INTRODUCTION

Definition

Binocular refraction is a clinical procedure in which the subjective refraction is performed monocularly under binocular-viewing conditions. This situation may be achieved by several methods. These include positioning a septum, using polarized targets, or blurring vision in one eye such that each eye sees only its respective target.

History

Bannon has provided a survey of many of the suggested procedures used for binocular refraction. The following is intended largely as a historical overview, since some of these procedures are no longer used with any frequency in contemporary clinical practice.

Cyclodopia was first reported in 1930 by Smith. It represents one of the first attempts to measure the refractive error under binocular conditions. By having the patient view the letters through the retinoscopic findings, with the working distance dioptric equivalent in place, the patient was "fogged" and, thereby, encouraged to relax accommodation maximally. The power of the spherical lenses was gradually reduced and the cylindrical correction checked by cross cylinder under binocular conditions. In 1940, Copeland proposed a method of binocular refraction that was a variation of that suggested by Smith. With this procedure a +2.00-D working lens was placed before the eye not undergoing refraction. This served to "fog" vision of one eye yet allow binocular fixation.

Sugar in 1944, suggested using the cross cylinder on each eye following the monocular postcycloplegic examination under binocular-viewing conditions. According to his procedure the cross cylinder test for cylinder axis and power was performed on each eye in succession. He did not utilize any means to suspend or occlude vision in the eye not undergoing testing.

In 1945, Turville, an English optometrist, introduced the procedure of binocular refraction that was modified by Morgan and others in subsequent years. The basic premise was to block or occlude a binocularly viewed target so that the right eye views the right side of the target and the left eye views the left side of the target. Turville accomplished this by placing a vertical septum over the patient's viewing mirror, thereby preventing the possibility of the right eye viewing the left target. This is the same procedure used in contemporary practice if one has access to an optically folded operatory or examination room.

Several investigators have used polarizing techniques that covered the entire chart or only the letters, or developed special instrumentation utilizing polarizing methods. A new approach to binocular refraction was introduced in 1966 by American Optical. The American Optical Vectorscope slide was manufactured by depositing a dichroic dye on a stretched polyvinyl alcohol film. In this manner, polarized or vectorial symbols and characters were formed. This allowed the projection of a target in which, with analyzers in place, the right eye sees only characters designed to be seen by the right eye and the left eye would see only characters designed to be seen by the left eye, yet both eyes remain open. This represented a unique method, not only in character design, but in chart or slide design as well. It allowed easy access to procedures that could be used in a 20-ft operatory or examination room.

In 1963, Humphries described the procedure of binocular refraction in which a low power plus lens (+0.75 D) was used to suspend foveal vision while refraction was performed on the eye.
not under fog. He called this immediate contrast refraction. Although not a procedure that is widely used, it is easily available and does not necessitate any extra or special equipment.

Clinical Use

As most patients have binocular vision, it seems reasonable that clinicians should use procedures that permit measurement of the refractive error under binocular viewing conditions. Several procedures have been proposed for this purpose, some simple in design, others more elaborate, yet binocular refraction remains relatively unused by most clinicians. Why is this so? Is it from a lack of knowledge of the procedure, a result of having to use different instrumentation, a result of not having the proper perspective about the procedure, or all of these? It is most likely a combination of all the foregoing factors. This chapter on subjective refraction will explore the rationale for binocular refraction as well as describe the more commonly used procedures.

Binocular refraction has a variety of advantages over the monocular subjective refractive procedure. Eskridge has provided an excellent review of the clinical research supporting the rationale for binocular refraction (Table 19–1). Several investigators have concluded that refractive differences may be measured in a substantial number of patients under monocular versus binocular viewing conditions. However, these differences are usually not significant for most patients. In certain conditions, however, the binocular refraction procedure may result in significantly different measurements, and it is clearly indicated as the refractive procedure of choice (Table 19–2). These conditions include hyperopic anisometropia, anisometropia, amblyopia, latent hyperopia, pseudomyopia, cyclophoria, latent nystagmus, and paretic extraocular muscles, among others.

A principal advantage of binocular refraction is that it allows greater relaxation of accommodation than do traditional monocular procedures. This permits a more complete and accurate measurement of such conditions as hyperopic anisometropia, anisometropia, latent hyperopia, or pseudomyopia. In conditions such as cyclophoria or latent nystagmus, binocular refraction prevents the interruption of fusion and, therefore, the manifestation of these conditions. Without their manifestation, they are unable to influence the refractive condition or visual acuity.

**INSTRUMENTATION**

Theory

The theoretical principle involved in binocular refraction is that by some means each eye views its respective target, yet both eyes remain open. The right eye views only the right target, the left eye only the left target, and the single precept is represented cortically.

<table>
<thead>
<tr>
<th>Table 19–1</th>
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<tr>
<td><strong>Rationale for Binocular Refraction</strong></td>
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<td><strong>Study</strong></td>
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<td>Morgan</td>
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<td>Norman</td>
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<td><strong>Spherical Balance</strong></td>
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<td>Campbell</td>
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<td><strong>Cylindrical Axis</strong></td>
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<th>Table 19–2</th>
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<td><strong>Clinical Indications for Binocular Refraction</strong></td>
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<td><strong>Refractive Considerations</strong></td>
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<td>Hyperopic anisometropia</td>
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<td>Anisometropia</td>
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<td>Latent hyperopia (Intermittent)</td>
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<td>Pseudomyopia</td>
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<td><strong>Visual Acuity Considerations</strong></td>
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<td>Aniseikonyopia (unequal acuity between the eyes)</td>
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<td>Unilateral amblyopia (physiologic or organic)</td>
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<td>Unilateral reduced acuity as a result of ocular disease</td>
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<td>Physiologic differences between best corrected acuities</td>
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<td><strong>Ocular Motility Considerations</strong></td>
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<tr>
<td>Significant horizontal, vertical, or cyclo-associated phoria</td>
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<td>Cyclophoria (physiologic or paretic)</td>
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<td>Latent nystagmus</td>
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This monocular viewing under binocular conditions may be achieved by several methods.

Use

**Septum**

A commonly used method for each eye viewing its respective target is to physically block or obstruct part of the target. The septum concept was originally described by Turville, and its effect is illustrated diagrammatically in Figure 19–1. This technique is particularly effective when using an optically folded operatory or examination room because the septum may be quickly centered on the mirror. However, it may also be utilized in a 20 ft. examination room.

**Polarization**

A variety of investigators have suggested the use of polarization as a means to achieve monocular viewing under binocular conditions. With this method, the analyzer and polarized target have the same axis of polarization, allowing the right eye to view the right half of the target, but blocking the left half of the target from view (Fig. 19–2). A variation of this technique is to polarize only the letters, leaving the background normal. This is the technique utilized in the Reichert (formerly American Optical) Vectographic slide (Fig. 19–3).

**Fogging**

A different approach to monocular refraction under binocular conditions is to slightly blur the central vision in the eye not under test. This slight blurring suspends foveal vision, such that each eye is refracted under conditions of binocular vision with peripheral fusion (Fig. 19–4).

**COMMERCIAL AVAILABLE INSTRUMENTS**

The American Optical Vectograph slide has been the only commercially available equipment made expressly for binocular refraction in the United States. This slide, originally introduced in 1966, is now commercially available from Reichert Ophthalmic Instruments. Slides are available for adults and children. Stereo Optical Company has introduced a similar slide for binocular refraction. When Turville first introduced the infinity balance test in 1946, his apparatus consisted of a double vertical column of test characters that were viewed in a mirror and to which a 3 cm wide opaque septum was attached. As a result of the almost exclusive use of 20 ft. examination rooms in the United States at that time the procedure never gained popularity. The test cabinet was commercially available for many years in the United Kingdom, especially England.

![Figure 19–1](image1.png)

**FIGURE 19–1.** The effect of occluding the central portion of an acuity target by placing a septum midway between the patient and the target.

![Figure 19–2](image2.png)

**FIGURE 19–2.** The polarizing method for producing monocular viewing under binocular conditions. The viewing analyzers have crossed axes and thus prevent the right eye from seeing the left target and vice versa.

![Figure 19–3](image3.png)

**FIGURE 19–3.** The vectograph slide illustrating polarized presentation of targets to the right, left, and both eyes.

* Reichert Ophthalmic Instruments, a division of Cambridge Instrument Inc., Buffalo, NY 14240.
† Available from Stereo Optical Company, 3539 North Kenton Ave., Chicago, IL 60641.
in the center of the patient’s viewing mirror and the patient instructed to hold his or her head in an upright position and not to move the head from side to side. If, for example, the 20/50 line of letters of the American Optical Paraboline slide is used, the septum should be positioned such that with the right eye closed only the U and S are visible with the left eye. Conversely, with the left eye closed only the E and G are visible with the right eye. When both eyes are open and binocular overlap is present all four characters will be visible (two to each eye) and the center letter (in this case N) will be blocked by the septum. The edge of the mirror and frame will serve as peripheral fusion stimuli and stabilize binocular vision.

2. Proper alignment is achieved the procedure for binocular refraction may begin. The patient’s attention is directed to the right side of the chart and, with the retinoscopic findings or present prescription in place, the appropriate-sized characters are projected on the screen.

3. If the letters are blurred, then a best-sphere determination should be made until approximately 20/25 or 20/20 characters are clear. If this level of visual acuity is not attainable, then retinoscopy should be repeated or other factors such as amblyopia or ocular disease considered.

4. Once the appropriate level of visual acuity is attained, the patient’s attention should be directed to the right side of the chart, and the cross cylinder introduced parallel to the axis of the cylinder present. If cylinder is not present, then an arbitrary amount and position of the cylinder may be introduced (e.g., −0.50 × 180). In this manner, the presence, amount, and orientation of astigmatism may be measured in the right eye using the same procedure described in Chapter 18.

5. The next step after astigmatism determination is to blur or fog the characters to approximately the 20/40 level. This may be achieved by adding 0.75- or 1.00-D sphere more plus or less minus to the sphere power. From this point, power is decreased in 0.25-D steps until best or maximum visual acuity is attained.

6. Care should be taken to avoid overminising the patient by questioning him or her as to the improvement in clarity of the letters with each step in decreased power. It is important to monitor the patient concerning character size and clarity, since any decrease in clarity or size is likely to indicate the sphere power has been decreased too much. This same end point may be monitored by red–green balance, as opposed to visual acuity.

7. The same procedure is repeated for the left eye. Next each eye is blurred or fogged by +0.75 D or 1.00 D, and this amount reduced binocularly until best visual acuity is attained. A separate step for balancing sphere power is not necessary because the best procedure to ensure equal stimulus to accommodation is best visual acuity in each eye.

FIGURE 19-5. An example of a septum that can be hung over the upper edge of the viewing mirror to occlude the middle letter in a line of acuity letters. The figure on the left illustrates what the left eye sees, the middle figure shows what both eyes see, and the right figure illustrates what the right eye sees.
**Vectographic Technique**

The technique using the American Optical Vectographic slide involves changing the position of the slide.

1. With the slide in place, polarizing lenses must be placed in front of the patient's eyes, either by having them available in the lens well of the phoropter or by hanging analyzer lenses in front of the phoropter. Most contemporary phoropters have polarizing analyzers built in the phoropter.

2. The polarizing analyzers are oriented in a 45° to 135° axis orientation. In this manner the 45° axis is placed over the right eye and the 135° axis is placed over the left eye. With this orientation, the right eye sees those characters composed of crystals that are oriented along the 45° axis, and the left eye sees those oriented along the 135° axis. Remembering that the characters are polarized also, the right eye sees only those characters with polarization axis 45° and the left eye sees only those characters with polarization axis 135°. Those characters intended to be viewed with both eyes are not polarized. Therefore, the right eye cannot see the letters viewed by the left eye and vice versa.

3. With a portion of the top chart (right eye), refraction is performed on the right eye in the usual manner of axis and power determination of the astigmatism and appropriate sphere power. The procedure is then repeated for the left eye.

4. The slide also has charts containing the clock dial, binocular balance, binocular function (suppression), monocular and binocular acuity, fixation disparity, and stereopsis. The monocular and binocular acuity charts may also be used for refraction.

**Immediate Contrast Technique (Psychological Septum)**

1. A +0.75 D sphere, such as that found in a trial set, is placed before one eye and serves to inhibit foveal vision by blurring central vision.

2. The fellow eye may then be refracted in the usual manner.

**Clinical Implications**

**Clinical Significance**

The value of binocular refraction lies not so much in its being a procedure for routine refraction, but in its use for specific conditions. Foremost among these is hyperopic anisometropia or anisometropia, in which monocular refraction under binocular conditions encourages greater relaxation of accommodation and, thereby, allows the correction of a greater amount of hyperopia.

Binocular refraction may also be the procedure of choice for determining the appropriate spectacle correction for the management of latent hyperopia. This is particularly true in cases of intermittent latent hyperopia, in which accommodation is more likely to relax its tonic position.

Binocular refraction frequently allows sufficient plus power to be prescribed to relieve the patient's symptoms in a manner that makes adaptation to the spectacles relatively easy for the patient. Plus power may then be gradually increased over time until the entire refractive error has been optically compensated. This results in a more agreeable approach than having the patient suffer decreased vision while they adapt to spectacles.

One of the best features of binocular refraction is that it does not require a separate step for the balancing technique. In cases of unilaterial or unequal functional amblyopia, or physiological differences between best corrected visual acuity, or decreased vision as a result of ocular disease, balance is achieved when best visual acuity is measured in each eye. Possible errors are avoided by circumventing fogging procedures for biocular balancing, as conducted in monocular subjective refraction procedures.

Occasionally, the clinician encounters a patient with latent nystagmus in which, as one eye is covered, both eyes manifest a jerk-type nystagmus. As a result of the nystagmus, visual acuity is slightly decreased. Binocular refraction does not result in the occlusion of either eye and permits refraction without the annoyance and visual decrement induced by the nystagmus.

The same concept is involved in circumventing the effects of cyclo deviation on visual acuity in the presence of an astigmatic refractive error. In those rare cases for whom a physiologic cyclo phoria significantly changes the cylinder axis, thereby decreasing visual acuity, its effect may be negated by employing binocular refraction. A change in cylinder axis, in the presence of significant cylinder power, may also occur in a paretic cyclovertical extraocular muscle that produces 3° or more cyclo deviation. In these cases, since this procedure does not interrupt fusion, the cyclo deviation is not manifested.

**Clinical Interpretation**

In general, interpretation of the measurement of refractive error using the procedure of binocular refraction is straightforward. The usual clinical interpretation, particularly in the conditions listed in Table 19-2 is to prescribe the dioptric values measured under manifest conditions. Modification of the prescription may be made based on such usual considerations as age of the patient, refractive amount, and occupation, among others.

**REFERENCES**


* The polarizing analyzers must be oriented in the same axes as the target are to be visible. In theory this could be any axis as long as the orientation of the analyzers over each eye are 90° apart.