

Measurement of deviation

Hirschberg test

The Hirschberg test gives a rough objective estimate of the angle of a manifest strabismus and is especially useful in young or uncooperative patients or when fixation in the deviating eye is poor. It is also useful in excluding pseudostrabismus. A pen torch is shone into the eyes from arm's length and the patient asked to fixate the light. The corneal reflection of the light will be (more or less) centred in the pupil of the fixating eye, but will be decentred in a squinting eye, in the direction opposite to that of the deviation. The distance of the corneal light reflection from the centre of the pupil is noted; each millimetre of deviation is approximately equal to 7° ($1^\circ \approx 2$ prism dioptres). For example, if the reflex is situated at the temporal border of the pupil (assuming a pupillary diameter of 4 mm), the angle is about 15° ; if it is at the limbus, the angle is about 45° . As the pupil size varies, the estimated angle varies.

Krimsky and prism reflection tests

Corneal reflex assessment can be combined with prisms to give a more accurate approximation of the angle in a manifest deviation.

- **The Krimsky test** involves placement of prisms in front of the fixating eye until the corneal light reflections are symmetrical. This test reduces the problem of parallax and is more commonly used than the prism reflection test.
- **The prism reflection test** involves the placement of prisms in front of the deviating eye until the corneal light reflections are symmetrical.

Cover–uncover test

The cover–uncover test consists of two parts:

- **Cover test** to detect a heterotropia. It is helpful to begin the near test using a light to observe the corneal reflections and to assess fixation in the deviating eye. It should then be repeated for near using an accommodative target and for distance as follows:
 - The patient fixates on a straight-ahead target.
 - If a right deviation is suspected, the examiner covers the fixing left eye and notes any movement of the right eye to take up fixation.
 - No movement indicates orthotropia or left Heterotropia
 - Adduction of the right eye to take up fixation indicates right exotropia and abduction, right esotropia
 - Downward movement indicates right hypertropia and upward movement right hypotropia.
 - The test is repeated on the opposite eye.
- **The uncover test** detects heterophoria. It should be performed both for near (using an accommodative target) and for distance as follows:

- The patient fixates a straight-ahead distant target.
- The examiner covers the right eye and, after 2–3 seconds, removes the cover.
- No movement indicates orthophoria . A keen observer will frequently detect a very slight latent deviation in most normal individuals, as few individuals are truly orthophoric, particularly on near fixation.
- If the right eye had deviated while under cover, a refixation movement (recovery to BSV) is observed on being uncovered.
- Adduction (nasal recovery) of the right eye indicates exophoria and abduction esophoria .
- Upward or downward movement indicates a vertical phoria.
- After the cover is removed, the examiner notes the speed and smoothness of recovery as evidence of the strength of motor fusion.
- The test is repeated for the opposite eye.
- Most examiners perform the cover test and the uncover test sequentially, hence the term cover–uncover test.

TIP When undertaking cover testing, the patient must fixate on an accommodative target rather than on a light source.

Alternate cover test

The alternate cover test induces dissociation to reveal the total deviation when fusion is disrupted. It should be performed only after the cover–uncover test.

- The right eye is covered for several seconds.
- The occluder is quickly shifted to the opposite eye for 2 seconds, then back and forth several times. After the cover is removed, the examiner notes the speed and smoothness of recovery as the eyes return to their pre-dissociated state.
- A patient with a well-compensated heterophoria will have straight eyes before and after the test has been performed whereas a patient with poor control may decompensate to a manifest deviation.

Prism cover test

The prism cover test measures the angle of deviation and includes the alternate cover test with prisms. It is performed with the patient fixing on a distant target in the primary position and in the eight diagnostic positions of gaze. It is repeated in the primary position with near fixation and in patients with intermittent exotropia, with fixation in the far distance. It is performed as follows:

- The alternate cover test is first performed to establish the direction and approximate extent of deviation.

- Prisms of increasing strength are placed in front of one eye with the base opposite the direction of the deviation (i.e. the apex of the prism is pointed in the direction of the deviation). For example, in a convergent strabismus the prism is held base-out and in a right hypertropia, base-down before the right eye.
- The alternate cover test is performed continuously as stronger prisms are introduced, typically using a prism bar consisting of a column of prisms of progressive strength. The amplitude of the re-fixation movement should gradually decrease as the strength of prism approaches the extent of deviation.
- The end-point is approached when no movement is seen. To ensure the maximum angle is found, the prism strength can be increased further until a movement is observed in the opposite direction (the point of reversal) and then reduced again to find the neutral value; the angle of deviation is then taken from the strength of the prism.

Maddox wing

The Maddox wing dissociates the eyes for near fixation (1/3 m) and measures heterophoria. The instrument is constructed in such a way that the right eye sees only a white vertical arrow and a red horizontal arrow, whereas the left eye sees only horizontal and vertical rows of numbers .

- Horizontal deviation is measured by asking the patient to which number the white arrow points.
- Vertical deviation is measured by asking the patient which number intersects with the red arrow.
- The amount of cyclophoria is determined by asking the patient to move the red arrow so that it is parallel with the horizontal row of numbers.

Maddox rod

The Maddox rod consists of a series of fused cylindrical red glass rods that convert the appearance of a white spot of light into a red streak. The optical properties of the rods cause the streak of light to be at an angle of 90° with the long axis of the rods. When the glass rods are held horizontally, the streak will be vertical and vice versa.

The double Maddox rod test is used to determine cyclodeviations.

A Maddox rod is placed in front of each eye in a trial frame or phoropter with the lines arranged vertically so that the patient sees horizontal line images.

The patient or examiner rotates the axes of the rods until the lines are perceived to be parallel. To facilitate the patient's recognition of the two lines, it is often helpful to dissociate the lines by placing a small prism base-up or base-down in front of one eye. The degree of deviation and the direction (incyclo- or excyclo-) can be determined by the angle of rotation that causes the line images to appear horizontal and parallel. Traditionally, a red Maddox

is placed before the right eye and a white Maddox before the left.

- The rod is placed in front of the right eye . This dissociates the two eyes: the red streak seen by the right eye cannot be fused with the unaltered white spot of light seen by the left eye .
- The amount of dissociation is measured by the superimposition of the two images using prisms. The base of the prism is placed in the position opposite to the direction of the deviation.
- Both vertical and horizontal deviations can be measured in this way but the test cannot differentiate a phoria from a tropia.

Motility tests

Ocular movements

Examination of eye movements involves the assessment of smooth pursuit movements followed by saccades.

- **Versions** towards the eight eccentric positions of gaze are tested by asking the patient to follow a target, usually a pen or pen torch (the latter offers the advantage of corneal light reflections to aid assessment). Check versions and ductions (if required) first and then perform cover tests as discussed above. Versions may also be elicited involuntarily in response to a noise or by the doll's head manoeuvre in uncooperative patients.
- **Ductions** are assessed if reduced ocular motility is noted in either or both eyes. A pen torch should be used with careful attention to the position of the corneal reflexes. The fellow eye is occluded and the patient asked to follow the torch into various positions of gaze. Rotatory deficiencies are qualitatively assessed. A simple numeric system may be employed using 0 to denote full movement and -1 to -4 to denote increasing degrees of underaction . Using the lateral rectus muscle for example, -4 would denote an inability to abduct the eye past the midline, -3 an inability to abduct the eye more than 22.5° past the midline, -2 inability to abduct the eye more than 45° past the midline and -1 inability to abduct the eye more than 67.5° past the midline. In the same way, overactions are assessed on a $+1$ to $+4$ basis. Both are recorded pictorially. These measurements can be accurately repeated with agreement between different observers.