Effects of astigmatism on the Humphrey Matrix perimeter

TOSHIAKI YOSHII, TOYOAKI MATSUURA, EIICHI YUKAWA, YOSHIAKI HARA

Department of Ophthalmology, Nara Medical University, Nara - Japan

PURPOSE. *To evaluate the influence of astigmatism in terms of its amount and direction on the results of Humphrey Matrix perimetry.*
METHODS. *A total of 31 healthy volunteers from hospital staff were consecutively recruited to undergo repeat testing with Humphrey Matrix 24-2 full threshold program with various induced simple myopic astigmatism. All subjects had previous experience (at least twice) with Matrix testing. To produce simple myopic astigmatism, a 0 diopter (D), +1 D, or +2 D cylindrical lens was added and inserted in the 180° direction and in the 90° direction after complete correction of distance vision. The influences of astigmatism were evaluated in terms of the mean deviation (MD), pattern standard deviation (PSD), and test duration (TD).*
RESULTS. *A significant difference was observed only in the MD from five sessions. The MD in cases of 2 D inverse astigmatism was significantly lower than that in the absence of astigmatism.*
CONCLUSIONS. *In patients with inverse myopic astigmatism of ≥2 D, the influences of astigmatism on the visual field should be taken into consideration when the results of Humphrey Matrix perimetry are evaluated. (Eur J Ophthalmol 2009; 19: 425-8)*

KEY WORDS. *Astigmatism, Frequency doubling technology, FDT Matrix, Perimetry*

INTRODUCTION

Refractive error is one of the factors affecting the results of perimetry. Refractive error causes blurring of retinal images, reducing perception sensitivity. Therefore, conventional static perimeters require appropriate correction of refraction according to the examination distance. The frequency doubling technology (FDT) perimeter was developed as a screener for glaucoma (1). This perimeter presents a grating with alternating black and white bars that undergo counterphase flicker, during which the width of bars is perceived to be half of their actual width (frequency-doubling illusion; thus, the number of bars appears to be doubled). Many studies have shown the usefulness of FDT for glaucoma screening (2-4) and its potential usefulness for the early diagnosis of glaucoma (5-10). Recently, the Humphrey Matrix perimeter (Carl Zeiss Meditec, Dublin, CA; Welch-Allyn, Skaneateles, NY) was developed

as an FDT perimeter and became commercially available. In this perimeter, the examination time was shortened due to changes in the algorithm, the target size was made smaller, and measurement at a maximum of 69 points became possible, allowing for comparison with the Humphrey Field Analyzer (HFA) and a detailed examination of the central area. The Humphrey Matrix perimeter uses sine wave grating targets of low spatial frequency (0.5 cycle/deg) that flicker at a high frequency (18 Hz) for 24-2 and 30-2 testing strategies; therefore, this perimeter is relatively unaffected by blur due to refractive error. Indeed, its manual indicates that refractive error within ±3 diopters (D) requires no correction.
Refractive error changes with age. In the aged, the incidences of hyperopia and astigmatism are high and direct astigmatism changes with age to inverse astigmatism. The Blue Mountains Eye Study (11) showed astigmatism of ≥ 0.75 D in 37% of 3654 subjects aged 49-97 years and
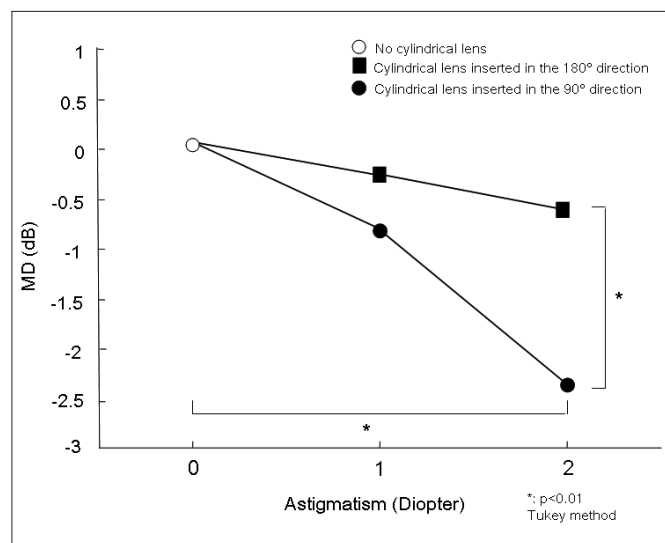
Fig. 1 - *Changes in the mean deviation (MD) in the type of astigmatism. Symbols show the mean MD.*

astigmatism of ≥1.5 D in 13%. The mean amount of astigmatism increased with age: –0.6 D in subjects 49–59 years old; –0.7 D in subjects 60–69 years old; –1.0 D in subjects 70–79 years old; and –1.2 D in subjects 80–89 years old. In the study performed by Asano et al (12) in 2161 subjects aged 40–79 years, the mean amount of astigmatism increased with age: –0.79 D in subjects 40–49 years old; –0.89 D in subjects 50–59 years old; –1.04 D in subjects 60–69 years old; and –1.25 D in subjects 70–79 years old. In the oldest group (70–79 years), astigmatism of ≥2 D was observed in about 20%. The age-related increase in the incidence of astigmatism may affect the results of Humphrey Matrix perimetry. Since in Humphrey Matrix perimetry the contrast sensitivity of flickering sine wave vertical gratings is measured, contrast sensitivity may decrease when there is horizontal blurring due to astigmatism. The influences of astigmatism on the results of Humphrey Matrix perimetry have not been clarified. The purpose of this study was to evaluate the influences of astigmatism in terms of its amount and direction on the results of Humphrey Matrix perimetry.

METHODS

A total of 31 healthy volunteers from hospital staff were consecutively recruited to undergo repeat testing with Humphrey Matrix 24-2 full threshold program with various induced simple myopic astigmatism. All subjects had previous experience (at least twice) with Matrix testing. Their mean age was 28.7 years (range, 19–38 years). They had no eye disease, past history of eye operation, history of glaucoma in first-degree family members, or migraine, neurologic disorder, hypertension, or diabetes mellitus. The contralateral eye showed no abnormalities from the anterior segment to the fundus. Refractive error was in the range from +1 D to –7 D, and the degree of astigmatism was ≤1 D. The highest corrected visual acuity was ≥30/20, and intraocular pressure was ≤21 mmHg. Pupil diameter, measured using a video eye monitor of the Humphrey Matrix perimeter, was ≥3 mm. One of the eyes in each subject was randomly selected. For each eye, a Humphrey Matrix 24-2 full-threshold program was performed consecutively at a 15-minute interval on the same day. To produce simple myopic astigmatism, a +1 D or +2 D cylindrical lens was added after complete correction of distance vision. The cylindrical lens was inserted in the 180° direction to produce vertical blur and in the 90° direction to produce horizontal blur. The test was performed under five conditions in total including insertion of the 0 D lens to avoid forming astigmatism as the control. The test order was random, and tests were double-blind for the subjects and examiners. All tests were performed in a dimmed room by an examiner who is skilled in the use of the device. Signed informed consent was obtained from all subjects. The influences of astigmatism were evaluated in terms of the mean deviation (MD), pattern standard deviation (PSD), and test duration (TD). Statistical analysis was performed using analysis of variance and multiple comparison (Tukey method), and p<0.05 was regarded as significant.

RESULTS

Fixation losses were ≤20% and false negative and false positive rates were ≤10% in all tests. Humphrey Matrix perimetry showed high reliability in all subjects. MD value in cases of 2 D inverse astigmatism was judged abnormal (p<5%) based on the Humphrey Matrix findings in 5 of the 31 subjects. Significant differences in MD were observed among the groups, but there were no significant differences in PSD or TD (Tab. I). To evaluate the influences of astigmatism on MD, the MD in each type of astigmatism was plotted (Fig. 1). Comparison between direct astigmatism and inverse astigmatism showed a more marked de-

TABLE I - MD, PSD, AND TD FOR THE FIVE SESSIONS

	0 D	1 D, 90°	1 D, 180°	2 D, 90°	2 D, 180°	p value
MD (dB)	0.03±1.6	–0.85±1.6	–0.27±1.9	–2.40±1.8	–0.56±1.8	1.17×10^{-6}
PSD (dB)	2.64±0.4	2.53±0.3	2.51±0.3	2.50±0.4	2.54±0.3	0.51
TD (sec)	306±13	300±10	303±10	304±9	303±8	0.35

All results given as mean ± standard deviation. Analysis of variance.
MD = mean deviation; PSD = pattern standard deviation; TD = test duration; D = diopter.

crease in MD in inverse astigmatism than in direct astigmatism irrespective of the amount of astigmatism; a significant difference was observed between the two types of astigmatism when the amount of astigmatism was 2 D (p<0.01). When the amount of astigmatism was 1 D, MD decreased only slightly with both direct and inverse astigmatism, showing no significant difference from that in the absence of astigmatism. In 2 D astigmatism, MD did not significantly decrease with direct astigmatism, but did significantly decrease with inverse astigmatism (p<0.01).

DISCUSSION

The Humphrey Matrix Perimeter is a second generation FDT perimeter using a frequency-doubling illusion. In conventional FDT perimeters, the targets are squares with sides of about 10°, and the maximum number of measurement points is 19. In the Humphrey Matrix perimeter, 5° square targets are used, and the maximum number of measurement points is 69. This improvement allows the evaluation of more regional visual fields and increased sensitivity and specificity for the detection of glaucomatous visual field defects (13-15). To compensate for the decrease in contrast sensitivity due to the decrease in the target size, the spatial frequency of sine wave grating targets is increased from 0.25 to 0.5 cycle/deg while the temporal frequency is reduced from 25 to 18 Hz. These changes decrease the resistance of the Humphrey Matrix perimeter to blurring due to refractive error. Conventional FDT perimeters do not require correction of refractive error of ≤7 D, but the Humphrey Matrix perimeter does not require correction of refractive error of only ≤3 D. Anderson and Johnson (16) surveyed the detailed influences of optical defocus in FDT. They evaluated the influences of defocus (0 D–6 D) on the sensitivity of the central fovea using three targets differing in size, spatial frequency, and temporal frequency (10°, 0.25 cycle/deg, 25 Hz; 5°, 0.5 cycle/deg, 18 Hz; and 2°, 0.5 cycle/deg, 18 Hz). A marked decrease in sensitivity due to optical defocus was observed using small targets (2°, 5°) with high spatial frequency (0.5 cycle/deg). In addition, 24-2 FDT perimetry revealed influences of optical defocus on MD, but not on PSD, and defocus of ≥4 D caused abnormal MD values (p<0.05). However, they added a plus spherical lens after correction to produce defocus, and the blur was omnidirectional. In this study, MD was negligibly affected by direct myopic astigmatism, but significantly affected by 2 D inverse myopic astigmatism. Since the targets of the Humphrey Matrix perimeter are vertical gratings of a relatively high spatial frequency, measurement results may be significantly unaffected by vertical blur, but significantly affected by horizontal blur. Astigmatism affected MD but not PSD. These results suggest that astigmatism induces general visual field depression, similar to the influence of refractive error previously observed (16). The influence of hyperopic astigmatism was not investigated in this study because we considered that the accommodation using negative cylindrical lenses may alter the astigmatic level and axis in the test. Accordingly, the influence of hyperopic astigmatism on the results of the Humphrey Matrix perimetry was unclear. The Humphrey Matrix perimetry may not have been affected in hyperopic astigmatism due to an accommodative ability unless the astigmatic power was higher. Thus, it is also necessary to investigate hyperopic as well as congenital astigmatism, including oblique astigmatism. Glaucoma is a chronic disease showing very slow progression in most cases. Therefore, the influences of age-related optical changes are potential problems. Refractive error is one of them. This study showed that astigmatism ≥2 D significantly decreases MD when its blur is horizontal. Therefore, in patients with in-

verse myopic astigmatism of ≥2 D, the influences of astigmatism on the visual field should be taken into consideration when the results of Humphrey Matrix perimetry are evaluated.

Proprietary interest: None.

Reprint requests to:
Eiichi Yukawa, MD
Department of Ophthalmology
Nara Medical University
840 Shijo-cho, Kashihara-shi
Nara 634-8521, Japan
y-eiichi@mrh.biglobe.ne.jp

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