FDT Perimetry for the Detection of Glaucomatous Visual Field Loss

The effectiveness of the FDT and Humphrey Matrix Perimeters.

BY CHRIS A. JOHNSON, PHD

The frequency doubling effect was described more than 40 years ago,[1] but it took an additional 25 years or more for it to be implemented as a clinical diagnostic testing procedure for detecting visual field loss in glaucoma and other ocular and neurologic disorders.[2,3] Today, frequency doubling technology (FDT) perimetry is used by tens of thousands of eye care specialists throughout the world. Two generations of FDT devices have been produced for clinical use, Frequency Doubling Technology (Welch Allyn, Skaneateles, NY) and the Humphrey Matrix (Carl Zeiss Meditec, Inc., Dublin, CA). This article provides a general overview of FDT and its use for the evaluation of glaucomatous visual field loss.

THE UNDERLYING BASIS FOR FDT PERIMETRY

A low spatial frequency sinusoidal grating (lower than 1 cycle per degree) that undergoes high temporal frequency counterphase flicker (greater than 15 Hz) appears to have approximately twice as many light and dark bars than are physically present, a phenomenon known as *frequency doubling*. It was initially believed that the frequency doubling effect was mediated by retinal ganglion cells within the visual pathways that had nonlinear response properties.[2] Recent studies, however, indicate that higher-order cortical visual areas are also involved and that the appearance of this effect is usually fractional (between one and two-and-a-half times the physical frequency) rather than doubled.[4,5] Fortunately, the clinical FDT perimetry test does not depend on the *appearance* of the target but rather the minimum contrast needed to *detect* the stimulus at different locations in the visual field. The testing procedure is quite similar to those employed for standard automated perimetry.

THRESHOLD AND SCREENING PROCEDURES

Both the FDT and Humphrey Matrix devices have procedures available for threshold testing as well as rapid screening evaluations. Two screening procedures (N30-5 and N30-1) are available on the FDT and Matrix, and a third screening procedure is also available on the Matrix (24-2-5 screening).

The N30-1 procedure initially presents targets that 99% of the normal population of the subject's age can detect. If the subject detects a target, no further testing is performed at that location, and the sensitivity is determined to be within normal limits. If the target is not detected, it is presented a second time. If it is still not detected (mild loss), the device presents the stimulus corresponding to the 99.5% normal limit (moderate loss if not detected). If this stimulus is not detected, then the device presents the maximum contrast. If the subject does not detect this stimulus, severe loss is indicated. The specificity is approximately 85% to 100%, and the sensitivity is about 78% to 92%. This testing procedure takes 20 to 30 seconds per eye for normal vision and up to 110 seconds for eyes with visual field loss. The procedure is most appropriate for population-based screening where false-positive outcomes need to be minimized.

The N30-5 test is similar to the N30-1 test, but the first presentation is of targets that are detected by 95% of the

normal population of that age. A missed target at this level is repeated once. If missed again, a 98% detection target is presented, followed by (assuming another miss) a 99% target. The time for this test is equivalent to the N30-1 test, sensitivity is slightly higher (85% to 95%), and specificity is slightly lower (80% to 90%).

The 24-2-5 screening procedure uses a similar testing strategy to the N30-5 procedure, but it has 54 test locations arranged in a grid with 6° spacing that brackets the horizontal and vertical meridians.[6] Testing time is approximately 1.5 to 2.5 minutes for this procedure, depending on the status of the visual field. Subsequent portions of this article briefly discuss threshold procedures.

THE FDT PERIMETER

Details

The original FDT perimeter presents 0.25 cycle/degree sinusoidal gratings that are counterphase flickered at 25 Hz in 16 10° X 10° targets (four per quadrant), plus a 5° diameter circular central stimulus and two additional targets between 20° and 30° eccentricity above and below the horizontal meridian (Figure 1).

Current Findings

A published review of the performance of the FDT perimeter[7] nicely summarizes its clinical performance for visual field loss in glaucoma and other ocular and neurologic disorders. As expected, clinical performance for the threshold procedure is somewhat better than the screening procedures, and quantitative information can be obtained. The testing time is longer, requiring about 5 minutes per eye to complete the examination, using a modified binary search staircase strategy.[6] For those interested, additional details of the testing strategies and procedures may be found in the publication by Anderson and Johnson[7] and in the FDT primer by Johnson et al[8] (Figures 1 and 2).

THE HUMPHREY MATRIX FDT PERIMETER

Details

A number of changes were made to the second-generation FDT perimeter (known as the Humphrey Matrix), including smaller (5° X 5°) targets presented along a grid that have higher spatial resolution (24-2, 30-2, 10-2, and macula tests), a slightly higher spatial frequency sinusoidal grating (0.5 cycles/degree) and a slightly lower temporal frequency counterphase flicker (18 Hz), a Bayesian threshold estimation strategy (ZEST), direct monitoring of the eye's position, more informative printouts, more flexible methods of storing and exporting data, a more sophisticated statistical analysis package, and many other features. These improvements have greatly enhanced clinicians' ability to detect, evaluate, and monitor visual field loss with this procedure.

Current Findings

Most reports that compare the results for the Humphrey Matrix with those of the Humphrey Field Analyzer (Carl Zeiss Meditec, Inc.) indicate that the two visual field techniques produce highly similar results.[9-15] Most studies have shown good-to-excellent clinical performance and strong correlations with standard automated perimetry for the Humphrey Matrix compared with the Humphrey Field Analyzer.[9-17] Additionally, Humphrey Matrix perimetry has been reported to have reasonably uniform variability properties for all levels of glaucomatous visual field loss,[16] and some studies have suggested that FDT testing may be useful for determining

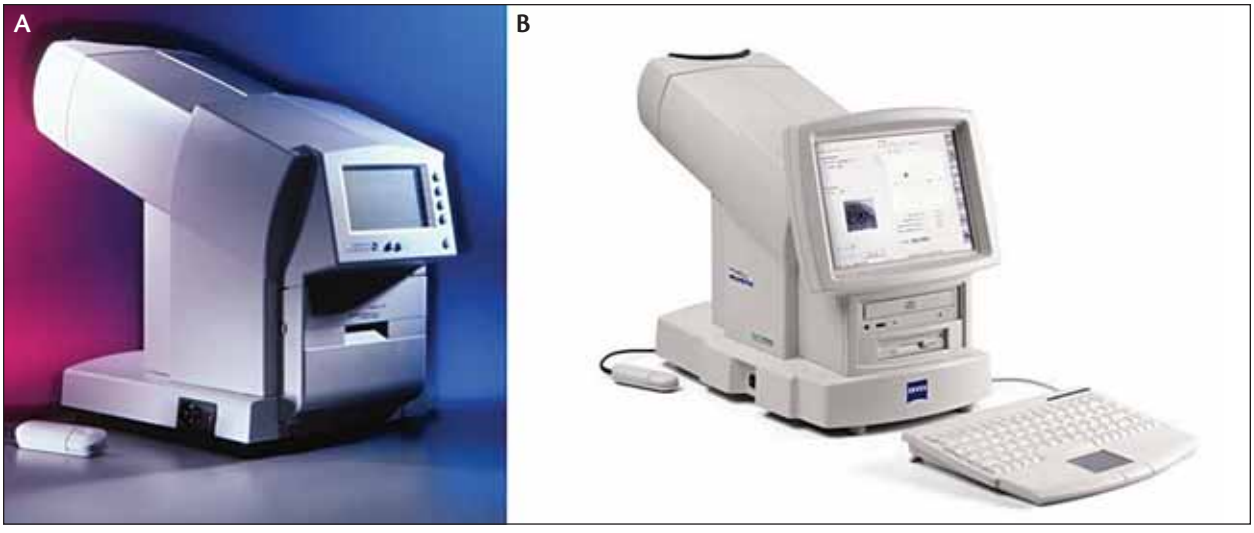

Figure 1. The FDT perimeter (A) and the Humphrey Matrix FDT perimeter (B).

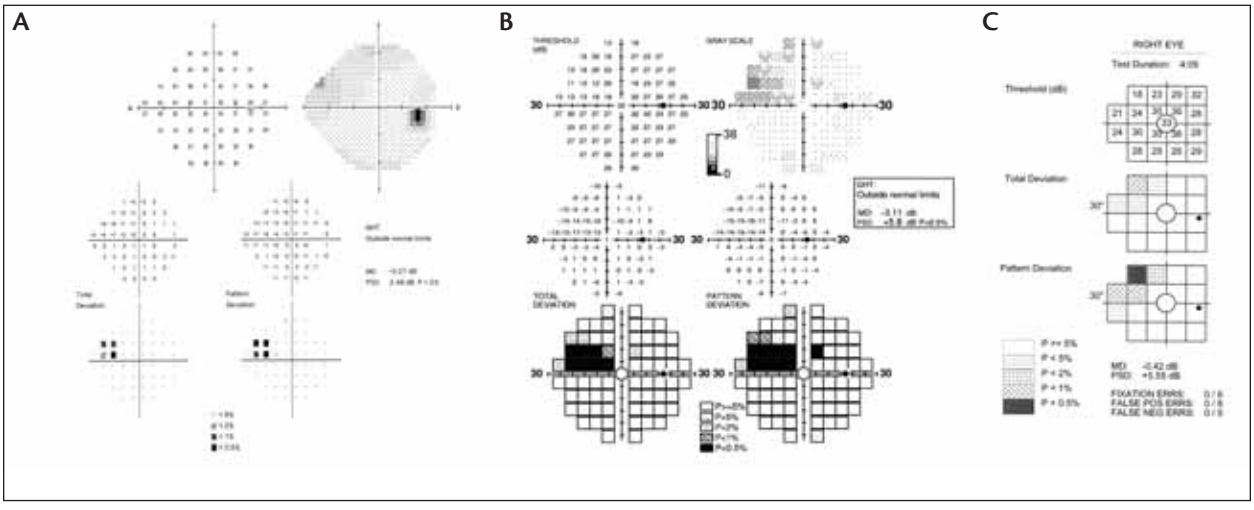

Figure 2. Test results with the Humphrey Field Analyzer (Swedish interactive threshold algorithm-standard, 24-2 testing pattern) (A), Humphrey Matrix (B), and FDT (C) for the right eye of a patient with glaucomatous visual field loss. Note that the similarity between the test results with the Humphrey Field Analyzer, the Humphrey Matrix, and the FDT perimeter is remarkably good.

glaucomatous visual field progression.[18-20] The duration of a threshold testing procedure is approximately 5 minutes per eye for a 24-2 procedure and about 6.5 minutes for a 30-2 test.

CONCLUSION

FDT and Humphrey Matrix perimetry have generally been found to be useful for screening, evaluation, and the follow-up of visual field loss in glaucoma and other ocular and neurologic diseases. Rapid screening procedures permit testing in community-based populations, children, individuals who are not able to perform conventional visual field testing, and individuals with limited access to standard healthcare. FDT and Humphrey Matrix perimetry have been shown to be effective in the detection, evaluation, and follow-up of glaucomatous visual field loss. At the present time, however, there is limited information available about the ability of this testing procedure to characterize the pattern and shape of visual field loss and to monitor progressive changes over time. It is to be hoped that future refinements of and improvements to this technique will provide these additional benefits for the clinical assessment of patients. ❑

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