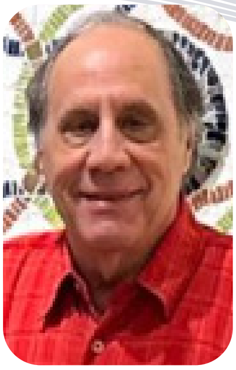
Viewpoint • Assessment of Fixation

Kenneth J. Ciuffreda, OD, PhD • SUNY College of Optometry • New York, New York
Daniella Rutner, OD, MS, MBA • SUNY College of Optometry • New York, New York



Kenneth J. Ciuffreda, OD, PhD
New York, New York

SUNY College of Optometry, Distinguished Teaching Professor Emeritus

PhD, UC-Berkeley/Optometry, 1977

OD, Massachusetts College of Optometry, 1973

BA, Seton Hall University, 1969

Fellow Dipl-AAO, ARVO, COVD, & NAP

The ability to fixate accurately and stably is critical for optimal viewing of the world. However, many of our patients do not fixate well.[1] This would include those with nystagmus, macular degeneration, optic atrophy, albinism, stroke, traumatic brain injury, and more.[1-3] Thus, it is incumbent upon the optometrist and others (e.g., a vision therapist or neurologist) to assess a patient's fixational ability appropriately. In this paper, various methods for assessing fixation, both traditional clinical and objective approaches, will be considered.

Table 1 presents a wide array of the more traditional clinical approaches to assess fixation.[1,4,5] Gross visual observation is perhaps the most common and simplest approach, although it requires excellent observational skills and knowledge of potential abnormalities on the part of the clinician (Figure 1). The doctor has the patient fixate upon a small target, such as a pen tip or Wolff wand, for 10 seconds (or more), monocularly and binocularly, and integrates by visual memory what is observed, such as the number of fixational losses and their estimated magnitudes, differences noted between each eye and binocularly, the presence of large saccadic intrusions or drift, subtle nystagmus, and more.[1] Then it is repeated across different diagnostic gaze positions (e.g., downgaze in reading). This is an adequate screening tool for detecting gross abnormalities. It can also be performed using the slit-lamp for higher magnification and hence better detectional ability, especially for abnormalities such as subtle, small, intermittent nystagmus.[1] The next four approaches listed in Table 1 mainly apply to the assessment of eccentric fixation (EF) in amblyopic eyes. The Haidinger brush technique is very useful, as it is easy for the patient to visualize, readily provides both direction and magnitude, and can be performed in a young child. The others listed are rarely used in the clinic.

The last approach, however, namely 30-second, low-light visuoscopy developed by Selenow and Ciuffreda,[4] is extremely useful and very informative. It not only provides the EF location but also allows the clinician to observe directly on the retina the actual fixational pattern and the underlying types of eye movements (e.g., increased amblyopic drift). It was based in part on an earlier experiment by Lawwill in 1966,[4] in which he observed that excessive light intensity exacerbated, or even "created" (i.e., iatrogenically induced), any fixational abnormalities. Hence, what Selenow and Ciuffreda developed and tested was a low-light technique. Thus, the light intensity of the visuoscope is reduced until the doctor can "just" detect the projected calibrated grid and central target on the patient's fundus. Of course, the patient readily perceives it. The patient is then instructed to fixate carefully on the central target. Since EF is a time-average, perceptual-motor phenomenon,[4] the foveal/macular region is assessed for 30 seconds (or more) to build up a sufficient mental image of the EF's direction, magnitude, variability, and overall pattern. The observed details are then fully described and recorded. The fellow eye is likewise tested for comparative purposes. It is repeated during the course of therapy to assess for likely reduction and hopefully

Table 1. Traditional Clinical Approaches to Assess Fixation

Gross visual observation
Angle kappa determination
Blind spot comparison
Maxwell's spot
Haidinger's brush
Visuoscopy

Figure 1. Test of fixation by visual observation

Table 2. Objective Approaches to Assess Fixation

Infrared limbal sensing
Video recording
Microperimetry

the attainment of consistent and accurate foveation.

Table 2 presents some of the objective approaches to assess fixation. This allows for a more detailed, quantitative, and unbiased appraisal of fixational ability, including the overall pattern and types of abnormal eye movements (e.g., increased amblyopic drift, large saccadic intrusions).

An early approach was the infrared, horizontal, limbal technique (Figure 2).[1] Basically, the eyes are bathed with safe levels of infrared light, and the two detectors for each eye are aimed at the horizontal nasal and temporal regions to assess the differential light reflection on the sensors: the white sclera reflects more light than the darker iris. This type of system has been used in many laboratories over the past 75 years, as well as in the clinical domain (e.g., ReadAlyzer; https://www.compevousa.com/). Again, the patient is instructed to fixate carefully on a small target on a screen, usually 40-57 cm away along the midline in the primary position, for several seconds. The resultant horizontal fixational pattern can be viewed as a function of time, printed out for the record, and even quantified if a prior calibration was performed.

Newer technology uses a video-based approach (Figure 3).[1] Here, small video cameras are aimed at each eye, and both the horizontal and vertical eye movements are recorded during fixation. Thus, this provides a more complete picture of fixation. These systems are easy for the clinician to use and provide a wide linear range of movement for accurate assessment. This includes various laboratory devices (e.g., Tobii; https://gaming.tobii.com/) as well as clinical devices (e.g., RightEye; https://righteye.com/). However, the latter system does not allow for testing of fixation under monocular conditions, which is critical for both

Figure 2. Infrared limbal eye movement system

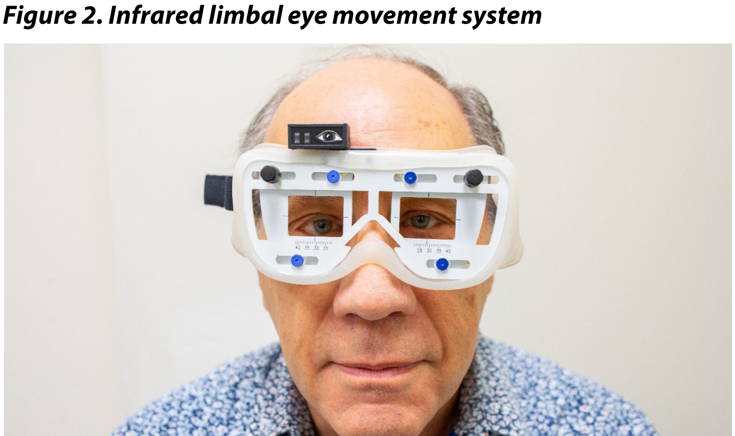


Figure 3. Tobii eye tracking video system assessing reading eye movements

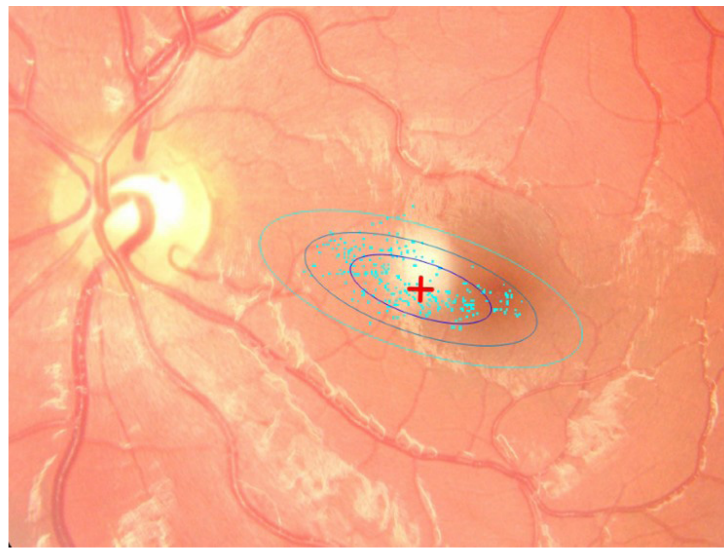


Figure 4. Microperimetry showing eccentric and unsteady fixation in an amblyope

EF assessment in amblyopic eyes, as well as eccentric viewing (EV) assessment in ocular disease/visual field loss situations; furthermore, it does not present the eye movements as a function of time like most instruments do. Rather, it presents each fixational sample in x,y Cartesian coordinate space with disregard for time.

The third and newest approach has been the use of microperimetry for fixational testing (Figure 4).[7-9] This involves direct visualization of the fundus area of interest (similar to visuoscopy), typically the foveal/macular region of only one eye. The patient is asked to fixate the target carefully, and the calibrated system samples both the horizontal and vertical eye positions at 25 Hz (i.e., 25 samples per second) or higher for 30 seconds. Once the test is completed, an overlay of the area of fixation is presented as a series of calibrated bivariate ellipses, typically enclosing the retinal regions of fixation 25, 50, 75, and 100% of the time:[1] the less fixational scatter, the smaller the ellipse, and the better the fixation. From this, one can obtain the retinal point of maximal fixation and its variability, all objectively documented—that is, either the fovea, the EF point, or the EV point. This approach is so important because the clinician can visualize the oculomotor activity and the visuomotor, spatial centrode directly on the patient's fundus in real time.

In conclusion, the clinical and laboratory assessment of fixation in our patients has expanded greatly over the past 20 years. This is mainly the result of improved technology and rapid automated analyses, with excellent graphical display for the clinical record. Such objective documentation is helpful for the parent to understand how the abnormal eye movements negatively impact their child (e.g., slowed reading), as well as for presentation as an expert witness in the courtroom.[10] Future technological advances are likely to include expanded use of virtual/augmented reality to create more naturalistic viewing/testing scenarios.

Acknowledgements: We thank Dr. Putnam for her discussions regarding microperimetry and Dr. Wang and Bhavatharini Ramakrishnan for providing the microperimeter fundus image.

References

1. Ciuffreda KJ, Tannen B. Eye Movement Basics for the Clinician. St. Louis: Mosby, 1995.
2. Han Y, Ciuffreda KJ, Kapoor N. Reading-related oculomotor training protocols for acquired brain injury in humans. Brain Res Brain Res Protocols 2004;14:1-12.
3. Ciuffreda KJ. Eye Movements in Patients with Oculomotor Disturbances. In: Ygge J, Lennerstrand G. (eds.). Eye Movements in Reading. New York: Pergamon; 1994: 168-88.
4. Ciuffreda KJ, Levi D, Selenow A. Amblyopia: Basic and Clinical Aspects. Boston: Butterworth-Heinemann, 1991.
5. Schapero M. Amblyopia. New York: Chilton Book Co., 1971.
6. Lawwill T. The fixation pattern in the light-adapted and dark-adapted amblyopic eye. Am J Ophthalmol 1966;61:1416-9.
7. De Guimaraes TAG, Kalitzeos A, Bainbridge J, Michaelides M. Distance from the foveal center: A method for the calculation of eccentric fixation. Transl Vis Sci Technol 2025;14(5):9.
8. Molina-Martin A, Perez-Cambrodi RJ, Pinero DP. Current clinical application of microperimetry: A review. Sem Ophthalmol 2018; 33:620-8.
9. Seiple W, Rosen RB, Castro-Lima V, Garcia PMT. The physics and psychophysics of microperimetry. Optom Vis Sci 2012;89:1182-91.
10. Ciuffreda KJ, Tannen B, Rutner D, Yadav NK, Suter PS. Objective vision-based testing in mild traumatic brain injury. Vis Dev Rehabil 2023:9:127-32.

Correspondence regarding this article should be emailed to Kenneth J. Ciuffreda, OD, PhD at kciuffreda@sunyopt.edu.
Ciuffreda KJ, Rutner D. Assessment of fixation Optom Vis Perf 2025;14(2):121-3.