") is required to focus the parallel light rays at a one-meter distance. This is known as making the customer's eye conjugate with the refractionist's eye.

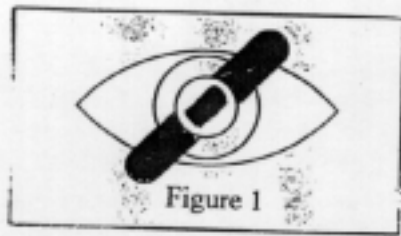


If the "working distance" (the separation from the customer's eye and the refractionist's eye) is one-half meter, then a +2.00 D sphere working lens is required.

To eliminate calculations for each customer, most refractionists place the required "working distance" lens power in the trial frame. When using a phoropter, the auxiliary dial contains a "retinoscopy lens" indicated by the letter "R." This also will compensate for the working distance. Many refractionists seem to prefer a working distance of two-thirds of a meter (66 cm or 26 inches). The "working distance" of each refractionist will depend upon what distance is comfortable for him or her to reach and operate the lens dials on the phoropter.

When the refractionist performs retinoscopy, he or she is holding the retinoscope next to their eye and peering through the small round viewing window on the back side of the scope. The adjustable sleeve can be moved up or down. However, in the down position and the power switch turned on, the scope will send a parallel beam of light directed toward the customer's eyes.

The refractionist can evaluate the refractive condition of the customer's eye by observing the "fundus reflex," which is the light reflected off the customer's retina from the retinoscope. In the streak retinoscope, the bulb has a fine filament which creates a streak or (bandlike) image. By rotating the sleeve on the retinoscope, the band can be rotated 360- to ascertain the axis of astigmatism. The refractionist will observe the "reflex" and providing there is no oblique astigmatism, the reflex will appear as in Figure 1. In the event that oblique astigmatism is present, then the reflex will appear as in Figure 2.



The refractionist determines the axis of the cylinder correction by aligning narrow streak or "reflex" seen in the customer's pupil with that outside of the pupil (on the sclera and iris). For some customers, objective refraction is the only way to determine an Rx. This would certainly apply to young children, illiterate s, the hearing imoaired who are unable to verbally respond, and perhaps someone who is unable to understand or speak the same language as the refractionist. Objective refraction with retinoscopy is required anytime a subjective test is not possible.

The refractionist with practice becomes competent in interpreting the various characteristics of the reflex motions. Reflexes that are fast or slow, dull or bright, and vary in shape or size reveal the different refractive conditions of the eye.

Retinoscopy, with practice, becomes a valuable skill requiring only several minutes to perform on each eye. This procedure determines the main refractive status of the eye and sets the stage for the subjective testing which will "fine tune" the final Rx.

With no "working lens" in place before the customer's eye, the reflected rays of light will be parallel in an emmetropic customer, converge in myopia, and diverge in hyperopia.

If the customer's eye is emmetropic with a "working lens" in place, the refractionist will see no movement of the reflex in the customer's pupil. The

reflected light will be very bright and the pupil will appear full and round, full of reflected light, and is referred to as neutrality.

Viewing a myopic eye with a "working lens" in place, the refractionist will see "against movement" of the fundus reflex.

As the refractionist shines the 'streak" (band of light) on the customer's eye in the vertical position and moves the streak of light to the right, for example, the image reflex that appears in the pupil will appear to move the opposite direction (to the left).

In a hyperopic eye with a "working lens" in position, the refractionist will observe a "with motion." As the refractionist directs the "streak" (band of light) on the eye, and for example, aligns the "streak" vertically and moves the streak of light from right to left across the customer's eye, the reflected image that appears as a band of light in the pupil will appear to move in the same direction as the movement of the light.

It should be pointed out that all the "reflexes" that have been described so far are with the retinoscope sleeve in the "down" position, or what may be referred to as the "plane mirror" position. To avoid confusion, the "concave mirror" position will not be discussed. That is when the position of the retinoscope sleeve handle is in the up position and all the "fundus reflex" movements are reversed or opposite to that when the plane mirror position is used.

When performing streak retinoscopy, the refractionist could summarize the characteristics of the "fundus reflexes" in the table below.

REFLEXES OF THE FUNDUS			
	WEEK RX AMETROPIA	STRONG RX AMETROPIA	NEUTRALITY (AMETROPIA NEUTRALIZED)
Brightness (of Reflected streak)	Very bright	Dull	Very bright
Speed	Rapid	Much Slower	No Motion (or

(of movement)		(sluggish)	Very Fast)
Size	Big	Much smaller	Much larger
Basic Shape	Spherical errors = round reflex Astigmatic errors = oval		

When the sleeve on the retinoscope is in the up or 'plane mirror" position, the band or streak of light is a wide band on the customer's eye. The refractionist, while observing the band or "streak" of light, can determine the axis of the cylinder correction quite accurately by aligning the narrow streak observed in the customer's pupil with the image outside the pupil on the sclera and iris.



When first mastering the techniques of retinoscopy, the refractionist must read and understand the theory and principles involved in the use of the retinoscope. Then it is simply a matter of practice and applying the techniques required to recognize and evaluate the various reflexes or bands of

light observed in the pupil. The refractionist learns to evaluate the reflex motions based on such things as speed, fast or slow, bright or dim, size and shape. When learning retinoscopy, a schematic or "practice" eye is extremely valuable in mastering the basic techniques. The 'practice" eye can be adjusted or "set" to simulate various degrees of myopia, hyperopia, or astigmatism. The refractionist can learn to "neutralize" or correct the simulated ametropia by placing the appropriate trial lens in front of the schematic eye. Unlike a live customer, the schematic eye will not accommodate and is able to maintain a constant state of 'fixation."

Although it may sometimes seem difficult in the beginning, retinoscopy, with practice, will soon become a rewarding skill. Retinoscopy requires only

several minutes for each eye, but this procedure will reveal the basic refractive error to be refined by subjective testing with trial lenses or a phoropter.

Cycloplegia simply refers to the loss of power of accommodation through inhibition of the ciliary muscle due to the introduction of a cycloplegic drug. Any drug that produces cycloplegia is called a cycloplegic.

There seems to be little doubt that one of the best methods of suppressing accommodation is to use a cycloplegic. During the early years of childhood, the "fogging technique" (putting plus lenses in front of the eyes) will not replace the use of cycloplegic drugs. As the customer becomes older, the fogging technique seems to work quite well. By placing plus lenses (+1.50); for example, (in front of each eye) will "fog" out the distance vision and relax the customer's accommodation.

The phoropter, an instrument which is a uniquely-designed lens holder, allows the refractionist to easily and efficiently change lenses. Basically, it has four groups of controls.

The phoropter has two sets of lens controls, one dial for spherical lenses, and a separate dial for minus plano cylinder lenses. At each side of the phoropter is a large wheel called the weak sphere dial. The dial or wheel controls spherical lenses from plano to + or - 20.00 diopters in .25 diopter steps.

Two knobs control the minus cylinder lenses that are mounted inside the instrument in a rotating wheel. The lenses in the cylinder wheel can be rotated to any axis position. The two controls are called the cylinder power knob and the cylinder axis knob. The axis of the cylinder lenses is shown on the cylinder power scale. The axis position of the cylinder lenses are shown on the cylinder axis reference scale, easily found and read on the face of the phoropter.

What the customer actually looks through, when seated behind the phoropter, is determined by the auxiliary lens knob/aperture control. This control

has different positions. The most frequently-used positions are OCcluded which means the eye is completely blocked, or Open which means the customer sees through only the lenses that the refractionist has "dialed into" position before the customer eye. Most phoropters also contain a "Retinoscopy lens opening which holds a +1.50 or sometimes a +2.00 diopter lens. This lens is used along with the sphere or minus cylinder lenses placed in front of the customer's eye. The purpose of the "Retinoscopy lens" is to fog out vision and eliminate accommodation while the refractionist performs retinoscopy on the customer. Other apertures included on some phoropters are a pinhole

(P.H.), red lens (R.L.), a \pm .50 diopter Jackson Cross-Cylinder (J.C.C.), a polaroid (P.), and horizontal and/or vertical prisms.

Many controls are located on the phoropter to position and adjust the instrument to fit the individual customer. These include:

1. Leveling knob (with liquid level)
2. P.D. knob
3. Pantoscopic tilt control
4. Vertex distance control

The basic purpose of the phoropter is "To determine the refractive status of the eye by using the patient's subjective responses. When the distance subjective refraction is completed, a distant point stimulus should form a point image on the retina with accommodation fully relaxed." (Clinical Procedures for Ocular Examination, Nancy B. Carlson, Daniel Kurtz, David A. Heath, Catherine Hines, Pg 63)

The equipment needed by the refractionist is either a Snellen Eye Chart or a projector with a visual acuity slide, a screen to project the eye chart on, and a standard phoropter.

The set up should proceed as follows:

1. The customer should be seated and comfortable.
2. The phoropter should be set to match the customer's distance P.D.
3. The phoropter should be positioned comfortably in front of the customer like a pair of glasses.
4. The phoropter must be leveled.
5. A full-screen visual acuity chart with a 20/15 line at the bottom must be well illuminated for the customer.

6. As a starting point for the customer's refraction, the final retinoscopy finding is usually set in place in the phoropter. An alternative starting point would be to place the customer's current distance prescription in the phoropter.

With the customer seated comfortably, the refractionist is ready to begin the distance "subjective refraction" one eye at a time. The purpose of this is to determine the most plus or (least minus) spherical power that will provide the customer with his or her best visual acuity. The refractionist will follow these basic steps:

1. Occlude the left eye and open the right eye with the auxiliary lens knob on the phoropter.
2. Blur or "fog" the vision in the right eye by placing the "Retinoscopy lens" in place over the right eye by turning the auxiliary knob on the phoropter. This should fog the customer's vision so that he or she cannot see the 20/20 line on the eye chart.
3. Refractionist's use the "rule of thumb" that basically the customer should be able to read one additional line of visual acuity for each 0.25 diopter of minus sphere added (or each 0.25 diopter of plus sphere power that is removed).

4. The refractionist reduces the plus power or adds minus power, 0.25 diopter, at a time. With each click of the wheel, the customer is encouraged to read the next smaller line.

5. The refractionist must be careful not to give the customer too much minus power. This will cause the letters to look smaller and darker, but not allow them to read the next smaller line in the case of a myope. Likewise, too much minus power on a hyperope will cause the customer without cycloplegia to begin to accommodate to see in the distance.

The degree of myopia or nearsightedness is determined by the phoropter to be the weakest minus sphere power for each individual eye (monocularly) which will provide 20/20 visual acuity. Too much minus power will stimulate the customer's accommodation and result in an over-minused Rx.

Unlike the myope, the hyperope sees better at a distance than for close vision. A younger hyperope can improve their vision by accommodation. This creates more of a challenge for the refractionist to determine the best visual correction for the customer.

When cycloplegia (drugs) are not used to eliminate the hyperope's accommodation, the determination of the amount of hyperopia found with the phoropter may not reveal the full amount present. Luckily, for most customers, that amount of hyperopia found with the phoropter usually proves satisfactory to provide the customer with comfortable clear vision. The strongest plus sphere which will correct distance vision (20/20) is what is provided for the customer.

The objective portion of the refraction that was performed during retinoscopy provides valuable clues as to the strength and type of refractive error found in the customer's eyes. This provides a good starting point for the refraction. The "final word" is provided by the subjective tests which provide verbal response from the customer to determine the final Rx. In the end, the customer is the only person who can judge what gives him or her the clearest and most comfortable visual acuity.

There are two separate techniques used to determine the cylinder power and the cylinder axis on those customers who have astigmatism. One is a set of astigmatic charts. The refractionist with the correct combination of plano-cylinder lenses should be able to have the customer see **all** the lines (similar to spokes of a wheel) on the astigmatic chart equally sharp, dark, and clearly.

The other option for refractionists is to use the Jackson Cross Cylinder (lens) found on the phoropter. The cross cylinder usually contains a (+0.25 cyl. combined with a -0.25 cyl.). The refractionist can rotate this lens to determine the axis of the cylinder. With each flip of the cross cylinder, the customer is asked to respond to the clarity of the letters in position one and position two. Once the correct axis position is found, the letters will appear equally clear in position one and position two. A good refractionist should be able to perform both tests **well**. Some customers respond better on one test than the other.

Spherical balance is a procedure performed once the astigmatism, if present, has been corrected in each eye. The customer is shown the eye chart and asked to read the smallest line of letters possible, with one eye at a time and then with both eyes (binocularly). Assuming that each eye is capable of good vision, the customer should just be able to read the 20/20 line with each eye independently, binocularly. However, he or she may read the 20/20 line quite easily. If the refractionist now adds +0.25 diopter of power monocularly, the added +0.25 diopter of power should blur that eye by one line of letters (e.g., from 20/20 to 20/25) visual acuity. This confirms that each eye is corrected with the maximum plus or the minimum minus spherical correction. When the visual acuity of each eye blurs equally for the same amount of increased plus sphere power, this is an indication that the correct spherical balance has been achieved.

The auxiliary dial on the phoropter contains a pinhole disc (P.H.) which may be used as part of the subjective refraction. It can be quite useful, especially in refracting a customer with subnormal vision. The pinhole disk can

help determine whether or not a customer's vision may be improved by lenses (an Rx change).

If a customer's visual acuity improves when looking through the pinhole, this indicates that the poor vision is the result of a refractive error. With the correct Rx, the customer should have vision equal to that obtained by use of the pinhole.

However, if there is no improvement or sometimes a reduction in visual acuity when using the pinhole technique, this usually indicates opacities of the crystalline lens or cornea, disease, or amblyopia.

The pinhole disk provides a quick test for the refractionist to determine if the reduced visual acuity (less than 20/20) can be improved by a different set of optical lenses.

There are various tests that can be used to evaluate the indications for using a prism correction. Customers may react to the unpleasant symptoms created due to the addition of prism to the customer's Rx. Many refractionists add small amounts of prism and gradually increase the amount over a period of time. If occluding one eye relieves the customer's symptoms, most refractionists feel that prism added to the customer's Rx will help relieve the symptoms.

There are some basic guidelines for refractionists to follow when prescribing prism. However, it is very important for the refractionist to keep in mind that the prism prescribed for the customer only relieves the symptoms.

In order for the refractionist to determine the correct add for each customer, consideration must be given to the following:

1. What are the normal distances that are required for the customer's near activities (what extremes)?
2. How much time is spent by the customer doing activities requiring near vision?
3. How important is the visual acuity requirement for the customer (e.g., casual reading versus performing surgery)?

4. How much accommodation does the customer maintain?

Other factors to be considered are the amount and type of lighting in which the customer normally performs the near visual tasks. If the customer is tall or short, what is the normal head position of the near visual requirements?

Some refractionists prefer to use the Dynamic Cross Cylinder Test. Basically, this test determines the near point requirement to give the customer adequate near vision while using the amount of accommodation that he or she is "comfortable" with. It is interesting to note that many nonpresbyopics prefer to have a small amount of plus power (+.250 to +.50 D sphere) added to their distance Rx which will "relax" their accommodation when they are given the choice.

The refractionist will perform tests on the customer to determine at what distance fine print appears sharp and clear.

In today's work place, a technician or ophthalmic assistant is usually quite able to operate the various automated instruments for clinical refraction. The operator of the automated refracting instrument does not require much training, nor is there a need for extensive knowledge of refractometry techniques.

An auto refractor is "a mechanical and optical diagnostic instrument usually of table top design which makes objective measurements of the refraction of the human eye." (Dictionary of Ophthalmic Optics, A. H. Keeney,

R. E. Hagman, Cosmo J. Fratello, Pg 256)

Recent technology has now produced automated refracting instruments that are quite accurate and practical to use. Using an objective refractor today basically requires that the customer avoids any head movement and looks straight ahead. Subjective refractors, however, requires verbal response from the customer, especially in the final refinement stage of the refraction process. "Modern technology has introduced over 20 automated refracting instruments including manual objective refractors, automatic infrared retinoscopes, and

sophisticated subjective refractors." (The Ophthalmic Assistant, Fundamentals and Clinical Practice, H. A. Stein, B. J. Slatt,

R. M. Stein, Pg 239)

Although automatic refractors may be accurate to within 0.25 D of the customer's final Rx, in over 80 percent of the time, it is still necessary for most refractionists to use the Rx obtained from the automatic refractor as a starting point for subjective refraction.

In summary, the final goal of refractometry is to render the retina in focus with optical infinity by application of lenses in front of the customer's eye. The main point to remember is that the refractionist must refract for people, not for eyeballs. He or she must always keep in mind that vision occurs in the brain, not the eye. The final goal should always be to determine the lenses that will allow the customer to obtain comfortable and clear vision without eyestrain or visual discomfort.

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