113 Diplopia

ROBERT H. SPECTOR

Definition

The law of projection of images establishes that an object forming its image on any point in the retina is projected to a point in space directly opposite. When a distant object is viewed with both eyes, the visual axes—a line connecting the center of the cornea with the fovea—are parallel or almost so, and each fovea receives an image of the object.

Binocular single vision, defined as the coordinated use of both eyes to produce a single mental impression, occurs when each eye has intact foveal function and synergistic action of yoked extraocular muscles. Conjugate gaze to the right, for example, depends upon simultaneous and equal innervation to the right lateral rectus and left medial rectus muscles. Gaze up and to the right is accomplished by similar innervational activity to the right superior rectus and left inferior oblique muscles. These pairs of eye muscles yoke or move the eyes conjugately. If one of the two yoke muscles lags behind the other or does not move the eye at all, images do not fall on corresponding retinal points, retinal correspondence is absent, the images become disparate, and diplopia results. Thus, double vision represents a situation in which retinal images cannot be fused because disparate points in the retina have been simultaneously stimulated.

Technique

Several questions can help the examiner accurately localize the weak eye muscle in a patient who complains of double vision. The first question functionally differentiates whether the paretic muscle acts predominantly in a horizontal or vertical plane: Are the two images side by side or on top of each other? A side-by-side separation betrays the presence of lateral or medial rectus dysfunction, while vertical diplopia implicates a vertically acting eye muscle.

Second, determine whether double vision is worse in gaze to the right, left, up, or down. A horizontal separation of images that becomes worse in left gaze implies paresis either of the left lateral rectus or right medial rectus muscle, since double vision is always worse in the field of action of the weakened muscle. Third, ask whether double vision is worse at near or distance. Horizontal diplopia, worse in left gaze and with distance fixation, suggests limitation of left lateral rectus movement. If the horizontal diplopia had been worse at near (e.g., while reading), the right medial rectus would be culpable since a near-vision task like reading requires convergence and active medial rectus contraction. A vertical separation of images at near, down, and to the right suggests left superior oblique paresis. By meticulous history taking and by asking just the few pertinent questions related to the disposition of double images in various positions of gaze, the examiner can gain a wealth of information before the actual evaluation of eye movements.

Furthermore, observe the position of the patient's head, face, and chin, since many forms of diplopia may be totally eliminated by a compensatory head posture. If the right lateral rectus is paralyzed, turning the head to the right produces lateral rotation of the eyes to the left when ocular fixation is maintained. Since the right eye is taken out of the field of action of the paretic right lateral rectus muscle, single vision is achieved. *Face turning* to the right or left helps reduce horizontal separation of images. *Face rotation* up or down is used to correct vertical separation of images. The patient rotates the face in the direction of the maximum pull of the muscle, so the eyes deviate in the opposite direction and are therefore out of the field of action of the paretic muscle. Thus, in right superior rectus palsy (the superior rectus acts primarily to elevate the eye in abduction), the face turns up and to the right. This throws the eyes to a relatively down and to the left position, away from the field of action of the right superior rectus.

Head tilting lessens the torsional component of diplopia. Superior oblique muscle weakness, for instance, produces diplopia with two images separated vertically. The false image will also be angulated. Because the superior oblique is a strong intorter, muscle weakness will cause the affected eye to be relatively extorted; thus, the projected image from that eye is intorted relative to the image of the opposite eye. If a patient with a weak right superior oblique muscle looks at a straight horizontal line, the false image from the right eye is not only below the true image but is also bent, right side tilted up. To correct the vertical separation of images, the patient rotates the face downward, and to correct the torsional component the patient tilts the head to the left shoulder. This evokes right eye extorsion, a movement not dependent on the right superior oblique. Such patients will enter the office with their heads tilted away from the weakened superior oblique, a sign that has strong localizing value in the evaluation of vertical diplopia.

Monocular diplopia is never related to a neurologic disturbance of ocular motility. The examiner should look for early cataractous changes, corneal opacities, severe astigmatic errors, or dislocation of the lens. It is usually described on a psychogenic basis when no cause can be determined.

Basic Science

Each eye is moved by six extraocular muscles: four rectus muscles (superior, inferior, lateral, medial) and two oblique muscles (superior, inferior). The primary muscles that move the eye horizontally are the medial and lateral recti. The lateral rectus muscle runs from the apex of the orbit to the lateral side of the orbit and abducts the globe. The medial rectus inserts on the opposite side of the eye; its principal action is adduction (Figure 113.1).

The superior rectus muscle runs from the apex of the

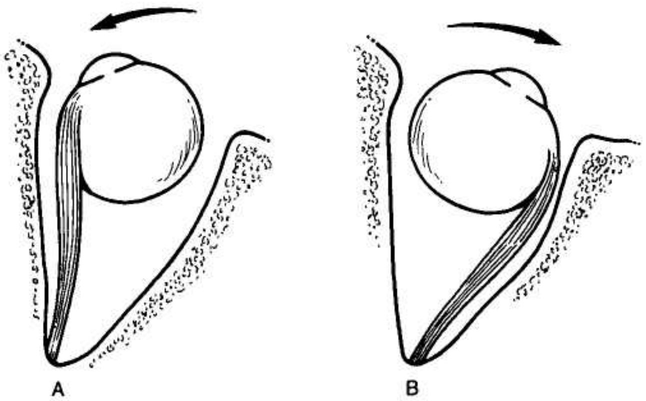

Figure 113.1
(A) Contraction of left medial rectus adducts globe or moves it medially. *(B)* Lateral rectus abducts globe.

orbit anteriorly and temporally and inserts in the eye 8 mm behind the *upper* limbus (Figure 113.2). When the eye is in primary position, the muscle plane of the superior rectus forms an angle of 23 degrees with the visual axis. If the eye is abducted 23 degrees, such that the superior rectus fibers are parallel to the visual axis, the superior rectus elevates the globe. If the anterior pole of the eye is abducted, such that the visual axis of the eye stands more or less perpendicular to the insertion of the superior rectus, the superior rectus adducts and intorts the globe. Intorsion is an inwardly rotation of the eye around the longitudinal axis. The inferior rectus muscle runs from the orbital apex, under the globe, anteriorly and temporally, parallel to the superior rectus muscle and inserts about 6 mm behind the *lower* limbus. The relationship between the muscle plane and visual axis is identical to that of the superior rectus. In abduction, the inferior rectus depresses the globe; secondary actions include excyclotorsion and adduction.

The superior oblique muscle also originates at the orbital apex (Figure 113.3), but it runs medially and anteriorly where its tendon inserts into the pulley of the trochlea. The tendon then courses posteriorly and temporally and forms an angle of about 54 degrees with the visual axis, to insert in the posterior part of the upper surface of the eye. If the visual axis is parallel to the direction of the pulling tendon, that is, in the maximal adduction (approximately 50 degrees), the superior oblique depresses the globe by elevating the posterior pole of the eye. When the eye is in primary position, the principal action of the superior oblique is one of incyclotorsion whereas abduction is a secondary action. The inferior oblique originates in the anteromedial part of the orbital floor. It runs parallel to the tendon of the superior oblique, but under the globe, to insert in the posterior, inferior, and lateral surface of the eye. When the eye is adducted, the inferior oblique pulls down the posterior pole, thus elevating the cornea. In primary position, secondary actions include excycloorsion and abduction.

Therefore, four muscles move the eye in a vertical direction. When the eye is adducted, the inferior oblique moves the eye upward, the superior oblique moves it downward; with the eye in abduction, the superior rectus functions as an elevator, the inferior rectus as a depressor. All other positions of gaze—straight up or straight down and oblique movements of the globe—result from simultaneous action of two or more eye muscles.

Besides horizontal and vertical eye movement, the globes rotate around the longitudinal axis: the two "superiors" (superior rectus and superior oblique) are inward rotators or intorters; the two "inferiors" (inferior rectus and inferior oblique) are outward rotators or extorters. These actions become important during normal vestibular eye movement,

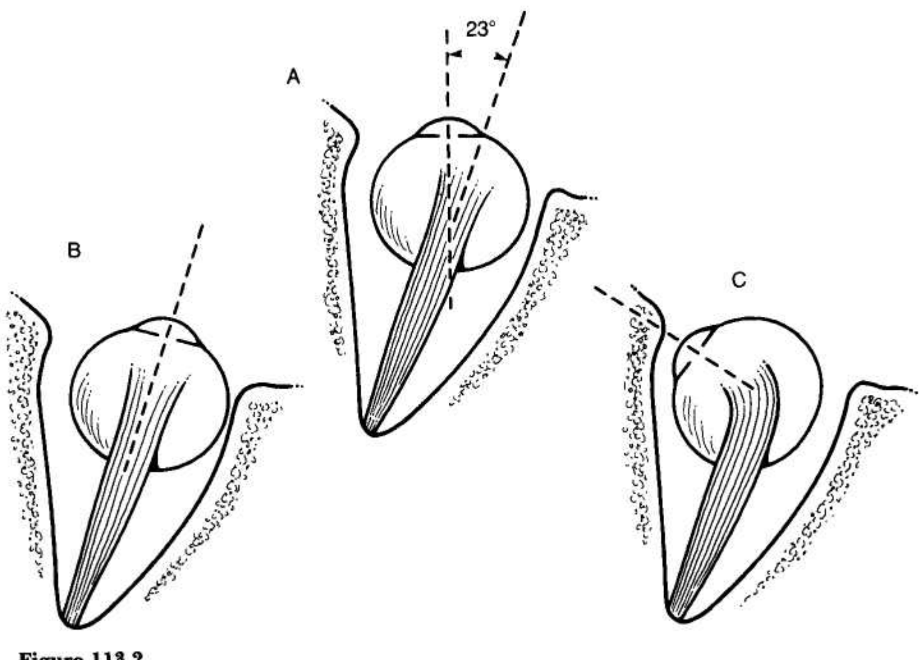

Figure 113.2
The superior and inferior recti form a plane that is vertical to the floor of the orbit. This plane makes an average angle of 23 degrees with the anteroposterior axis of the head (or the medial wall of the orbit). In the primary position of gaze (Figure 2A), the superior rectus intorts and elevates the globe; with the eye rotated outward 23 degrees, the SR is a pure elevator (Figure 2B). In full adduction, the SR becomes a pure intorter (Figure 2C).

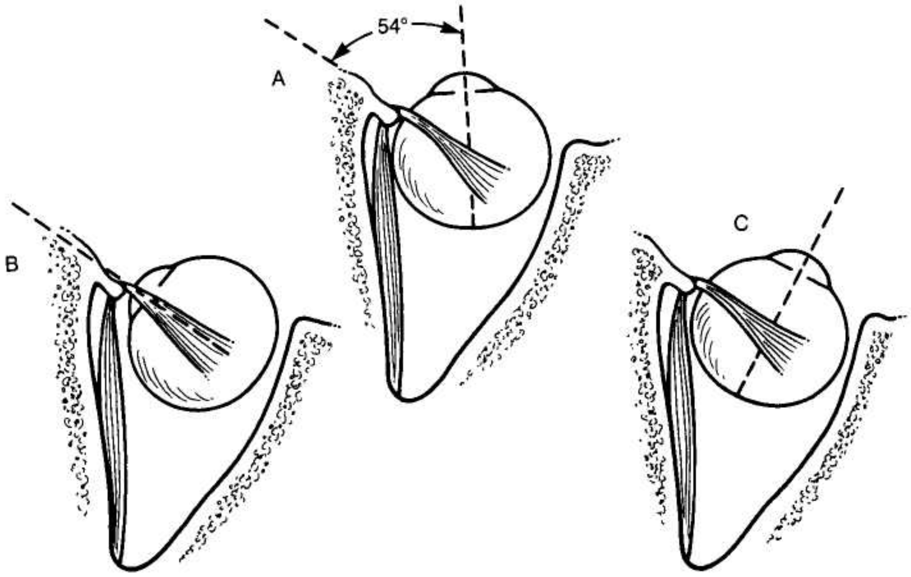

Figure 113.3
The intersection of the superior oblique (SO) muscle forms an angle of 54 degrees with the optical axis (A). When the globe is rotated inward, the SO depresses the globe (B); in abduction, the globe is intorted by the SO muscle (C).

and also explain some of the subjective complaints offered by patients with weakness of a torsional eye muscle. For instance, the normal eye maintains accurate fixation with the head tilted to one shoulder by intorsion of the ipsilateral eye and extorsion of the contralateral eye—all part of the doll's eye reflex. A patient having a right fourth nerve palsy, with weakness of the right superior oblique muscle, will complain of seeing two images, one below *and* tilted away from the other. The torsional or tilting component of their diplopia becomes more obvious if the patient tilts the head to the right shoulder, a maneuver that intorts the right eye and accentuates weakness of the right superior oblique muscle.

Clinical Significance

The term *paralysis* means complete absence of eye muscle activity; *paresis* refers to incomplete movement, and *palsy* encompasses either paralysis or paresis.

Remember that diplopia is always greatest in the field of action of a weakened eye muscle. With mild left lateral rectus paresis, there may be no double vision when the patient looks straight ahead or to the right. But left gaze, which evokes contraction of the left lateral rectus muscle, will evoke diplopia and greater degrees of left gaze will evoke greater diplopia because the false image is projected farther away from the fovea (Figure 113.4). In the case of a left lateral rectus weakness, the patient will see two images in left gaze, and the "outside," or false, image will disappear with occlusion of the left eye. A red glass held before one eye enables a patient to differentiate easily between the two images; in this manner, one image is red, the other is white.

The false image is always projected outside the true image. In a patient with a right superior rectus palsy there will be greatest vertical separation of the images when the patient looks up and to the right, since the right superior rectus has its greatest action on the eye in this position of gaze. Because the right eye fails to elevate fully in that position, the fixational target projects back into the right eye below the macula, and the image is seen being above fixation or outside the true image from the fixating left eye.

Phorias and Tropias

Orthophoria means straightness of the eyes during fixation for distance and near objects. When orthophoria is present, there is no deviation of either eye when the other is covered.

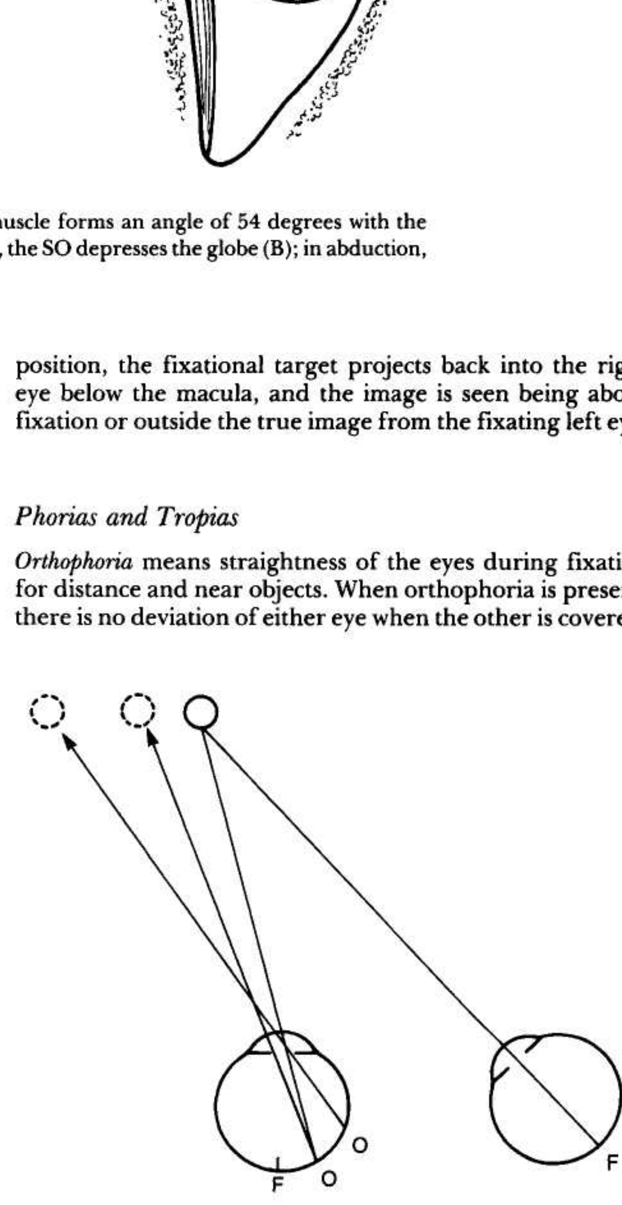

Figure 113.4
Diplopia resulting from left lateral rectus weakness. Notice that the real image (O) projects on to the fovea (F) of the right eye. The (O), however, projects onto the medial retina of the left eye. The eye projects this false image (dotted O) temporarily and the patient sees two images side by side with the false image being to the left of the true image.

Heterophoria is a condition in which the eyes appear straight when both eyes are fixating, but as soon as an eye is covered, it deviates behind the cover. In this condition, ocular fusional power is sufficient to keep both eyes straight during binocular fixation, but decompensates when fusion is broken (i.e., when one eye is covered). *Esophoria* indicates a tendency of the covered eye to deviate inward, *exophoria* means the eye deviates outward; *hyperphoria* indicates a tendency for the covered eye to be higher than its fellow, and *hypophoria* means the covered eye assumes a lower position. Patients with phorias have straight eyes when both eyes are open. The ocular deviation becomes evident when fusion is interrupted by covering one eye.

Tropia is a manifest deviation, that is, it is present with both eyes open. If the heterotropia is small, the patient may complain of diplopia, yet the eyes appear straight in primary position and routine testing of eye movements give normal results. In such cases, the cover–uncover test proves useful. The patient is asked to fixate with both eyes open. An occluder is moved slowly over one eye, and the examiner observes the fixating or uncovered eye. If it shows no movement, the eye was obviously maintaining fixation during binocular conditions. If the uncovered eye moves to take up fixation, heterotropia is present. Movement of the fixating eye downward is called a *hypertropia;* upward, a *hypotropia;* inward, an *exotropia;* and outward, an *esotropia.* Each eye must be covered in turn while the examiner inspects the fellow eye. If the performance of this test yields heterotropia, it should be measured in all the positions of gaze to determine which eye muscle is weak. Prisms are utilized for this purpose. The deviation will be greatest in the field of action of the weakened muscle.

Hering's Law of Equal Innervation

According to Hering, equal and simultaneous innervation flows to synergistic or yoke muscles. During left gaze, for instance, there is symmetric innervation to the right medial and left lateral rectus muscles. The greatest practical significance of Hering's law is its application to the diagnosis of paralytic strabismus. Since the amount of innervation flowing to both eyes is always determined by the fixating eye, the angle of deviation will vary, depending upon whether the patient fixates with the sound eye or paretic eye. Thus, measurements of the deviation in all the positions of gaze, with each eye fixating in turn, are of paramount importance in detecting the paretic muscle or muscle groups.

Take the case of a right lateral rectus palsy. During right gaze, normal innervational activity adducts the left eye, but the paretic right eye does not fully abduct because of right lateral rectus weakness. The amount of lateral deviation the paretic eye makes during attempted right gaze, when the sound eye is fixating, is called *primary deviation.* With right lateral rectus weakness, this primary deviation is relatively small. Now, if the paretic right eye is forced to fixate, by occluding the left eye, the right lateral rectus receives an extra boost of innervational activity. Since this enhanced amount of innervational stimulation is fed to both yoke muscles, the left medial rectus deviates far more medial than necessary. The amount of deviation that the sound eye makes when the paretic eye is forced to fixate is called *secondary deviation.* In paralytic strabismus, secondary deviation is always greater than primary deviation. By measuring primary and secondary deviation in various positions of gaze, even small amounts of diplopia can be diagnosed.

All the foregoing techniques serve to identify the weak muscle(s) in a patient who complains of double vision. The examiner must then decide if the pathology lies in the eye muscle itself, neuromuscular junction, or the cranial nerve that supplies that eye muscle. The reader should consult the appropriate chapters for the diagnostic evaluation of these conditions.

References

Glaser JS. Neuro-ophthalmology. Hagerstown, MD: Harper & Row, 1978.

Miller, NR. Walsh and Hoyt's clinical neuro-ophthalmology. Vol 2. Baltimore: Williams and Wilkins, 1985.

Von Noorden GK, Maumenee AE. Atlas of strabismus. St. Louis: CV Mosby, 1987.