

Correlation between Central Corneal Thickness and Intraocular Pressure among Normal IOP, Ocular Hypertensive and Primary Open Angle Glaucoma Patients

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Abstract

Background: Glaucoma is an optic neuropathy characterized by a typical appearance of optic nerve head and characteristic visual field loss. The diagnosis of primary glaucoma, normal tension glaucoma and ocular hypertension is made on the basis of an IOP cut-off point of 21 mmHg. Thus, any factor that alters the value of the IOP can lead to a misclassification of the patient. There is a growing consensus that assessment of Central Corneal Thickness (CCT) has become an important element of the clinical evaluation of the glaucoma patient. This study intends to analyse the CCT trends amongst three study groups: Normal subjects; Primary Open Angle Glaucoma subjects; and Ocular Hypertension subjects. It also intends to explore the relationship between CCT and GAT IOP amongst the three study groups. Lastly, this study aims to evaluate if CCT can be used as a useful tool for prognostication of disease progression in ocular hypertensives, and for glaucoma diagnosis. **Aims and Objective:** 1. To study and compare the CCT amongst patients with Normal IOP, ocular hypertension and glaucoma. 2. To study and compare the correlation between CCT and IOP amongst patients with Normal IOP, ocular hypertension and glaucoma. **Material and Methods:** IOP was measured using Goldmann's Applanation Tonometer and CCT was measured using the ultrasound pachymeter in 60 eyes of 30 normal subjects, 60 eyes of 30 glaucoma patients and 60 eyes of 30 ocular hypertensive patients. A correction factor based on the CCT was applied and corrected IOP values were calculated for the three cohorts. Analysis of Variance and Pearson Correlation Test was used to determine any significant difference in CCT, the correction factors and the CCT adjusted IOPs between the three groups. The study was conducted between November 2014 to November 2016. **Results:** There was a statistically significant difference in the mean CCT of the normals ($554.38 + 17.67\mu\text{m}$) as compared to the glaucomas ($554.15 + 16.39\mu\text{m}$) and ocular hypertensives ($568.18 + 30.52\mu\text{m}$). Applying the described correction factor for corneal thickness, 40% of eyes with ocular hypertension were found to have a corrected IOP of 21mmHg or less. **Conclusion:** Increased corneal thickness in ocular hypertension may lead to an overestimation of IOP in 39% of cases. Measurement of central corneal thickness is advisable when the clinical findings do not correlate with the applanation IOP.

Keywords: Glaucoma, Ocular Hypertension, CCT, GAT, IOP

1. Introduction

Glaucoma is defined as an optic neuropathy characterized by raised Intraocular Pressure (IOP), typical optic nerve head changes and characteristic visual field loss¹.

Raised IOP is a known causal risk factor for glaucoma, it is the only modifiable risk factor than can be therapeutically manipulated², thus making its accurate measurement essential for disease detection and patient follow up. Goldmann applanation tonometry, the current GOLD

standard for the measurement of IOP², is based on the Imbert-Fick law. Goldmann observed that when the area applanated was 7.35mm², the surface tension due to the tear film counterbalanced the resistance to indentation of the cornea, thus making it unnecessary to consider the rigidity of the globe and the surface tension of the tear film in applanation tonometry³. More recent evidence indicates that these, as well as a number of other factors (e.g. significant astigmatism, corneal curvature) do affect the accuracy of applanation tonometry⁴. All devices to record IOP measurements have a transcorneal approach and thus are indirect. Hence, IOP is always estimated rather than truly measured. Goldmann himself discussed the influence of variations of Central Corneal Thickness (CCT) on IOP measured by applanation⁵. However, he felt that significant variations in CCT occurred only rarely and hence assumed a «normal» CCT of 520 µm for his instrument. A positive correlation between increased corneal thickness and IOP has been reported earlier⁶⁻⁸. Studies in eyes with manometrically controlled IOP have demonstrated a significant disparity between the actual IOP and simultaneous applanation tonometry readings. This disparity was related to the CCT. The underestimation of IOP was as much as 4.9mmHg in thin corneas, while thick corneas produced an overestimation of about 6.8mmHg⁹⁻¹¹. Accordingly it has been suggested that measurement of corneal thickness is necessary for the accurate interpretation of applanation tonometry. This study intends to analyze the CCT trends amongst three study groups: Normal IOP patients; Primary Open Angle Glaucoma patients; Ocular Hypertensive patients. It also intends to explore the relationship between CCT and GAT IOP amongst the three study groups. Lastly, this study aims to evaluate if CCT can be used as a useful tool for prognostication of disease progression in ocular hypertensives, and for glaucoma diagnosis.

[The term glaucoma is used to denote Primary Open Angle Glaucoma in this study].

2. Aims and Objective

- To study and compare the CCT amongst patients with Normal IOP, ocular hypertension and glaucoma.
- To study and compare the correlation between CCT and IOP amongst patients with Normal IOP, ocular hypertension and glaucoma.

3. Material and Methods

Study was conducted in Dept. of Ophthalmology, Dr. Vasantrao Pawar Medical College, Nasik after Institutional

review board approval. Total of 90 patients, 30 in each group.

4. Study Design and Study Population

A) Study design: Comparative cross-sectional study. B) Study setting: Department of Ophthalmology Medical College and Hospital, Tertiary care centre. C) Duration of the study: Period of Two years from November 2014 to November 2016 D) Sample size: 90 (30 in each group) E) Study Participants:

Eligibility Criteria

Inclusion criteria

Group 1: Normal subjects:

- IOP < 21 mmHg.
- Normal optic discs.
- Angles open on gonioscopy.

Group 2: Ocular hypertensives:

- IOP > 21 mmHg on atleast 2 occasions (morning and evening).
- Healthy optic discs with no glaucomatous features.
- No nerve fibre layer defects.
- No glaucomatous field defects.
- Open angles on gonioscopy.

Group 3: Glaucoma subjects:

- IOP prior to treatment > 21 mmHg, with current IOP on treatment ≤ 21 mmHg.
- Glaucomatous optic disc ± nerve fibre layer defects.
- Glaucomatous field defects.
- Open angles on gonioscopy.

Exclusion criteria

- Age < 40 years.
- Evidence of other anterior segment pathology including corneal opacities, keratoconus.
- Previous intraocular or corneal surgery.
- Diabetes mellitus, use of contact lens and any other condition which might affect corneal thickness.
- Any other optic nerve or intracranial disease.
- Corneal oedema.
- Corneal astigmatism > 2D.
- Angle closure glaucoma.
- Patients not willing to give consent.

IOP was measured using Goldmann's Applanation Tonometer and CCT was measured using the ultrasound

pachymeter in 60 eyes of 30 normal subjects, 60 eyes of 30 glaucoma patients and 60 eyes of 30 ocular hypertensive patients. A correction factor based on the CCT was applied and corrected IOP values were calculated for the three cohorts. Analysis of Variance and Pearson Correlation Test was used to determine any significant difference in CCT, the correction factors and the CCT adjusted IOPs between the three groups.

5. Results

Mean CCT in normal subjects is $554.38 \pm 17.67 \mu\text{m}$, mean CCT in glaucoma subjects is $554.15 \pm 16.39 \mu\text{m}$ and mean CCT in OHTN subjects is $568.18 \pm 30.52 \mu\text{m}$.

Applying the described correction factor for corneal thickness, 40% of eyes with ocular hypertension were found to have a corrected IOP of 21mmHg or less.

6. Discussion

Mean IOP in normal subjects is $14.17 \pm 2.16 \text{ mmHg}$
 Mean IOP in glaucoma subjects is $16.93 \pm 1.69 \text{ mmHg}$
 Mean IOP in OHTN subjects is $22.93 \pm 1.19 \text{ mmHg}$

Thus ocular hypertensives had statistically significant higher IOP as compared to normal population and glaucoma subjects.

Mean CCT the three study groups which shows that:
 Mean CCT in normal subjects is $554.38 \pm 17.67 \mu\text{m}$
 Mean CCT in glaucoma subjects is $554.15 \pm 16.39 \mu\text{m}$
 Mean CCT in OHTN subjects is $568.18 \pm 30.52 \mu\text{m}$
 Mean CCT in the normal group ($554.38 \pm 17.67 \mu\text{m}$) and the glaucoma group ($554.15 \pm 16.39 \mu\text{m}$) was similar and was significantly lower than the mean CCT in the OHTN group ($568.18 \pm 30.52 \mu\text{m}$). (Table 1)

Thus ocular hypertensives had statistically significant thicker corneas as compared to normal population and glaucoma subjects.

These findings are similar to a study done by Dr. (Prof) Jyoti Bhuyan and Dr. Ranjita Borkotoky in 2016 in Assam¹². The Central corneal thickness in Ocular Hypertension Treatment Study(OHTS) which was done in 2001 by James D. Brandt et al and by Ehler et al⁸.

A substantial number of subjects in the OHTN cohort [36.7%], the CCT-adjusted IOP was underestimated by 2mm Hg or more. The maximum underestimation noted in this study was -4.00 for a subject with a CCT of 625 μm , whose GAT IOP was 24 mmHg, but CCT adjusted IOP was 20 mmHg. (Table 2,3)

In all, 24 out of 60 OHTN eyes (40%) had corrected IOP $\leq 21\text{mmHg}$.

This implies that 40.0% of the eyes were misclassified as ocular hypertensive when they were actually normotensive.

Table 1. Comparison of Central Corneal Thickness (CCT) among three groups

	Group	N	Mean	SD	p- value
CCT	Normal	60	554.38	17.67	<0.01
	Glaucoma	60	554.15	16.39	
	OHT	60	568.18	30.52	
p- value		Normal vs Glaucoma - 1.0	Normal vs OHT <0.01	Glaucoma vs OHT <0.01	

Table 2. Comparison of Correction Factor among three groups

	Group	N	Mean	SD	p- value
CF	Normal	60	-0.47	0.88	<0.01
	Glaucoma	60	-0.46	0.82	
	OHT	60	-1.17	1.52	
p- value		Normal vs Glaucoma - 1.0	Normal vs OHT <0.01	Glaucoma vs OHT <0.01	

Table 3. Comparison of Corrected IOP among three groups

	Group	N	Mean	SD	p- value
Corrected IOP	Normal	60	13.70	1.79	<0.01
	Glaucoma	60	16.47	2.64	
	OHT	60	21.81	1.71	
p- value		Normal vs Glaucoma -0.869	Normal vs OHT <0.01	Glaucoma vs OHT <0.01	

7. Conclusion

Our study concludes that

- Ocular hypertensives are younger as compared to their glaucoma counterparts. Thus they need to be monitored longer over time for their progression to POAG.
- They have significantly greater GAT IOP as compared to the normal and the glaucoma groups.
- They also have significantly greater CCT as compared to the normal and the glaucoma groups.
- The CCT adjusted CF for OHTN group is significantly higher as compared to the normal and the glaucoma groups.
- On applying the appropriate correction factors, nearly half of the OHTN eyes become normotensive.

Hence a substantial number of OHTN patients may be getting erroneously classified and subjected to glaucoma surveillance and/ or long-term treatment.

8. References

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