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Corneal Hysteresis as a Biomarker for Screening and Diagnosis of Normal Tension Glaucoma

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Abstract

Background: NTG stands as a subtype of glaucoma, which results in optic nerve damage with visual field loss when IOP remains within the normal range. The traditional IOP measurement technique causes NTG diagnosis to be delayed. Glaucoma risk assessment and progression evaluation now rely on corneal hysteresis as a measurement for understanding corneal biomechanics.

Objective: The study aims to explore corneal hysteresis as a diagnostic tool in NTG diagnosis at the same time examining its relationship to RNFL measures.

Methodology: This analytical cross-sectional research involved 100 participants, including 50 patients who had received an NTG diagnosis and 50 healthy subjects matched for age and gender. A complete eye examination, including a procedure for IOP measurement by Goldmann applanation tonometry and CH evaluation through Ocular Response Analyzer (ORA) testing and assessment of central corneal thickness (CCT) with pachymetry and RNFL thickness assessment with optical coherence tomography (OCT), was performed on 100 participants. SPSS conducted the statistical evaluation utilizing $p<0.05$ as the significance threshold.

Result: NTG patient CH levels averaged 9.2 ± 0.6 mmHg, which showed a significant difference compared to control values at 9.5 ± 0.8 mmHg ($p=0.036$). The average RNFL thickness was considerably thinner in NTG eyes (77.3 ± 8.6 µm) than in control eyes (96.8 ± 7.2 µm) based on statistical assessment ($p=0.001$). Reduction of CCT measured at 512.9 ± 23.7 µm occurred in subjects with NTG and produced statistically significant results when compared with controls (521.6 ± 19.8 µm, $p=0.049$). Research results identified a statistically significant relationship between decreased CH and RNFL thinning in patients suffering from NTG (Pearson correlation, $p = 0.002$), indicating optic nerve structure damage based on reduced CH levels.

Conclusion: The clinical value of corneal hysteresis emerges from its ability to predict progression of retinal nerve fiber layer thickness deterioration in NTG patients as the study shows lower corneal hysteresis in NTG patients is associated with increased retinal nerve fiber layer thinning, making it a possible additional tool for screening NTG patients and to support risk assessment through non-invasive testing

Keywords: Corneal hysteresis; Normal tension glaucoma; Retinal nerve fiber layer thickness; Intraocular pressure; Ocular biomechanics; Glaucoma diagnosis;

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Introduction

Glaucoma is the second leading cause of permanent eyesight loss in the United States, primarily affecting adults [1]. In 2023, the WHO reported that approximately 7.7 million people worldwide are suffering from vision impairment or blindness due to glaucoma [2]. Allison K. et al. (2020) predicted that 111.8 million people will experience glaucoma by 2024 [3]. Glaucoma is a complex group of eye diseases that leads to damage of the optic nerve due to elevated intraocular pressure (IOP) [4], whereas Normal Tension Glaucoma (NTG) is a progressive optic neuropathy known as low pressure or normal pressure glaucoma [5]. In NTG, eye pressure remains within 10 to 21 mmHg, and vision loss occurs due to optic nerve damage [6]. Due to the consistency of normal eye pressure, diagnosing NTG becomes challenging; almost 30-50% of cases remain undiagnosed in instances of Normal Tension Glaucoma [7]. The diagnostic challenge of normal tension glaucoma (NTG) arises because this condition develops without elevated intraocular pressure (IOP), which characterizes primary open-angle glaucoma (POAG). In recent times, corneal hysteresis is considered a potential biomarker for Normal Tension Glaucoma [8]. The viscoelastic damping of the cornea is measured by the ability of the cornea to absorb and dissipate energy in corneal hysteresis [9]. Central corneal thickness is related to the risk of glaucoma progression; corneal hysteresis detects the presence of glaucoma, risk progression, and effectiveness of glaucoma treatments than central corneal thickness examination according to recent research [10]. Corneal Hysteresis is a recently discovered biomechanical parameter that shows a light of hope in NTG diagnosis. Hysteresis is measured by the Ocular Response Analyzer [11]. In this study, the researcher aims to provide a comprehensive review of the current understanding of corneal hysteresis as a biomarker for the screening and diagnosis of normal tension glaucoma.

Methodology

This two-year research evaluated corneal hysteresis (CH) function as a clinical tool for diagnosing normal tension glaucoma (NTG) through a cross-sectional study design. The study took place at Vision Eye Hospital, Dhaka, Bangladesh during the timeline of 2023 to 2024 The research population included 100 participants, divided between NTG subjects and non-glaucoma controls, totaling 50 patients each. Participants were selected based on specific study inclusion and exclusion criteria.

Inclusion criteria

Patient aged ≥50 years.

NTG patients who receive a diagnosis (IOP ≤21 mmHg with glaucomatous changes).

Willingness to provide informed consent.

Exclusion criteria

History of ocular surgery within 6 months.

Associated ocular or systemic disease affecting eye health.

Medications that influence IOP or corneal integrity have been taken by the patient within the last 3 months.

Demographic and clinical information for every study participant was retrieved by individual case report form. The research studied two demographic factors (age and gender) and several clinical indicators, which consisted of IOP, central corneal thickness (CCT), retinal nerve fiber layer (RNFL) thickness, and corneal hysteresis (CH). IOP measurements was done using Goldmann applanation tonometry, while CCT evaluation took place with ultrasonic pachymetry, and RNFL thickness assessment happened through optical coherence tomography (OCT), and CH measurements utilized the Ocular Response Analyzer (ORA). After a successful data collection, all data were set to analyze by MS Excel and SPSS 25.0. A p-value<0.05 was considered significant by statistical analysis.

Results

Table 1 compares the demographic characteristics of the study population. There were no significant differences in age (64.3 ± 7.4 years in NTG vs. 61.9 ± 6.3 years in controls, p=0.084) or gender distribution (29 males and 21 females in NTG vs. 26 males and 24 females in controls, p=0.546) between the two groups.

Table 1: Comparison of demographic characteristics of subjects of two groups (N=100).

Characteristics	Patients with NTG	Patients with no glaucoma	P value
Age	64.3±7.4	61.9±6.3	0.084^{ns}
Gender			
Male	29	26	0.546^{ns}
Female	21	24	

Table 2: The clinical value of corneal hysteresis emerges from its ability to predict progression of retinal nerve fiber layer thickness deterioration in NTG patients as the study shows lower corneal hysteresis in NTG patients is associated with increased retinal nerve fiber layer thinning, making it a possible additional tool for screening NTG patients and to support risk assessment through non-invasive testing.

Characteristics	Patients with NTG	Patients with no glaucoma	P value
IOP	14.1±3.2	12.9±3.1	0.059^{ns}
CCT (µm)	512.9±23.7	521.6±19.8	0.049^{s}
RNFL (microns)	77.3±8.6	96.8±7.2	0.001^{s}
CH	9.2±0.6	9.5±0.8	0.036^{s}

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Table 2 presents the clinical characteristics of the study population. The mean IOP was slightly higher in the NTG group compared to the control group (14.1 ± 3.2 mmHg vs. 12.9 ± 3.1 mmHg, p = 0.059), but this difference was not statistically significant. The mean CCT was significantly lower in the NTG group than in the control group (512.9 ± 23.7 µm vs. 521.6 ± 19.8 µm, p=0.049). The mean RNFL thickness was also significantly lower in the NTG group compared to the control group (77.3 ± 8.6 µm vs. 96.8 ± 7.2 µm, p=0.001). Similarly, the mean CH was significantly lower in the NTG group than in the control group (9.2 ± 0.6 mmHg vs. 9.5 ± 0.8 mmHg, p=0.036).

Figure 1 illustrates the relationship between CH and RNFL loss. A significant negative correlation was observed between CH and RNFL thickness in the NTG group, indicating that lower CH values are linked to greater RNFL loss.

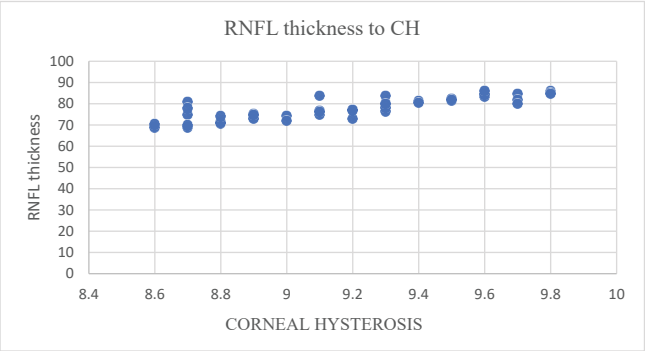

Figure 1: Correlation of CH with RNFL loss.

Discussion

The study on corneal hysteresis (CH) as a biomarker for screening and diagnosing normal tension glaucoma compares the demographic and clinical characteristics of glaucoma patients with those of patients with normal tension glaucoma (NTG). Evaluating low CH levels should become an independent risk factor for glaucoma diagnosis, as it contributes to the ongoing deterioration of the optic nerve and visual field [8]. Instances of low corneal hysteresis (CH) exist specifically in Normal Tension Glaucoma patients, while higher CH values present in healthy participants alongside reduced levels of retinal nerve fiber layer (RNFL) [12]. This study included 50 healthy patients with NTG and 50 healthy patients with no glaucoma. The mean age of NTG patients detected was 64.3±7.4 years, and the mean age of glaucoma patients was 61.9±6.3 years in this study. Stamper et al., 2009 stated that NTG mostly appears in the era of the 60s, but in rare cases, it can be observed in 50 years of age [13]. A 2015 study compared the characteristics of glaucoma patients across two different periods, finding a mean age of 54.76 ± 19.72 years in the 2003-2005 timeline and 58.03 ± 17.07 years in the 2010-2012 timeline [14]. This is a male-dominant study, with 29 males and 21 females in the NTG group versus 26 males and 24 females in the control group. A comparative study of NTG and primary open-angle glaucoma (POAG) opposed the finding with 58.9% female patients in NTG and 26.8% patients with POAG [15]. Another gender based comparative study also showed that women are more susceptible (60%) to glaucoma than men [16]. However, demographic variants can vary based on region, time, and population. This study found that the variation of Intraocular pressure (IOP) is not clinically significant for both non-glaucoma and NTG patients. Central Corneal Thickness (CCT), another important parameter; according to the CCT diagnosis, it has near to non-significant differences for NTG and non-glaucoma patients (p=0.049). The mean normal thickness of the cornea is 540 µm [17]. A noticeable decrease in corneal thickness was detected by Corneal Hysteresis in both groups in Bangladeshi region. The Retinal Nerve Fiber Layer (RNFL) score determines the damage of retinal ganglion cells and their axons. There is a significant distinction observed in control and NTG groups (p=0.001). RNFL decreases to NTG patients to 77.3±8.6 microns while the normal ranges are 95±13 microns for females and 92±1 microns for male [18]. Control patients findings are similar to normal ranges, 96.8±7.2 microns. Corneal Hysteresis also showed a significant potentiality in detecting NTG (p=0.036). The research data showed NTG patients exhibited reduced CH measurements at 9.2 ± 0.6 mmHg compared to control subjects (9.5 ± 0.8 mmHg) (p = 0.036). Previous studies also agree with this finding that low CH level increases the risk of glaucoma progression [19]. Congdon et al., 2006 discovered that glaucoma patients exhibited significantly reduced CH when compared to healthy subjects, which implies CH might serve as a reflection of corneal and lamina cribrosa biomechanical behavior leading to glaucoma development [20]. By the graphical representation, the current study displays a significant negative correlation between CH and RNFL thickness in NTG patients, indicating that lower CH values are associated with greater RNFL loss. Sullivan-Mee et al., 2012 established that CH shows a direct link with various glaucoma severity metrics, including RNFL thickness measurements [21]. Furthermore, Zhang C et. al., 2016 showed that lower Central Hemianopic vision yield increased the speed of Retinal Nerve Fiber Layer deterioration across periods [12].

The investigation indicates that CH represents a prospective biosignal for NTG detection, which can help medical professionals determine cases without standard risk factors. Measurements of low CH values indicate an elevated possibility of glaucoma developing further, and the relationship between CH and RNFL reduction indicates monitoring disease severity potential for this parameter. Evidence supporting biomechanical elements in glaucoma disease development continues to increase so this research

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becomes vital. Sit A J et. al., 2023 et al emphasized that CH offers value for glaucoma risk assessment when used alongside established clinical tools but mainly helps doctors evaluate NTG patients [22].

Limitation

The study brings important insights about CH in NTG but faces several limitations. The cross-sectional research technique restricts our capacity to show causal relationships or explain timing changes between CH development and glaucoma disease advancement. The initial sample size was adequate, but it might not accurately portray the full range of CH values that exist within different populations. Longitudinal studies with expanded participant numbers should investigate future CH behavior in NTG patients to establish long-term predictive abilities.

Conclusions

The results of the research project reinforce the current evidence that supports using CH as a screening tool for detecting NTG cases. Research evidence demonstrates that reduced corneal biomechanical properties are significantly linked with the reduction of retinal nerve fiber layer thickness. Clinical practice would benefit from adding CH assessments as a supportive tool for glaucoma risk evaluation, including people with NTG.

Conflicts of Interest

The authors declare that they have no potential conflicts of interest relevant to this article.

Author Contributions

Siddiqur Rahman conceptualized and supervised the study. Abir Bin Sajj and Omar Faroque carried out the experiment. Tohura Sharmin conducted all statistical analysis, numerical calculations and data interpretation. Abir Bin Sajj took the lead in preparing the manuscript and all authors have contributed to manuscript revisions and provided critical feedback.

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Abbreviation

CH: Corneal hysteresis

NTG: Normal tension glaucoma

IOP: Intraocular pressure

CCT: Central Corneal Thickness

RNFL: Retinal Nerve Fiber Layer

References

1. Ngozika Esther Ezinne OS. Visual Impairment and Blindness among Patients at Nigeria Army Eye Centre, Bonny Cantonment Lagos, Nigeria. Healthcare (Basel) 10 (2022): 2312.
2. WHO. Blindness and vision impairment. World Health Organization (2023).
3. Karen Allison DP. Epidemiology of Glaucoma: The Past, Present, and Predictions for the Future. Cureus 12 (2020): e11686.
4. Dietze J, Blair K, Zeppieri M, et al. Glaucoma. In Treasure Island (FL). StatPearls (2024).
5. Gosling D, Meyer JJ. Normal Tension Glaucoma. In Treasure Island (FL). StatPearls (2022).
6. Machiele R, Motlagh M, Zeppieri M, et al. Intraocular Pressure. In Treasure Island (FL). StatPearls (2024).
7. Brian J, Song JC. New directions in the treatment of normal tension glaucoma. Indian J Ophthalmol 62 (2014): 529–537.
8. Larae Zimprich JD. Corneal Hysteresis as a Biomarker of Glaucoma: Current Insights. Clin Ophthalmol 10 (2020): 2255–2264.
9. Melissa Murphy OP. Corneal hysteresis in patients with glaucoma-like optic discs, ocular hypertension and glaucoma. BMC Ophthalmology 17 (2017).
10. Madhvi Deol DA. Corneal hysteresis and its relevance to glaucoma. Curr Opin Ophthalmol 26 (2015): 96–102.
11. Dana Blumberg AS. Chapter 5 - Emerging risk factors for glaucoma onset and progression. In Progress in Brain Research. 221 (2015): 81-101.
12. Chunwei Zhang AJ-F. Corneal Hysteresis and Progressive Retinal Nerve Fiber Layer Loss in Glaucoma. Am J Ophthalmol 166 (2016): 29–36.
13. Robert L Stamper MF. Becker-Shaffer's Diagnosis and Therapy of the Glaucomas. ScienceDirect (2009): 239-265.
14. Zhao Y, Fu J-L, Li Y-L, et al. Epidemiology and clinical characteristics of patients with glaucoma: An analysis of hospital data between 2003 and 2012. Indian J Ophthalmolm 63 (2015): 825–831.
15. Bharathi N, Kumari SC, Sadananda RC, et al.

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DOI:10.26502/fjor.2644-002400102

Comparitive study between normal tension glaucoma and primary open-angle glaucoma. Indian J Clin Experiment Ophthalmol 7 (2021): 562-567.

16. Vajaranant TS, Nayak S, Wilensky JT, et al. Gender and glaucoma: what we know and what we need to know. Curr Opin Ophthalmol 21 (2015): 91–99.
17. Kniestedt C, Lin S, Choe J, et al. Correlation Between Intraocular Pressure, Central Corneal Thickness, Stage of Glaucoma, and Demographic Patient Data. J Glaucoma 15 (2006): 91-97.
18. Alasil T, Wang K, Lee H, et al. Analysis of Normal Retinal Nerve Fiber Layer Thickness by Age, Gender, and Race Using Spectral Domain Optical Coherence Tomography. J Glaucoma 52 (2013): 210.
19. Medeiros FA, Lisboa R, Kuang T-M, et al. Corneal hysteresis as a risk factor for glaucoma progression: a prospective longitudinal study. Ophthalmology 120 (2013): 1533-1540.
20. Nathan G Congdon, Broman AT, Bandeen-Roche K, et al. Central corneal thickness and corneal hysteresis associated with glaucoma damage. Am J Ophthalmol 141 (2006): 868-75.
21. Sullivan-Mee M, Katiyar S, Pensyl D, et al. Relative Importance of Factors Affecting Corneal Hysteresis Measurement. Optom Vis Sci 89 (2012): E803–E811.
22. Sit AJ, Chen TC, Takusagawa HL, et al. Corneal Hysteresis for the Diagnosis of Glaucoma and Assessment of Progression Risk: A Report by the American Academy of Ophthalmology. Ophthalmology 130 (2023): 433-442.

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