FACTORS INFLUENCING MEASUREMENT AND RESPONSE TO STRABISMUS SURGERY

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Thank you for attention

Testing Factors:

- The basic strabismus deviation is measured while fixation is maintained by the dominant eye, accommodation controlled, and all fusion-vergence eliminated under normal visual environmental conditions.
- To achieve this, the examiner must control fixation and accommodation and completely suspend fusion.
- To obtain accurate fixation, the patient must be using the fovea for fixation. Refractive errors should be corrected to maximize visual acuity in each eye.
- The underlying principle behind the use of a 20-ft testing distance (estimate used for infinity), wearing of the full hyperopic correction, and providing an accommodative target is to eliminate all influence of accommodation on strabismus measurement.
- In performing the alternate cover test, it is imperative that all fusional vergence mechanisms—divergence and convergence—be suspended while the effects of accommodation are controlled.
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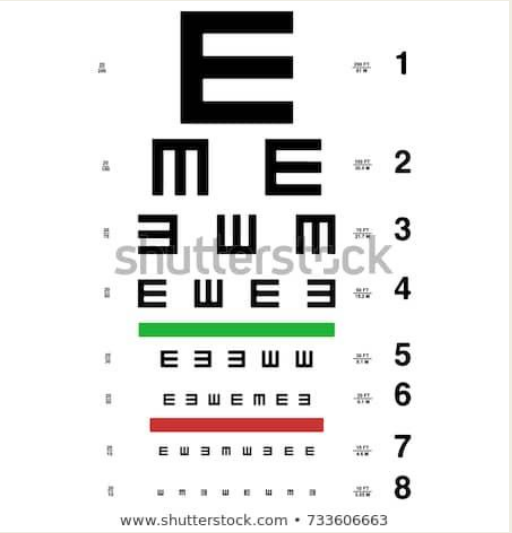
- TYPE OF TARGET FOR FIXATION:
- To ensure accurate fixation and eliminate accommodative effort, a target of regard with recognizable and resolvable contours should be presented.
- The target should have sufficient detail, sustain the patient's interest, and be larger than the patient's threshold acuity.
- For example, a patient with 20/50 Snellen acuity should be presented with a 20/70 letter as a fixation target.
- Deviations can vary by more than 3 PD in as many as 35% of esodeviations and 25% of exodeviations when measurements using accommodative and nonaccommodative targets are contrasted.
- The patient should wear the maximum hyperopic or least myopic spectacle correction so that no accommodative effort is required at the 20-ft testing distance.



DISTANCE BETWEEN PATIENT AND TARGET:

- The standard 20-ft test distance is designed to eliminate any meaningful accommodative effort, because only 0.13D of accommodation is required at this distance in the emmetropic patient.
- The distance at which the fixation target is placed contributes to the amount of deviation measured. Exodeviation was increased by 2 to 40 PD in 34 of 105 patients when the fixation target was moved from 100 to 20 ft.
- Esotropic patients with a high accommodative convergence/accommodation (AC/A) ratio often exhibited higher distance deviation in 10-ft lanes than in 20-ft lanes. The difference was often greater than 5 PD, which could affect the amount of surgery performed.

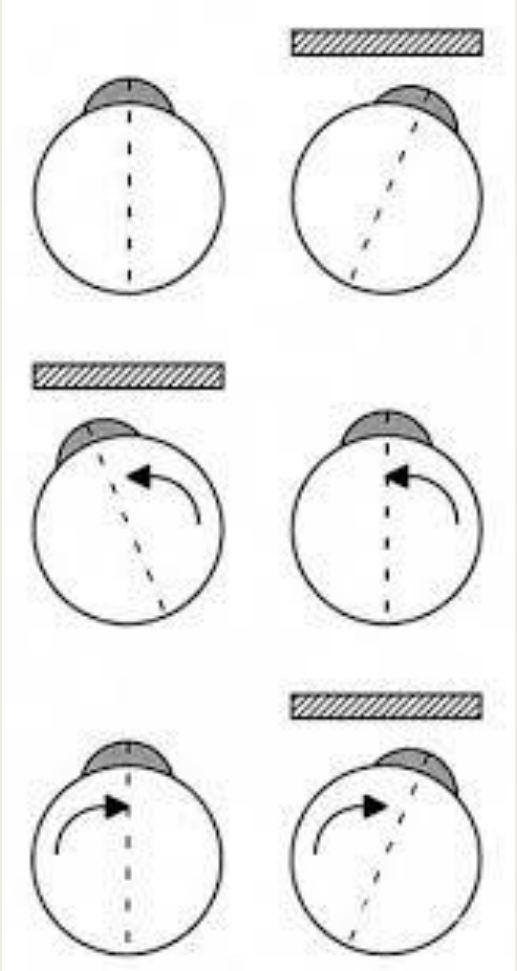
METHOD OF TESTING USED TO OBTAIN MEASUREMENTS:

- Alternate Cover Tests and Monocular Occlusion:
- The most effective ways to suspend fusion are the alternate cover test and prolonged monocular occlusion.
- The alternate prism cover test suspends fusional convergence and divergence, permitting measurement of the misalignment to within 1 PD.
- In performing the alternate cover test, the patient is never allowed to regain fusion while the cover is transferred from one eye to another.

TABLE 4-4. Objective Testing Procedures for Detection of Strabismus in Ascending Order of Sensitivity

Direct observation
Hirschberg test
Krimsky test
Four base-out prism test
Unilateral cover test
Brückner test

- Prolonged monocular occlusion was developed by Marlow" to uncover the full amount of heterophoria. This is needed to completely eliminate tenacious fusion in patients who have developed strong fusional vergence.
- Owing to the long duration of occlusion (3 to 7 days), the test is not practical. However, shorter periods of monocular occlusion such as 45 minutes have been effective, especially in patients with exotropia." ** The basic angle of deviation can increase by more than 5 PD after prolonged occlusion in patients with exotropia.



Angle Kappa:

- Angle kappa is the angle between the visual axis and the pupillary axis It is practically the same as angle alpha, which is the angle formed at the first nodal point by the intersection of the optic axis and the visual axis.
- Testing is performed monocularly under dim room illumination. The patient fixate to a penlight at a distance of approximately 50 cm.
- The examiner's sighting eye must be directly behind the light source. The position of the corneal light reflection in relation to the center of the pupil is observed and estimated.

- The magnitude of angle kappa (actually lambda) customarily is referred to in terms of millimeters rather than prism diopters (~) or degrees. Although the normally expected magnitude is from 0.25 mm positive (nasalward) to 0.5 mm positive, there is nothing abnormal about a larger or smaller angle kappa (even a negative, or temporalward, angle) provided the magnitude is the same for each eye.

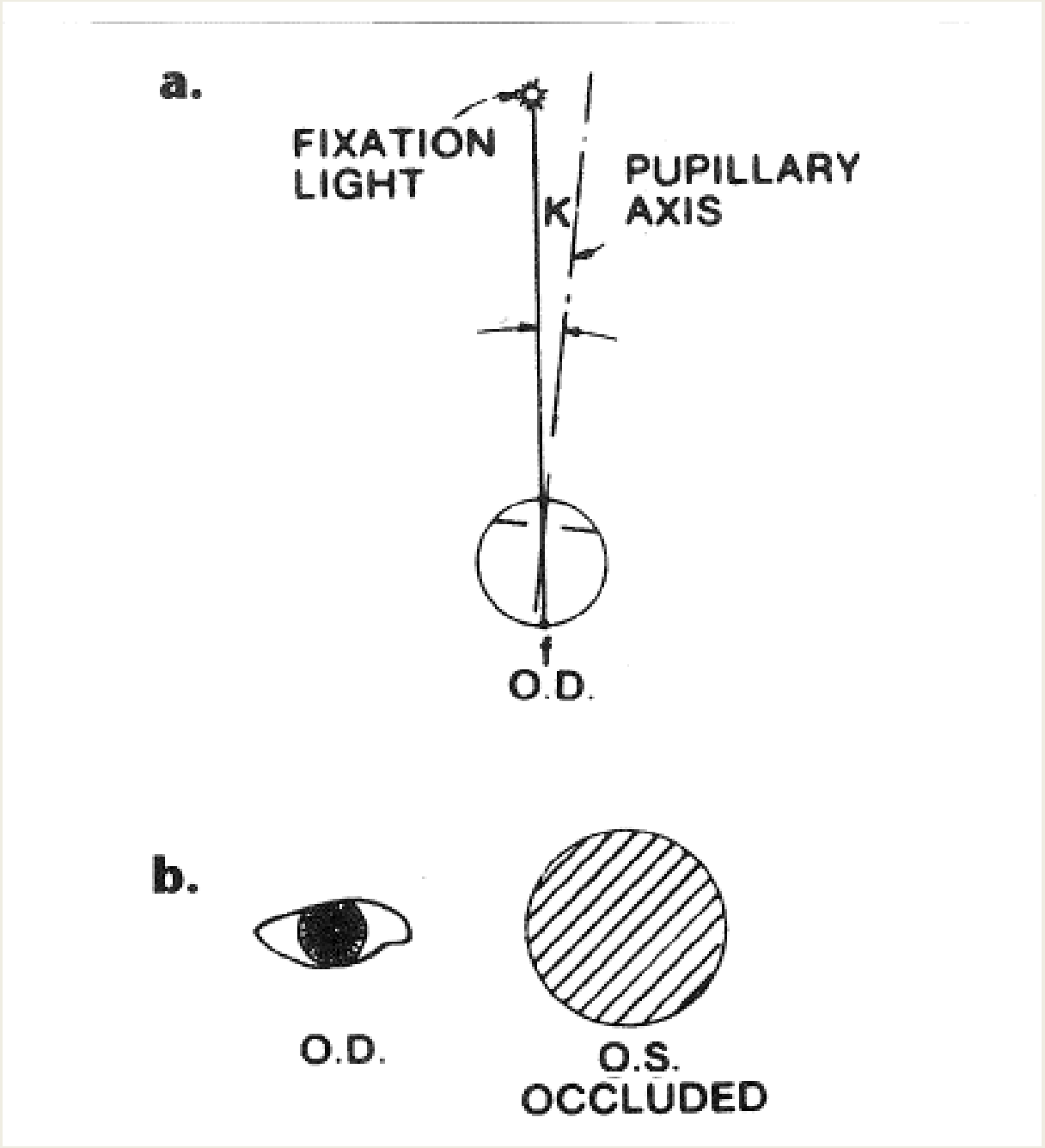
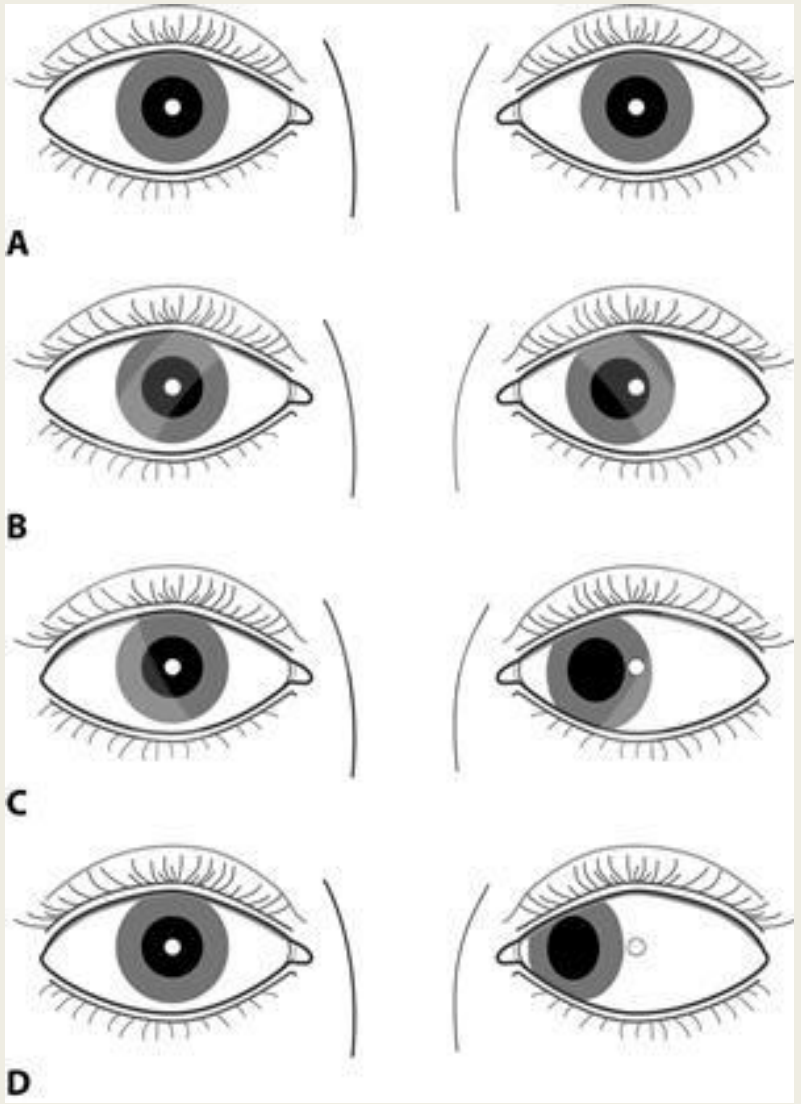


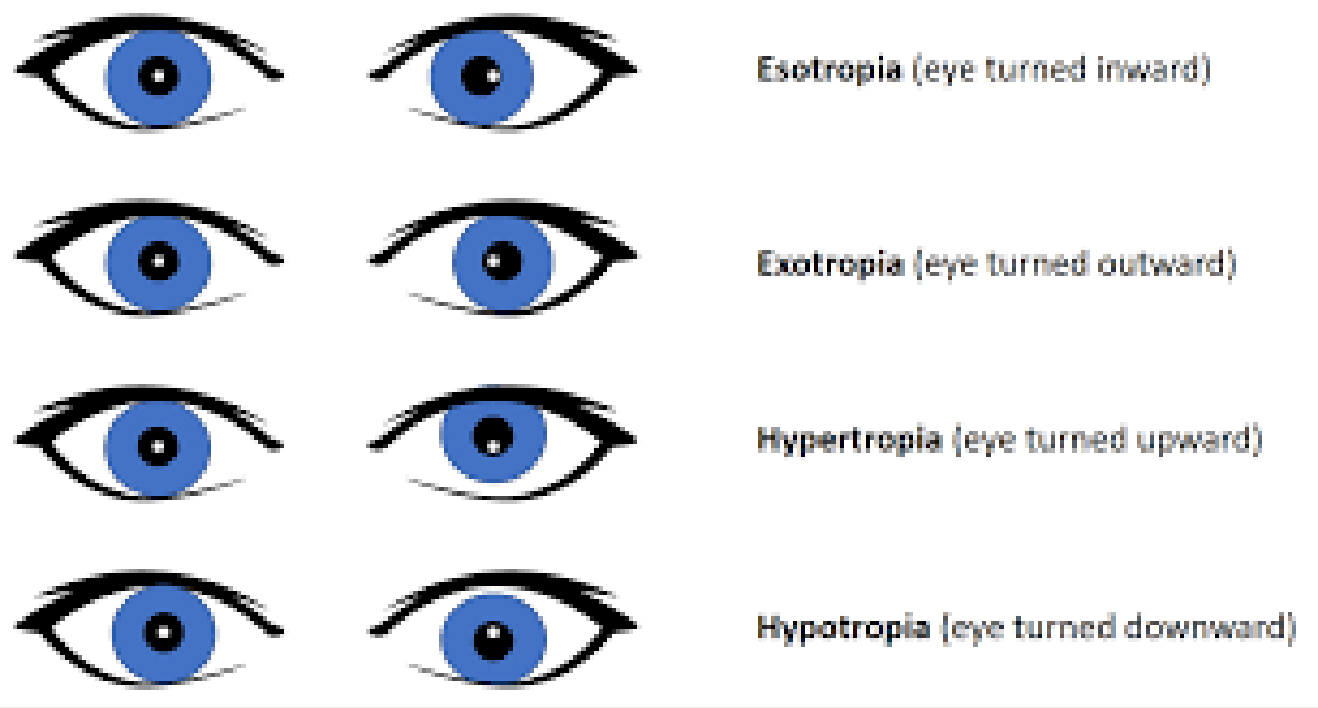
TABLE 4-17. Anatomic Factors in Strabismic Cosmesis

Favorable for Esotropia, Unfavorable for Exotropia	Favorable for Exotropia, Unfavorable for Esotropia
Positive angle kappa	Negative angle kappa
Narrow bridge of nose	Wide bridge of nose
Absence of epicanthus	Presence of epicanthus
Large interpupillary distance	Small interpupillary distance
Narrow face	Wide face

- Light Reflex Tests:
- Some patients are too immature to cooperate with alternate cover testing. The deviation then may be estimated using corneal reflex tests such as the Hirschberg" and Krimsky” methods.



- The Hirschbergtest is performed by directing a small light source,such as a penlight (Hirschberg used a candle flame), onto the patient's eyes. From behind the light, the examiner sights the eyes while the patient is fixating the light. The examiner's dominant eye for sighting is directly behind the light, preferably less than 10 cm from the light source. Hirschberg recommended approximately a30~cm distance between the light and the patient, although this may be increased to 1 m and still maintain accuracy. We recommend a range between 0.5 and 1.0 m for clinically measuring an angle of strabismus.



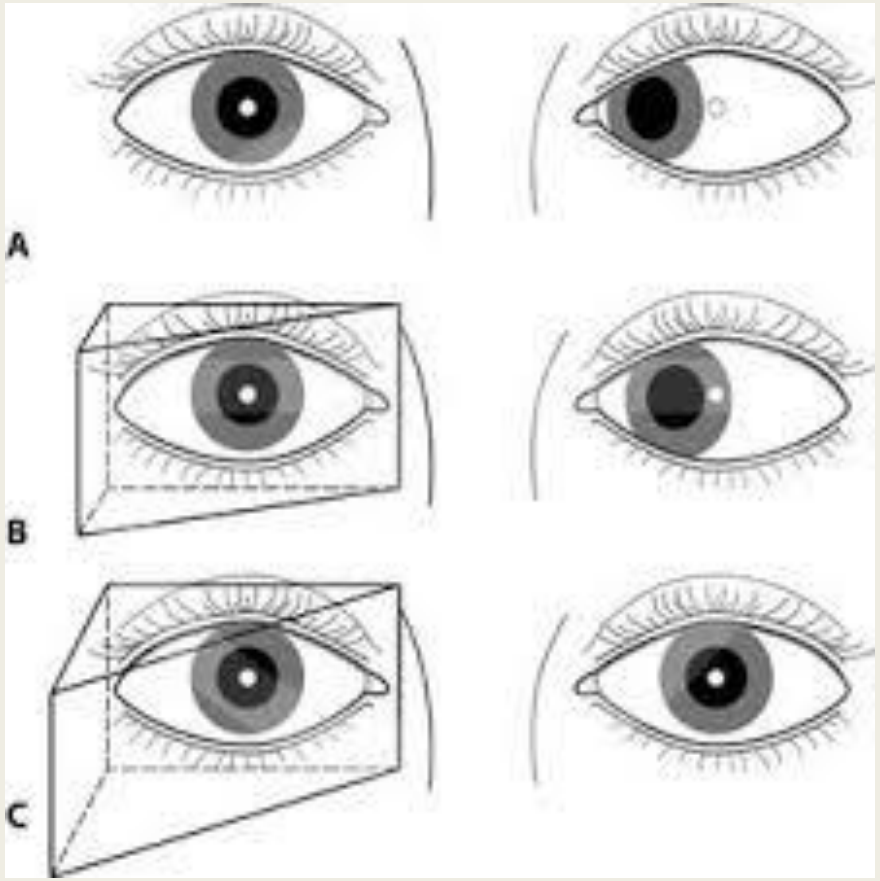
- Hirschberg found that each millimeter of decentration of the corneal reflex corresponds to 7 degrees of deviation of the visual axis. Whereas the true relationship between degrees and prism diopters is trigonometric, for angles less than 100 PD, every 2 PD is approximately equal to 1 degree. Later studies using photographic calibration established a conversion factor of 21 PD/mm of displacement.
- The sensitivit of the Hirschberg test is limited to approximately:5prism for horizontal deviations.
- A convenient clinical ratio is 20 Δ/mm, which means that a relative displacement of 0.25 mm of the corneal reflex on the deviating eye represents 5prism.

Krimsky Test:

- The Krimsky test has slightly more sensitivity than the Hirschberg test, yet it is similar, with one exception: Prisms are used to reposition the corneal light reflex of the deviating eye to the same relative location as the reflex on the fixating eye. The magnitude of the prism necessary to accomplish this is the measurement of the angle of strabismus.
- A confounding factor in the Krimsky test is the possibility

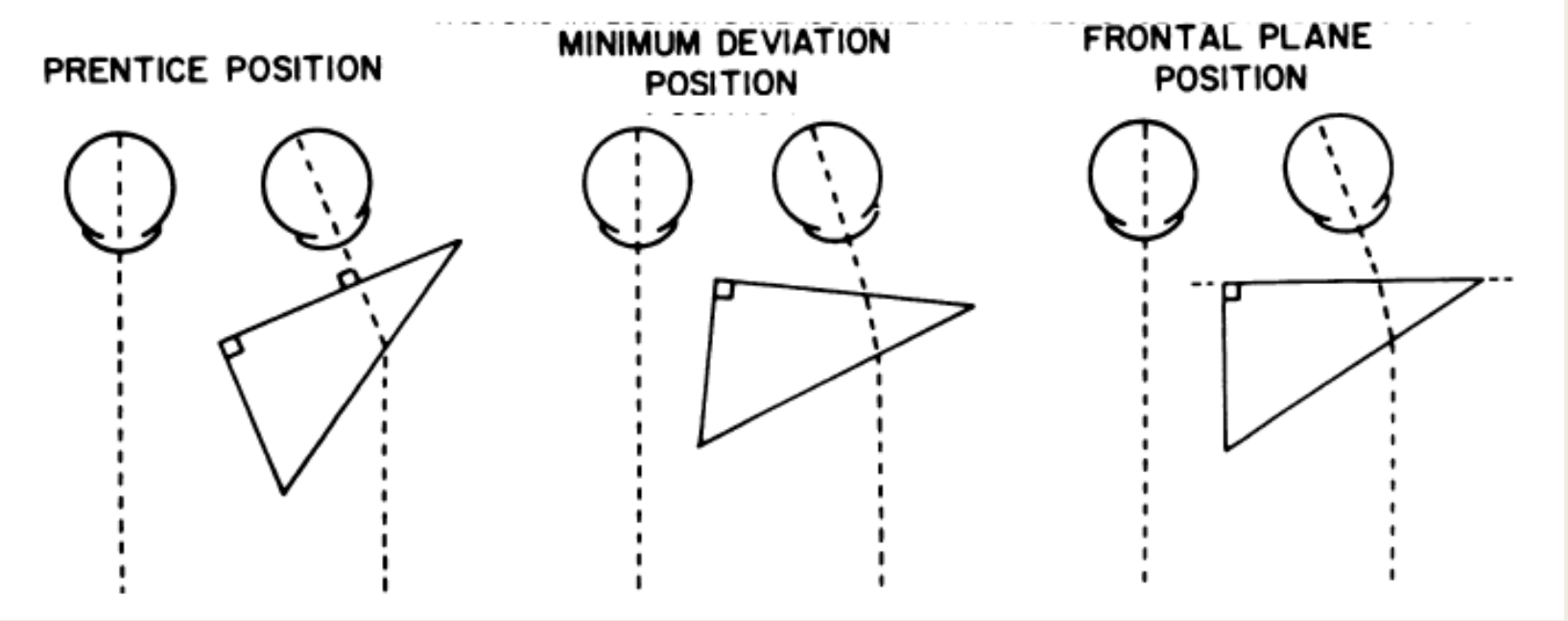
of prism adaptation. Therefore, the testing time must

be brief, 2-3 seconds at most



PRISM PLACEMENT:

- Errors in quantitative measurements of strabismus can also be induced by improperly placing prisms while measuring the deviation.
- When deviations exceed the amount of the largest available prisms, the examiner should not stack prisms. Light rays cross the interface between the two prisms at a much greater angle than the calibrated angle of incidence, producing a deviation larger than the sum of the labels of the stacked prisms.

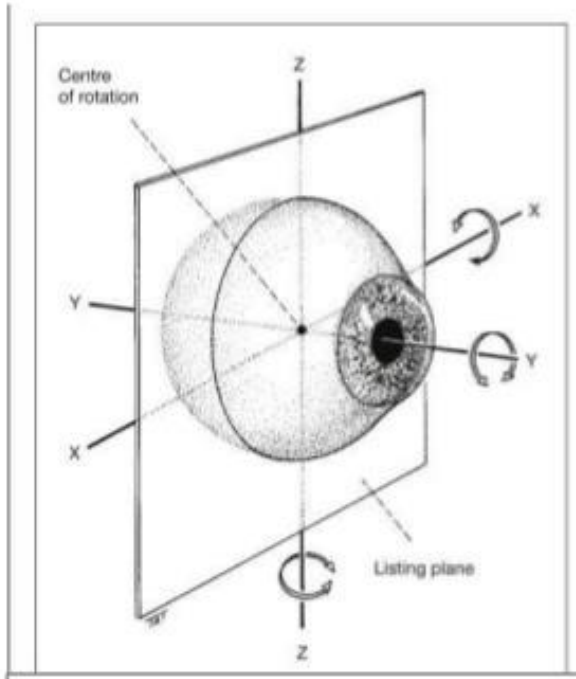


TORSIONAL DEVIATION:

- The axes of Fick remind us that the eyes rotate in the vertical, horizontal, and torsional planes. Prisms are unable to correct misalignments around the torsional y-axis.

FICK'S AXES

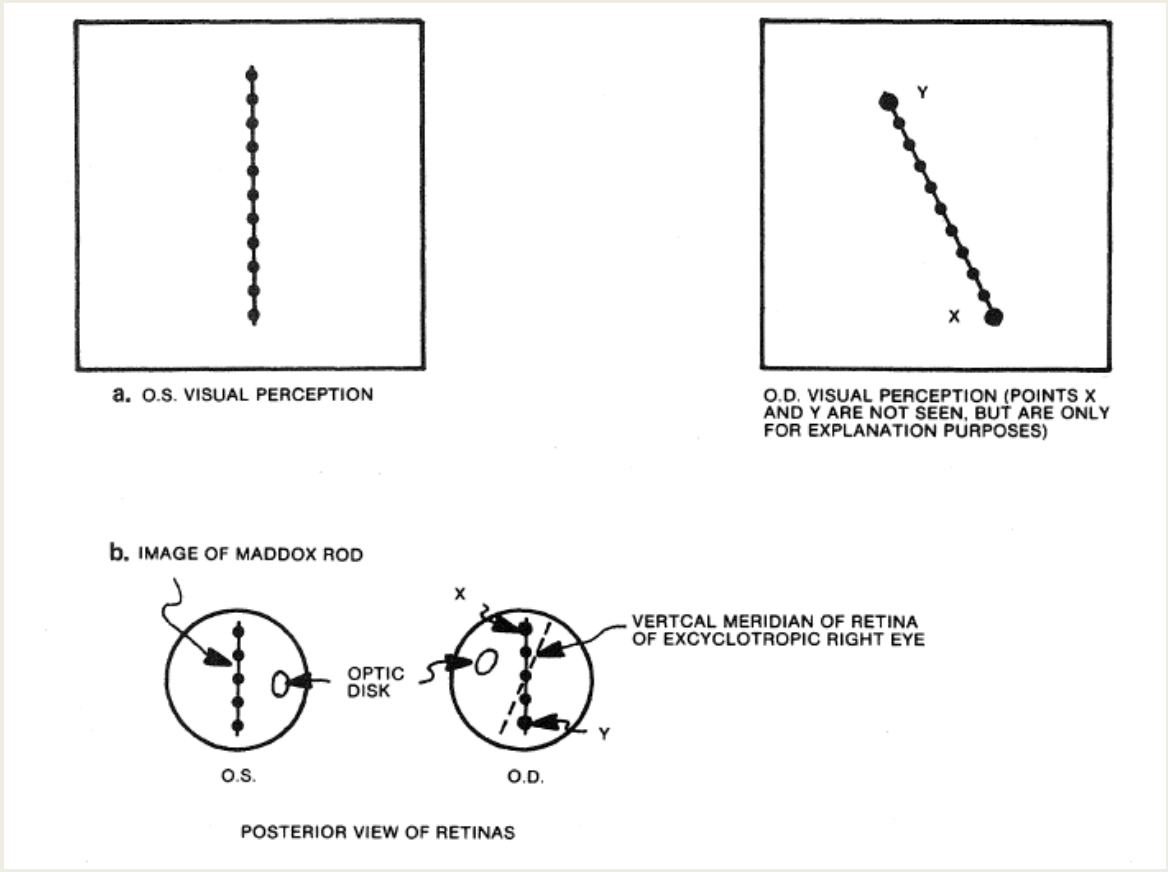
- X (horizontal) axis
  - Lies horizontally when head is upright
  - Elevation / Depression
- Y (antero-posterior) axis
  - Torsional movements
  - Extorsion / Intorsion
- Z (vertical axis)
  - Adduction / Abduction



- Torsional alignment can be assessed using both subjective and objective techniques. Commonly used subjective measurement methods include the Maddox rod and Bagolini striated lenses.
- The synoptophore can neutralize the deviation in all three dimensions.
- Patients who demonstrate preoperative fusion after neutralization of torsion will benefit from surgical correction of the torsional imbalance.

Maddox rod:

- Cyclo deviations require the use of a Maddox rod for each eye. If a Maddox rod is placed before the right eye with its axis at 180 degrees and another Maddox rod with its axis at 180 degrees is placed before the left eye, two vertical streaks may be seen (assumIng a horizontal deviation is also present to prevent the superimposition of the two vertical streaks).



AC/A RATIO:

- The AC/A ratio refers to the amount of accommodative convergence exerted per unit of accommodation. It may be measured clinically with the gradient method or the heterophoria method. The heterophoria method is defined by the equation:

$$\frac{AC}{A} = IPD + \frac{\Delta N - \Delta D}{D}$$

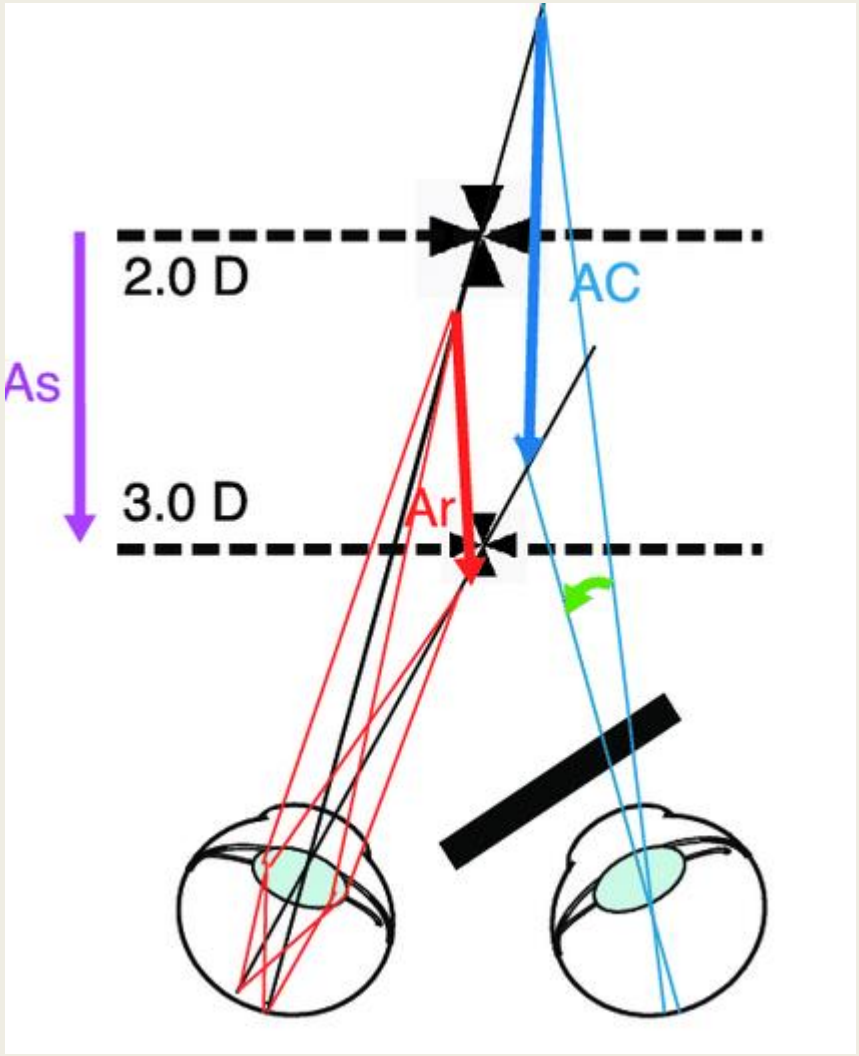
- The gradient method uses concave lenses at 6 m (20ft) or convex lenses at 33 cm. Lenses are inserted in trial frames in strengths up to 3 D. As soon as the test target is seen, the alternate prism cover test is repeated. The ratio is calculated using the formula:

$$\frac{AC}{A} \equiv \frac{(\Delta + L) - (\Delta - L)}{D}$$

- The heterophoria method can result in a falsely elevated AC/A ratio owing to convergence at near and is dependent on the IPD.
- Clinically, the gradient Ac/A ratio is most often determined at near by using a phoropter. The nearpoint heterophoria is measured subjectively by either the von Graefe method or Maddox rod. Spheres of + 1 .00 D are added, and the heterophoria is remeasured.
- The magnitude change of the angle of deviation indicates the gradient. Greater precision is gained by using + 1.00-D, then -1.00- D added lenses to evaluate the amount of deviation change. If there is a large depth of focus, either +1.00 D or -1.00 D may be an insufficient stimulus to elicit a sufficient accommodative response. In such cases, larger increments of lens power might be required.
- The gradient method will usually give a lower AC/A ratio than will the near-far calculation method.
- A gradient value of more than 5/1 is considered high. The depth of focus causes the reduced AC/A magnitude, particularly if low-powered lens additions are used.

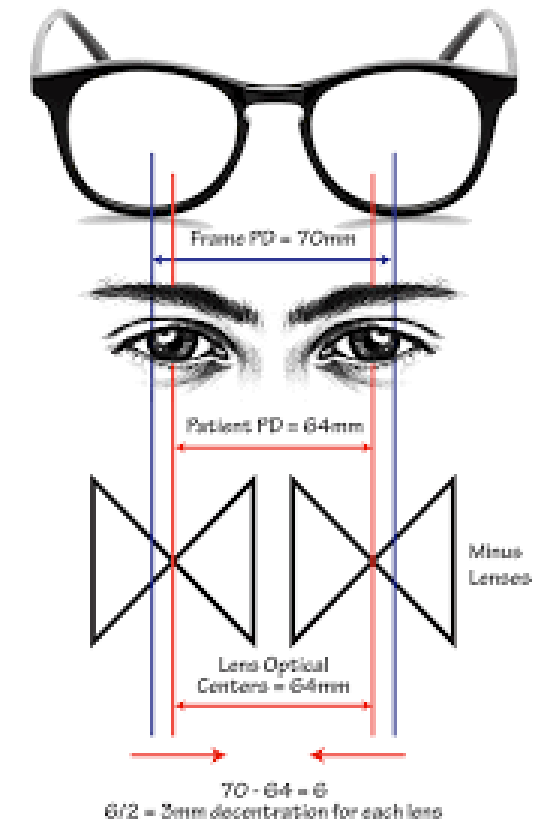
- The calculation method usually yields a higher value, because proximal convergence is a factor when fixation is shifted from far to near.
- Both methods are useful, however. In general, the calculated AC/A ratio is more reliable than the gradient method, but the gradient value may be more useful for prognosis, because it directly shows the effect of added lenses on the angle of deviation.

- Added lenses often are used in vision therapy to change the magnitude of deviation, in cases of both phoria and strabismus. For example, in cases of esotropia, it is often useful to measure the Ac/A ratio in children by the gradient method using large lens changes such as +3.00 D and -3.00 D to observe the effect of added lenses on the angle of strabismus at near.



HIGH REFRACTIVE ERRORS:

- The peripheral prismatic effects of corrective spectacles introduce an artifact when measuring strabismus." Plus lenses decrease, whereas minus lenses increase, the measured deviation.
- This effect is clinically significant with corrective lenses of more than 5.00 D.
- This artifact from the peripheral lens of spectacles may also be reduced by using lenses in trial frames and moving them until they are centered in front of the visual axis of the deviating eye."



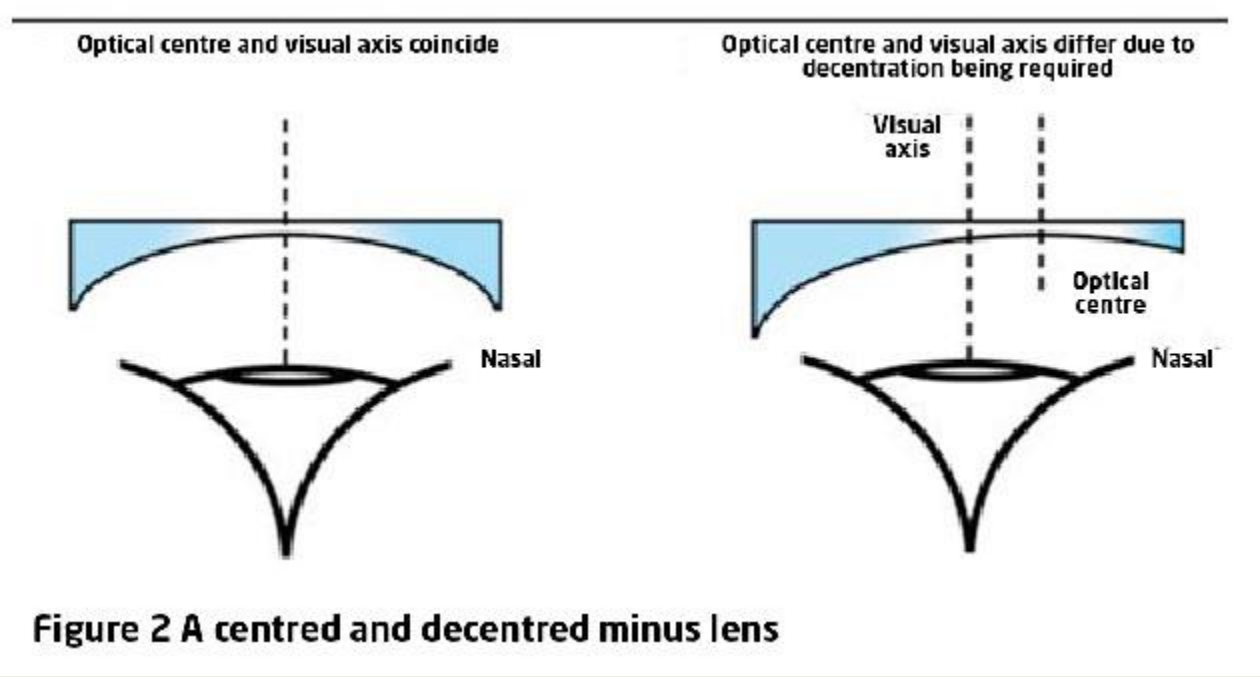
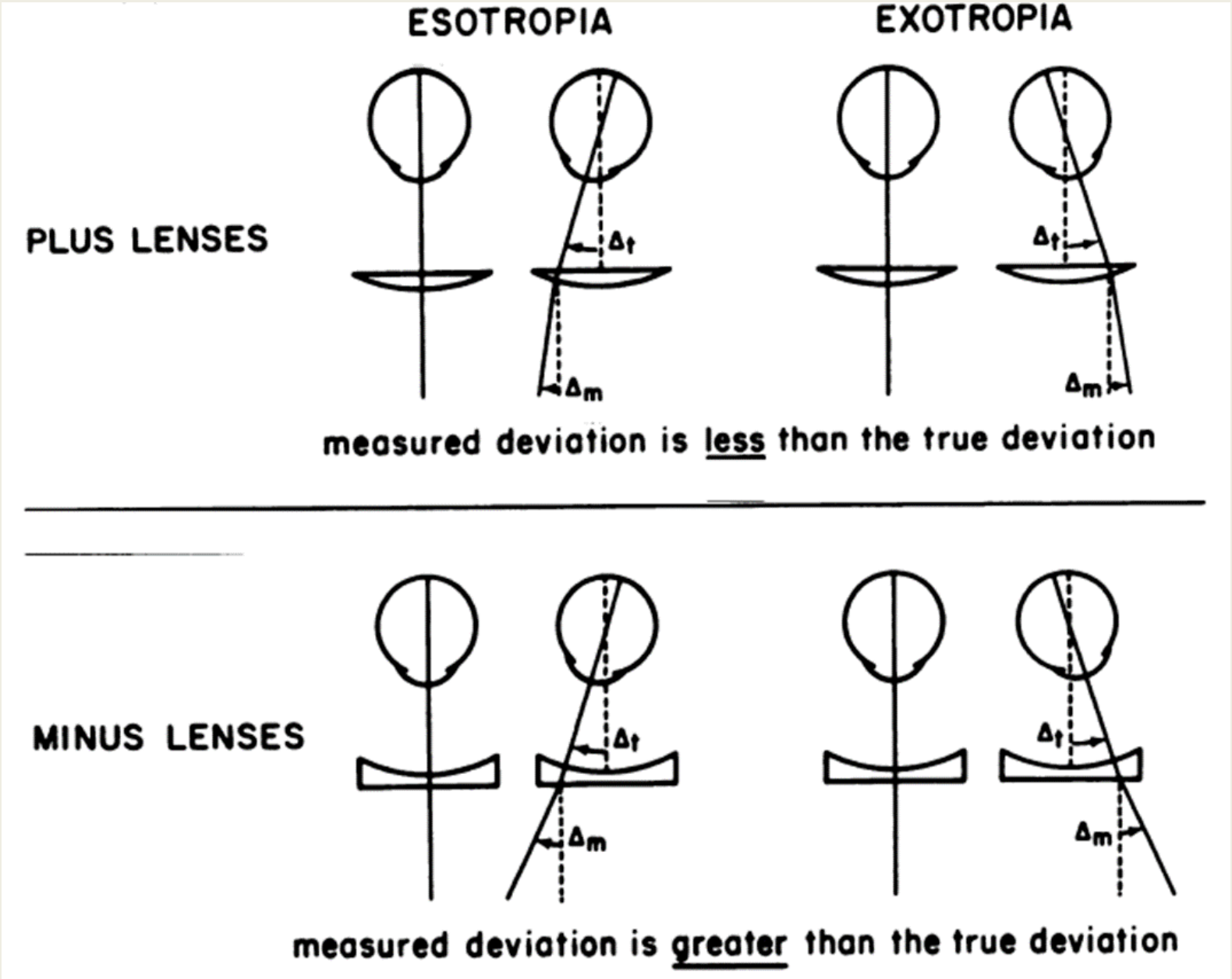
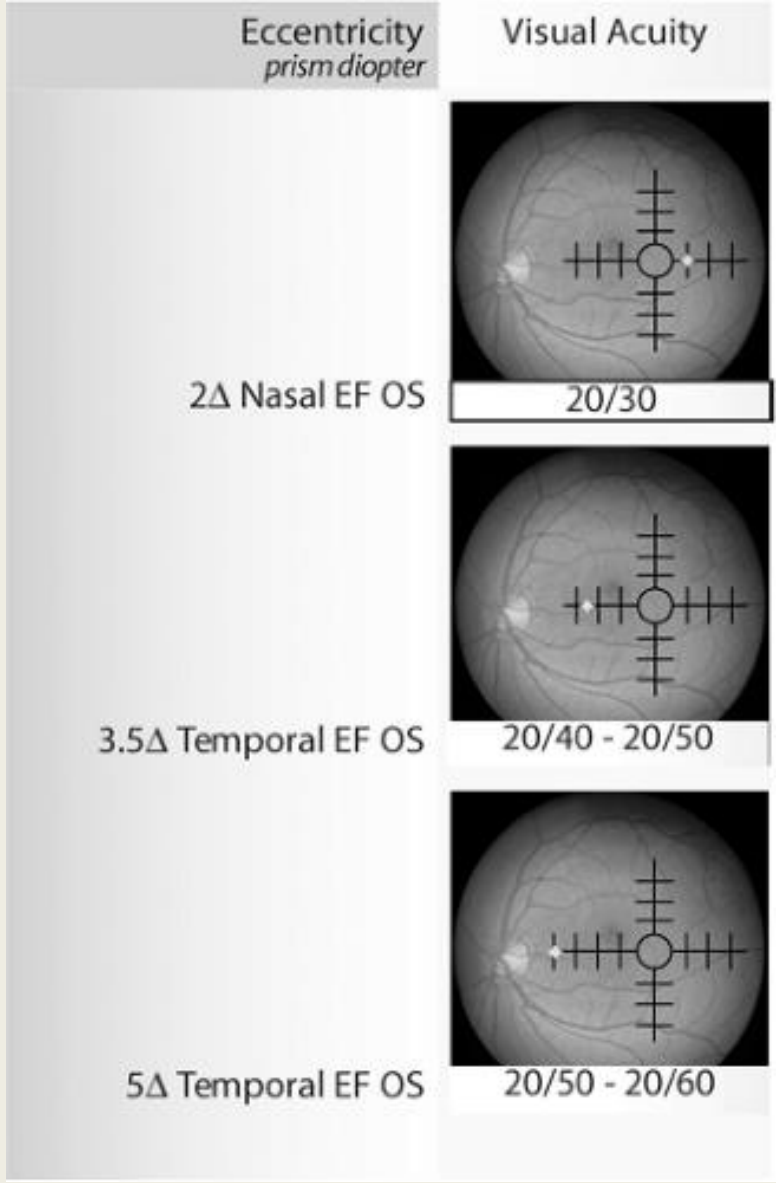


Figure 2 A centred and decentred minus lens


ESOTROPIA
EXOTROPIA
PLUS LENSES
Δt
Δm
Δt
Δm
measured deviation is less than the true deviation
MINUS LENSES
Δt
Δm
Δt
Δm
measured deviation is greater than the true deviation

ECCENTRIC FIXATION:

- For patients suffering from reduced visual acuity due to amblyopia or abnormalities of the fovea, precise fixation is unobtainable.
- The results of tests that require fixation by an eccentrically fixing eye such as the cover test and alternate cover test will underestimate or overestimate the true strabismic angle by an amount equal to the magnitude of eccentricfixation.
- To screen for the contaminating effect of eccentric fixation, one should search for eccentric fixation using the direct ophthalmoscope's calibrated reticular target in all patients with decreased acuity, poor or imprecise fixation, or an abnormal angle kappa. For example, a patient with 10 PD of left esotropia on cover testing with 5 PD of nasal eccentric fixation will note relief of diplopia when the surgical target angle is 5 PD of exotropia on alternate cover testing. This patient will benefit from surgery that aims to correct 15 PD of esodeviation.



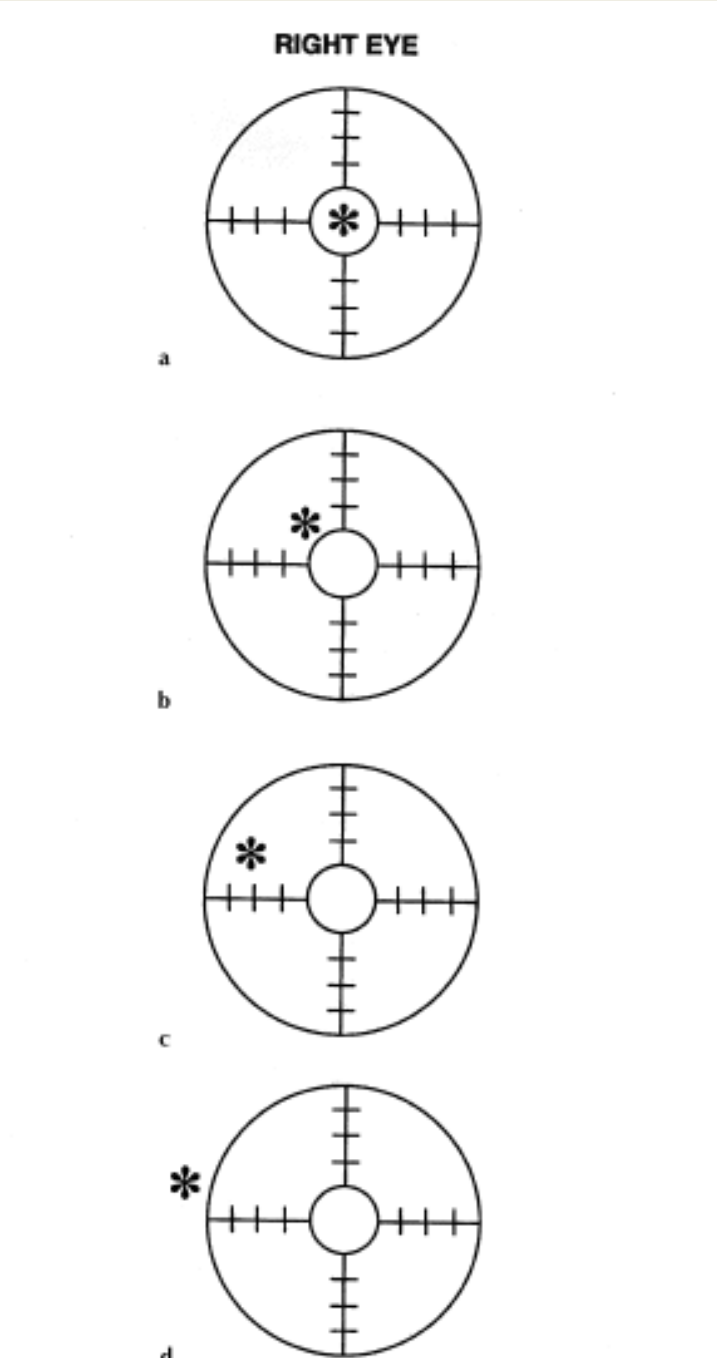


TABLE 5-6. Classification of Centricity of Fixation

Central fixation	Foveal
Eccentric fixation (EF)	Parafoveal (between fovea and 2 degrees EF)
	Macular (2–5 degrees EF)
	Peripheral (beyond 5 degrees EF)

TABLE 4-5. Effects of Eccentric Fixation on Measurement Results of the Cover Test

Direction of Deviation	Nasal Eccentric Fixation	Temporal Eccentric Fixation
Eso	Smaller measurement	Larger measurement
Exo	Larger measurement	Smaller measurement

NEUROLOGIC OR ORBITAL DISEASE:

- Neurologic or orbital disorders may result in variable strabismus deviations. They include cerebral palsy, myasthenia gravis, and thyroid orbitopathy.
- here is a higher than normal frequency of strabismus in patients with cerebral palsy, ranging from 15% to 62%.
- Developmentally delayed children have an increased effect from the same amount of surgery than do normal children."
- Bilateral medial rectus recession for esotropia resulted in satisfactory alignment in only 39% of developmentally delayed children, compared with 73% of normal children after a mean follow-up of 24 months.
- Dyskinetic or variable strabismus is seen in 30% of strabismic patients with cerebral palsy.
- While fixating on an accommodative target, the child may exhibit esotropia, followed by orthotropia, and then exotropia. These variable angles are accompanied by slow tonic vergence movements. This type of strabismus does not usually evolve to a more constant deviation over time. Patients with dyskinetic strabismus are not appropriate candidates for surgical correction.

CHILDHOOD STRABISMUS:

- Restoring normality in a child with strabismus means attaining orthotropia, asymptomatic heterophoria in all positions of gaze, bifoveal fixation, normal stereoacuity, and normal motor fusion.” Unfortunately, there are some types of strabismus that preclude the development of bifoveal fixation after strabismus surgery. Except for anecdotal case reports, the goal of restoring bifoveal fixation in children with infantile esotropia has proved elusive.” A subnormal degree of binocularity can nonetheless be obtained in the majority of patients with infantile esotropia.” Fortunately, children with acquired esotropia or intermittent exotropia have the potential to completely regain bifoveal fixation.

ANATOMIC FACTORS
Axial Length and Globe Size:

- The smaller size of neonatal eyes has been invoked as an explanation for poor predictability of surgical results in these cases." Most ocular growth occurs in the postequatorial sclera, half of it during the first 6 months of life. Although the distance from the insertions of the extraocular muscles to the limbus is 80% of that in adults, the insertions are closer to the equator.
- Three- to 4-mm recession of the horizontal rectus muscles may place the muscles posterior to the equator in a patient younger than 6 months.
- Axial length measurements correlate closely with the surgical dose-response relation." * Larger eyes have a lesser response to the same amount of surgery than do smaller eyes.
- This correlation, however, was regarded as not clinically important because of the much stronger influence of preoperative deviation.

- The clinical responses of esotropic patients who had recession of both medial rectus muscles posterior to the equator were analyzed.”

- Three of 28 patients developed consecutive exotropia and underaction of the medial rectus muscles. In all 3 the medial rectus muscles were recessed more than 1.5 mm posterior to the equator.
- All these estimates are arc measurements from the limbus. A curved ruler" or a piece of suture should be used instead of a caliper to determine arc distances.
- Mismatch between the curvature of the curved ruler and the curvature of the globe is a potentially important source of measurement error as well." The curved ruler should directly overlay the sclera to allow precise measurement of arc length.

Table 5–4. Estimated Location of the Equator Underneath the Medial Rectus Muscle Based on Axial Length and Corneal Diameter

Axial Length (mm)*	Corneal Diameter (mm)*				
	10.00	*10.50*	*11.00*	*11.50*	*12.00*
17.00	8.60	8.27	7.92	7.55	7.16
17.50	8.98	8.64	8.29	7.92	7.53
18.00	9.35	9.01	8.55	8.29	7.91
18.50	9.73	9.39	9.03	8.66	8.28
19.00	10.11	9.76	9.41	9.04	8.65
19.50	10.48	10.14	9.78	9.41	9.02
20.00	10.86	10.51	10.16	9.78	9.39
20.50	11.24	10.89	10.53	10.16	9.77
21.00	11.62	11.27	10.91	10.53	10.14
21.50	11.99	11.65	11.28	10.91	10.51
22.00	12.37	12.02	11.66	11.28	10.89
22.50	12.75	12.40	12.04	11.66	11.26
23.00	13.13	12.78	12.42	12.04	11.64
23.50	13.51	13.16	12.79	12.41	12.02
24.00	13.89	13.54	13.17	12.79	12.39
24.50	14.28	13.92	13.55	13.17	12.77
25.00	14.66	14.30	13.93	13.55	13.15
25.50	15.04	14.68	14.31	13.93	13.42
26.00	15.42	15.06	14.69	14.31	13.90

Muscle Length-Tension Properties:

Surgical Factors:

- . **Timing** :
- Patients who achieve satisfactory alignment before age 2 years have a better binocular outcome than those whose eyes are aligned after this time.”
- It should be noted, however, that even adults with infantile esotropia who have never undergone previous surgical correction can develop subnormal binocularity after surgery.
- In patients with accommodative esotropia, a positive correlation was found between the development of normal binocularity and prompt correction of strabismus soon after its onset.
- Surgery should not be delayed in a child or adult who is medically stable and has a reproducible angle of deviation.

Artifacts Introduced in Surgery:

- Many surgeons measure the distance of the anterior aspect of the insertion before disinserting the muscle from the globe. The muscle can then be recessed a predetermined amount posterior to the original site of the insertion before anterior displacement (by measuring recession from the limbus). Surgeons may also inadvertently distort the insertion site by applying traction on the globe during suture placement.This produces a V-shaped deformity, which results in anterior displacement of the insertion.
- If the amount of recession is measured from the anteriorly displaced V deformity, less recession will be performed than was planned. Sutures should be placed no more than a millimeter from the end of the insertion. Placing the sutures too far posterior will impose a resection effect on a recessed muscle.