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Comparison of Visual Field Measurement with Heidelberg Edge Perimeter and Humphrey Visual Field Analyzer in Patients with Ocular Hypertension

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Abstract

Background. Glaucoma is a group of eye diseases which result in damage to the optic nerve and vision loss. The most important examination in glaucoma patients is visual field assessment. One of the newer perimeters is Heidelberg Edge Perimeter (HEP).

Objectives. The aim of the study was to compare visual field measurements made with Humphrey II 740 Visual Field (Carl Zeiss Meditec) and Heidelberg Edge Perimeter (HEP) (Heidelberg Engineering). FDF stimulus (flicker defined form) in HEP stimulates magnocellular retinal cells, which are the first to be damaged in the early stage of glaucoma. Even a small loss of magnocellular cells may influence HEP visual field.

Material and Methods. The observed group consisted of 45 patients (82 eyes), age 60 ± 9.8 years, glaucoma suspects, not treated pharmacologically or surgically before, with intraocular pressure ≥ 22 mm Hg. Visual field values were measured with two different devices: Humphrey II 740 Visual Field (Carl Zeiss Meditec, Jena, Germany) and Heidelberg Edge Perimeter (Heidelberg Engineering, Heidelberg, Germany). The patients were divided into two groups: Group 1 – tested with SITA Standard program on Humphrey perimeter and ASTA Standard HEP, and Group 2 – tested with SITA Fast program on Humphrey perimeter and ASTA Standard on HEP.

Results. Few positive ΔMD results ($\Delta MD = MD_{HEP} - MD_{HUM}$) were obtained in Groups 1 and 2, which means that the deviation value on the HEP perimeter was only slightly higher than the mean deviation value on Humphrey. Therefore, one can conclude that HEP perimeter may detect visual field defects with greater precision. The visual field measurements between ASTA Standard on HEP and SITA Standard on Humphrey as well as ASTA Standard on HEP and SITA Fast on Humphrey are not equal: MD values on HEP perimeter are lower than MD on Humphrey, which can mean that HEP perimeter provides more precise results and shows even early visual field lesions.

Conclusions. HEP perimeter measures visual field defects with greater precision so it should be taken into consideration for earlier glaucoma detection in routine ophthalmological diagnosis (*Adv Clin Exp Med* 2016, 25, 5, 937–944).

Key words: glaucoma, visual field, Heidelberg Edge Perimeter, ocular hypertension.

The aim of this study was to compare visual field examinations performed with two different devices: Heidelberg Edge Perimeter (HEP) and Humphrey perimeter. HEP is one of the newer devices, which can detect even very early stages of glaucoma. Humphrey allows for an easy diagnosis

and progression analysis in patients with glaucoma, which is especially important in everyday medical practice [1]. Standard Automated Perimetry is presently the most common examination method of the visual field. Flicker perimeters, including HEP, are static perimeters using different types of

stimulus [2, 3] and are especially useful in the early detection of glaucomatous changes [4–6].

In frequency-doubling technology (FDT), a sinusoidal grid of low spatial frequency flickering with high frequency is observed and the eye perceives this grid as the element of twice higher spatial frequency [7–9], which is an optical illusion. It seems that such stimuli react to large, magnocellular (M) ganglion cells [10], which allows us to detect very early glaucoma stages, in which M-type retinal ganglion cells are damaged at the onset [10–13]. HEP consists of randomly flickering points against a background of medium illumination (50 cd/m^2); the background remains identical during the entire examination of the visual field. FDF (flicker defined form) is a five-stage, circular stimulus, formed through phase inversion of flickering black and white dots and creates illusory contours. It stimulates M cells of the retina, which constitute 4% of the retinal population of ganglion cells. M cells, with M_y subtype, are very sensitive to damage as a result of glaucoma and are damaged during an early stage of the disease [10, 14]. Even a small loss of the large ganglion cells influences visual functions and, as a result, this type of visual field. For this reason, early detection of their loss is very important and allows for an early therapy.

Standard Automated Perimetry (SAP) examination can be performed just as well with HEP. HEP offers two kinds of stimuli: 1) FDF – 3° circular width for the 10-3 test and 5° circular width for the 24-2, 30-2, S-30 tests; and 2) SAP – Goldmann scale II for the 10-2, 24-2 and 30-2 tests; Goldmann scale V for the 10-2, 24-2 and 30-2 tests. The HEP also offers various test strategies, including three different kinds of ASTA (Adaptive Staircase Thresholding Algorithm; which uses up or down staircase procedure, modified in relation to a database): 1) ASTA Standard, which uses probability estimates generated from normal distributions in order to optimize the performance of the test; 2) ASTA follow-up, which compares the results of the present examination with previous ones; and 3) ASTA Fast, which uses 4 : 2 stairs that speed up the examination. ASTA Fast is recommended for screening procedures on patients remaining “within normal range” or those who have demonstrated a high fatigue level. The results are less repeatable than ASTA Standard, but the duration of the tests is shorter.

Material and Methods

Fifty-five individuals participated in the study, including 27 women and 28 men (110 eyes). The study was conducted at the Clinic of Oph-

thalmology, Wroclaw Medical University, Poland between September 2012 and July 2013. The study considered only those parameters in which fixation errors were $\leq 20\%$ and false positive and negative errors were $\leq 30\%$, leaving 45 (82 eyes) individuals for further analysis; 27 (60%) were women and 18 (40%) were men. The mean age of the patients was 60 ± 9.8 years. The examined group consisted of individuals with suspected glaucoma that has not been treated pharmacologically or surgically and whose intraocular pressure was above 21 mm Hg (average intraocular pressure – 26.3 mm Hg). Diabetics and patients with neurological medical history were not qualified. Each person was subjected to a refraction examination in order to select the best correction and the examined patients with $V \geq 0.8$ visus had no changes in visual field.

Two devices were used to perform the examinations: Humphrey II 740 Visual Field Analyser (Carl Zeiss Meditec; Jena, Germany) and HEP (Heidelberg Engineering; Heidelberg, Germany). We used HEP software release 2.2, which includes HEP Acquisition Module (AQM) v. 2.2, HEP Viewing Module (VWM) v. 2.2 and Heidelberg Eye Explorer (HEYEX) v. 1.7. All examinations were performed in the same darkened rooms. The examinations of the visual field with both perimeters were conducted over two subsequent days.

The examined patients were divided into two groups. One group was examined using SITA Standard program with Humphrey perimeter and ASTA Standard program using HEP (20 individuals, 12 women and 8 men), while the second group was examined using SITA Fast with Humphrey perimeter and ASTA Standard with HEP (25 individuals, 15 women and 10 men).

Because a scale in HEP runs from 0 to 25 dB, it cannot be easily compared with the results obtained using the Humphrey perimeter. For this reason, HEP values were converted into a scale generally assumed for SAP perimeters (including Humphrey's), which allowed for a comparison of the obtained results. The values were converted by HEP due to its standard function. The difference of mean values between HEP and SAP was 1.7 dB.

The mean deviation (MD) for each eye was calculated separately as a mean for the values in the Total Deviation graph; δMD was calculated as the standard deviation. To verify the null hypothesis, $H_0: \Delta\text{MD} = 0$, against the alternative hypothesis, $H_1: \Delta\text{MD} \neq 0$, where ΔMD is a mean value of the MD differences, the non-parametrical Wilcoxon test was performed using STATISTICA v. 19. This test shows that the p-value of obtaining statistical test results close to zero is less than 0.001, assuming the null hypothesis is true and the p-value is less than the predetermined significance level of

0.05. Therefore, we can accept that measurements with two perimeters yield significantly different MD values.

Results

MD (mean deviation) was calculated separately for each eye using the Total Deviation graph in HEP and Humphrey perimeters (marked as HUM in tables). MD, as well as Δ MD (Δ MD = MD HEP – MD HUM), values for the left and right eye obtained from HEP and Humphrey's perimeters, respectively, are presented in Table 1. A cross in the tables marks no examination for a given eye (only one measurement out of all examinations in eight individuals could have been used for further studies). Δ MD values were calculated through a comparison of the results obtained with both perimeters. Positive values which demonstrate that the mean deviation for a given patient was lower with HEP than with Humphrey perimeter are marked

red in the tables. All Δ MD values marked black mean a lower result was obtained with HEP.

As shown in Table 1, only one positive Δ MD result (out of 38; 2.6%) was obtained for Group 1, indicating that the MD value obtained with the HEP was higher than the MD value obtained with the Humphrey perimeter. The mean MD value (MD_{mean}) for the left eye was -5.71 ± 4.3 dB (Δ MD LE) and for the right eye was -4.74 ± 4.1 dB (Δ MD RE). Only two positive Δ MD results (out of 44; 5%) were obtained with the Humphrey perimeter (Table 2). The MD_{mean} value for the left eye was -5.07 ± 2.9 dB (Δ MD LE) and for right eye was -4.33 ± 3.9 dB (Δ MD RE). In addition to the whole visual field, results were compared by quadrants; the distribution is shown in Fig. 1. The results of MD difference are presented for specific quadrants for HEP and Humphrey perimeters, where those marked in red are cases in which Humphrey's perimeter was lower than HEP.

For Group 1, 8 results (out of 152; 5%) are positive, i.e. measurements with HEP give higher MD

Table 1. MD values of right (RE) and left eye (LE) and comparison of MD for both perimeters: Group 1

Patient's number	MD LE	MD LE	MD RE	MD RE	Δ MD LE	Δ MD RE
	HEP [dB]	HUM [dB]	HEP [dB]	HUM [dB]	[dB]	[dB]
1	-13.79	-1.35	-8.35	-0.06	-12.44	-8.29
2	-2.63	0.31	-2.40	-0.71	-2.94	-1.69
3	-4.23	1.13	-3.60	1.63	-5.37	-5.23
4	-2.54	0.27	-1.17	0.46	-2.81	-1.63
5	-2.10	-1.40	-0.58	-0.83	-0.69	0.25
6	-21.00	-7.10	-16.04	-5.73	-13.90	-10.31
7	-22.23	-9.21	-19.35	-5.56	-13.02	-13.79
8	-17.90	-8.27	-14.13	-4.06	-9.63	-10.08
9	-11.08	0.10	-7.63	-0.23	-11.17	-7.40
10	-9.96	-0.92	-9.71	0.50	-9.04	-10.21
11	-3.23	1.65	-0.56	0.65	-4.88	-1.21
12	-2.33	-0.44	-3.62	0.21	-1.88	-3.83
13	-5.85	-0.25	-1.81	-0.17	-5.60	-1.63
14	-3.92	-1.35	-3.81	-2.48	-2.58	-1.33
15	-4.54	-1.50	-1.94	-0.23	-3.04	-1.71
16	-4.75	-1.31	-0.50	-0.15	-3.44	-0.35
17	-7.27	-5.04	-10.40	-4.19	-2.23	-6.21
18	-3.60	-0.54	-4.13	-1.46	-3.06	-2.67
19	X	X	-13.92	-11.13	X	-2.79
20	-1.15	-0.46	X	X	-0.69	X

Table 2. MD values of right (RE) and left eye (LE) and comparison of MD for both perimeters: Group 2

Patient's number	MD LE	MD LE	MD RE	MD RE	Δ MD LE	Δ MD RE
	HEP [dB]	HUM [dB]	HEP [dB]	HUM [dB]	[dB]	[dB]
1	-11.27	-0.85	-3.69	0.98	-10.42	-4.67
2	-7.48	-0.29	-5.77	-0.06	-7.19	-5.71
3	-3.21	0.23	-4.77	-0.04	-3.44	-4.73
4	-2.92	-0.23	-1.73	0.35	-2.69	-2.08
5	-3.73	0.73	-3.54	-1.63	-4.46	-1.90
6	-2.54	-1.73	-1.88	1.21	-0.81	-3.10
7	-9.38	-3.83	-7.71	-3.79	-5.56	-3.92
8	-14.92	-2.10	-13.63	-1.88	-12.83	-11.75
9	-9.25	-8.21	-2.33	-0.62	-1.04	-1.71
10	-6.08	-1.12	-5.10	-0.44	-4.96	-4.65
11	-6.06	-1.96	-8.44	-0.19	-4.10	-8.25
12	-6.04	1.02	-5.81	0.08	-7.06	-5.88
13	-4.81	0.71	-1.94	0.81	-5.52	-2.75
14	-4.90	-0.58	-3.77	-0.71	-4.33	-3.06
15	-3.96	-0.63	-6.69	-0.35	-3.33	-6.35
16	-6.44	-2.63	-4.13	-0.90	-3.81	-3.23
17	-18.19	-13.48	-15.54	-11.40	-4.71	-4.13
18	-4.21	-2.38	-2.21	0.65	-1.83	-2.87
19	-9.23	-0.81	-18.62	-2.38	-8.42	-16.23
20	X	X	2.92	-1.48	X	4.40
21	X	X	-3.00	0.62	X	-3.62
22	X	X	-3.44	0.69	X	-4.13
23	X	X	-5.79	-6.94	X	1.15
24	X	X	-2.77	1.94	X	-4.71
25	-6.73	-1.83	X	X	-4.90	X

Fig. 1. Visual field quadrants division. The quadrants are color-marked: yellow – MD1 (upper temporal); blue – MD2 (upper nasal); green – MD3 (lower temporal); red – MD4 (lower nasal)

Table 3. The MD values comparison of right (RE) and left (LE) eye in different quadrants: Group 1

Patient's number	Δ MD1 LE [dB]	Δ MD1 RE [dB]	Δ MD2 LE [dB]	Δ MD2 RE [dB]	Δ MD3 LE [dB]	Δ MD3 RE [dB]	Δ MD4 LE [dB]	Δ MD4 RE [dB]
1	-11.93	-7.43	-12.08	-9.50	-10.86	-7.86	-15.25	-8.58
2	-3.64	-0.36	-0.83	-0.50	-4.14	-3.43	-2.83	-2.42
3	-4.64	-4.57	-5.58	-4.75	-5.50	-6.29	-5.83	-5.25
4	-3.00	0.00	-1.33	-0.25	-3.71	-3.29	-3.00	-3.00
5	-0.43	-0.86	-1.25	-1.50	-0.93	2.71	-0.17	0.42
6	-15.21	-5.14	-13.08	-11.83	-12.14	-12.64	-15.25	-12.08
7	-12.79	-9.21	-5.67	-15.75	-15.43	-15.79	-17.83	-14.83
8	-10.00	-7.64	-5.17	-11.25	-14.36	-8.93	-8.17	-13.08
9	-11.29	-8.07	-11.17	-5.83	-11.64	-7.07	-10.50	-8.58
10	-9.50	-8.71	-6.92	-9.92	-9.64	-9.86	-9.92	-12.67
11	-5.57	-0.43	-4.00	0.75	-5.50	-2.86	-4.25	-2.17
12	-2.29	-3.71	-1.50	-3.25	-0.86	-4.07	-3.00	-4.25
13	-6.14	-1.43	-7.58	-0.08	-4.00	-1.50	-4.83	-3.58
14	-3.29	-0.50	-2.00	-2.17	-3.14	0.21	-1.67	-3.25
15	-5.36	-2.14	-1.58	-1.75	-2.64	-1.07	-2.25	-1.92
16	-2.86	-0.86	-2.92	0.25	-5.43	0.71	-2.33	-1.58
17	-3.86	-5.29	-3.08	-1.83	1.71	-5.07	-4.08	-13.00
18	-2.79	-4.29	-2.08	-0.92	-3.57	-3.64	-3.75	-1.42
19	X	-7.79	X	-12.50	X	8.00	X	0.17
20	-0.93	X	-1.83	X	0.57	X	-0.75	X

Table 4. Mean MD values (MD_{mean}) and standard deviation (δMD) for each quadrant: Group 1

	Δ MD1 LE [dB]	Δ MD1 RE [dB]	Δ MD2 LE [dB]	Δ MD2 RE [dB]	Δ MD3 LE [dB]	Δ MD3 RE [dB]	Δ MD4 LE [dB]	Δ MD4 RE [dB]
MD_{mean}	-6.08	-4.13	-4.72	-4.87	-5.85	-4.30	-6.09	-5.85
δMD	4.35	3.27	3.86	5.22	5.04	5.51	5.27	5.06

values (Table 3). Table 4 shows the MD_{mean} results, as well as standard deviation δMD . Evidently, HEP measurements yield results that are 4–6 dB lower. For Group 2, 12 results (out of 176; 7%) are positive (Table 5); the MD_{mean} and δMD are shown in Table 6. HEP measurements appear to yield results that are 4–5 dB lower.

Discussion

HEP is one of the newer perimeters available and its suitability in diagnosing and monitoring glaucoma is currently being intensely investigated.

To date, only a very few reports on examinations with this fieldmeter have been published. Lamparter et al. compared the results from SAP, FDF perimetry, FDT perimetry and laser ophthalmoscopy [14]. In their study the Humphrey perimeter was a SAP, FDT perimetry used the Humphrey Matrix-FDT, while the FDF perimeter used HEP. The greatest correlation was obtained with the FDF type perimetry, with the FDT perimetry coming second best and SAP having the lowest result correlation; measurements were performed in temporal regions where glaucomatous changes progress most rapidly. In addition, three subsequent measurements with the FDT perimeter were performed

Table 5. The MD values comparison of right (RE) and left (LE) eye in different quadrants: Group 2

Patient's number	Δ MD1 LE [dB]	Δ MD1 RE [dB]	Δ MD2 LE [dB]	Δ MD2 RE [dB]	Δ MD3 LE [dB]	Δ MD3 RE [dB]	Δ MD4 LE [dB]	Δ MD4 RE [dB]
1	-8.79	-3.71	-10.75	-5.08	-9.71	-5.29	-12.83	-4.67
2	-8.57	-4.57	-6.25	-6.42	-9.00	-6.07	-4.42	-5.92
3	-2.71	-3.29	-3.25	-3.00	-3.57	-4.36	-4.33	-8.58
4	-3.21	-2.79	-2.42	-4.25	-2.14	-1.07	-3.00	-0.25
5	-4.93	-4.93	-5.67	0.58	-2.79	-3.29	-4.67	0.75
6	-1.86	-4.21	-1.67	-2.42	0.07	-2.43	0.25	-3.25
7	-7.50	-3.71	-2.92	-2.50	-7.43	-6.14	-3.75	-3.00
8	-16.93	-14.29	-11.50	-12.08	-12.43	-11.71	-9.83	-8.50
9	-3.79	-1.86	3.00	-1.67	-1.71	-2.07	-1.08	-1.17
10	-6.50	-4.43	-4.83	-5.83	-4.29	-4.93	-4.08	-3.42
11	-1.07	-4.86	-3.50	-4.83	-6.00	-14.07	-6.00	-8.83
12	-11.14	-4.57	-5.67	-4.58	-5.14	-7.93	-5.92	-6.33
13	-7.50	-3.07	-4.17	-4.92	-4.86	-1.00	-5.33	-2.25
14	-5.50	-2.64	-2.67	-5.75	-6.64	-3.21	-1.92	-0.67
15	-4.21	-7.00	-2.50	-5.92	-3.71	-6.43	-2.67	-5.92
16	-2.71	-0.36	-2.58	-2.75	-4.57	-4.50	-5.42	-5.58
17	-3.86	-4.14	-10.75	-4.67	-1.07	-5.93	-3.92	-1.50
18	0.14	-2.57	-4.25	-0.33	-2.14	-4.86	-1.33	-3.42
19	-12.64	-23.86	-8.25	-16.33	-6.43	-14.21	-6.00	-9.58
20	X	5.71	X	4.33	X	2.93	X	4.67
21	X	-3.57	X	-2.50	X	-4.43	X	-3.83
22	X	-5.00	X	-4.25	X	-4.21	X	-2.92
23	X	5.50	X	5.83	X	-2.14	X	-4.75
24	X	-5.21	X	-3.92	X	-4.50	X	-5.17
25	-5.57	X	-2.67	X	-6.00	X	-5.08	X

Table 6. Mean MD values (MD_{mean}) and standard deviation (δMD) for each quadrants: Group 2

	Δ MD1 LE [dB]	Δ MD1 RE [dB]	Δ MD2 LE [dB]	Δ MD2 RE [dB]	Δ MD3 LE [dB]	Δ MD3 RE [dB]	Δ MD4 LE [dB]	Δ MD4 RE [dB]
MD_{mean}	-5.94	-4.31	-4.66	-3.89	-4.98	-5.08	-4.57	-3.92
δMD	4.18	5.60	3.52	4.43	3.11	3.91	2.94	3.34

over a three-month period and used for comparison [15]. Differences in MS (mean sensitivity), MD, PSD (pattern standard deviation), test duration and reliability index were also analysed and the results indicated that MS, MD ($p \leq 0.01$) and PSD ($p \leq 0.02$) improved. Test duration decreased

significantly ($p < 0.01$) and the number of fixation errors was reduced between subsequent tests. Taken together, the results suggest it is necessary to examine a patient several times in order to sufficiently and precisely examine the visual field with the FDF perimeter. It is very important to give the

eyes time to rest between subsequent examinations, as it is possible to obtain more precise results in this way.

Describing the initial study results, Hasler and Sturmer stated that in patients with ocular hypertension or suspicion of glaucoma, HEP seems to be more sensitive than conventional static perimetry [16]. Following the initial studies, other authors reported a good correlation between Humphrey and HEP perimeter in some global values [17]. Similar test results were observed when comparing SAP performed with both perimeters [18, 19]. Comparable results were observed at both lower (< 15) and higher (> 16) dB values, which confirms that the application of a larger target in HEP is equally detectable as a brighter, smaller target in Humphrey.

In our studies, Δ MD values were calculated by comparing the results obtained with both perimeters, allowing us to determine which perimeter is worse, as lower results (lower dB value) were obtained. Positive values marked with red in the tables demonstrate that the mean deviation for a given patient with HEP was lower than with Humphrey; thus, the results obtained with the Humphrey perimeter were worse. All Δ MD values marked with black indicate a lower result with HEP. Our results show that the MD with HEP was usually worse, which may suggest that the device is more precise and detects early lesions on the retina, or the test might be more difficult for the patient. Several positive Δ MD results were obtained in Group 1 (Table 1) and in Group 2 (Table 2), which means that the MD value measured with HEP was only slightly higher than the MD value measured with the Humphrey perimeter. Therefore, it is pos-

sible to assume that the HEP measures possible losses in the visual field with greater accuracy.

Following the comparison of results obtained after a single examination with HEP and Humphrey perimeters, we obtained MD values for both eyes as well as for individual quadrants. The results obtained with HEP were worse than those obtained with Humphrey perimeter, which might result from the detection of early losses in the visual field by HEP or difficulty in performing the test. Moreover, worse results were observed while comparing repeatability of the test results in the first examination to subsequent ones, which was also noted by other authors conducting studies on bigger groups [15].

Another important aspect is connected to the sensitivity of the examined individuals, which was not considered in the study, but which may greatly influence the results of the tests. In the case of decreased contrast sensitivity, the patients examined with HEP can have problems with noticing the stimulus, which is dark grey and displayed on a grey, blinking background.

The test results comparing ASTA Standard with HEP and SITA Standard with Humphrey perimeter, as well as ASTA Standard with HEP and SITA Fast with Humphrey perimeter are not identical. MD results obtained with HEP are lower than MD obtained with Humphrey perimeter, which might mean that HEP yields more accurate results and detects very early losses in the visual field. Thus, check-up examinations should be performed with the same perimeters, since the results of examinations performed interchangeably with Humphrey and HEP perimeters cannot be properly compared.

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