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Assessment of Binocular Visual Function in Glaucoma: Looking Beyond Perimetry

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Opinion

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Background

Glaucoma is a type of progressive optic neuropathy marked by structural changes in the optic disk (increased vertical cup disk ratio (VCDR) or VCDR asymmetry), as well as specific functional abnormalities in automated visual field tests [1], Management of glaucoma is targeted at lowering the intraocular pressure. Glaucoma causes irreversible visual impairment which requires lifelong management [2]. Early recognition is essential for preserving visual function in glaucoma patients. The disability caused by glaucoma is related pathologically to the progressive damage of the retinal ganglion cells.

Various studies done in past mainly focuses on perimetry and optical coherence tomography in glaucoma diagnosis and progression. These are considered benchmark tests in glaucoma [3]. Glaucoma is not only a major neurodegenerative disease of visual neurons in the eye, but also in the brain. Traditionally, glaucoma pathogenesis involves retinal ganglion cell death from axonal injury at the lamina cribrosa as a result of high intraocular pressures. Recently glaucoma is viewed as transneuronal degeneration of retinal ganglion cells [4]. The loss and/or dysfunction of retinal ganglion cells results in loss of nerve fiber layer eventually leading to visual field defects. The assessment of functional changes in glaucoma is commonly perimetry based, but it may not be the only functional change associated with glaucoma [5]. Since glaucoma may affect one eye more than the other, a binocular measure is likely to be the best way to predict the impact of visual field impairment on visual disability.

Visual Field Loss in Glaucoma

Visual field loss which is irreversible is the most prevalent and characteristic form of visual function loss associated with glaucoma [2]. Earlier on course of disease, glaucoma patients do not have symptoms. However, with advanced stage of glaucoma, individuals with visual field defect experience an increased difficulty in daily activities. Glaucoma patients have constricted peripheral visual field leading to difficulty in mobility as bumping into the objects and tripping over the things, which is more common with binocular involvement [6]. Some patients of glaucoma may have superior and others inferior visual field defects. Superior visual field defects will cause near vision problem whereas inferior visual field defect will have general and peripheral visual problem [7]. Currently, perimetry is the standardized tool for assessing glaucoma progression since visual field loss is the most common form of functional vision loss associated with glaucoma. Advances in imaging technology with availability of optical coherence tomography can objectively measure the structural progression in glaucoma which along with perimetry is used to monitor glaucoma progression [8].

Glaucomatous visual field loss often occurs asymmetrically not only between two eyes but also across the visual field. The neural processing of binocular disparity of glaucomatous visual field deficits is assumed to result in the deterioration of binocular function, often leading to a detrimental effect on various visual functions such as face recognition, reading, and mobility and hence affecting quality of life [9]. In clinical settings, perimetry is done as monocular assessment and binocular testing is rarely carried out. Binocular integrated visual fields could be more useful in measuring visual disability in glaucoma patients [10].

Binocular Visual Functions

Binocular vision requires the ability to process inputs from both eyes. Binocular visual functions in patients with glaucoma may provide the most accurate representation of

the patient's visual function in daily basis. Visual function measurements in glaucoma include electrophysiology, visual acuity and psychophysical testing such as stereopsis, color vision and contrast sensitivity. Involvement of both parvocellular and magnocellular pathways early in the disease is suggested for these parameters to get involved. Sensitivity for detection of fine spatial detail, motion and color signals, and stereopsis can be selectively damaged in glaucoma and may precede visual field loss [11]. Assessing the effects of neuronal disruption on visual performance which can lead to early detection of glaucoma.

Visual acuity could not detect early changes in primary open angle glaucoma because the central macula is spared until late stages of glaucoma. Initially, the disease involves peripheral fields and tends to go unnoticed, till the time it progresses to involve central and paracentral areas [7]. Many population-based studies relying on acuity measurement of visual function by in large may not detected other binocular function impairment not just in glaucoma but other disease as well. In glaucoma, visual field defects in the left and right eye may be non-overlapping, resulting in an intact binocular visual field unless in advanced cases [12]. Clinically, these patients are often considered to have normal vision. Patients with more advanced glaucoma at diagnosis are at greatest risk of visual impairment.

Color vision deficiency in glaucoma was detected as early in 1883. Color vision deficiency is acquired in glaucoma. Red-green loss is almost as common as blue-yellow loss in glaucoma patients. Blue-yellow deficiencies generally are associated with early glaucoma, and red-green deficiencies generally are associated with advanced glaucoma. There have been reports of color contrast thresholds are elevated in patients with glaucoma [13]. Glaucoma has been shown to affect monocular as well as binocular contrast sensitivity [12,14]. Stereopsis is one of the key measures of binocular vision and requires the ability to process inputs from both eyes. Binocular disparity is a key component of depth perception. Depth perception deficit may precede visual field loss in glaucoma. Stereoacuity deficits is found to be associated both for distance and near. Many studied done in glaucoma and suspects have shown to have increased sterothreshold with decrease in depth perception more with advancement of disease [15,16].

Glaucoma patients are also found to have delayed dark adaptation [17]. Patients with glaucoma report difficulty with reading and other near-vision tasks. Studies have shown that glaucoma can impair reading speed and performance, especially in settings of low text contrast, small text size, and more severe visual field loss [6]. Glaucoma patients also show alterations in eye movement behavior. They manifest as increased saccade latencies.

Patients with bilateral glaucoma are found to have more difficulties in binocular visual functions as compared to unilateral glaucomatous patients or non-glaucomatous patients. Though age related changes in lens as well as aging is associated with structural and functional changes in cortical networks are found to have effect on binocular visual function tests, this earlier and more pronounced with glaucoma [16].

Conclusion

Evaluation of stereopsis, color perception as well as contrast sensitivity and detecting deficits in them might unveil overt glaucomatous damage. Rather than relying solely on visual defects and retinal nerve fiber loss, other components of vision need to be addressed in glaucoma patient to detect and manage them early so that quality of life can be preserved.

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