Sohag University | Sohag Medical Journal | Faculty of Medicine

Importance of peripapillary retinal nerve fiber layer, Ganglion cell complex and visual field severity indices in primary open angle glaucoma

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Abstract:

Glaucoma defined as a progressive damage of the optic nerve with functional visual field defects. That is defined as a progressive affection of retinal ganglion cells (RGCs) and their axons (RNFL).

Optical coherence tomography (OCT) is an important technology used to detect the structural alteration, which has the advantage of both high-resolution cross-sectional images of retina in vivo. So, we can detect:

Retinal nerve fiber layer in peripapillary area and retinal thickness in this area is compared with normal populations, Optic nerve head: which has the advantage that it is assessed objectively and Ganglion cell complex (GCC) analysis which measure the retinal thickness at the macula that has the advantage of early-stage glaucomatous damage detection.

Defects in visual field can be evaluated using standard automated perimetry (SAP**)**: we can evaluate VF severity indices and VF defects either early defects as small paracentral depressions, nasal steps, temporal wedge or more advanced VFDs as arcuate defects, ring scotoma or even end stage characterized by a tunnel vision.

Key words: glaucoma, OCT, VF severity indices.

DOI: **10.21608/SMJ.2023.246235.1426**

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Received:02 Novamber 2023
Revised: 14 Novamber 2023
Accepted: 17 December 2023
Published:01 January 2023

INTRODUCTION

Glaucoma is a progressive optic neuropathy which is defined as structural changes of the optic nerve and retina with functional visual field (VF) deficits that present at corresponding area of these anatomical changes.[1,2]

Between all types of glaucoma " Primary open angle glaucoma "(POAG) is the commonest type and characterized by: high IOP (more than 21mm-hg at some stage), optic nerve damage, open angle, visual field defects while there is no signs of secondary glaucoma or a non-glaucomatous ca-use of the optic neuropathy.[3]

Anatomical changes can be evaluated by many ne-w technologies, one of which is optical coherence tomography (OCT) which enable us to have high-resolution cross-sectional images of retina and quantitively measure the retinal thickness. [4]

OCT now is widely used for assessment of glaucoma to detect:

1- Pre-papillary retinal nerve fiber layer and retinal thickness compared with normal . [5]

2-Optic nerve head which is objective. [6]

3-Ganglion cell complex (GCC) analysis in which we measure retinal thickness at the macula to detect early-stage glaucomatous damage which now is an important parameter.[7]

Visual field defects either early defects as small paracentral depressions, nasal steps, temporal wedge or more advanced VFDs as arcuate defects, ring scotoma or even end stage characterized by

tunnel vision. VF severity indices now are important part of glaucoma assessment.[8]

Incidence of glaucoma:

Nearly 64.3 million people are glaucomatous all over the world in 2014, and an expected increase by 2040.[9]

The commonest type is primary open angle glaucoma (POAG) as about three-quarters of all glaucomatous patients.[10]

There is geographical preference in prevalence. Higher prevalence in Black populations, and it is more common in lower income countries, specially Asia[11]

Both genders are affected equally. [11]

Pathogenesis of glaucomatous optic neuropathy:

The pathogenesis which leads to optic nerve damage are not completely known, programmed cell death/ apoptosis is greatly acused.[12]

The theoretical theories are:

1-The mechanical theory: High IOP is the accused to be the cause of damage as it mechanically affects the optic nerve head (ONH) and lamina cribrosa.[13-14]

2-The ischemic theory: disturbance of blood flow.[15]

Many apoptotic factors are known now, such as BCL2-associated X protein (BAX)[16], and apoptosis stimulating fragment (FAS) that start apoptosis process. [17]

In BCL2 family, the BAX protein has proapoptotic abilities by antagonizing BCL2 .[18]

Glaucoma diagnosis is mainly using:

1- **fundus examination:** [19] one of the most difficulties in glaucoma diagnosis is to differentiate between pre-perimetric glaucoma and a normal variation of optic nerve head (ONH) morphology.[20] normal disc has no absolute value but there is a great variation in its value and appearance.[20] In 1967 Armaly describe the cup/disc ratio (CDR).[21] But neither the OD size nor the neuro-retinal rim changes were taken in consideration.[22] For example large discs have larger CDRs so were more likely to be diagnosed as glaucomatous.[22]Spaeth et al describe The disc damage likelihood scale (DDLS) which include the disc size and focal rim width in clinical grading chart in 2002.[23]

2-intraocular pressure (IOP) measurement: IOP is very important parameter in management and follow-up of suspect or glaucomatous patients. [24]

3-visual field testing: to detect the functional loss is a major diagnostic tool for glaucoma.

Global Indices

One number could statistically summarize the field. They are important for follow-up any progress in glaucoma[25].

- Mean Deviation (MD): it represented in A negative or positive value, negative one indicates field loss, while a positive value indicates better field than normal populations. For example, P <1% means that less than 1% of the normal people have visual field defects worse than measured. [26]
- Pattern Standard Deviation (PSD): detects focal loss only. A high PSD, indicating irregular vision, so it is a very valuable indicator for glaucomatous progression. [27]

Glaucoma Hemifield Test (GHT)

Compares five corresponding and mirrored areas in the superior and inferior visual fields**.** The result 'Outside Normal Limits' (significant difference in superior and inferior fields), 'Borderline' (suspicious differences) or 'Within Normal Limits' (no differences) is only considered when the patient has, or is a suspect for, glaucoma.[27]

Glaucomatous visual field defects

Generalized depression

May be the first defect in glaucoma, but take care the same occurs with old age, miotic pupils and with hazy media. [28]

Nasal step or depression

The nasal area is the most useful area in the mid-periphery and periphery to be tested.[29]

Temporal step or depression

Either alone or with other glaucomatous defects.[30]

Isolated paracentral scotoma

In Early stages of glaucoma defects may have a small, dense center.[31]

Arcuate defects (nerve fiber bundle defect):

Which known as "Bjerrum defect" which is a classic finding in moderate and advanced glaucoma. [32]

End-stage defects

Central and temporal islands

When glaucoma is advanced and most axons are damaged, except the papillo-macular bundle and some nasal fibers. So, a small central island and a larger temporal crescent is the only remaining. [32]

4- Imaging of ganglion cell complex, RNFL and optic nerve head: e.g., optic disc photography, optical coherent tomography (OCT) and GDx (scanning laser polarimetry), confocal scanning laser ophthalmoscopy.[20]

Optical coherent tomography (OCT): measure retinal nerve fiber layer (RNFL) thickness, objectively evaluate the ONH and can capture early morphological changes. [33]

Recently imaging in glaucoma is mandatory, since 1991 when Huang et al introduce the optical coherence tomography (OCT). [4]

Optical principle of OCT is based on low coherence interferometry so their ability to recognize different retinal layers depending on the variable time delay in their reflections. [34,35]

- Recently the peripapillary retinal nerve fiber layer (RNFL) is a major factor in glaucoma evaluation. [36] However, there is some limitations to be used in those have deformities in their optic nerve head, tilted discs and those with high myopia, as the imaging programs database do not take consideration to these variants in the optic nerve head. [37]
- ONH parameters is very important part in glaucoma evaluation. Specially the vertical rim thickness, rim area, and vertical cup to disc ratio. These ONH parameters are as important as RNFL thickness parameters in glaucoma evaluation. [38]
- Similarly, GCL parameters, are very important in glaucoma evaluation. [39]
- Significant RNFL damage occurs before functional visual field loss can be detected. So, in pre-perimetric disease, SD-OCT RNFL is valuable in diagnosing glaucoma before VF defects. In perimetric disease, RNFL affection on SD-OCT occur with a corresponding abnormality in the visual field so confirm and useful in diagnosis, management and follow-up glaucoma. [40]

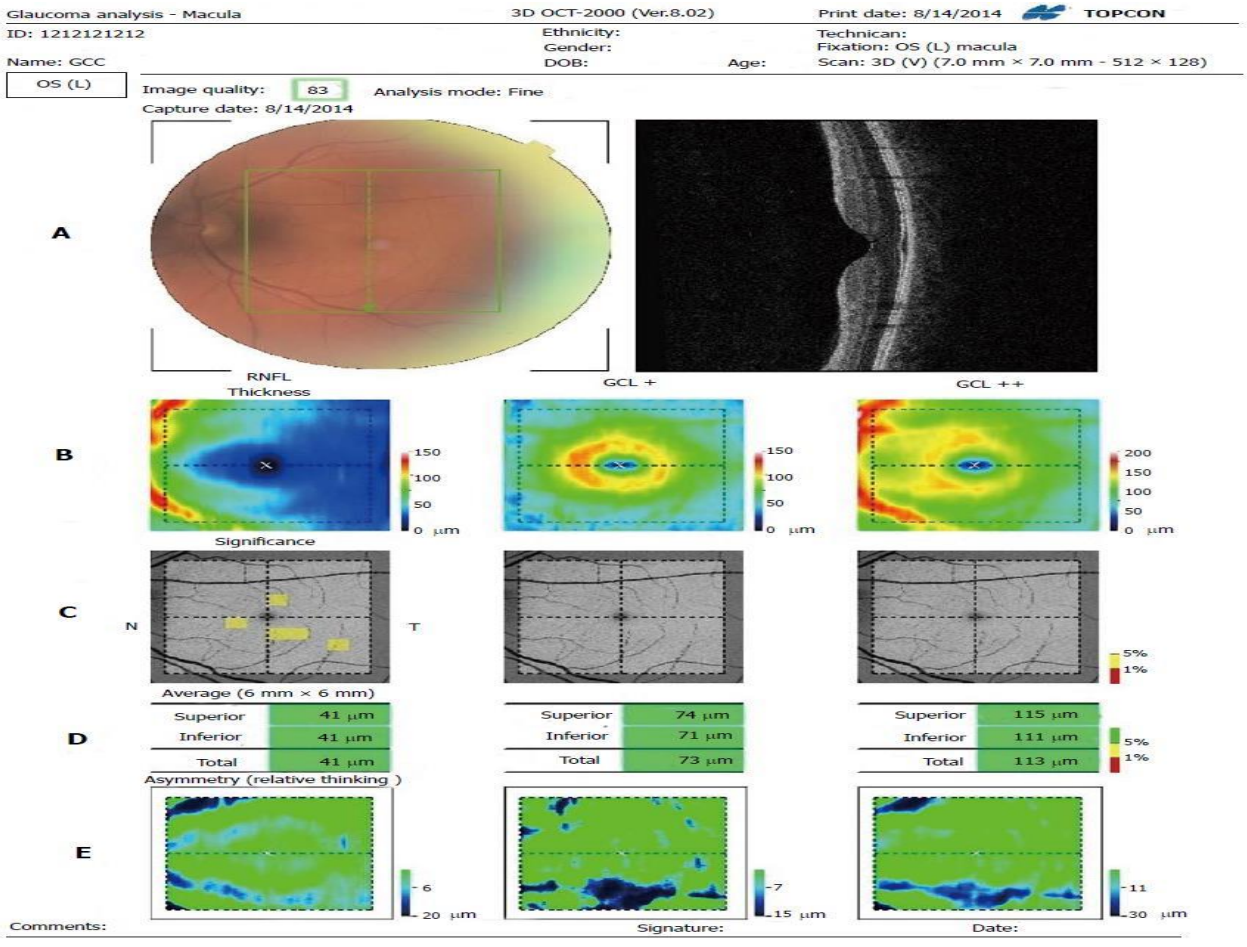

Figure.1 macular retinal nerve fiber and ganglion cell layers thickness.

Conclusion:

Glaucoma permanently damages visual function, which can impair the quality of life adversely so early diagnosis is important.

- Visual field severity indices, measured by standard automated perimetry (SAP) is correlated and helpful when taken in consideration with RNFL thickness, GCA and ONH analysis, as determined by spectral-domain optical coherence tomography (SD-OCT), to assess both anatomical and functional damage.
- macular scans have a great importance in glaucoma evaluation, especially in eyes with variations in their ONH size, tilted optic disc, peripapillary atrophy as in pathological myopia, or when images for the optic disc cannot be captured.
- Routinely we need to perform VF test, macular and p.RNFL imaging in all suspected patients for earlier diagnosis as they have better sensitivity and also who are already diagnosed patients for better follow-up and management and decrease the incidence of irreversible glaucomatous damage.

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