Optic Disc Torsion Presenting as Unilateral Glaucomatous-Appearing Visual Field Defect in Young Myopic Korean Eyes

Kyoung Sub Lee, MD, Jong Rak Lee, MD, Michael S. Kook, MD

Purpose: To investigate the ocular features of companion eyes in an attempt to find eye-related factors that are associated with unilateral glaucomatous-appearing visual field (VF) defects in young myopic subjects.

Design: Retrospective, cross-sectional study.

Participants: Thirty-nine patients (age range, 20–50 years) with unilateral glaucomatous-appearing VF defect and myopia.

Methods: A comparison was performed between VF-affected eyes and contralateral normal eyes. Optic disc torsion and tilt ratio were measured from disc photographs. Logistic regression analysis and linear regression analysis were performed to investigate various ocular parameters, including torsion degree and tilt ratio, that may be associated with the presence and severity of VF defect.

Main Outcome Measures: Torsion degree, tilt ratio, and the severity of VF defect.

Results: Optic disc torsion degree (16.63±9.78°) of VF-affected eyes was statistically greater than that of the normal contralateral eyes (8.69±7.28°; $P<0.001$). Optic disc torsion was more prevalent in VF-affected eyes (66.6%) than in normal contralateral eyes (15.3%; $P<0.001$). In the multivariate analysis, the degree of optic disc torsion was associated significantly with the presence of VF defect ($P = 0.005$). The torsion degree ($P = 0.006$) and retinal nerve fiber layer thickness ($P = 0.004$) were associated significantly with the severity of VF defect.

Conclusions: The prevalence and degree of optic disc torsion in the VF-affected eyes were significantly greater than those of contralateral normal eyes in unilateral, young, myopic patients with glaucomatous-appearing VF defect. Optic disc torsion should be considered in the presence of unilateral glaucomatous-appearing VF defect in young myopic eyes. *Ophthalmology 2014;121:1013-1019 © 2014 by the American Academy of Ophthalmology.*

Patients with normal-tension glaucoma often have visual field (VF) loss in both eyes at the time of diagnosis. However, the 2 eyes may have a variable degree of asymmetry in terms of VF damage, and in some patients, the VF loss may be localized to 1 eye at presentation. In this case, studies have shown that a high frequency of optic nerve head (ONH) damage also is found in eyes with a normal VF in unilateral normal-tension glaucoma patients, suggesting that the disease has a bilateral course with an asymmetric progression rate.[1,2] In other normal-tension glaucoma cases, a higher level of intraocular pressure (IOP) is found in the eyes with more severe VF defects than in eyes with normal VFs, even when the IOP is in the statistically normal range in both eyes.[3–5]

The prevalence of myopic refractive error has greatly increased in the past few decades in young and middle-aged Asians.[6–9] Frequently, young Asian patients with myopia are found incidentally to have glaucomatous optic nerve changes, VF defects, or both with normal IOP during a routine refractive examination or work-up for refractive surgery. However, despite a well-known epidemiologic relationship between myopia and open-angle glaucoma (OAG) indicating that myopia is one of the risk factors for OAG prevalence,[10–14] the underlying mechanisms related to glaucomatous damage in young myopic patients with glaucomatous cupping and VF abnormalities remain unclear. It has been hypothesized that progressive myopia may lead to optic nerve damage or visual loss in these patients owing to a strain gradient on susceptible axons within the prelaminar ONH tissue from the temporal tilting of the ONH, which can increase the IOP-related strain placed on certain axons.[15] In this scenario, the ONH change, VF damage, or both may slow or halt after the axial myopic process, including ONH tilting, ends. Indeed, optic disc tilt has been reported to be highly prevalent in Asian populations, particularly in young myopic individuals.[15–18]

Occasionally, young myopic individuals are encountered with unilateral glaucomatous-appearing VF defects confined to 1 eye, despite having similar refractive errors or outpatient IOP levels in both eyes. To our knowledge, the pathogenesis for unilateral glaucomatous-appearing VF defects in these young myopic Asian subjects has not yet been studied or reported. We hypothesized that optic disc tilting, torsion, or both may contribute to unilateral glaucomatous-appearing VF defects in young myopic eyes on the condition that both eyes have similar ocular risk factors for glaucoma, such as IOP and central corneal thickness (CCT). The aim of the present study was to investigate and compare

ISSN 0161-6420/14/$ - see front matter
http://dx.doi.org/10.1016/j.ophtha.2013.11.014

the ocular features of companion eyes in an attempt to find eye-related factors that are associated with unilateral glaucomatous-appearing VF defects in young myopic subjects. Furthermore, we studied the relationship between ocular features, including optic disc tilt and torsion, and the presence and amount of VF defects.

Methods

Patients

The medical records of patients who visited the outpatient glaucoma clinic of the Asan Medical Center in Seoul, Korea, from March 2012 through February 2013 were reviewed retrospectively. This study was approved by the Asan Medical Center Institutional Review Board and adhered to the Declaration of Helsinki. All study subjects underwent ophthalmologic examinations that included manual refraction, Goldmann applanation tonometry, VF testing (Humphrey Field Analyzer; Carl Zeiss Meditec, Dublin, CA), axial length (AL) measurement (IOL Master; Carl Zeiss Meditec), retinal nerve fiber layer (RNFL) thickness and ONH measurement with the Cirrus HD spectral-domain optical coherence tomography (SD-OCT) device (version 5.0; Carl Zeiss Meditec), nonmydriatic retinal camera photography (Canon, Tokyo, Japan), CCT measurement (ultrasonic pachymetry), stereoscopic optic disc photography, and red-free fundus photography (Canon).

Visual field-affected eyes in our study were defined as having glaucomatous-appearing VF defects confirmed by at least 2 reliable VF examinations, regardless of IOP level, and the presence of a compatible glaucomatous-appearing optic disc that showed increased cupping (vertical cup-to-disc [C/D] ratio, >0.7), a difference in the vertical C/D ratio of more than 0.2 between eyes, diffuse or focal neural rim thinning, disc hemorrhage, or RNFL defects. Eyes were defined as having glaucomatous-appearing VF defects if they met 2 of the following 3 criteria, as confirmed by more than 1 reliable consecutive test: (1) a cluster of 3 points with the probability of less than 5% on the pattern deviation map in at least 1 hemifield and including at least 1 point with a probability of less than 1% or a cluster of 2 points with a probability of less than 1%; (2) glaucoma hemifield test results outside normal limits; and (3) a pattern standard deviation outside 95% of the normal limits.

All patients had to have the following inclusion criteria to be entered into the study: newly diagnosed unilateral glaucomatous-appearing VF defect without previous treatment, in-hospital 24-hour monitoring of IOP, consistently reliable VFs (defined as a false-negative rate of $<15\%$, a false-positive rate of $<15\%$, and fixation losses of $<20\%$), age between 20 and 50 years, spherical equivalent (SE) of less than -2.00 diopters, and AL of more than 24.0 mm. Patients were excluded on the basis of any of the following criteria: a history of any retinal disease, including diabetic or hypertensive retinopathy; a history of eye trauma or surgery; any optic nerve disease except glaucoma; a history of systemic or neurologic diseases that may affect the VF; and an age older than 50 years, because myopia can be affected by lenticular changes and aging can increase OAG incidence as well as myopic contribution.

All measurements of in-hospital 24-hour monitoring of IOP were obtained in the habitual body position with the Tono-Pen XL (Mentor Ophthalmics, Santa Barbara, CA) at 8 AM, 10 AM, 12 PM, 2 PM, 4 PM, 6 PM, 8 PM, and 10 PM (diurnal IOP, sitting position) and at 12 AM, 3 AM, and 6 AM (nocturnal IOP, supine position) in both eyes of each patient. The VFs were evaluated with the Swedish Interactive Threshold Algorithm (SITA) 24-2 program of the Humphrey Field Analyzer. The first perimetric result was excluded from the analysis to obviate learning effects. The second VF analysis was performed within 2 to 4 weeks of the first perimetric analysis. Unaffected contralateral eyes were defined as having a normal VF, regardless of the appearance of the optic disc. Measurement of optic disc parameters and RNFL thickness was performed by SD-OCT.

Measurement of Optic Disc Tilt and Torsion

Digital red-free photographs centered on the optic disc were obtained with standardized settings via a nonmydriatic retinal camera. Optic disc tilt and torsion were measured on these photographs by a glaucoma specialist (K.S.L.) with the National Institutes of Health ImageJ image analysis software (version 1.52; developed by Wayne Rasband, National Institutes of Health, Bethesda, MD). The definitions of optic disc tilt and torsion have been described by Park et al.[18] Briefly, optic disc tilt was identified by the tilt ratio, defined as the ratio between the longest and shortest diameters of the optic disc.[19–21] When the tilt ratio was more than 1.30, the optic disc was classified as a tilted disc. Optic disc torsion was defined as the deviation of the long axis of the optic disc from the vertical meridian.[16,17] The vertical meridian was identified as a vertical line 90° from a horizontal line connecting the fovea, which is 2° to 6° below the optic disc, to the center of the optic disc. The degree between the long axis of the optic disc and vertical meridian of the optic disc was named the torsion degree. The optic disc was classified as having torsion when the degree of torsion was more than 15° (Fig 1). A positive torsion value indicated inferotemporal torsion, and a negative value indicated supranasal torsion.[18]

Presence of Parapapillary Atrophy

β-zone parapapillary atrophy (PPA) was defined as an inner crescent of chorioretinal atrophy with visible sclera and choroidal vessels. From the stereoscopic optic disc photography, the optic disc was divided manually into 4 quadrants (superior, inferior, nasal, and temporal; 90° each). Any eye containing PPA that involved the temporal 90° margin of the optic disc was defined as having PPA in the current study.

Statistical Analysis

Descriptive statistics (number, percentage of each categorical variable, and the mean ± standard deviation of each continuous variable) were evaluated to show the demographic and ocular parameters. An independent t test was used to assess the differences between glaucomatous-appearing eyes and contralateral normal eyes. The chi-square test was used to compare the fellow eyes in terms of the frequency of clinical characteristics related to ONH features. These included the presence of PPA (yes vs. no), optic disc tilting (yes vs. no), and optic disc torsion (yes vs. no).

Binary univariate and multivariate logistic regression analyses were performed to investigate various ocular parameters that may be associated with the presence of a VF defect. For this analysis, the independent variables were SE, AL, office mean IOP, 24-hour mean IOP, 24-hour trough IOP, 24-hour peak IOP, 24-hour IOP fluctuation, CCT, disc area, average RNFL thickness, tilt ratio, and torsion degree. The dependent variable was the presence of a glaucomatous-appearing VF defect. Both VF-affected eyes and contralateral normal eyes were included. Parameters with a P value of less than 0.2 in the univariate analysis were included in the multivariate logistic regression analysis model.

Correlation studies were performed with univariate and multivariate linear regression analyses to investigate the association between ocular factors (age, SE, AL, 24-hour mean IOP, CCT, optic disc tilt, optic disc torsion, baseline RNFL thickness, and disc area) and VF mean deviation (MD). Variables with $P < 0.2$ in the univariate analyses were included in the multivariate models.[22]