Original Article

DOI: 10.7860/JCDR/2021/48907.15227

Comparison of Central Corneal Thickness and Endothelial Cell Density in Patients with Various Types of Glaucoma and Patients without Glaucoma: A Case-control Study

Ophthalmology Section

KHUSHBOO CHAWLA[1], SHAILESH GADAGINAMATH[2], ASHISH KUMAR SHAH[3]

ABSTRACT

Introduction: Corneal affection in glaucoma patients is very high due to various risk factors that may lead to unforeseen and unplanned deleterious effects on the cornea leading to vision loss. Accurate intraocular pressure determination requires corneal thickness measurement and uncontrolled intraocular pressures, use of long term medication, intra ocular surgeries including cataract and glaucoma shunt surgeries may cause significant endothelial loss. Therefore, adequate planning and management and follow-up in these patients is required weighing all the long term consequences and emphasis the need for implementing adequate precautions.

Aim: To evaluate and compare the Central Corneal Thickness (CCT) and corneal Endothelial Cell Density (ECD) in patients with glaucoma and without glaucoma by specular microscopy.

Materials and Methods: A case-control study conducted in a Shekar Eye Hospital, Bengaluru, Karnataka, India, was conducted from August 2016 till April 2018 on a total 182 eyes from 182 patients were evaluated comprising of 91 cases and 91 controls. All participants underwent a detailed ophthalmological examination including slit lamp biomicroscopy, Intraocular Pressure (IOP) measurement, and CCT and ECD measurement by Tomey EM 3000 noncontact specular microscopy. The Statistical analysis was completes using Statistical Package For the Social Sciences (SPSS) 18.0 and R environment version 3.2.2 software's.

Results: The CCT of the glaucoma patients and the controls showed no significant difference (p-value=0.172). The CCT was comparatively thicker in Ocular Hypertension (OHTN) patients and thinner in Normal Tension Glaucoma (NTG) however statistical significance was not established. The mean ECD of controls was 2509.05±298.48 (cells/mm^3) and that of cases was 2465.68±392.91 (cells/mm^3) (p-value=0.404). The difference in the ECD amongst the glaucoma subgroups was not statistically significant (p-value=0.588). However, a lower ECD were seen in Pseudoexfoliation Glaucoma (PXG) and Primary Angle Closure Glaucoma (PACG) subgroups.

Conclusion: No significant difference was found in CCT and endothelial cell in cornea of patients with and without glaucoma. Normal Tension Glaucoma (NTG) patients have comparatively thinner corneas and OHTN patients had thicker corneas. There was no significant correlation established between ECD of Normal corneal vs. Glaucoma and its subgroups.

Keywords: Normal tension glaucoma, Ocular hypertension, Primary open angle glaucoma, Specular microscopy

INTRODUCTION

Worldwide glaucoma is one of the major causes of irreversible blindness affecting almost 63.4 million people worldwide [1] with Primary Open Angle Glaucoma (POAG) being the most common type. Early diagnosis and treatment of glaucoma becomes a major issue in order to decrease the prevalence of the blindness caused from glaucoma.

The Ocular Hypertension (OHTN) study and European glaucoma prevention study emphasised on the importance of cornea being the most predictable factor for glaucoma progression [2,3]. OHTN may progress to POAG if not diagnosed and managed on time. It is worth noting, that the early manifest glaucoma trial, Intraocular Pressure (IOP) and thus Central Corneal Thickness (CCT) was not the criteria for nothing its progression and its management [2]. However, the treating ophthalmologist remains in a dilemma at times regarding the contributory factors to be considered. Tonometry is the primary approach which is influenced by the mechanical and the morphological properties of the cornea, CCT being of paramount importance [2]. Study by Micheallester have shown variations in corneal thickness change the resistance of the cornea to indentation during IOP measurement [2,4]. It is attributed to the fact that various formulas used take into consideration the CCT and the curvature, but the biomechanics of the cornea play an important role [2,5]. Thus, this may affect the accuracy of the measurement of IOP. A thinner cornea may require less force to applanate it, leading to underestimation of the true IOP, while a thicker cornea would need more force thus giving an artifactually high IOP reading [6]. Corneal endothelial cells is a layer of hexagonal cells that play an important role in maintaining corneal clarity by actively dehydrating the corneal stroma and thereby allowing an orderly lattice of collagen fibrils to create a transparent tissue. Corneal endothelial cells do not regenerate but instead enlarge to maintain corneal clarity [7]. Many factors affect the corneal endothelium in glaucoma patients, including direct damage due to elevated IOP, altered trabecular meshwork in congenital cases and associated corneal structural changes, ocular surgery, and ocular trauma [8]. These may lead to a reduced corneal Endothelial Cell Density (ECD) in glaucoma patients [9].

The IOP is the only modifiable risk factor known for glaucoma thus should be recorded accurately. Misdiagnosis of new patients as POAG instead of Normal Tension Glaucoma (NTG) or normal, and normal being labelled as OHTN is attributed to imprecise measurement of IOP in the clinics. The follow-up of these patients is altered at times due to fallacious IOP recorded without considering the CCT also the line of management may differ based on the baseline and the target IOP set [10].

This study was conducted to evaluate the corneal morphology in glaucoma patients recently diagnosed or who are undergoing

multiple medical and surgical treatments in order to control the progression of disease. Misdiagnosis, unforeseen and unplanned deleterious effects on the cornea to the enumerated reasons may lead to vision loss. In addition, uncontrolled IOP, use of long term medication, intra ocular surgeries including cataract and glaucoma shunt surgeries may cause significant endothelial loss.

MATERIALS AND METHODS

A case-control study was conducted in Shekar Eye Hospital, Bangalore, Karnataka, India, for duration of 21 months from August 2016 till April 2018. The study was approved by the the Hospital Ethical Committee (Ref no: SEH/IEC/2016-18/32) and adhered to tenets of Helsinki Declaration.

Corneal morphology of total 182 eyes from 182 patients were evaluated comprising of 91 cases and 91 controls between the age group of 40-80 years. Right eye was considered for uniformity and only phakic patients were included.

Inclusion and exclusion criteria: Patients presenting to the Out Patient Department (OPD) for a routine/follow-up visit who were newly diagnosed as well as cases of proven glaucoma of different duration and types were included in study. Healthy individual with no ocular pathology, presenting for routine evaluation were taken as controls. Patients with active ocular infection, contact lens users, corneal conditions (Keratoconus, Fuchs dystrophy, corneal degeneration and dystrophies, chemical injury), and congenital diseases affecting cornea, history of previous retinal lasers and history of ocular trauma were excluded.

After considering inclusion and exclusion criteria CCT and ECD of patients with glaucoma were compared with the healthy subjects and between the different glaucoma subtypes namely POAG, Primary Angle Closure Glaucoma (PACG), Pseudoexfoliative Glaucoma (PXG), NTG, OHTN.

Study Procedure

After taking an informed consent, demographic details of the patients were collected. All patients were interviewed regarding diagnosis and duration of glaucoma, detailed ocular medication history. A comprehensive ophthalmic examination of anterior segment examination by slit lamp biomicroscopy and detailed fundus examination was done to establish a diagnosis of the type of glaucoma and any associated ocular pathology. The IOP was measured by well calibrated Goldmann Applanation tonometry, the average of two readings was taken as the final IOP and documented to monitor the treatment and planning of further management. Gonioscopy was done with Goldmann three-mirror Gonioscope to assess the angle. The glaucoma patients were then further categorised into five subgroups. Specular microscopy (by Tomey EM 3000 Specular microscope) was done for all the cases and controls and analysed.

STATISTICAL ANALYSIS

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean±SD (min-max) and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance. Analysis of variance (ANOVA), Student t-test (two tailed, independent), Chi-square/Fisher's exact test has been used to find the significance of study parameters. The Statistical analysis was completes using Statistical Package For the Social Sciences (SPSS), and R environment version 3.2.2 software's.

RESULTS

The mean age of patients in glaucoma group was 62.31±9.02 years and in control group 63.26±9.01 years (p=0.475, ANOVA test). The cases were subdivided into five subgroups based on the type of glaucoma diagnosed namely POAG, NTG, PACG, PXG and OHTN [Table/Fig-1].

Variables	Controls n (%)	Cases n (%)	Total n (%)	p-value#
Age (in years)				
40-50	9 (9.9)	8 (8.8)	17 (9.3)	p=0.475
51-60	20 (22)	29 (31.9)	49 (26.9)	
61-70	43 (47.3)	38 (41.8)	81 (44.5)	
71-80	19 (20.9)	16 (17.6)	35 (19.2)	
Total	91 (100)	91 (100)	182 (100)	
Mean±SD	63.26±9.01	62.31±9.02	62.79±9.00	
Gender				
Female	50 (54.9)	40 (44)	90 (49.5)	p=0.138
Male	41 (45.1)	51 (56)	92 (50.5)	
Total	91 (100)	91 (100)	182 (100)	

[Table/Fig-1]: Age and Gender of control and case group.

Among cases, 26.4% (n=24) did not have any medical history. The IOP of most patients was within normal limits i.e., <20 mmHg [Table/Fig-2]. Specular microscopy was conducted and the CCT and ECD (number of endothelial cell per square millimeter) [11] values were taken into consideration. The mean CCT of cases was 513.41±38.51 µm and that of controls group was 520.71±33.15 µm. The mean ECD of the cases was 2465.68±392.91 (cells/mm^3) and control was 2509.05±298.48 (cells/mm^3). Both the parameters showed no statistically significant difference among the two groups (p-value=0.172 and p-value=0.404, respectively) [Table/Fig-3].

Variables	n (%)
Medical history in cases	
No	24 (26.4)
Yes	67 (73.7)
Diabetes mellitus	31 (34.0)
Hypertension	33 (47.2)
Asthma	6 (6.6)
Anemia	3 (3.3)
Hypothyroid	2 (2.2)
Heart	7 (7.7)
Migraine	1 (1.1)
Diagnosis in cases	
POAG	39 (42.9)
NTG	19 (20.9)
PACG	13 (14.3)
PXG	12 (13.2)
OHTN	8 (8.8)
Total	91 (100)
IOP in cases (mmHg)	
<20	67 (73.6)
20-40	19 (20.9)
>40	2 (2.2)
NA	3 (3.3)

[Table/Fig-2]: Demographic data of cases.
#ANOVA test; POAG: Primary open angle glaucoma; PACG: Primary angle closure glaucoma; OHTN: Ocular hypertension; NTG: Normal tension glaucoma; PXG: Pseudoexfoliation glaucoma; IOP: Intraocular pressure

Variables	Controls	Cases	Total	p-value#
CCT (µm)	520.71±33.15	513.41±38.35	517.08±35.92	0.172
ECD (cells/mm^3)	2509.05±298.48	2465.68±392.91	2487.49±348.35	0.404

[Table/Fig-3]: CCT and ECD comparison between cases and controls.
#Student t-test (two tailed, Independent); CCT: Central corneal thickness; ECD: Endothelial cell density

Variables	Diagnosis						p-value#
	Controls	POAG	PACG	NTG	OHTN	PXG	
CCT (µm)	520.71±33.15	513.28±35.73	525.58±49.57	499.68±35.83	531.25±23.88	511.50±42.99	0.053
ECD (cells/mm^3)	2509.05±298.48	2517.87±245.30	2378.17±677.94	2420.63±515.70	2559.75±268.21	2392.17±258.37	0.588

[Table/Fig-4]: CCT and ECD according to subgroups of glaucoma.
#ANOVA test; CCT: Central corneal thickness; ECD: Endothelial cell density; POAG: Primary open angle glaucoma; PACG: Primary angle closure glaucoma; OHTN: Ocular hypertension; NTG: Normal tension glaucoma; PXG: Pseudoexfoliation glaucoma

The CCT was measured between the subgroups of Glaucoma patients and was compared within the five subgroups and with controls using ANOVA Test. The comparison between these tests revealed the maximum corneal thickness (531±23.88 µm) was present in OHTN group and the thinnest (499.68±35.83 µm) observed in NTG subgroup (p-value=0.053) [Table/Fig-4].

The ECD was also measured by specular microscopy and comparison between the controls and the glaucoma subtypes, also within the glaucoma subgroups was done. The mean ECD was maximum in POAG and Ocular HTN types (2517.87±245.30 cells/mm^3) and 2559.75±268.21 (cells/mm^3) respectively) and was minimum in PACG group (2378.17±677.94 cells/mm^3) followed by PXG. However, this comparison between these groups done using ANOVA test did not show statistically significant result (p-value=0.588) [Table/Fig-4].

[Table/Fig-4] shows the mean CCT and mean ECD of the cases with respect to the duration of disease. The comparison showed a significant association with the duration of disease with p-value=0.098. It was observed that patients with more than five year duration of disease had the thinnest average CCT which could have been a contribution of long term IOP fluctuations and increased IOP for a longer duration of disease. But comparatively thicker corneas were seen among patients with less than two years [Table/Fig-5]. The Mean ECD comparison between cases of different duration of prevalence of disease showed no statistical difference among cases with glaucoma of different durations (p-value=0.521).

Variables	Duration of disease			
	<2 years (n-14)	2-5 years (n-48)	>5 years (n-29)	p-value
CCT (µm)	504.64±23.85	521.32±34.16	499.61±45.76	0.098
ECD (cells/mm^3)	2373.93±563.70	2523.47±336.29	2407.7±413.63	0.521

[Table/Fig-5]: Corneal morphology based on duration of disease.
CCT: Central corneal thickness; ECD: Endothelial cell density

Many studies in the past few decades have proven myopia as one of the most common risk factor of glaucoma. In our study, the spherical equivalent of 64.8% cases was low hyperopia i.e., between 0 and +3D followed by 22% patients having low myopia (i.e., 0 to -3D). The type of refractive error may vary with type of glaucoma such as hyperopia being common among ACG and myopia amongst POAG groups. In the present study, there was only one high hyperopia (i.e., > +6) but was a known case of POAG.

DISCUSSION

Glaucoma is a chronic optic neuropathy, with newer advances there are evidences of associated corneal morphological changes in longstanding glaucomatous eyes. CCT is the most common risk factor in predicting the progression of glaucoma which is the static property of cornea. Eyes with thin corneas have an underestimation of IOP, and eyes with thick corneas have an overestimation of IOP [12].

Hypothesis by Gagnon M et al., states constant high IOP results in compression damage on the endothelial cells, long term use of ocular hypotensive drugs with added preservatives have deleterious effect on the cornea [13]. In addition to these glaucoma surgeries with antifibrotic use may have toxic effect on the cornea.

This study included 182 eyes of cases and controls comparing them for CCT and ECD changes. Comparison made between cases controls but also among subgroups of cases (glaucoma) namely, POAG, PACG, PXG, NTG and ocular HTN. The data showed no significant difference in the CCT and ECD among age matched cases and controls (p-value=0.172 and p-value=0.475). However, aging may influence our results with respect to the endothelial cell count as advancing age is related to progressive decline in ECD [14,15].

The subgroup analysis, done among glaucoma cases for CCT, showed OHTN patients had a comparatively higher CCT and patients with NTG had the least CCT (p=0.153) amongst all, which was found to be in accordance with the study conducted by R. Thomas in Vellore on NTG and OHTN patients. They found thicker CCT in OHTN patients which lead to overestimation of IOP thus recommended use of correction factor for actual IOP determination [6]. Similar results were found by Morad Y who found a significantly lower CCT in NTG patients when compared to OAG and normal patients thus underestimation of IOP and misdiagnosis was a major factor brought into light [16]. While Herndon LW et al., on comparison of CCT of OAG and normal individuals showed thicker corneas in OAG patients [17]. Lee J et al., concluded no significant difference between CCT of NTG and OAG [18].

Gagnon MM et al., and other studies conducted in other parts of Europe found that corneal endothelial cell counts were significantly lower in patients with glaucoma than in controls (p-value <0.0001) [13,19]. Whereas, Cho S et al., showed low ECD in POAG group as compared to NTG group in his study [9]. A research by Tomaszewski B et al., reflected that psudoexfoliation have a lower ECD irrespective of glaucoma development [20]. Another study by Stroligo MN et al., echoed the same result of lower central ECD in patients with PXG as compared to POAG and PACG. He also concluded a lower ECD in patients with glaucomatous eyes as compared to non-glaucomatous eyes [19].

In the present study, it was found comparable ECD between the cases and controls (p=0.404). Within the subgroups of glaucoma PACG and PXG group had the least ECD of 2378.17±677.94 cells/mm^2 and 2392.17±258.37 cells/mm^2 respectively compared to the POAG and OHTN, but was not clinically significant (p=0.550).

Cho H and Kee C conducted a study and found a positive relation between myopia, increased axial length as a risk factor for glaucoma in Asian population thus explaining the increased prevalence of disease among Asians than amongst White [21]. Also, Marcus M et al., stated in their study that risk of glaucoma development and progression increases with the degree of myopia [22]. In contrast this study, there was no such relationship between refractive status and glaucoma.

Various systemic illnesses are related to progression of glaucoma. The correlation between Diabetes and Glaucoma however being the most researched is still under debate. Other medical illness such as HTN, migraine asthma, usage of steroid medication in form of inhalers, have been analysed in our study highlighting no correlation to changes observed in the corneal morphology. HTN was common accounting for 47.2% of all medical conditions.

One patient with NTG had a known history of migraine and two patients with NTG complained of significant history of hypotension episodes, which could have been considered due to the similar vascular aetiology of vasoconstriction and inadequate dilatation of microcirculation. Study by Cursiefen C et al., highlighted individuals with migraine may develop NTG rather than high tension glaucoma [23]. The Tamiji study conducted in by Suzuki Y et., showed that HTN and POAG were age related morbidities coinciding with this study population [24].

The duration and constant high IOP and fluctuations are other factors found to have deleterious effects on CCT and the ECD. It was observed in this study that patients with IOP >20 mmHg the mean CCT and mean ECD were comparable to the control groups. The overestimation of actual IOP due to high corneal thickness and vice versa should be dealt in mind while doing the clinical work up of a patient. However, low CCT is a risk factor itself, independent of IOP but has not been determined completely [25]. The other contributory factors such as thicker corneas overestimating the IOP, duration of high IOP and previous use of Anti-Glaucoma Medication (AGM) come into role while determining the corneal health.

This study showed majority of patients having glaucoma diagnosed since 2-5 years. Out of the total 91 patients, 14 were recently diagnosed including those diagnosed in our hospital OPD on presentation for a routine check up. The CCT of patients with a progressive decline with duration of disease when comparing more than two years with more than five years duration, reached the least value amongst those with more than five years of glaucoma (p-value=0.098). However, other contributory factors such as decline in CCT with age have been inconsistent. Many studies did not find a significant difference in mean CCT with increasing age and agreed with our cross-sectional study [26]. On the other hand Barbados eye study showed an association between thinner corneas and age [27]. The ECD did not have any significant difference when compared based on the duration of disease.

The cornea can be defined by its physical dimensions, such as its thickness, or physical behaviour, for example, the biochemical behaviour of cornea also known as corneal hysteresis. Recent studies have shown that corneal hysteresis also provides valuable information regarding presence of glaucoma, risk of progression and management. Corneal hysteresis measurement has been made possible by the Reichert Ocular Response Analyzer (ORA) [5].

Limitation(s)

As corneal endothelium is a dynamic structure, the need was considered to follow-up the patients in the course of time for corneal morphology by specular microscopy. A serial monitoring would give a more insight into the prospective changes occurring as a result of the disease process, ageing and treatment. Also, considering the subgroups like PXG and PACG, a comparison with the PPXF without glaucoma and PAC/PAC suspects respectively will provide better understanding of the pathology occurring and thus, preventive measures can be taken while planning of management.

CONCLUSION(S)

No significant difference was found in Central Corneal Thickness (CCT) and Endothelial Cell Density (ECD) of glaucoma vs. healthy patients' cornea. NTG patients have comparatively thinner corneas and OHTN patients had thicker corneas. Thus, IOP should be corrected based on the corneal thickness to avoid any over or underestimation. The endothelial density was noted to be lower in angle closure glaucoma and pseudoexfoliation glaucoma subgroup, although the results were comparable with POAG and healthy controls. Formation of correct diagnosis of the type of glaucoma is essential as PXG and PACG may have endothelial compromise. With advancement in medical and surgical management, evaluation of cornea becomes an important factor during diagnosis, treatment and follow-up of glaucoma. Thus, for long term safety a detailed corneal examination including CCT and ECD is an essential step in the workup and follow-up of a glaucoma patient for comprehensive management and better outcome.

Acknowledgement

We acknowledge the staff of the investigation lab and patients in Department of Ophthalmology of the institute for the co-operation and participation in the study. We also acknowledge Dr. Rajashekar Y.L., Managing Director and Head of Department Ophthalmology for his expert assistance throughout the process of this study.

REFERENCES

[1] Tham Y, Li X, Wong T, Quigley H, Aung T, Cheng C. Global prevalence of glaucoma and projections of glaucoma burden through 2040: A systemic review and meta analysis. Ophthalmology. 2014;121(11):2081-90.
[2] Brandt JD, Gordon MO, Gao F, Beiser JA, Miller JP, Kass MA, et al. Adjusting intraocular pressure for central corneal thickness does not improve prediction models for primary open-angle glaucoma. Ophthalmology. 2012;119(3):437-42.
[3] McCafferty S, Tetrault K, McColgin A, Chue W, Levine J, Muller M. Intraocular pressure measurement accuracy and repeatability of a modified goldmann prism: Multicenter randomized clinical trial. Am J Ophthalmol. 2018;196:145-53.
[4] lester M, Mete M, Figus M, Frezzotti P. Incorporating corneal pachymetry into the management of glaucoma. Cataract Refract Surg. 2009;35(9):1623-28.
[5] Leung C, Ye C, Weinreb R. An ultra-high-speed scheimpflug camera for evaluation of corneal deformation response and its impact on IOP measurement. Investig Ophthalmol Vis Sci. 2013;54(4):2885.
[6] Thomas R, Korah S, Muliyil J. The role of central corneal thickness in the diagnosis of glaucoma. Indian J Ophthalmol. 2000;48(2):107-11.
[7] Tham CCY, Kwong YYY, Lai JSM, Lam DSC. Effect of a previous acute angle closure attack on the corneal endothelial cell density in chronic angle closure glaucoma patients. J Glaucoma. 2006;15(6):482-85.
[8] Hong C, Kandori T, Kitazawa Y, Tanishima T. Corneal endothelial cells in ocular hypertension. Jpn J Ophthalmol. 1982;26(2):183-89.
[9] Cho S, Kim J, Choi C, Park K. Changes in corneal endothelial cell density in patients with normal-tension glaucoma. Jpn J Ophthalmol. 2009;53(6):569-73.
[10] Parikh RS, Parikh SR, Navin S, Arun E, Thomas R. Practical approach to medical management of glaucoma. Indian J Ophthalmol. 2008;56(3):223-30. Doi: 10.4103/0301-4738.40362.
[11] Bernard E, Henry F, Michael J. Review of corneal endothelial specular microscopy for FDA clinical trials of refractive procedures, surgical devices and new intraocular drugs and solutions. Cornea. 2008;27(1):01-16.
[12] Jonas J, Stroux A, Velten I, Juenemann A, Martus P, Budde W. Central corneal thickness correlated with glaucoma dmage and rate of progression. Investig Ophthalmol Vis Sci. 2005;46(4):1269-74.
[13] Gagnon M, Boisjoly H, Brunette I, Charest M, Amyot M. Corneal endothelial cell density in glaucoma. Cornea. 1997;16(3):314-18.
[14] Krachmer JH, Mannis MJ, Holland EJ. Cornea. 2nd ed: Philadelphia Elsevier Mosby; 2005.
[15] Yanoff M, Duker JS. Ophthalmology. 2nd ed. St Louis Missouri: Mosby Elsevier; 2004:116.
[16] Morad Y, Sharon E, Hefetz L, Nemet P. Corneal thickness and curvature normal-tension glaucoma. Am J Ophthalmology. 1998;125(2):164-68.
[17] Herndon L. Central corneal thickness in normal, glaucomatous, and ocular hypertensive eyes. Arch Ophthalmology. 1997;115(9):1137-41.
[18] Lee J, Wong R, Chan J, Wong I, Lai J. Differences in corneal parameters between normal tension glaucoma and primary open-angle glaucoma. Int Ophthalmol. 2014;35(1):67-72.
[19] Stroligo M, Dunato Z, Kovacevic D, Mance T. Specular microscopy in glaucoma patients. Coll Antropol. 2010;34(2):209-10.
[20] Tomaszewski B, Zalewska R, Mariak Z. Evaluation of the endothelial cell density and the central corneal thickness in pseudoexfoliation syndrome and pseudoexfoliation glaucoma. J Ophthalmol. 2014;2014:123683.
[21] Cho H, Kee C. Population-based glaucoma prevalence studies in Asians. Surv Ophthalmol. 2014;59(4):434-47.
[22] Marcus M, de Vries M, Montolio F, Jansonius N. Myopia as a risk factor for open-angle glaucoma: A systematic review and meta-analysis. Ophthalmology. 2011;118(10):1989-94.e2.
[23] Cursiefen C, Wisse M, Cursiefen S, Jünemann A, Martus P, Korth M. Migraine and tension headache in high-pressure and normal-pressure glaucoma. Am J Ophthalmology. 2000;129(1):102-04.
[24] Suzuki Y, Iwase A, Araie M, Yamamoto T, Abe H, Shirato S, et al. Risk factors for open angle glaucoma in a Japanese population: The Tajimi study. Ophthalmology. 2006;113(9):1613-17.
[25] Shih CY, Zivin JSG, Trokel SL, Tsai JC. Clinical significance of central corneal thickness in the management of glaucoma. Arch Ophthalmol. 2004;122(9):1270-75.

[26] Siu A, Herse P. The effect of age on human corneal thickness. Statistical implications of power analysis. ActaOphthalmol (Copenh). 1993;71(1):51-56.

[27] Leske MC, Connell AM, Schachat AP, Hyman L. The Barbados Eye Study. Prevalence of open angle glaucoma. Arch Ophthalmol. 1994;112(6):821-29.

PARTICULARS OF CONTRIBUTORS:
1. Senior Resident, Department of Ophthalmology, Shekar Eye Hospital, Bengaluru, Karnataka, India.
2. Senior Consultant, Department of Ophthalmology, Shekar Eye Hospital, Bengaluru, Karnataka, India.
3. Senior Resident, Department of Psychiatry, Datta Megha Institute of Medical Sciences, Wardha, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Khushboo Chawla,
2E/20, Jhandewalan Extension, New Delhi-110055, India.
E-mail: khushboo.3dec@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Feb 09, 2021
- Manual Googling: May 20, 2021
- iThenticate Software: Jul 01, 2021 (16%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Feb 08, 2021**
Date of Peer Review: **Mar 25, 2021**
Date of Acceptance: **May 29, 2021**
Date of Publishing: **Aug 01, 2021**