Acta Scientific Ophthalmology (ISSN: 2582-3191)

Volume 4 Issue 11 November 2021

Research Article

Multifocal Visual Evoked Potential in Glaucoma

Mona Abdel Kader*

Professor, Department of Ophthalmology, Mansoura Ophthalmic Center, Egypt

***Corresponding Author:** Mona Abdel Kader, Professor, Department of Ophthalmology, Mansoura Ophthalmic Center, Egypt.

Received: August 16, 2021

Published: October 25, 2021

Abstract

Purpose: To determine the effect of glaucomatous damage on latency and amplitude of the multifocal visual evoked potential (MF-VEP), to compare latencies of conventional pattern visual evoked potential (C-VEP) and multifocal visual evoked potential and to compare diagnostic performance of MF-VEP and standard automated perimetry (SAP).

Participants: Thirty-five glaucomatous patients (70 eyes) and twenty- five normal controls (50 eyes) were enrolled in this study.

Methods: Monocular MF-VEP were recorded from glaucoma group and control group. Both eyes of (60) individuals were evaluated. Subjects ranged in age from 30 to 60 years in control and from 32 to 65years in glaucoma group. C- VEP and MF-VEP were obtained by using (Roland consult, Brandenburg, Germany) with four - electrode array. SAP visual field (Humphrey Field Analyzer, 640 Carl Zeiss, Co, Sanleandro, Calif) were obtained within days from VEP.

Results: Fifty-five eyes in glaucoma group had Humphrey field defect, of which 50 eyes (90%), Humphrey field defects were correlated with MF-VEP amplitude. Topographic location was well correlated with Humphrey field. Mean amplitude was significantly reduced in glaucoma eyes.

In 15 glaucoma patients with no scotoma by definition in the fellow eye, 13 had abnormal multifocal perimetry. In 55 glaucoma eyes with abnormal Humphrey visual field one had normal multifocal perimetry. Of 140 hemi field (35 glaucoma patients x two eyes x two hemi field), 110 hemi field showed significant clusters on HVF and 134 hemi field showed significant cluster on the MF-VEP. The amplitude of MF-VEP was correlated with Humphrey MD (r = 0,7, P = 0,000).

Conclusion: MF-VEP can assess the visual field and identify glaucomatous visual field defect. It may have the potential for identifying defects earlier than conventional perimetry. MF-VEP showed more abnormalities than SAP. However, although there were abnormalities detected by the MF- VEP that were missed by SAP, the reverse was true.

Keywords: Multifocal Visual Evoked Potential (MF-VEP); Conventional Pattern Visual Evoked Potential (C-VEP); Standard Automated Perimetry (SAP)

Introduction

At present, there is no completely reliable test for the detection of glaucoma. Current methods depend on the subjective detection of visual field defects and assessment of optic nerve damage. However, it is estimated that 25% to 50% of nerve fibers can be lost before a field defect is detected on perimetry [1-3].

Many patients perform poorly on subjective tests, particularly the elderly. There is also a learning curve associated with perimetry that complicates interpretation in new patients. Therefore, there is a strong demand for an objective measure of the visual field to supplement the variable performance seen on psychophysical test, to provide a means of monitoring for progressive change, and to offer the possibility of earlier defection of glaucomatous damage. The objective assessment of the visual field using multifocal stimulation has been reported [4-6]. Recording the activity of the visual cortex in response to stimulation of localized areas of the visual field has the potential for diagnosis and management of various ophthalmic and neurological disorders, in particular where the visual system experience focal areas of dysfunction, such as glaucoma.

Baseler and associated, first recorded a multifocal visual evoked potential [7]. The method of pseudorandom presented multifocal stimulation together with cortical scaling of the size of stimulated patches was used.

The technique of MF-VEP was limited by large inter-subject variability of responses found in normal subjects. This variability is due largely to anatomic difference in the visual cortex, in relation to the placement of external electrodes and differences in the local folding of the cortex within VI [8]. One approach for overcoming this problem is based on the finding that the MF-VEP responses from the 2 eyes of the same individual are almost identical in the wave form and amplitude of signals between the two eyes of the normal subjects [10].

For patients with glaucoma who have asymmetrical visual field defects, an intraocular comparison of monocular MF-VEP responses (Intraocular test) reveals the deference between the eyes [10,11]. One of the drawbacks of this method is the possibility that bilateral damage will be missed. It is reported that visual field defects can also be detected with MF-VEP by comparing the amplitude of the response of each eye to group norms (monocular test) [13,14].

Aim of the Study

The aim of this work is to determine the effect of glaucoma on MF-VEP and C-VEP parameters, to compare MF- VEP and C-VEP and to compare MF-VEP and SAP.

Subjects and Methods

This study was carried out on patients attending the Outpatient's Clinic of Mansoura Ophthalmic Center during the period from March to December 2020. The study included 120 eyes of 60 subjects (70 eyes with glaucoma and 50 eyes were normal). All subjects underwent full ophthalmic examination including visual acuity, slit lamp biomicroscopy, stereoscopic optic nerve head photography, static Achromatic automated perimetry, ME-VEP, C-VEP. The same ophthalmologist examined all subjects. The inclusion criteria for control group were normal intraocular pressure and ophthalmoscopy and no family history of glaucoma or retinal dystrophy. All required normal Humphrey (24-2) threshold fields tests (Humphrey Field Analyser, 640 Carl Zeiss, Co, Sanleandro, Calif) confirmed by normal result on the glaucoma hemi field test analysis [14] and showed no clusters of points that could constitute a scotoma as defined for glaucoma patients. The inclusion criteria for both the normal and glaucoma group required a corrected visual acuity 6/12 or better and pupil at least 2.5 mm without dilation. Subjects with refractive error exceed ± 6D, diabetes, previous cataract surgery, or any other ocular disorders were excluded. All subjects had reliable visual fields with fewer than 33% fixation loss, false positives and false negatives.

The diagnosis of glaucoma required a confirmed visual field defect on Humphrey 24-2 and glaucomatous optic disc as judged by stereo disk photography. Intraocular pressure was 22 mmHg or more on applanation tonometry. The definition of a field defect used the pattern deviation plot on the Humphrey 24-2 program. A minimum scotoma required a cluster of three or more abnormal points including at least two points depressed by P-value less than 5% on the pattern deviation probability plot. The cluster of abnormal points could not cross the horizontal meridian and points immediately above and below the blind spot could not qualify as part of the overall scotoma but at least two of the points qualifying as the nucleus had to be non rim. The glaucoma hemifield test needed to be abnormal patients had previously performed Humphrey 24-2 fields on two or more occasions and had demonstrated reproducible field defects. Both eyes were tested so that asymmetry analysis could be performed.

Conventional pattern visual evoked potential (C-VEP)

C-VEP and MF-VEP were recorded using (Roland consult, Brandenburg, Germany). The conditions of stimulation and recording followed ISCEV guide- lines [15]. The display, a reversing checkerboard, was 48° in diameter and had mean luminance of 80 cd/m^2 and a contrast close to 100% (> 99%). Two checkerboard stimuli with check sizes of 15 and 60 minutes were used. Each reversed at

two reversals per second. Subjects were refracted for viewing distance and wore the appropriate refractive correction. The stimuli were viewed through natural pupils. Recordings were obtained for each eye separately, the non tested eye was occluded. A small red dot was placed at the center of the stimulus to aid in fixation. Subjects were seated at distance 1 meter. Three types of electrodes are connected to subjects. Active (positive) electrode is connected to midline of head (2) finger breadth above inion (projection at back head). Ground electrode is connected in midline of head at level of ear lobule. Negative electrode is connected to middle of forehead (Figure 1A). The sites of electrode are cleaned with cleaning cream before putting the electrode. The electrodes (gold, cup-shaped) are filled with connecting gel before putting in their sites. Impedance was kept below (10 K). For each eye and each check size two recordings were obtained.

Figure 1: A- Patient with C-VEP connection. B- Patient with MF-VEP connection.

MF- VEP

The stimulus display, viewed through natural pupils with appropriate refractive correction, consisted of 61 (segments) sectors in dartboard configuration with two sectors located in the nasal region. Each sector contains checker board pattern (16 checks); 8 white (200/cd/m^2) and 8 black (< 1 cd/m^2). The segments were cortically scaled with eccentricity to stimulate approximately equal areas of cortical (striate) surface which produces a signal of similar amplitude from each simulated segment. The stimulus array was displayed on a black and white monitor driven at frame rate of 75 HZ. The mean background luminance was 100%. Stimulation was monocular after occlusion of the other eye. 4 channel silver - silver chloride electrodes were connected to subjects. First channel electrode is connected 3.5cm above inion, second channel electrode and third channel electrode were connected 4cm right and left of inion respectively and fourth channel electrode is connected 3 cm below inion (Figure 1B). The ground electrode is connect to middle of forehead. Conductive gel or/and sodium chloride solution is used to ensure good conduction of electrode. The impedance should be below 10K. The subjects were seated at distance 30 cm from stimulus display with chin slightly elevated to relax neck muscles.

They were asked to fixate a fixation target at the center of the stimulus display. The extent of field was 25˚ central up to 42˚ nasal. The central area of 1 degree was not stimulated but was used as fixation point. The signal was amplified and filtered. MF-VEP responses from each channel were exported from the system and the two recordings from each eye were averaged. These averaging as well as all other analysis were computed. Mean peak to trough amplitudes for each wave were determined and compared among channels for every stimulated segment of the visual field. Monocular latencies were measured and analyzed. The wave of maximal amplitude from each point in the field was automatically detected and a combined topographic map was created by software. To assess the ability at MF-VEP to detect glaucoma damage and to determine its correlation with Humphrey global indices and local threshold, the results were analyzed in several ways:

- **First:** In combined VEP trace array, all individual responses with amplitude less than 120 nv were determined for each patient and these points were correlated with Humphrey mean deviation (MD) and corrected pattern standard deviation. The arbitrary value 120 nv was chosen since at this level the wave form is difficult to identify from background noise.
- **Second:** VEP amplitudes of glaucoma patients in combined trace array were compared with healthy Volunteer. Points with difference in amplitude of more than 1.96 standard deviation (i.e. $P < 0.05$) from the mean value from that point in healthy volunteer database were considered abnormal. The number of abnormal points was correlated with Humphrey MD and corrected pattern standard deviation values for the same patient.
- **Third:** The local distribution of VEP points with amplitude less than 120 nv was then compared with the distribution of

abnormal points (p < 0.5%) on the Humphrey total deviation plot. Because the distribution and the size of these points varies with eccentricity for the VEP stimulation but is constant for Humphrey, a direct point by point comparison was not possible. Therefore, a correlation between the number of abnormal points within the same quadrant was performed (Figure 2). Similarly, the number of abnormal points (compared with healthy volunteer) in each quadrant of VEP trace array was then correlated with number of abnormal points (P < 0.5%) in the same quadrant of Humphrey pattern deviation plot. For the recognition of scotomas to give a measure of overall test sensitivity, the criterion for abnormality used was at least three adjacent points reduced to less than 120nv, in a similar distribution to the Humphrey scotoma. To detect early VEP changes, in each participant the intereye asymmetry was calculated for every segment of the tested visual field dividing the difference in amplitude between right and left eyes by their sum:

- **Response Asymmetry Coefficient (RAC) =** (Amplitude 1 - Amplitude 2)/(Amplitude 1 + Amplitude 2).
- Amplitude 1 = Maximal peak to trough amplitude of the response at a particular segment from the left eye.
- Amplitude 2 = Maximal peak to tough amplitude of the response of the same segment from the right eye.

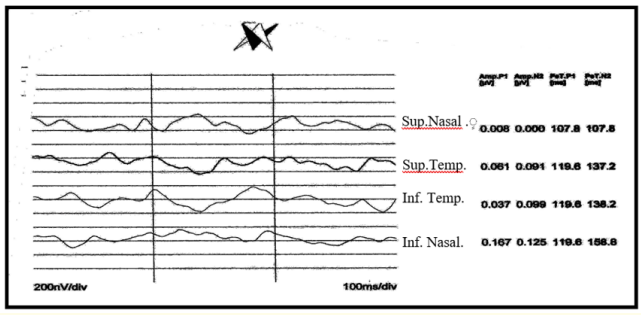

Figure 2: Average quadrants in glaucoma group.

Statistical analyses

Data were analyzed using SPSS (statistical Package for social sciences version 10). Chi square test, Fisher exact and test of significance were used for comparison between group. All variables were tested for normality by Kolmogorov-Smirnov test. Spearman's correlation coefficient was used to calculate correlation between variables P < 0.05 statistical significant, R ≥ 0.5 good correlation, R < 0.5 weak correlation.

Results

This study included 120 eyes of 60 subjects. The study included two groups: control group, (25 subjects, 50 eyes, 15 males and 10 females) and glaucoma group (35 patients, 70 eyes, 18 males and 17 females). The age of subjects ranged from 30 to 60 years (mean 45 ± 10.2) in control group and from 32- 65 years (mean 43 ± 18.6 years) in the glaucoma group. Patients with glaucoma showed changes in their multifocal objective perimetry results in almost all cases. The mean amplitude of multifocal objective perimetry (MOP) which is a relatively global measure of function, similar to Humphrey MD, showed a highly significant reduction compared with normal subjects. For normal subjects, mean amplitude for all eyes was 250 ± 50 nv whereas for patients with glaucoma mean amplitude was 110 ± 80 nv (Table 1). The mean visual evoked potentials amplitude was therefore substantially lower in the glaucoma eyes. However, this could not identify all individual cases. There was one eye with Humphrey field defect couldn't identify with MF-VEP.

	Normal	Glaucoma	P
Mean amplitude (nv)	250 ± 50	110 ± 80	0.001
Relative latency (milli-second)	70 ± 10.05	95 ± 15	0.001

Table 1: MF-VEP parameters among groups.

The sensitivity of calculating the mean amplitude as a marker for glaucoma was (95.7%) (Table 2).

	Normal (50 eyes)		Glaucoma (70eyes)
Mop averaged amplitude(1)	(0.04%)	2	67 (95.7%)

Table 2: Sensitivity of MF-VEP.

(1): The number of normal subjects who demonstrated an abnormal (false - positive).

Mop = Multifocal Objective Perimetry.

The intereye asymmetry for healthy volunteers was seen to be very small with almost identical traces recorded from the same part of the visual field for the two eyes. The patient with glaucoma had significantly greater mean quadrant RAC values compared with control group (Table 3).

Quadrants	Normal	Glaucoma	P
Lower-nasal	0.020 ± 0.01	0.090 ± 0.030	0.000
Lower-temporal	0.022 ± 0.02	0.098 ± 0.060	0.000
Upper-nasal	0.030 ± 0.011	0.099 ± 0.080	0.000
Upper-temporal	0.033 ± 0.012	0.100 ± 0.099	0.000

Table 3: Response asymmetry coefficient among groups (RAC).

The number of abnormal points on VEP perimetry correlated strongly with Humphrey MD (r = 0.7), P = 0.000) in the glaucoma group. A high correlation (R = 0.8, P = 0.001) was also found between Humphrey MD and the number of points in VEP perimetry that were statistically different in amplitude from control group. The correlation with corrected pattern standard deviation also held but was weaker (R = 0.45, p = 0.001) in glaucoma. Topographic location of scotomas was also highly correlated between Humphrey and VEP perimetry (Figure 3).

V.F.	Normal	Glaucoma
Mean deviation (MD)	1 ± 0.5	6 ± 10.1
Corrected Standard Pattern deviation (CSPD)	0.5 ± 0.5	4.2 ± 6.55

Table 4: Visual field (V.F) among groups (P = 0,005).

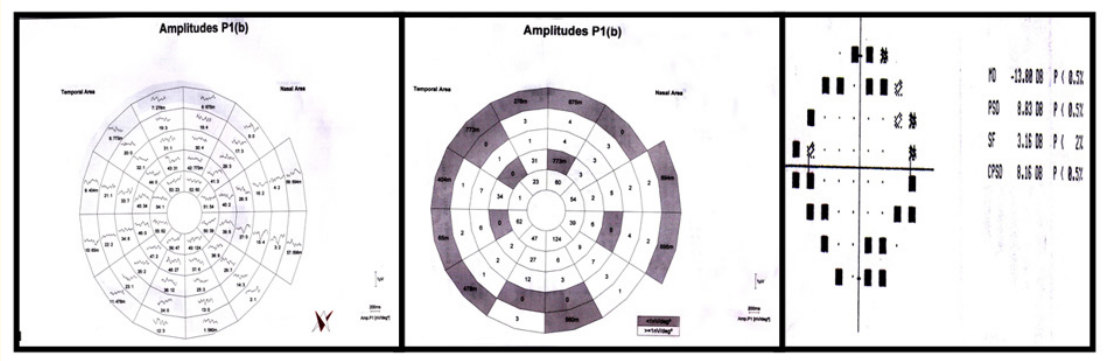

Figure 3: A case double arcuate scotoma in HVF with corresponding multifocal visual evoked potential. There is close topographic correlation between the two tests (in the areas of the visual field defect).

There was generally good concordance between MOP amplitude and Humphrey V.F. threshold scores, while there was poor correlation between latency delay and degree of visual field loss in glaucoma (Table 5) respectively. In many cases the multifocal objective perimetry defect was more prominent (Figure 4), but in few cases the Humphrey defect was more apparent (Figure 5).

In 15 glaucoma patients the fellow eye had a Humphrey visual field (HVF) with no scotoma identified according to the definition. In 13 of these patients, the multifocal objective perimetry (MOP)

MF-VEP				
	Normal		Glaucoma	
	Latency	Amplitude	Latency	Amplitude
MD R	0.3	0.8	0.2	0.7
p	0.001	0.001	0.002	0.000
CSPD R	0.1	0.49	0.15	0.45
p	0.000	0.000	0.001	0.000

Table 5: Correlation between MF-VEP and V.F.

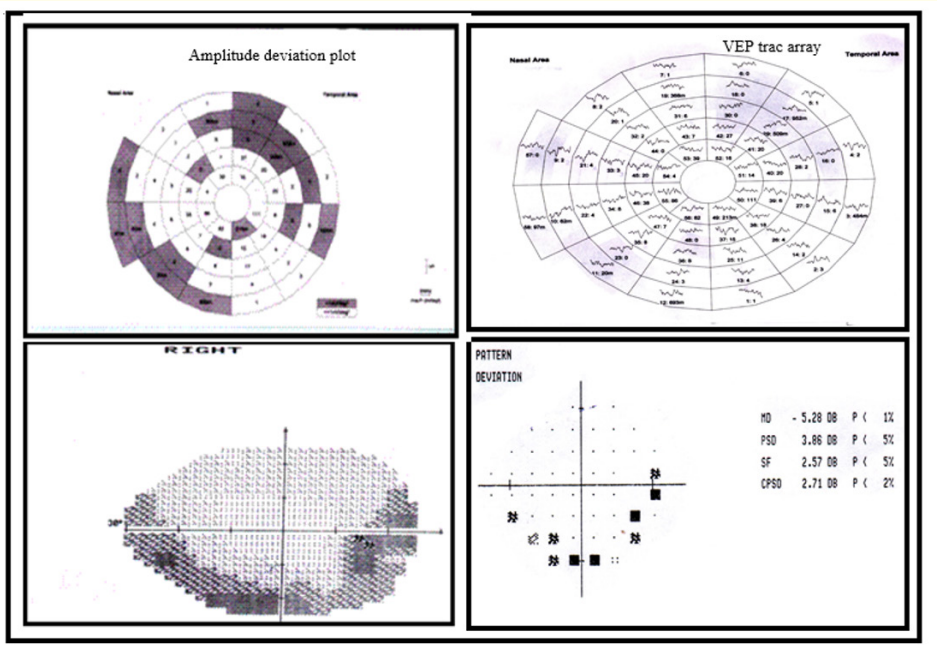

Figure 4: A case of glaucoma where MF-VEP result was more significant than Humphrey visual field (HVE).

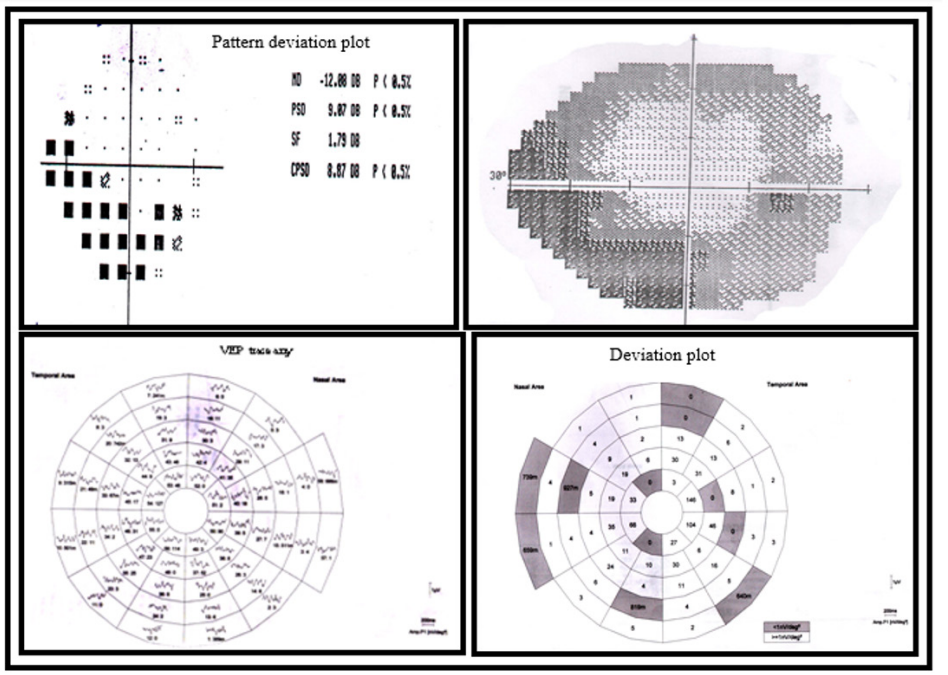

Figure 5: Case of glaucoma where HVF shows more significant scotoma than MF-VEP.

showed an abnormality in the second eye (Figure 6). One eye had normal multifocal objective perimetry values but an abnormal Humphrey MD (Table 6).

For each eye, latency of C- VEP (P 100) was measured for both, check size. 60 second and 15 minute (Table 7). There was good correlation between MD of HVF and latency of C- VEP (r = 0.66 P = 0.002) in check size 60 minute, r = 0.7. p = 0.001 in check size 15 minute, there was difference between mean latency in glaucoma group, and that of the control group.

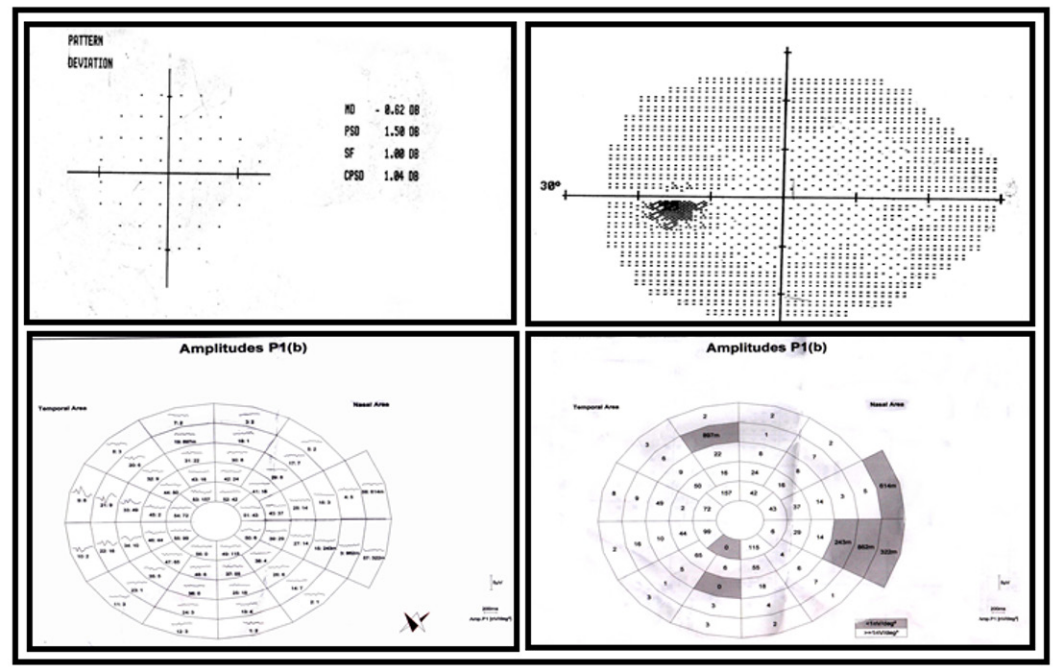

Figure 6: A case of early glaucoma where MF-VEP was abnormal while HVF was normal.

	No cluster HVF	Cluster on HVF	Total
No cluster on MF-VEP	4	2	6
Cluster on MF-VEP	26	108	134
Total	30	110	140

Table 6: Number of Hemi fields on the HVF and MF- VEP in glaucoma groups.

Group	C-VEP Latency (60 minute)	C-VEP Latency (15 minute)
Control	90 ± 9	100 ± 10
Glaucoma	115 ± 20	135 ± 25

Table 7: Relative C.VEP latency among groups.

The C-VEP and MF-VEP latencies showed good correlation among groups, for 15 minute stimuli (r = 0.77, p = 0.001 in glaucoma r = 0.7, p = 0.001 in control) and for 60 minute stimuli (r = 0.65, p = 0.002 in glaucoma r = 0.7, p = 0.000 in control) Similar values were obtained when the latencies of two C-VEP stimuli were compared (r = 0.72 in glaucoma, r = 0.69 in control).The correlation between the CVEP and the MFVEP was about as good as between CVEP for two check size.

Discussion

The technique of multifocal objective perimetry used in this study provides an objective measure of visual field loss. The test detected scotomas in nearly all cases of glaucoma where field defects had been established on subjective test [13].

Current methods of perimetry depend on the subjective responses of patients to detect visual field defects. Two or three field tests needed to be done before a reliable result is achieved. In clinical practice, many patients are unable to perform reliable subjective test but can perform MOP. Many patients, particularly the elderly, have stated that they find this form of perimetry less stressful, because it does not involve decision making.

The use of multi-channel bipolar occipital recording enhances the ability to detect signals from all parts of the visual field using MF-VEP. In glaucoma patients with established field defects, the scotoma is detected by this form of objective perimetry. Combined results from four channels reduces the great variability between individuals seen as a result of underlying convolution of the cerebral cortex because most of these orientations are covered by at least one channel. The horizontal electrodes provides a much greater signal from the test points along the horizontal of the striate cortex for this part of visual field. Improved detection in this area is extremely important for the application of objective perimetry to the detection of the glaucoma because nasal steps often are the first defect to occur.

Grippo., *et al*. found that glaucoma had a relatively small effect on the latency of MFVEP. It was found that small patients with glaucoma that had prolonged latencies and the delays were not large. It was noted that either a delayed VEP is not good indicator of damaged as opposed to dead RGCS, or there are relatively few patients who exhibit evidence of damaged RGCS [16].

Also, Klistoner, found that there is some delay in MFVEP latency in glaucoma patient [17].

Similarly, Rodarte., *et al*. agreed that there was small delay in MFVEP latency in glaucoma patients and substantial reduction in the amplitude [18].

In this study, there was small significant delay in latency of MFVEP in glaucoma (95 ± 15) compared to latency in normal (70 ± 10.5). and there was poor correlation between latency of MF-VEP and Humphrey visual field.

As regards to amplitude of MF VEP, in this study there was reduction in amplitude. The amplitude was correlate well with Humphrey visual field indices.

Also, Graham., *et al*. found there was poor correlation between MFVEP latency and degree of visual field loss. In contrast amplitude was more strongly correlated with Humphrey visual field threshold scores [4].

Similarly, Hood and Greenstein reported that the amplitude of signal in the MFVEP decreases in proportion to the local field loss as measured in HVF [19,20].

Also, Klistoner., *et al*. found that the number of abnormal points on VEP perimetry correlated strongly with Humphrey MD [6,17,25].

In contrast, Bengtsson, reported high false positive rate for the MF VEP [23,24].

While Grippo., *et al*. found that there was no clear relationship between latency of MF VEP and MD of HVF [18].

It was predicted that while MFVEP can detect abnormalities missed on the HVF, the reverse will also be true. The MFVEP can be superior or inferior to HVF in detecting damage depending on the signal noise ratio of the recordings and the field location of the damage. The MFVEP has an advantage when there is a relatively small defect in the central area of the field because there are more test stimuli concentrated in this region in the MFVEP than HVF. In contrast the HVF can have an advantage in the periphery where three or four of test points on 24-2 HVF can fall within single sector [21].

Also, Goldberg., *et al*. found that MFVEP was abnormal in more than 50% of 29 glaucoma patients that had normal field in HVF in fellow eye. It was recorded that glaucoma Humphrey field defects were correlated with visual evoked potential amplitude. It was found that 22 patients had abnormal MFVEP with normal HVF [13].

Similarly, Thienprasiddhi., *et al*. reported that the MFVEP detect deficits in hemi fields with apparently normal HVF results in glaucoma patients with unilateral hemi field defects [22].

In this study, there was 13 cases had abnormal MF VEP with normal HVF and one case with normal MFVEP had abnormal HVF.

For each individual, between eye analysis looking for asymmetry in signal amplitude at congruous areas could be a useful technique. Because the same area of striate cortex receives projections from similar areas of both visual fields, it responds to both eyes with wave form of identical character. Asymmetry analysis is limited to those with eyes of similar status and does miss individuals in whom a defect appears in the same part of the field in both eyes simultaneously. In such persons, the amplitude plots would need to be examined closely.

Klistorner., *et al*. found that intereye asymmetry for healthy volunteers was seen to be very small with identical traces recorded from the same part of the visual field for the two eyes [25].

Also, Hood., *et al*. and Graham., *et al*. revealed remarkable similarities in the wave form and amplitude of the signals between the two eyes of the same individual [9,10].

Even though different parts of the retina are being stimulated in the two eyes, the information from similar parts of the visual field of both eyes projects to identical areas of visual cortex [31].

In this study, there was similarity in the wave form and amplitude in both eyes in control group.

Many papers have examined the C-VEP in glaucoma and identified latency changes [26-29].

Parisi., *et al*. suggested that glaucoma could have a major effect on the latency of VEP. There was no overlap between groups, 100% of the patients had C-VEP latencies greater than the control [30].

Also, Grippo., *et al*. found significant delay in C.VEP and reported that there was good correlation between MF-VEP and C-VEP [16].

Rodarte., *et al*. said that there was marked delay in latency of C-VEP in glaucoma and good correlation between MF-VEP and C-VEP [18].

Similarly in this study, there was delay in latency in C-VEP and significant correlation between MF-VEP and C-VEP.

Because MOP can reliably demonstrate visual field loss, it may be considered a useful alternative to psychophysical testing and provide objective date for long-term follow up when looking for disease progression. The application of VEP perimetry to glaucoma screening and initial diagnosis is still limited by significant inter-individual variability in amplitude seen in healthy population.

The multifocal objective perimetry technique provides an objective measure of visual function in glaucoma. It shows significant but not exact correlation with subjective perimetry. It has high patient acceptance with no learning curve. It is useful in patients with unreliable fields that cannot be interpreted where it can be used to confirm or exclude field loss. It has the potential to detect malingers and may be useful in children. The main limitation of MFVEP as form of objective perimetry remains inter individual reproducibility, sharp amplitude reduction with increase retinal eccentricity and noisy recordings which can lead to false positives. There is still a level of patient cooperation required with technician experience to recognize noise such as patient losing concentration, muscle noise and other artifacts.

Conclusion

MF-VEP can assess the visual field and identify glaucomatous visual field defect. It may have the potential for identifying defects earlier than conventional perimetry. MF-VEP showed more abnormalities than SAP. However, although there were abnormalities detected by the MF- VEP that were missed by SAP, the reverse was true.

Bibliography

1. Fortune B., *et al*. "Structural and functional abnormalities of retinal ganglion cells measured in vivo at the onset of optic nerve head surface change in experimental glaucoma". *Investigative Ophthalmology and Visual Science* 53 (2012): 3939-3950.

2. Medeiros FA., *et al*. "Retinal ganglion cell count estimates associated with early development of visual field defects in glaucoma". *Ophthalmology* 120 (2013): 736-744.

3. Subramanian SK., *et al*. "Low luminance/eye closed and monochromaticstimulation variability of visual evoked potential latency". *Annals of Indian Academy of Neurology 16*.4 (2013): 641-648.

4. Odom JV., *et al*. "ISCEV standard for clinical visual evoked potentials (2016 update)". *Documenta Ophthalmologica* 133 (2016): 1-9.

5. Graham SL., *et al*. "The diagnostic significance of the multifocal pattern visual evoked potential in glaucoma". *Current Opinion in Ophthalmology* 10 (1999): 140-146.

6. Kothari R., *et al*. "Influence of visual angle on pattern reversal visual evoked potentials". *Oman Journal of Ophthalmology* 7 (2014): 120-125.

7. Hood DC and Zhang X. "Multifocal ERG and VEP responses and visual fields: Comparing disease- related changes". *Documenta Ophthalmologica* , 100 (2000): 115-137.

8. Graham SL., *et al*. "Objective perimetry in glaucoma, astrymmetry analysis to identify early deficits". *The Journal of Glaucoma* 9 (2000): 10-19.

9. Hood DC., *et al*. "An interocular comparsian of the multifocal VEP: a possible technique for detecting local damage to the optic nerve". *Investigative Ophthalmology and Visual Science* 41 (2000): 1580.

10. Hood Dc., *et al*. "Visual field defects and multifocal visual evoked potentials: evidence of a linear relationship". *Archives of Ophthalmology* , 12 (2002): 3-15.

11. Hood Dc., *et al*. "Detecting glaucomatous damage with multifocal visual evoked potentials: how can a monocular test work?" *The Journal of Glaucoma* 12 (2003): 3-15.

12. Goldberg I., *et al*. "Multifocal objective perimetry in detection of glaucomatous field loss". *American Journal of Ophthalmology 1*33 (2002): 29-39.

13. Anderson DR and Patella VM. "Automated, Static perimetry". 2nd edition. St louis: Mosby (1996).

14. Odom JV., *et al*. "Visual evoked potentials". *Documenta Ophthalmologica* 108 (2004): 115-123.

15. Grippo TM., *et al*. "Comparison between Multifocal and convential VEP latency changes secondary to glaucomatous damage". *Investigative Ophthalmology and Visual Science* 47 (2006): 5331-5336.

16. Klistoner A., *et al*. "Objective perimetry in glacame: recent advances with multifocal stimuli". *Survey of Ophthalmolog* 43.2 (1999): 5199-5209.

17. Rodarte C., *et al*. "The effects of glaucoma on the latency of the multifocal visual evoked potential". *British Journal of Ophthalmology* 90 (2006): 1132-1136.

18. Hood DC and Greenstien VC. "The multifocal VEP and ganglion cell damage. Applications and limitations for the study of glaucoma". *Progress in Retinal and Eye Research* 22 (2003): 201-251.

19. Hood DC., *et al*. "Visual field defects and multifocal visual ecoked potentials: evidence for a linear relation ship". *Archives of Ophthalmology* 120 (2002): 1672-1681.

20. Hood DC., *et al*. "Detecting early to mild glaucomatous damage: A comparsion of multifocal VEP and automated perimetry". *Investigative Ophthalmology and Visual Science* 45 (2004): 492-498.

21. Thienprasiddhi P., *et al*. "Multifocal VEP responses in glaucoma patient with unilateral hemifild defects". *American Journal of Ophthalmology* 136 (2003): 34-40.

22. Bengisson B. "Evaluation of VEP perimetry in normal subjects and glaucoma patients". *Acta Ophthalmologica Scandinavica* 80 (2002): 620-626.

23. Hood Dc. "Comment on Bengisson paper". *International Glaucoma Review* 4-3 (2003): 473-474.

24. Klistorner A and Gracam SL. "Objective perimetry in glaucoma". *Ophthalmology* 107 (2000): 2283-2299.

25. Sood NN., *et al*. "Assesment of visual evoked response in chronic simple glaucoma". *Indian Journal of Ophthalmology* 35 (1987): 274-277.

26. Accornero N., *et al*. "A new color VEP procedure discloses asymptomatic visual impairments in optic neuritis and glaucoma". *Neurology India* 102 (2000): 258-263.

27. Price Mj., *et al*. "The pattern electroretinogram and visual evoked potential in glaucoma". *Gaede's Archive for Clinical and Experimental Ophthalmology* 226 (1988): 542-547.

28. Atkin A., *et al*. "Flicker threshold and pattern VEP latency in ocular hypertension and glaucoma". *Investigative Ophthalmology and Visual Science* 24 (1983): 1524-1528.

29. Parisi V., *et al*. "Clinical ability of pattern electroretin ogram and visual evoked potentials in detecting visual dysfunction in ocular hypertension and glaucoma". *Ophthalmology* 113 (2006): 216-228.

30. Aine CJ., *et al*. "Retinotopic organization of human visual cortex. departures from the classical model". *Cerebral Cortex* 6 (1996): 354-361.

31. Bertuzzi F., *et al*. "Evaluation of retinal nerve fiber thickness measurements for glaucoma detection: GDx ECC versus spectral-domain optical coherence tomography". *Journal of Glaucoma* 23 (2014): 232-239.

Volume 4 Issue 11 November 2021