

Original research article

Association between the pressure-to-cornea index and both structural and functional indicators of glaucoma: A cross-sectional study

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Abstract

Aim: To evaluate the correlation between the pressure-to-cornea index and both structural and functional measures of glaucoma.

Methods: A cross-sectional study was conducted in the Department of Ophthalmology, Total 100 patients with OHT or primary open angle glaucoma (POAG) older than 40 years of age of both genders, with 20/20 best corrected visual acuity and any ethnicity.

Results: 40 patients were male (40%) and 60 female (60%). Mean age was 61.9 ± 24.5 years. The mean values of the MD and PSD from automated perimetry of the 100 eyes were -9.8 ± 7.7 dB and 5.3 ± 3.2 dB, respectively. The median C/D ratio was 0.9 (range, 0.2–1.1). The mean CCC was 523.0 ± 41.4 m, mean IOP was 20.7 ± 5.2 mmHg, and mean PCI was 130.8 ± 50.5 . The PCI showed a statistically significant negative correlation with MD ($r = -0.347$, 95% CI, -0.539 to -0.116 ; $P = 0.002$).

Conclusion: PCI can be used as a unified risk factor. Statistical correlation between structural and functional measures of glaucoma to pressure to cornea index (PCI) was observed.

Keywords: glaucoma, indicators, PCI

Introduction

Glaucoma is a multifactorial disease with a characteristic damage to the optic nerve with or without increasing in intra-ocular pressure and definite visual field deformities. ¹ Elevated IOP is the most significant modifiable risk factor along with other risk factors like family history, race, age older than 40 years, myopia, diabetes mellitus and hypertension. ²⁻⁵

Measurement of intra-ocular pressure is influenced by Central corneal thickness. Also there may not be a linear relationship between applanation IOP and CCT.⁶

To find an alternative indication, few researches have taken into account IOP and CCT as single risk factor and have coined the term Pressure to Cornea Index.⁷

PCI is a simple method where the values of IOP and CCT are both important. The study focuses on importance of PCI in structural and functional measurement of glaucoma. The pressure-to-cornea index (PCI) was proposed in order to integrate IOP and CCT as a single-risk factor for glaucoma.⁸

Until date, no study has explored the possible use of PCI as a parameter for disease severity. The purpose of the study was to correlate the PCI with a structural and two functional measures of glaucoma.

Materials and methods

A cross-sectional study was conducted in the Department of Ophthalmology, Icare Institute of Medical Science And Research and Dr. Bidhan Chandra Hospital, Haldia, West Bengal, India

For 12 months .After taking informed consent detailed history was taken from the patient or the relatives. The technique, risks, benefits, results and associated complications of the procedure were discussed with all patients.

Methodology

Total 100 patients with OHT or primary open-angle glaucoma (POAG) older than 40 years of age of both genders, with 20/20 best corrected visual acuity, and any ethnicity. Subjects with cataracts or any other ocular disease, and previous incision or laser surgery for glaucoma were not included in the study. In order to be included in the study, POAG patients had typical optic disc damage (diffuse or localized rim thinning, enlarged cupping, disc hemorrhage, asymmetry in cup-to disc (C/D) ratio, 0.2 or greater between eyes) with corresponding visual field loss on reliable automated perimetry (at least 3 adjacent points in the expected location of the central 24° - field that have $P < 5\%$ on the pattern deviation plot, one of which with $P < 1\%$; glaucoma hemi field test “outside normal limits”; pattern standard deviation [PSD] with a $P < 5\%$), and open angles on gonioscopy. A reliable perimetry was an exam with $< 33\%$ of both false negative and false positive. OHT was defined as any individual with IOP higher than 21 mmHg with no glaucoma medication, healthy appearing optic disks and no visual field defect on automated perimetry. Seventy eyes of 36 patients with POAG or OHT enrolled this cross-sectional study. 40 patients were male (40%) and 60 female (60%). Mean age was 61.9 ± 24.5 years. Proceedings After explaining the procedures,

all subjects signed an informed consent and underwent a complete eye examination with evaluation of the visual acuity, anterior segment biomicroscopy, tonometry with the Goldmann tonometer (Haag-Streit AG, Switzerland) after instillation of proparacaine and fluorescein drops, gonioscopy with a three mirror lens OG3M (Ocular Instruments, Bellevue, Washington, USA), and optic disk assessment with 78 D Volk lens (Volk Optical Inc., Mentor, OH, USA) on a tropicamide dilated pupil. The IOP was measured after discontinuation of all glaucoma medications for at least 21 days. The C/D ratio assessment was done by two observers, which in common agreement classified the optic disk according to a decimal system. Standard automated perimetry (SITA standard 24-2) was done with the HFA 730 (Carl-Zeiss Humphrey, Dublin, CA, USA) with appropriate refractive correction. Patients with unreliable exams were instructed to do the perimetry a second time in an attempt to get a reliable test, and those who remained with an unreliable test were not included in the study. CCT was measured with ultrasonic pachimeter (300P Pacscan, Sonomed-Escalon, Wayne, PA, USA); the probe was placed at the 5 mm central diameter of the cornea after instillation of proparacaine drops and three measurements were averaged to obtain one single value.

Results

The mean values of the MD and PSD from automated perimetry of the 100 eyes were -9.8 ± 7.7 dB and 5.3 ± 3.2 dB, respectively. Table 2 The median C/D ratio was 0.9 (range, 0.2–1.1). The mean CCC was 523.0 ± 41.4 m, mean IOP was 20.7 ± 5.2 mmHg, and mean PCI was 130.8 ± 50.5 . The PCI showed a statistically significant negative correlation with MD ($r = -0.347$, 95% CI, -0.539 to -0.116 ; $P = 0.002$) table 3. the correlation between PCI and PSD values of automated perimetry, however, failed to reach statistical significance ($r = -0.205$, 95% CI, -0.423 to 0.021 ; $P = 0.06$) [table 4]. Good correlation was found between PCI and C/D ratio ($r = 0.319$, 95% CI, 0.08 to 0.516 ; $P = 0.007$) table 4

Table 1. Demographic profile of the patients

Gender	Number of patients	Percentage
Male	40	40
Female	60	60
Age in years		
Below 40	10	10
40-50	15	15
50-60	25	25

Above 60	50	50
Mean age	61.9 ± 24.5 years	

Table 2. The mean of MD and PSD

Parameter	Mean
MD	- 9.8 ± 7.7 dB
PSD	5.3 ± 3.2 dB

Table 3. Mean value of CCC,IPO and PCI

Parameter	Mean
CCC	523.0 ± 41.4 m
IPO	20.7 ± 5.2 mmHg
PCI	130.8 ± 50.5

Table 4. The correlation between PCI and MD,PSD,C/D

PCI with MD	r = -0.347, 95% CI, -0.539 to - 0.116; P = 0.002
PCI and PSD	r = -0.205, 95% CI, -0.423 to 0.021; P = 0.06
PCI and C/D ratio	r = 0.319, 95% CI, 0.08 to 0.516; P = 0.007

Discussion

Many studies have shown that the central corneal thickness (CCT) is an important parameter which influences the accuracy of tonometric readings and our decision-making in the management of glaucoma.⁹⁻¹² CCT affects the IOP measurement by various tonometers, and mainly the Goldmann applanation tonometer, where thin corneas lead to an underestimation and thick corneas to an overestimation of the true IOP.¹³

In an attempt to integrate IOP and CCT into a unified risk factor, rather than simply attempting to correct for IOP measurement inaccuracy, Iliev et al. have proposed a new glaucoma index, the PCI. The authors believed that PCI could better reflect the individual susceptibility to glaucomatous damage than either IOP alone or CCT by itself. In a group of 220 normal controls, 53 patients with normal-tension glaucoma (NTG), 76 with OHT, and 89 with POAG, the authors have assessed the ability of PCI to discriminate between glaucoma

(NTG + POAG), and non-glaucoma (controls + OHT) and compared with that of three published formulae for correcting IOP for CCT. Mean PCI value for normal control was 92 ± 24.8 and for glaucoma patients 173.6 ± 40.9 . PCI demonstrated a larger area under the receiver operating characteristic curve (area under the curve [AUC]) and significantly higher sensitivity at fixed 80% and 90% specificities compared with each of the correction formulas. The authors proposed the range of 120–140 as the upper limit of “normality,” and concluded that PCI may reflect individual susceptibility to a given IOP level, and thus represent a glaucoma risk factor.⁸ Eballe et al. analyzed CCT and IOP in the Cameroonian non-glaucomatous population and the PCI values for this population was close to the cut-off proposed by Iliev et al.¹⁴ Since its introduction, the PCI has not been studied by other authors. To the best of our knowledge, this is the second study that evaluated the usefulness of PCI in glaucoma patients. In our study, we have evaluated the utility of PCI as an index of glaucoma severity, and our results have shown a correlation between the index and the MD value of automated perimetry. Visual field sensitivity is expressed on a logarithmic (decibel) scale; hence, one might expect a curvilinear relationship between PCI and MD. The relationship between PCI and MD depends solely and directly from the formula that defines the relationship between them, and does not depend on the logarithmic nature of retinal sensitivity with respect to luminous magnitudes. Therefore, it is absolute and necessarily linear. Patients with lower MD presented with higher PCI values. The MD value of automated perimetry is a weighted average decibel deviation from age normal database; the lower the MD value, the more damaged the visual function is. Nevertheless, the MD can be affected by media opacity such as cataract and uncorrected refractive error. In our study only patients with 20/20 vision and no cataract were included, and the automated perimetry was done with the patient’s appropriate refractive correction, so that MD values were very representative of glaucoma-related visual dysfunction. The PSD value is the standard deviation of the difference between the threshold value at each test location and expected value and as an indicator of localized defects it reflects the roughness of the visual field. It is calculated by summing the absolute value of the difference between the threshold value for each point and the average visual field sensitivity at each point. As higher PSD indicates more damaged visual fields, and assuming that PSD has a positive correlation with PCI, one would expect that the higher the PCI value, the higher the PSD. In this study, however, the correlation between PCI and PSD revealed a trend toward a negative correlation, not statistically significant, though. We are unsure if these results are due to the sample size or any selection bias. In general, automated perimetry, as a psychophysical test, is subject to patient

cooperation and individual cognitive function causing imprecision of the measurements. These can degrade the relationship between functional measures and the PCI. We have tried to minimize this imprecision by selecting only automated perimetry exams with good reliable indices. Our results revealed good linear correlation between the PCI and the C/D ratio. Patients with higher C/D ratios presented with higher PCI values. The C/D ratio is a subjective, qualitative method to assess the optic nerve head in glaucoma patients. It is widely used in clinical practice, and it gives an appraisal of the cup diameter in relation to the optic disk size; on a decimal scale, it ranges from zero (no cupping) to one (optic nerve head completely excavated). However, it does not take into account localized defects of the neural rim, disk hemorrhages or the posterior bowing of the lamina cribrosa. Besides, glaucoma patients with small optic discs will have proportionally small C/D ratios, giving a falsely impression of healthy looking optic disk. Conversely, normal subjects with macro disks will present with large C/D ratios giving a false impression of damaged optic disk. Hence, the C/D ratio is not a precise surrogate of glaucomatous optic disc damage without consideration of the relative disc size, area, and the quantitative assessment of neural rim width and area. Using this structural measure is a major shortcoming and quantitative measures of the optic disk structure as provided by new technologies should have been a better choice for correlation studies. Another shortcoming of the study is the use of both eyes of the same individual. Doing so for the measurement of an attribute or variable, rather than selecting one eye at random or the more severe affected eye for analysis tend to overestimate variability, artifactually influencing P value and decreasing chances of observing a significant effect, decreasing statistical power and increasing chances of type II error. Besides, we have not used any regression models to appropriately treat the eye as the unit of analysis, which tends to bias observations. However, incomplete data collection or selection of eyes for inclusion in a study on clinical grounds has the potential to introduce bias, and we decided to use both eyes of the same patient to avoid waste of data. The results of the study seem to dependent on a single outlier case with a PCI value greater than 400, which is above the maximum range described in a much larger population in the paper by Iliev et al. This was a patient with untreated IOP of 38 mmHg and CCT of 0.46 mm. A-post-hoc analysis eliminating this data point revealed that the value of r is reduced, but P still is significant (except for PCI and PSD). However, we have decided to keep this patient in the study because an estimate indicated that increasing the number of cases could result in statistical significance. More recently, Leung et al. have proposed a new pressure-cornea-vascular index (PCVI). The index is derived from the PCI and extended with risk factors identified as associated with

field-progression in a prospective cohort of 415 patients with NTG followed for 3 years. The authors concluded that PCVI might be useful for predicting progression in NTG with a satisfactory AUC comparable to established scoring systems in neurovascular medicine.¹⁵ In our study, we had not assessed any vascular parameters and did not evaluate the PCVI. In summary, the results of our study have revealed that PCI has a correlation with both the MD value of automated perimetry and the C/D ratio. These observations concur with the hypothesis that PCI can be used to stage disease severity.

Conclusion

The present study concluded that PCI can be used as a unified risk factor. Also we have found statistical correlation between structural and functional measures of glaucoma to pressure to cornea index (PCI). Hence, we conclude that it can be used for evaluating glaucoma severity as well

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