Journal of Clinical & Experimental Ophthalmology

Garg et al., J Clin Exp Ophthalmol 2018, 9:6
DOI: 10.4172/2155-9570.1000763

Research Article Open Access

# Ocular Biometric Factors and its Association with Intraocular Pressure

**Pragati Garg*, Mohit Gupta, Luxmi Singh, Ritika Mullick and Bharti Nigam**

*Department of Ophthalmology, Era's Lucknow Medical College and Hospital, Lucknow, India*

***Corresponding author:** Dr. Pragati Garg, Department of Ophthalmology, Era's Lucknow Medical College and Hospital, Lucknow, India, Tel: +91 9628727420; E-mail: drpragati89@gmail.com

**Received date:** August 26, 2018; **Accepted date:** November 09, 2018; **Published date:** November 16, 2018



## Abstract

**Aim:** To study the role of ocular biometric factors like, central corneal thickness, corneal curvature, anterior chamber depth and axial length and to evaluate its association with intraocular pressure.

**Materials and method:** The study was done at a tertiary care hospital in North India. A detailed history from all the patients was elicited and complete ocular examination like visual acuity, slit lamp examination, tonometry, fundus examination, visual field evaluation, keratometry, gonioscopy, central corneal thickness, A-scan for axial length was performed.

**Observation and results:** A total of 800 subjects falling in sampling frame were enrolled in the study. Central corneal thickness was <540 µm in 85%, 540-600 µm in 14.3% and >600 µm in 0.7% cases. Axial length ranged from 20.1 to 33.9 with a mean of 23.02 ± 1.27 units. Anterior chamber depth was normal in 94.7%, deep in 2.2% and shallow in 3.1% cases. IOP of patients ranged from 10.1 to 37.5 mmHg. Maximum number of cases had IOP in 16-20 mmHg range (44.1%) followed by those having IOP in 12-16 mmHg range (40.1%), 20-24 mmHg range (11.4%), >24 mmHg (3.8%) and <12 mmHg (0.6%) respectively.

The correlation between CCT and IOP was found to be weak positive and significant. A weak, random and negative non-significant correlation between axial length and IOP was observed. IOP was minimum among those with deep anterior chamber depth (2.9%) and maximum among those with shallow anterior chamber depth (40%). Statistically, this difference was significant (p<0.001). In a multivariate model where IOP (>16 mmHg) was projected as a dependent variable with central corneal thickness, axial length and anterior chamber depth as independent variables, only anterior chamber depth showed a significant association with the outcome IOP

**Conclusion:** A significant association was found between IOP and CCT and anterior chamber depth, while we did not find a significant association between IOP and axial length.

**Keywords:** Intraocular pressure; Biometric factors; Ocular

## Introduction

The development of glaucomatous optic neuropathy, based on visual field loss and/or optic disc findings, is more likely to be associated with elevated intraocular pressure (IOP), although IOP is not the only risk factor for glaucomatous optic nerve damage [1].

The intraocular pressure (IOP) is defined as the hydrostatic pressure exerted by the aqueous humour, which inflates the eye to maintain proper alignment of the optical structures [2].

There is ample clinical evidence showing dependence of IOP on various ocular biometric factors like central corneal thickness (CCT), axial length, anterior chamber depth and refractive error.

Although, the multi-variability of IOP is undoubted, however, most of the studies evaluating the role of different ocular biometric parameters in regulation of IOP have addressed it in separate study and as such there are limited studies evaluating together the role of different ocular biometric parameters on IOP. In one such study, Tomoyose et al. [8] have addressed this problem in a multivariate scenario and found that thicker central corneal thickness and steeper corneal curvature were significantly correlated with higher IOP. However, this needs further exploration in different populations.

The relationship between ocular biometric factors and intraocular pressure is considered logical owing to the potential of ocular biometry in influencing the aqueous humor production as well as trabecular and uveoscleral flow. The ocular biometric factors evaluated for their relationship with intraocular pressure include-central corneal thickness, corneal curvature, axial length, anterior chamber depth, Shaffer angle and grade and refractive error [3-7].

With this background, the present study was carried out with an aim to evaluate the association of different ocular biometric factors with intraocular pressure in north Indian population.

## Materials and Method

The study was a hospital based cross sectional study conducted in the Department of Ophthalmology, over the duration of 18 months from October 2016 to March 2018. 800 healthy participants were enrolled in the study after acquiring proper written and informed consent and ethical clearance from the institute.

The exclusion criteria of the study were difficulty in measuring IOP, known cases of glaucoma, phthisis or prosthesis, uveitis, pterygium involving cornea, corneal opacity, moderate to severe strabismus and history of intraocular surgeries including laser iridotomy.

A detailed history was taken from all the patients including signs and symptoms of Glaucoma, family history of glaucoma, occupational history, history of any medicine intake that influences intraocular pressure, any other ocular complaints, any history of intraocular surgeries, history of any ocular trauma, history of any spectacle/contact lens use.

Complete ocular examination was performed, which included; visual acuity testing using Snellen's chart, slit lamp examination, intraocular pressure measurement by Goldmann applanation tonometer, visual field analysis by Humphrey field analyser, fundus examination, measurement of central corneal thickness, keratometery to measure the corneal curvature, gonioscopic examination for the evaluation of the angle, axial length measurement by A-Scan.

The statistical analysis was done using SPSS software version 15. Statistical formulas used are mean, standard deviation, chi-square test, student T test to test the significance of two means; Anova test was used to compare the within group and between group variances. Bivariate correction was done using the Pearson formula. P value was found, and it was considered as significant if it is <0.05.

## Observation and Results

The present study was carried out with an aim to evaluate the association of different ocular biometric factors with intraocular pressure. For this purpose, a total of 800 subjects falling in sampling frame were enrolled in the study. Mean age of patients was 57.21 ± 9.81 with almost 1:1 male to female ratio.

Central corneal thickness was <540 μm in 85%, 540-600 μm in 14.3% and >600 μm in 0.7% cases. Axial length ranged from 20.1 to 33.9 with a mean of 23.02 ± 1.27 mm. Anterior chamber depth was normal in 94.7%, deep in 2.2% and shallow in 3.1% cases. IOP of patients ranged from 10.1 to 37.5 mmHg. Maximum number of cases had IOP in 16-20 mmHg range (44.1%) followed by those having IOP in 12-16 mmHg range (40.1%), 20-24 mmHg range (11.4%), >24 mmHg (3.8%) and <12 mmHg (0.6%) respectively (Table 1).

| S.No. | Characteristic | Statistic | |
|---|---|---|---|
| 1 | Mean Age ± SD (Range) in years | 57.21 ± 9.81 (26-85) | |
| 2 | Gender | **No.** | **%** |
| | Male | 396 | 49.5 |
| | Female | 404 | 50.5 |
| 3 | CCT (μm) (No. of eyes) | (n=1600) | |
| | <540 μm | 1360 | 85 |
| | 540-600 μm | 229 | 14.3 |
| | >600 μm | 11 | 0.7 |
| 4 | Mean Axial Length ± SD (No. of eyes) in mm | 23.02 ± 1.27 (20.1-33.9) | |
| 5 | Anterior chamber depth | (n=1600) | |
| | Normal | 1515 | 94.7 |
| | Deep | 35 | 2.2 |
| | Shallow | 50 | 3.1 |
| 6 | IOP (mmHg) | (n=1600) | |
| | <12 | 9 | 0.6 |
| | 12-16 | 642 | 40.1 |
| | 20-24 | 183 | 11.4 |
| | >24 | 60 | 3.8 |

**Table 1:** General profile of patients.

Proportion of patients with IOP<16 mmHg was 43.4%, in those with central corneal thickness <540 μm as compared to 25.8% among those with 540-600 μm central corneal thickness and 18.2% among those with central corneal thickness >600 μm. Statistically this difference in CCT values with different IOP range was significant (p<0.001) (Table 2a).

| S.No. | CCT status | No. | <12 mmHg (n=9) | | 12-16 mmHg (642) | | 16-20 mmHg (n=706) | | 20-24 mmHg (n=183) | | >24 mmHg (n=60) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. | % | No. | % | No. | % | No. | % | No. | % |
| 1 | <540 µm | 1360 | 9 | 0.7 | 581 | 42.7 | 569 | 41.8 | 154 | 11.3 | 47 | 3.5 |
| 2 | 540-600 µm | 229 | 0 | 0 | 59 | 25.8 | 128 | 55.9 | 29 | 12.7 | 13 | 5.7 |
| 3 | >600 µm | 11 | 0 | 0 | 2 | 18.2 | 9 | 81.8 | 0 | 0 | 0 | 0 |
| $\chi^2$=33.87; p<0.001 | | | | | | | | | | | | |

**Table 2a:** Association between CCT and IOP; CCT and IOP category.

Mean IOP of those with CCT<540 µm was significantly lower (16.84 ± 3.42 mmHg) as compared to those having 540-600 µm CCT (17.75 ± 3.09 mmHg) and >600 µm CCT (17.75 ± 2.21 mmHg) (p=0.001) (Table 2b).

| S.No. | CCT | No. of cases | IOP | |
|---|---|---|---|---|
| | | | Mean | SD |
| 1 | <540 µm | 1360 | 16.84 | 3.42 |
| 2 | 540-600 µm | 229 | 17.75 | 3.09 |
| 3 | >600 µm | 11 | 17.75 | 2.21 |
| F=7.357; p=0.001 (ANOVA). | | | | |

**Table 2b:** Association between CCT and IOP; CCT and mean IOP.

Mean CCT value was minimum for those patients have IOP<12 mmHg (483.56 ± 47.78 µm) followed by those having 12-16 and 16-20 mmHg (504.33 ± 33.22 µm and 508.27 ± 36.85 µm) and 20-24 and >24 mmHg (515.49 ± 29.38 µm and 512.50 ± 24.81 µm) respectively. Statistically, this difference was significant (p<0.001) (Table 2c).

| S.No. | IOP category | No. of cases | CCT (µm) | |
|---|---|---|---|---|
| | | | Mean | SD |
| 1 | <12 mmHg | 9 | 483.56 | 47.78 |
| 2 | 12-16 mmHg | 642 | 504.33 | 33.22 |
| 3 | 16-20 mmHg | 706 | 508.27 | 36.85 |
| 4 | 20-24 mmHg | 183 | 515.49 | 29.38 |
| 5 | >24mm Hg | 60 | 512.5 | 24.81 |
| F (ANOVA) | | | 5.357 | |
| 'p' | | | <0.001 | |

**Table 2c:** Association between CCT and IOP; IOP and mean CCT.

Pearson correlation between CCT and IOP was found to be weak positive and significant (r=0.092; p<0.001) (Table 2d).

| Variable | 'r' | 'p' |
|---|---|---|
| CCT *vs.* IOP | 0.092 | <0.001 |

**Table 2d:** Association between CCT and IOP; Correlation (Pearson correlation).

Mean axial length value ranged from 22.65 ± 0.34 to 23.06 ± 1.08 among different IOP categories, however, this association was not significant statistically (p=0.520) (Table 3a). A weak, random and negative non-significant correlation between axial length and IOP was observed (r=-0.006; p=0.816) (Table 3b).

| S.No. | IOP category | No. of cases | AL | |
|---|---|---|---|---|
| | | | Mean | SD |
| 1 | <12 mmHg | 9 | 22.65 | 0.34 |
| 2 | 12-16 mmHg | 642 | 23.06 | 1.08 |
| 3 | 16-20 mmHg | 706 | 23.03 | 1.42 |
| 4 | 20-24 mmHg | 183 | 22.9 | 1.29 |
| 5 | >24 mm Hg | 60 | 22.92 | 1.11 |
| F=8.247; p=0.520 (ANOVA). | | | | |

**Table 3a:** Association between axial length and IOP; IOP Category and mean axial length.

| Variable | 'r' | 'p' |
|---|---|---|
| AL *vs.* IOP | -0.006 | 0.816 |

**Table 3b:** Association between axial length and IOP; Correlation (Pearson correlation).

Proportion of those with IOP>20 mmHg was minimum among those with deep ACD (2.9%) followed by normal (14.6%) and maximum among those with shallow ACD (40%). Statistically, this difference was significant (p<0.001) (Table 4a).

| S.No. | Anterior chamber depth | No. | <12 mmHg (n=9) | | 12-16 mmHg (642) | | 16-20 mmHg (n=706) | | 20-24 mmHg (n=183) | | >24 mmHg (n=60) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. | % | No. | % | No. | % | No. | % | No. | % |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Deep | 35 | 0 | 0 | 13 | 37.1 | 21 | 60 | 1 | 2.9 | 0 | 0 |
| 2 | Normal | 1515 | 9 | 0.6 | 625 | 41.3 | 659 | 43.5 | 167 | 11 | 55 | 3.6 |
| 3 | Shallow | 50 | 0 | 0 | 4 | 8 | 26 | 52 | 15 | 30 | 5 | 10 |
| $\chi^2$=40.88; π<0.001 | | | | | | | | | | | | |

**Table 4a:** Association between anterior chamber depth and IOP.

Mean IOP was minimum for deep ACD (16.41 ± 1.71) followed by normal ACD (16.92 ± 3.40 mmHg) and maximum among those with shallow ACD (19.22 ± 2.72 mmHg). Statistically this difference was significant (p<0.001) (Table 4b).

| SN | ACD | No. of cases | IOP | |
|---|---|---|---|---|
| | | | Mean | SD |
| 1 | Deep | 35 | 16.41 | 1.71 |
| 2 | Normal | 1515 | 16.92 | 3.4 |
| 3 | Shallow | 50 | 19.22 | 2.72 |
| F=11.91; p<0.001 (ANOVA). | | | | |

**Table 4b:** Association between ACD and mean IOP.

In a multivariate model where IOP (>16 mmHg) was projected as a dependent variable with CCT, Axial length and ACD as independent variables, only ACD showed a significant association with the outcome IOP (Table 5).

| | B | S.E. | Wald | df | Sig. | Exp (B) |
|---|---|---|---|---|---|---|
| **CCT** | 0.001 | 0.001 | 1.179 | 1 | 0.278 | 1.001 |
| **Axial length** | 0.007 | 0.013 | 0.298 | 1 | 0.585 | 1.007 |
| **ACD** | 0.484 | 0.142 | 11.669 | 1 | 0.001 | 1.623 |
| **Constant** | -1.103 | 1.05 | 1.104 | 1 | 0.293 | 0.332 |
| **Note:** (a) Variable(s) entered on step 1: CCTRE, Axial length RE, ACD. | | | | | | |

**Table 5:** Multivariate regression.

## Discussion

Despite a definitive role in causation of ocular ailments, the exact pathophysiology and factors affecting the intraocular pressure is not clearly understood. In the recent years it has been proposed that ocular biometric parameters also have a role to play in determining the intraocular pressure [3-7]. For this purpose, a total of 800 healthy individuals falling in sampling frame were included in the assessment. The study population was of 26 to 85 years of age, having a mean age of 57.21 years, with an almost equivalent male: female ratio of 1.02.

On ocular evaluation of (1600 eyes), we found that majority of patients had CCT<540 μm central corneal thickness (85%). These findings agree with the observations specifically made in Indian population that report the CCT of healthy female and male population to be 525.63 μm to 533.05 μm respectively, thus justifying the high proportion of cases with CCT<540 μm in our study.

In present study, axial length ranged from 20.1 mm to 33.9 mm with a mean value of 23.02 ± 1.27 mm. This mean value is close to the mean axial length value of 22.6 ± 0.91 mm as deduced by Nangia et al. [15] for an adult Indian population in the Central India Eye and Medical Study.

With respect to anterior chamber depth, majority of patients had normal depth (94.7%). There were only 2.2% patients with deep and 3.1% with shallow depth. Thus, the deviation from normal anterior chamber depth was only 5.3%. This nominal variation in anterior chamber depth in otherwise normal population could be incidental only.

IOP of cases ranged from 10.1 mmHg to 37.5 mmHg. However, only 15.1% cases had IOP>20 mmHg. There were only 3.8% cases having IOP>24 mmHg. Thus, median IOP lies in 16-20 mmHg range in present study. This value is close to the average intraocular pressure measurement for Indian population as reported by Gupta et al. [16] who reported the average IOP value in Indian population to be 15.37 ± 1.57 mmHg.

In present study, the proportion of patients with higher IOP was higher among those with Corneal thickness >600 μm as compared to those having Corneal thickness <600 μm. Mean CCT also showed an incremental trend with increasing IOP categories and mean IOP of those having CCT>600 μm was significantly higher as compared to that of patients with CCT<540 μm. Evaluation of linearity of this correlation also showed a weak positive and significant correlation (r=0.092; p<0.001). Similar to our study, Tomoyose et al. [8], Koban et al. [9], Baskaran et al. [10], Bilak et al. [11] in their study also found that thicker central cornea was associated with higher IOP levels. Yang et al. [12], Cho et al. [13], Kumar et al. [14], Nangia et al. [15], Gupta et al. [16], Wang et al. [17] also made similar assessment. Some other workers also made a similar observation [4,8,18]. Wolfs et al. [3] in the Roterdam study also saw that increased corneal thickness is related with increased IOP. However, Yang et al. [12] failed to find out a significant association between IOP reduction after phacoemulsification and central corneal thickness. Nevertheless, except for a limited study, most of the other studies show a significant and well elucidated relationship between CCT and IOP levels.

The present study did not find a significant association between IOP and axial length but found that anterior chamber depth was significantly associated with IOP. It was observed that shallow anterior chamber depth was significantly associated with increased IOP. There are studies that have investigated relationship of axial length, anterior chamber depth and refractive error [5-7]. In their study Wilson et al. [5] studied the association between diurnal variations in IOP and axial length and showed that rhythmic changes occur for both the parameters, however, there was no significant correlation between two.

Lee et al. [6] too in their study among children failed to find out a significant correlation between axial length and IOP.

However, in present study that included adults, although the relationship between axial length and IOP was not significant yet this association was significant for anterior chamber depth. However, contrary to this finding, Tomoyose et al. [8] found a significant association of axial length with IOP but did not find a significant association with anterior chamber depth. Kim et al. [19] too in their study showed that higher myopic refractive error was significantly associated with higher IOP. However, Lee et al. [6] also showed a significant association of refractive error with IOP in univariate model too, as seen in present study.

The present study had an extensive coverage of variables that might affect IOP. This is natural as we consider IOP to be dependent on a multitude of factors. Some of the associations derived on univariate assessment seemed vague and indicated effect of some confounder. To elaborate the role of independent factors associated with IOP, we carried out a multivariate analysis. In a multivariate model where IOP (>16 mmHg) was projected as a dependent variable with CCT, Axial length and ACD as independent variables. ACD showed a significant association with the outcome IOP.

## Conclusion

During the entire course of our study, we found that the association of IOP has been viewed and assessed variedly in different studies, thus including many variables in each of them, thus making each study projecting a unique predictive model. Although, all the researchers have tried to explain the problem with the set of variables available with them, however, there is a need to come up with a set of most strong predictors present in almost all the studies.

## References

1. Zheng Y, Cheung CYL, Wong TY, Mitchell P, Aung T (2010) Influence of height, weight, and body mass index on optic disc parameters. Invest Ophthalmol Vis Sci 51: 2998-3002.
2. Shaidull M, Al-Malki WH, Delamere NA (2011) Mechanism of aqueous humor secretion, its regulation and relevance to glaucoma. In: glaucoma-basic and clinical concepts. InTech pp. 1-32.
3. Wolfs RC, Klaver CC, Vingerling JR, Grobbee DE, Hofman A, et al. (1997) Distribution of central corneal thickness and its association with intraocular pressure: The Rotterdam Study. Am J Ophthalmol 123: 767-772.
4. Ventura AC, Böhnke M, Mojon DS (2001) Central corneal thickness measurements in patients with normal tension glaucoma, primary open angle glaucoma, pseudoexfoliation glaucoma, or ocular hypertension. Br J Ophthalmol 85: 792-795.
5. Wilson LB, Quinn GE, Ying G-S, Francis EL, Schmid G et al. (2006) The relation of axial length and intraocular pressure fluctuations in human eyes. Invest Ophthalmol Visual Sci 47: 1778-1784.
6. Lee AJ, Saw S-M, Gazzard G, Cheng A, Tan DTH (2003) Intraocular pressure associations with refractive error and axial length in children. BJO 88: 5-7.
7. Leydolt C, Findl O, Dexler W (2008) Effects of change in intraocular pressure on axial eye length and lens position. Eye 22: 657-661.
8. Tomoyose E, Higa A, Sakai H, Sawaguchi S, Iwase A, et al. (2010) Intraocular pressure and related systemic and ocular biometric factors in a population-based study in Japan: the Kumejima study. Am J Ophthalmol 150: 279-286.
9. Koban Y, Ozlece HK, Bilgin G, Koc M, Cagatay HH, et al. (2016) Intraocular pressure and ocular biometric parameters changes in migraine. BMC Ophthalmol 16: 70.
10. Baskaran M, Raman K, Ramani KK, Roy J, Vijaya L, et al. (2006) Intraocular pressure changes and ocular biometry during Sirsasana (headstand posture) in yoga practitioners. Ophthalmology 113: 1327-1332.
11. Bilak S, Simsek A, Capkin M, Guler M, Bilgin B (2005) Biometric and intraocular pressure change after cataract surgery. Optom Vis Sci 92: 464-470.
12. Yang HS, Lee J, Choi S (2013) Ocular biometric parameters associated with intraocular pressure reduction after cataract surgery in normal eyes. Am J Ophthalmol 156: 89-94.
13. Cho HJ, Hwang YH, Lee JH (2012) Intraocular pressure and ocular biometry change of healthy eyes in postural variation. J Korean Ophthalmol Soc 53: 306-310.
14. Kumar J, Verma A, Dwivedi S, Pathak A (2017) Central corneal thickness in adult Indians and its effect on glaucoma progression: the Bundelkhand region glaucoma study. IOSR J Dental Med Sci (IOSR-JDMS) 16: 01-03.
15. Nangia V, Jonas JB, Sinha A, Matin A, Kulkarni M, et al. (2010) Ocular axial length and its associations in an adult population of central rural India: the Central India Eye and Medical Study. Ophthalmology 117: 1360-1366.
16. Gupta SP, Mehta P (1971) Average distribution of intraocular pressure in Indians by applanation tonometer. Indian J Ophthalmol 19: 85-90.
17. Wang YX, Xu L, Zhang XH, You QS, Zhao L, et al. (2013) Five-year change in intraocular pressure associated with changes in arterial blood pressure and body mass index. The Beijing Eye Study. PLoS One 8: e77180.
18. Hashemi H, Khabazkhoob M, Emamian MH, Shariati M, Yekta A, et al. (2016) Distribution of intraocular pressure and its determinants in an Iranian adult population. Int J Ophthalmol 9: 1207-1214.
19. Kim MJ, Park KH, Kim CY, Jeoung JW, Kim SH (2014) The distribution of intraocular pressure and associated systemic factors in a Korean population: The Korea National Health and Nutrition Examination Survey. Acta Ophthalmol 92: e507-e513.