Research Article

Assessment of Structure and Function Relationship in Early Open Angle Glaucoma

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Abstract
Purpose: To determine whether significant correlations existed between the morphological and functional parameters of the macular region of eyes with Early open-angle glaucoma (OAG). **Methods:** Forty eyes of 21 early OAG and OAG suspect patients and were studied. The morphological parameters were obtained by optical coherence tomography (OCT), and the functional parameters were acquired by automated Humphrey Field Analyzer (HFA) and multifocal electroretinogram (mfERG). All of the tests were performed within 3 months of each other. **Results:** There was significant correlation between OCT findings and mfERG findings in both early OAG group and suspect group as regarding P wave amplitude. While, there was poor correlation between OCT finding and HFA parameters in both groups. **Conclusion:** mfERG may play a vital rule in diagnosis of early functional damage of glaucoma.
Keywords: Optical coherence tomography, Multifocal electroretinogram, Open-angle glaucoma, Humphrey Field Analyzer

Introduction
Glaucoma is a progressive optic neuropathy characterized by structural changes in the optic nerve head (ONH), retinal nerve fiber layer (RNFL), and associated with functional changes in the form of visual field defect (VFD).[1]

However, static automated perimetry (SAP) is the most widely used functional test to monitor glaucomatous functional damage, evidence suggests that in some eyes substantial structural damage can be detected before the development of clinically detectable VFD.[2]

Structural assessment of ONH and RNFL with imaging devices is a promising alternative, using either optical coherence tomography (OCT). Spectral-domain OCT (SD-OCT) with its improved resolution, scan speed, and reproducibility, potentially leads to earlier and more accurate detection of glaucoma progression. SD-OCT has been used to evaluate the patterns of progressive RNFL defect [3] and to estimate the thickness of retinal ganglion cells.[4]

Although optic nerve topography and retinal nerve fiber layer analyzers can be used to detect early structural damage, other objective tests multifocal electroretinogram (mfERG) and pattern electroretinogram (PERG) are used to detect early functional damage of ganglion cells.

The multifocal electroretinography (mfERG) technique can record large numbers of localized retinal responses within few minutes. This technique gives precise information about the electrical activity of the central retina. However, mfERG is most often used to detect damage of photoreceptor cells; several studies have also employed this technique to investigate glaucoma.[5]

Patients and Methods
The present study included 40 eyes of 21 patients. The patients were divided into two groups according to the stage of the disease: Primary open angle glaucoma suspect and early primary open angle glaucoma; Group 1: included 20 eyes of 10 patients of primary open angle glaucoma suspect.

Group 2: included 20 eyes of 11 patients of early primary open angle glaucoma. All patient included in this study were recruited, evaluated and subjected to automated perimetry , electrophysiological testing and optical coherence tomography, in outpatient clinic of Ophthalmology Department, Minia University Hospital.

Patients with history of ocular or systemic diseases, causes of secondary glaucoma, non-glaucomatous optic neuropathy, any retinal or macular dystrophy and history of ocular surgery were excluded from the study.

All patients underwent comprehensive ophthalmological evaluation. Standard automated perimetry was recorded using the Humphrey Field Analyzer II, Carl Zeiss. The strategy used was 24-2 Swedish interactive thresholding algorithm (SITA) full-threshold. The optical coherence tomography was performed with the SD-OCT (RTVue XR 100 $_{Avanti}$) in a dilated pupil. The multifocal electroretinogram was recorded on the RETI-port/scan2/ mfERG version 19-99_D4_7_14E (Roland Consult, Wiesbaden, Germany), according to the standard ISCEV guidelines of mfERG recording.

The data used in analysis were both global and hemispheric (superior and inferior hemispheres) to facilitate the analysis and make it more reliable as the correlation was done between the corresponding areas of the retina which assessed in OCT, mfERG and HFA.

Results

Table (1) shows demographic data

Groups	**Group 1 (Glaucoma suspect) N=10**		**Group 2 (Early POAG) N=11**	
Mean/Range	**Mean±SD**	**Range**	**Mean ± SD**	**Range**
Age	35.9 ± 7.86	24-47	32.36 ± 10.98	20-53
Sex (N/ %)	N	%	N	%
Male	3	30%	5	45.5 %
Female	7	70%	6	54.5 %

Table (2) shows IOP and C/D ratio of both groups

Group	**Glaucoma suspect group (N=10)**		**Early POAG (N=11)**	
Mean/Range	**Mean±SD**	**Range**	**Mean±SD**	**Range**
IOP(mmHg)	21.3±2.43	17.24	21.40±1.96	20-24
Cup/Disc ratio	0.56±0.1	0.4-0.7	0.58±0.08	0.4-0.7

Table (3) shows correlation between **OCT** parameters (total GCC and Avg.RNFL) and **mfERG** parameters (global P1& N1) in glaucoma suspect & early POAG groups

	GCC (Total)				**RNFL(Avg)**			
	Group1		**Group2**		**Group1**		**Group2**	
	r	**P**	**R**	**P**	**R**	**p**	**R**	**p**
GlobalP1 RAD	0.4	0.07	**0.5**	**0.03***	**0.05**	**0.03***	**0.5**	**0.03***
Global P1 IT	0.3	0.2	-0.3	0.2	0.2	0.5	-0.1	0.6
Global N1RAD	0.05	0.8	**0.5**	**0.03***	0.3	0.2	**0.5**	**0.05***
Global N1IT	0.4	0.1	-0.3	0.2	0.1	0.6	-0.1	0.6

Table (4) shows correlation between OCT Parameters (superior GCC & RNFL) and mfERG parameters (superior P1 &N1)

	GCC (Sup.)				RNFL (Sup.)			
	Group 1		Group 2		Group 1		Group2	
	r	P	r	P	r	p	R	P
Sup. P1 RAD	**0.5**	**0.04***	**0.5**	**0.05***	**0.6**	**0.01***	**0.4**	**0.05***
Sup. P1 IT	0.3	0.2	-0.4	0.09	0.2	0.4	-0.3	0.3
Sup. N1 RAD	-0.3	0.2	0.3	0.2	0.3	0.2	0.4	0.09
Sup. N1 IT	0.5	0.06	-0.4	0.09	0.03	0.9	-0.3	0.3

Table (5) shows correlation between **OCT** Parameters (Inferior GCC & RNFL) and **mfERG** parameters (inferior P1 &N1)

	GCC (Inf.)				RNFL(Inf.)			
	Group1		Group2		Group1		Group2	
	r	P	R	P	R	P	r	P
Inf. P1 RAD	0.4	0.1	**0.4**	**0.05***	0.3	0.2	**0.5**	**0.04***
Inf. P1 IT	-0.08	0.7	-0.1	0.6	-0.02	0.9	-0.04	0.9
Inf. N1 RAD	0.3	0.2	**0.5**	**0.02***	0.3	0.2	0.3	0.2
Inf. N1 IT	-0.01	0.09	-0.1	0.6	0.03	0.9	-0.04	0.9

Table (6) shows correlation between **MD** (Avg.) & **OCT** finding (total GCC &Avg. RNFL)

	MD (Avg.)			
	Group 1		Group2	
	R	P	r	P
GCC (Total)	-0.2	0.3	-0.3	0.2
RNFL (Avg.)	0.02	0.9	-0.3	0.3

Table (7) shows correlation between **MD** (Sup) & **OCT** finding (Inf. GCC & Inf. RNFL)

	MD (Sup.)			
	Group 1		Group2	
	R	P	R	P
GCC (Inf.)	-0.3	0.2	-0.2	0.5
RNFL (Inf.)	0.04	0.9	-0.1	0.6

Table (8) shows correlation between **MD** (Inf.) & **OCT** finding (Sup. GCC & Sup. RNFL)

	MD (Inf.)			
	Group 1		Group2	
	R	P	R	P
GCC (Sup.)	-0.1	0.6	0.1	0.6
RNFL (Sup.)	-0.01	0.9	-0.3	0.2

Discussion

Recently, many studies have been published concerning the association between structural and functional measures in glaucomatous patients. Most of these compare the morphological changes seen on OCT to subjective functional assessment in SAP.

In the present study, we relate standard multifocal electroretinogram findings in glaucoma suspect and early POAG and

static automated perimetry to structural measurement of the ONH and GCC using a spectral domain OCT.

When Correlating OCT parameters to mfERG findings, we found that RAD of global P1 was significantly correlated with average RNFL thickness in suspect group while in early POAG group it was significantly correlated to both total GCC and average RNFL thickness. As regarding hemispheric analysis, RAD of superior P1 was significantly correlated with both GCC & RNFL of the superior hemisphere in both groups. While in the inferior hemisphere, there was no significant correlation between OCT findings (RNFL & GCC thickness) and amplitude of averaged obtained mfERG response in glaucoma suspect group while in early POAG, there was a significant correlation between RAD of inferior P1 and GCC & RNFL thickness of the inferior hemisphere.

Rao et al.,[6] who conducted a study in 2013, correlating first and second order responses on mfERG with RNFL on OCT in glaucoma. In contrast to our results, they found that there was no significant correlation between the P1 amplitude and the average RNFL while RNFLST correlated significantly with the global amplitude of P1.

When correlating OCT findings to mean deviation of HFA, we found the following: There was poor correlation between RNFL and GCC thickness with the MD as regarding average and both superior and inferior hemispheres with the two groups (POAG suspect & Early POAG).There are many studies compared the structural changes seen on OCT to the functional changes of the automated perimetry.[7-9] For example, Leite et al.,[10] who reported a weak to moderate correlation between RNFL assessment using SD-OCT and MD of SAP. They found that correlation is weaker particularly in glaucoma suspect group, this comes in agreement with our results.

Conclusion

mfERG may be used as adjuvant functional tool to SAP in diagnosis of early functional damage of glaucoma.

References

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