The Hess Screen Test

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ABSTRACT

The Hess screen test was designed by Walter Rudolf Hess in 1908 with subsequent modifications.[1, 2] Hess was a famous neurophysiologist who was awarded the Nobel Prize in 1949 for his research into the functional organization of the vegetative nervous system.[3, 4] The original test used a black screen on which was marked a square-meter tangent scale. The tangent nature of the coordinate lines converts equidistant points, seen in a virtual sphere like a perimeter, into a two-dimensional chart. The test relies on color dissociation using red/green complementary filters. This maximizes the ocular deviation. A red target is illuminated or projected at the juncture where each tangent line crosses. A green light is projected by the patient and each plot is recorded. The test is repeated for the opposite eye resulting in a chart showing an inner and outer range of ocular rotation for each eye.

EARLY SCREEN TESTS

Methods of documenting the field of action of individual muscles in various gaze fields date back as far as 1874 by Hirschberg, who marked a tangent scale on the wall of his examining room. However, the test relied upon the separation of diplopic images described by the patient that were subsequently joined with prisms. This did not allow for full dissociation of the deviation.[5]

In 1907, Ohm designed a black cloth screen based on Hirschberg's tangent scale with blue strings outlining the coordinates. Complimentary red and blue filters used with a red arrow created color dissociation. He subsequently constructed a transparent screen from wire mesh so that the patient could be observed from the other side of the screen.[6]

In 1908, Krusius also designed a glass screen through which the examiner could observe the eye movements in different gaze fields, but mostly relied upon cor-

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neal reflections for interpretation.[7] In 1927, Sattler designed a black screen using red/green dissociation, but employed a system of green coordinate lines.[8] Further details and analyses of these modifications are described in the AOS thesis by Sloane.[9, 10]

HESS SCREEN TEST

Hess designed several versions of his screen. The original screen was constructed of black cloth 80 × 80 cm on which red embroidered dots were stitched where the tangent coordinates crossed. A pointer 50 cm long was used, on the end of which was a green arrow. One version had a string with a counterweight attached to the pointer, the string passing through the center of the screen.[2] Later versions showed a Y-shaped string with the top part extending from each corner and the lower part attached to the pointer.[11]

Hess used red/green color dissociation in all his versions, including the more recent screens. The patient wore complementary red and green glass lenses mounted in a spectacle frame. The cloth screens could be rolled to store or transport them or unrolled and hung on the wall. They were lightweight and portable.

Other screen tests were designed or modified after Hess, the best known being the Lancaster red-green test, initially called the Lancaster-Hess test and the Lees screen.[12–16]

MODERNIZING THE HESS SCREEN TEST

With the advent of electricity and the introduction of plastics, new equipment became available. By the late 1960s, the screen was gray, wall-mounted, and available in an electrically operated version.

The red and green glass lenses were replaced with Armstrong goggles, made from Kodak Wratten complementary red and green filters. These were molded to conform better to the midface and were held on by an adjustable elastic band.

Foster torches were designed and distributed by Clement Clarke in London. These can run off an electrical source or batteries. A goalpost filament is used to project a linear beam of light. A gray plastic sleeve with the matching complementary red or green filter at its distal end is slipped over the end of the flashlight. By moving this sleeve up or down, the image may be focused on the screen. These generally come as a pair and are used together to project a red fixation light onto the screen by the examiner while the patient, wearing the Armstrong goggles, aims the green line at the red one. The fixating eye can be changed by switching the goggles, so the red filter is on the opposite side, or by the examiner and patient exchanging the Foster torches.[16]

The modern electric Hess screen is a gray board on which is scored a tangent scale. The screen is mounted on the wall of the examining room. Small red lights at the juncture where each scored line crosses can be illuminated in turn by bulbs behind the screen. The examiner presses a keypad to switch on a specific target while the patient projects the green line and bisects the red dot. Since the red lights are an integral part of the screen, the goggles must be reversed to obtain the plots for the opposite field. The keypad is conveniently placed on a clipboard next to the chart being plotted (Figure 1).

Since the invention of personal computers, several newer versions of the Hess or Lancaster screens have been designed.[20–23] These are used in research settings and in some clinics, but are not yet in wide use. Some of the advantages include storage and manipulation of data retrieved during testing. Maintaining a distance of at least 33 cm is necessary to avoid inducing accommodative or convergence influences. If this can be surmounted, perhaps by a larger screen, the test may be used reliably on a laptop computer and allow the test to become portable again. Recent variations include a three-dimensional Hess test and testing aniseikonia on a computerized Hess screen.[24, 25]

PRINCIPLE OF THE HESS SCREEN TEST

The Hess screen test can be described as a fovea-to-fovea (maculo-macular) test. This occurs because two different colored test objects are used. Each fixation target is red and the projected light is green. Wearing complementary red and green filters means that neither eye can see the opposite test object. This is in contrast to a regular diplopia test (maculo-paramacular) or the Worth lights where red/green filters are used, but a white light is common to each eye. This means that the deviation in the Hess screen test is direct, or drawn as if each fovea were looking directly at the screen at the point to which it deviated. An esotropia looks crossed on the board in the same direction as the deviation. In contrast, in a regular diplopia test a white light is used and the images will appear uncrossed or homonymous. Each fovea perceives the image of its respective target to be located straight ahead. This is maculo-macular projection or confusion (Figure 2).

PLOTTING THE CHART

Armstrong goggles are worn by the patient during the test. The patient is seated 0.5 m from the screen with the head erect and immobile using a chin or headrest. The examining room lights are dimmed to re-

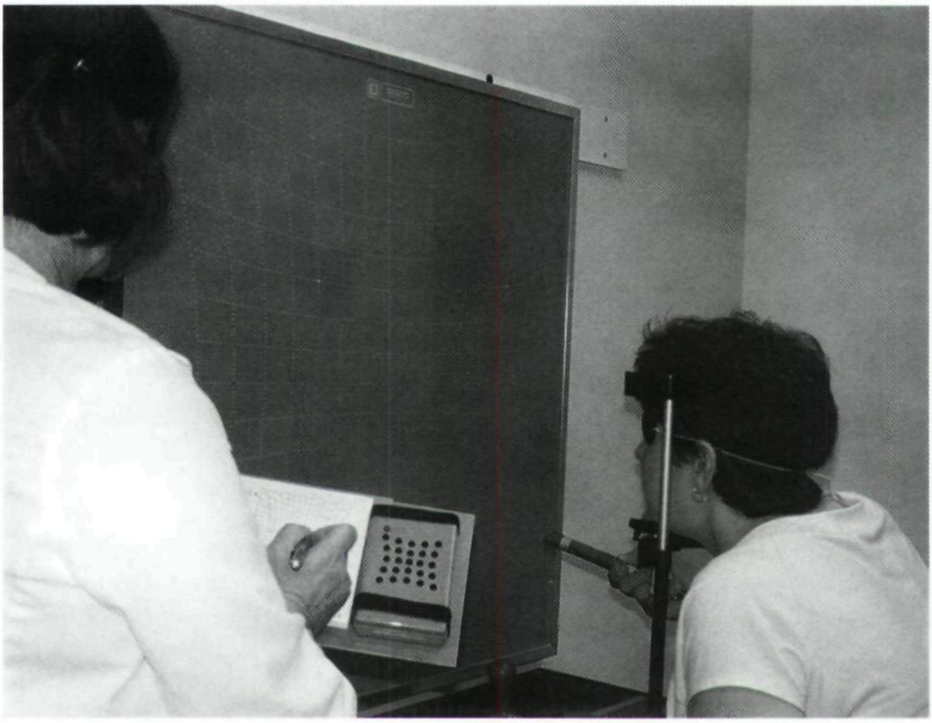

FIGURE 1: The electric Hess screen.

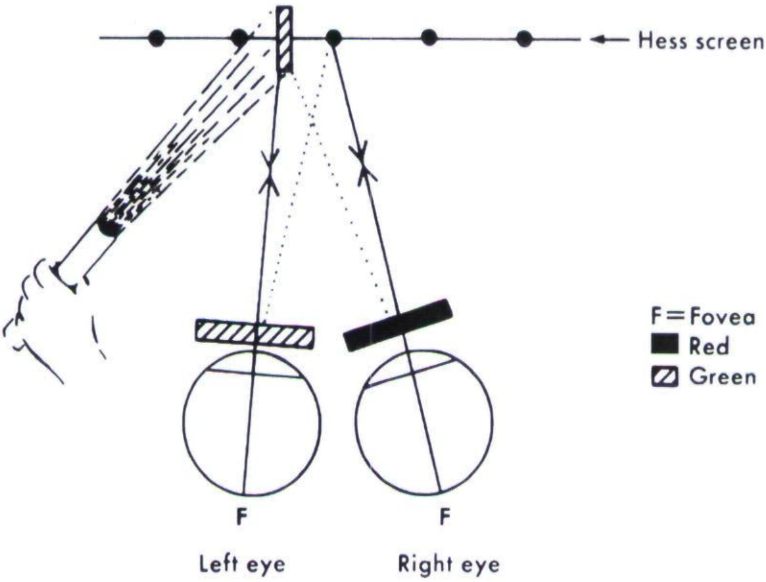

FIGURE 2: Fovea-to-fovea projection used to dissociate the eyes.

move fusional background cues and further dissociate the eyes. This is usually sufficient to reveal a well-controlled heterophoria. The patient projects a green line onto the screen and is asked to bisect each red dot with the green line as each dot is illuminated in turn. It is usually easier to plot a predominantly horizontal deviation, such as a sixth nerve palsy, with the green light projecting a vertical line and plot a vertical deviation, such as a fourth nerve palsy, with a horizontal line. Each dot is tested and plotted in turn—first for the inner field, then the outer. Once this task has been completed, the goggles are reversed, the patient still projecting a green line, and the test repeated.

The dots are joined by the examiner forming an inner and outer field for each eye. These can be thought of as isopters or lines joining points of equal value, the commonality being the distance from primary gaze in each direction. At 0.5 m each square represents 10^{Δ} so the inner square measures 30^{Δ} or about 15°. This is about the range an individual will move the eyes to view a target away from primary gaze without moving the head. The outer fields measure twice that amount, representing an exaggerated excursion, one that normally is accompanied by a head turn. Defects appearing on the inner field are likely to be more symptomatic.

INTERPRETATION OF THE HESS CHART

Once the chart is drawn, the examiner can assess the overall pattern to identify the eye with the muscle(s) involved (the smaller field), the biggest overactions in the opposite field (whether the overall pattern shows incomitance or concomitance), and generally whether the pattern looks paralytic or restricted (Figure 3). One of the most valuable roles that sequential Hess charts can provide is useful information about the course of a disorder, indicating whether it is resolving, progressing, or stabilizing. This will permit appropriate management decisions to be made (Figure 4).

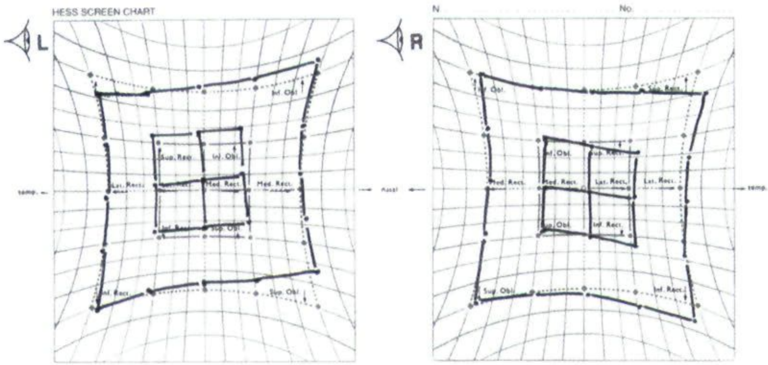

FIGURE 3: Hess chart in a patient with a longstanding concomitant hyperdeviation.

ADDITIONAL TECHNIQUES

Sometimes a patient will show variability during testing that is suggestive of ocular myasthenia. The test can be repeated using Tensilon®, with those parameters already plotted used as a baseline in the Tensilon-Hess test (Figure 5).[26] The presence of an intermittent or variable condition such as superior oblique myokymia, superior oblique click syndrome, or ocular neuromyotonia can also be documented during testing.

Occasionally, the patient's view of the screen will be obstructed by ptosis, a heavy brow, swelling from injury or surgery or the position of the goggles. The red and green filters overlap in the center of the goggles. This excludes all light because the colors are complementary and the goggles must be adjusted. In patients with marked exophthalmos, care must be taken to avoid touching the cornea; it is helpful to ask patients if they can blink freely when the goggles are first introduced.

Torsion cannot be interpreted easily on a Hess chart as it is difficult to relate the angle of the torted image when projecting a line of light onto a tangent scale. The test certainly can reveal the presence of torsion, but this is better quantitated using standard methods such as double Maddox rods or other methods such as the Harms or Lancaster screens.

On occasion, a patient will demonstrate difficulty in locating the next target, when nothing is obstructing their view. It is possible to detect scotomata in glaucoma patients or even suspect a hemianopic visual field defect from the manner or direction in which a patient hesitates during plotting.

Patients with Parkinson disease, ataxia, or other balance problems should be monitored during the test, perhaps assisted by a family member, to ensure that they remain seated upright in the darkened room. A helpful hand behind the patient's head will keep the head erect and not tilted, keep the forehead on the headrest and offer assurance that they will not fall. If there is pronounced dysmetria or tremor, holding the green light with both hands close to the chest is helpful.

It can be challenging to perform the test on someone with a hearing problem. It is not possible to lip-read while wearing goggles in the dark, with the examiner standing behind the patient. It may be necessary to give instructions face-to-face before the test begins, making sure the patient can understand. In patients with suppression or ARC it may not be possible to obtain responses on a Hess chart as the principle of the test relies on normal retinal

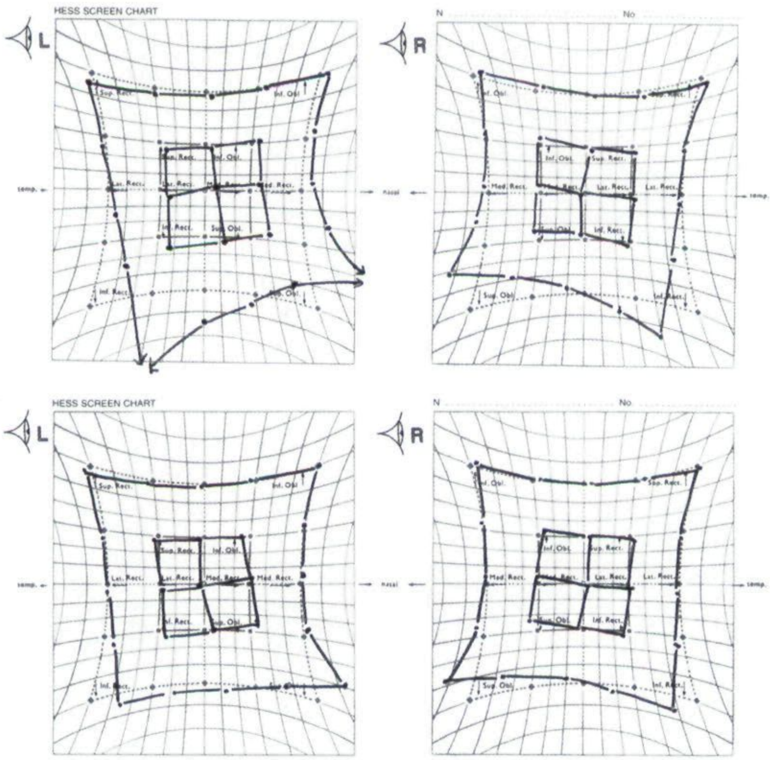

FIGURE 4: Hess charts (top, bottom) demonstrating resolving, bilateral fourth nerve paralyses.

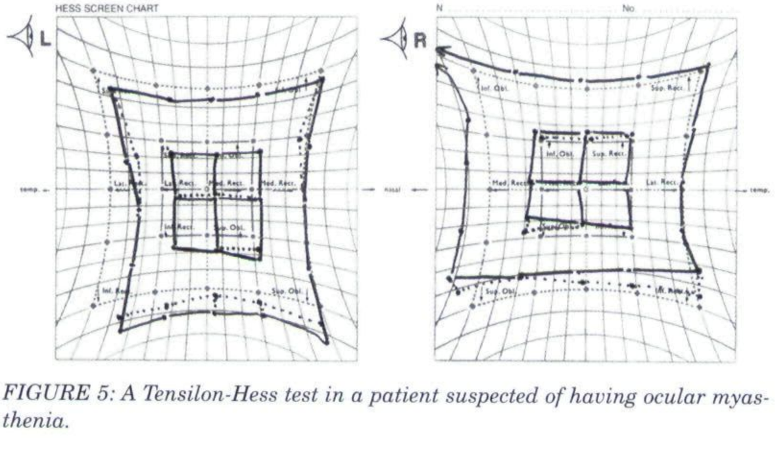

FIGURE 5: A Tensilon-Hess test in a patient suspected of having ocular myasthenia.

correspondence. However, sometimes the fovea-to fovea dissociation used is sufficient to disrupt suppression and the chart can be plotted. This is useful in a patient with a longstanding deviation with suppression and a newly acquired paralysis. It is sometimes possible to plot incomitance in a patient with paralysis or restriction with ARC but the angle of anomaly should be noted.

HESS CHARTS IN DIFFERENTIAL DIAGNOSIS

Hess charts are invaluable in the differential diagnosis of many different clinical conditions. Characteristic patterns are revealed on the chart in congenital disorders such as Duane or Brown syndrome. An obvious restriction in the affected gaze position does not produce the usual overaction of the ipsilateral antagonist as it would in a paralysis (Figure 6). The chart may help differentiate these conditions from sixth nerve palsy or an inferior oblique weakness, respectively.

Observing the nature of concomitance and spread of muscle sequelae can help differentiate a recently acquired paralysis from a longstanding and recently decompensating one (Figure 3). It is particularly useful in planning surgery on a patient with a stable superior oblique muscle palsy by comparing the overactions of the ipsilateral antagonist (inferior oblique) versus the contralateral synergist (opposite inferior rectus) in deciding which muscle should be weakened, or weakened first if two-staged surgery is planned.

Unilateral and bilateral fourth nerve palsies can be identified by their characteristic patterns (Figure 4). The Hess chart of a patient with an acquired superior oblique weakness often reveals asymmetric bilateral involvement not apparent on other clinical testing.

Most restrictive conditions such as orbital fractures with entrapment or thyroid restrictive disease have an accompanying history to guide the diagnosis. However, these can be differentiated from paralysis by the different patterns each condition exhibits (Figure 7).

A Hess chart can be instrumental in correctly identifying the affected eye when other clinical signs suggested otherwise. A sledding accident caused an orbital floor fracture in a 64-year-old grandmother. The fracture was confirmed by CT scan. She complained of vertical diplopia. The Hess chart revealed that she had sustained a mild traumatic fourth nerve palsy in the side opposite the fracture. The fracture was allowed to heal without intervention; the fourth nerve palsy also resolved.

CONCLUSION

A Hess screen is a valuable addition to any strabismus clinic, particularly one in which a high percentage of adults is seen. The test can be performed quickly and provides extensive information about the respective motility disorder. The baseline chart is used in differential diagnosis, and

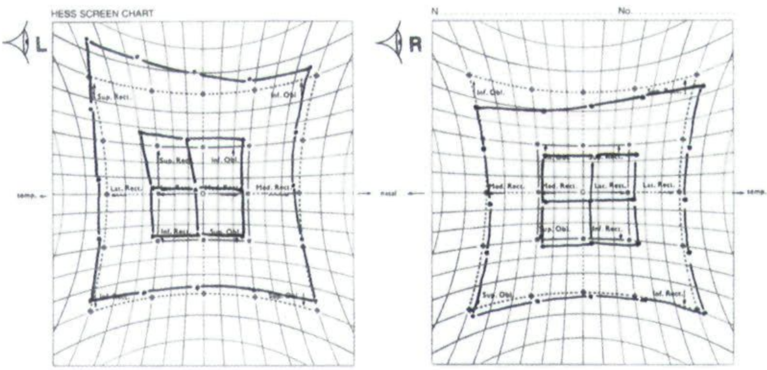

FIGURE 6: Hess chart of a patient with Brown syndrome. Note absence of any obvious problem in down-gaze.

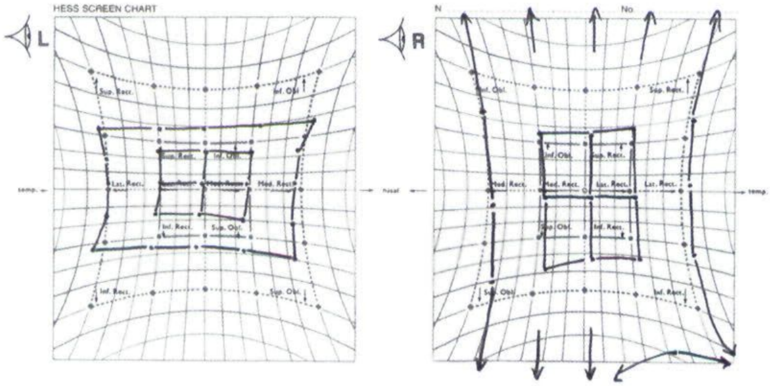

FIGURE 7: Hess chart of a patient with an orbital floor fracture with mild entrapment demonstrating restriction on both up and down-gaze in the right eye.

comparison of subsequent charts is important in management. It compares favorably with other screen tests, and provides graphic representation for interpretation.

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