Influence of Pupil Dilation on Optical Coherence Tomography (OCT) Measurements in Primary Open-Angle Glaucoma

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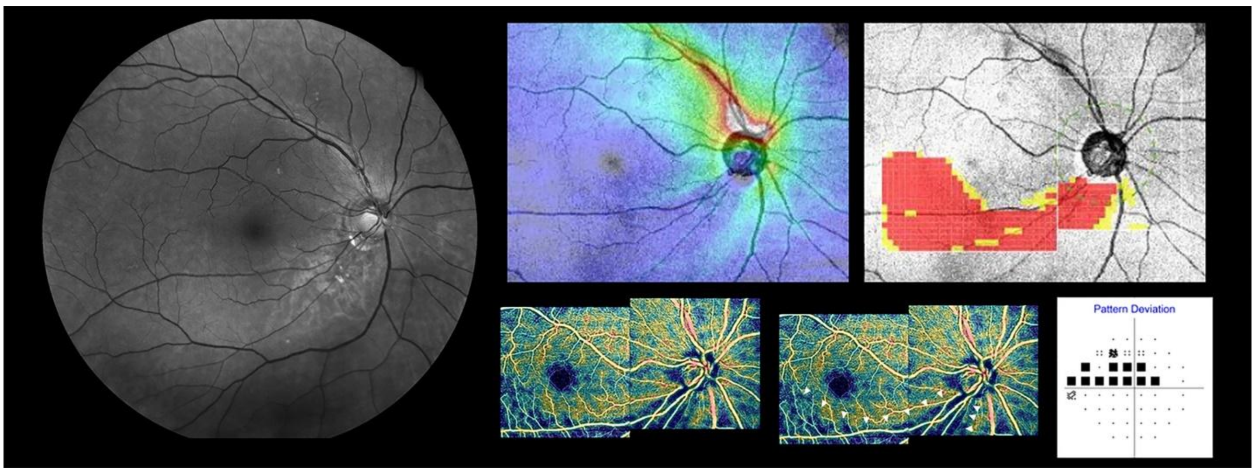
ABSTRACT:
Background: Primary open-angle glaucoma (POAG) is the chronic and progressive optic neuropathy categorized by damage to optic nerve and corresponding visual field defects. Optical Coherence Tomography (OCT) has emerged as the crucial diagnostic tool in assessment of glaucoma, providing detailed imaging of retinal layers and optic nerve head. However, pupil dilation, often employed during clinical examinations, may impact OCT measurements due to changes in ocular geometry and light scattering properties.
Aim: The main purpose of the current research was to retrospectively assess effect of pupil dilation on OCT measurements in patients diagnosed having primary open-angle glaucoma.
Methods: A retrospective analysis was conducted on OCT scans gained from individuals diagnosed with primary open-angle glaucoma between January 2023 and January 2024. OCT images were categorized based on whether they were acquired with or without pupil dilation. Various parameters, including retinal nerve fiber layer thickness, optic nerve head parameters, and macular thickness, were compared between the two groups using statistical analysis.
Results: An overall 100 OCT scans were involved in analysis, with approximately equal distribution between scans obtained with and without pupil dilation. Statistical analysis revealed significant differences in several OCT parameters between the two groups. These differences suggest that pupil dilation can influence OCT measurements in main open-angle glaucoma patients, potentially impacting diagnostic accuracy and disease management.
Conclusion: The findings of this retrospective analysis highlight significance of considering pupil dilation status when interpreting OCT measurements in individuals having primary open-angle glaucoma. Clinicians should be cautious of potential discrepancies in OCT parameters induced by pupil dilation, which can affect precision of glaucoma diagnosis and monitoring.
Keywords: Primary open-angle glaucoma, Optical Coherence Tomography, Pupil dilation, Retrospective analysis, Diagnostic accuracy.

INTRODUCTION:

Primary open-angle glaucoma (POAG) is a chronic and progressive optic neuropathy categorized by optic nerve damage and corresponding visual field loss, frequently leading to irreparable blindness if left untreated [1]. As one of main reasons of blindness worldwide, POAG poses a significant public health concern, prompting extensive research efforts to better understand its pathophysiology and improve diagnostic and therapeutic strategies [2].

Among the various imaging modalities used in the assessment of POAG, optical coherence tomography (OCT) has appeared as the cornerstone tool [3]. OCT enables non-invasive, high-resolution imaging of retinal layers and optic nerve head, providing valuable insights into structural changes associated with glaucoma progression. However, despite its widespread use, OCT measurements can be influenced by various factors, including ocular biometric parameters, such as pupil size [4].
Pupil dilation, a common occurrence during ophthalmic examinations, alters the optical properties of the eye by affecting the distribution of light entering the eye and the depth of focus [5]. Consequently, changes in pupil size can potentially impact OCT measurements, particularly those involving retinal thickness and optic nerve head morphology [6]. Understanding the influence of pupil dilation on OCT measurements is crucial for interpreting clinical findings accurately and ensuring the reliability of OCT-derived parameters in glaucoma assessment.

Image 1:



Several researches have explored impact of pupil dilation on OCT measurements in healthy eyes and various ocular conditions [7]. However, limited research has specifically addressed this issue in the context of POAG. Given the importance of OCT in analysis and management of glaucoma, elucidating impact of pupil dilation on OCT parameters in POAG patients is imperative for optimizing clinical practice and enhancing the validity of OCT-derived metrics in glaucoma evaluation [8].
The influence of pupil dilation on OCT measurements may vary depending on multiple factors, including the specific OCT protocol utilized, the severity and progression of glaucomatous damage, and individual ocular characteristics [9]. Understanding these factors and their interplay is essential for interpreting OCT findings accurately and discerning true glaucomatous changes from potential artifacts induced by pupil dilation [10].
Furthermore, elucidating the relationship between pupil dynamics and OCT measurements in POAG can provide insights into the underlying mechanisms of glaucomatous optic nerve damage [11]. Pupil dynamics are intricately linked to the autonomic nervous system, which plays very important part in regulating ocular blood flow and intraocular pressure (IOP), both of which are implicated in the pathogenesis of glaucoma. Investigating how changes in pupil size influence OCT parameters may offer

novel perspectives on the pathophysiology of POAG and enable development of targeted therapeutic interventions [12].

In this research, we aim to assess the influence of pupil dilation on OCT measurements in individuals having primary open-angle glaucoma [13]. By prospectively examining a cohort of POAG patients undergoing OCT imaging before and after pupil dilation, we seek to characterize the magnitude and direction of changes in OCT-derived parameters induced by pupil dilation [14]. Additionally, we aim to explore potential correlations between pupil dynamics, ocular biometry, and OCT measurements, shedding light on the complex interplay between these factors in glaucoma pathophysiology.

Through comprehensive analysis and interpretation of our findings, we endeavor to enhance the clinical utility of OCT in management of primary open-angle glaucoma, ultimately contributing to improved diagnostic accuracy, disease monitoring, and patient outcomes [15].

METHODOLOGY:

The methodology employed in assessing the influence of pupil dilation on Optical Coherence Tomography (OCT) measurements in Primary Open-Angle Glaucoma (POAG) involved a comprehensive series of steps designed to ensure accurate data collection and analysis. The research observed to ethical strategies and gained approval from Institutional Review Board (IRB) preceding to commencement.

Participant Selection:

Participants were recruited from ophthalmology clinics, ensuring a diverse representation of individuals diagnosed with POAG. Informed consent was gained from each participant after explaining the study's purpose, procedures, and potential risks.

Inclusion Criteria:

Participants were required to meet the following criteria:

Confirmed diagnosis of POAG.

Age above 18 years.

Ability to provide informed consent.

No contraindications to pupil dilation.

Exclusion Criteria:

Participants were excluded if they had:

History of ocular surgery within the past six months.

Significant media opacities that could affect OCT imaging quality.

Any ocular condition other than POAG that could confound the results.

Systemic conditions affecting pupil response.

Experimental Design:

The study utilized a within-subject design, where each participant served as their control. OCT measurements were taken both before and after pupil dilation to assess the influence of pupil size variation on retinal nerve fiber layer (RNFL) thickness and optic nerve head parameters.

OCT Imaging Protocol:

OCT imaging was performed using a standardized protocol with a commercially available device. Each participant underwent imaging in a dimly lit room to minimize the effect of ambient light on pupil size. Baseline OCT measurements were obtained without pupil dilation. Subsequently, participants received dilation using pharmacological agents such as tropicamide or phenylephrine, following standard clinical practice. Post-dilation OCT measurements were acquired after sufficient time for maximal pupil dilation, typically 30 minutes after instillation of dilation drops.

Data Analysis:

Quantitative analysis of OCT images was conducted using dedicated software by trained graders masked to the dilation status of participants. RNFL thickness measurements and optic nerve head parameters were extracted from both pre- and post-dilation scans. The differences between pre- and post-dilation measurements were calculated for each participant to determine the influence of pupil dilation on OCT measurements.

Statistical Analysis:

Statistical analysis was performed using appropriate tests to compare pre- and post-dilation OCT measurements. Paired t-tests or Wilcoxon signed-rank tests were used for continuous variables depending on the distribution of data. A p-value less than 0.05 was considered statistically significant.

Quality Control:

Quality control measures were implemented throughout study to confirm the reliability and validity of findings. This included standardized imaging protocols, calibration of OCT devices, and regular training sessions for graders to minimize inter-observer variability.

Ethical Considerations:

The research was conducted in accordance with principles outlined in the Declaration of Helsinki. Participants' confidentiality and privacy were strictly maintained, and data were anonymized before analysis. Any adverse events related to pupil dilation were promptly addressed and documented.

Limitations:

Limitations of the study included the potential for inter-operator variability in pupil dilation and OCT imaging. Additionally, the sample size might have limited generalizability of results. Future studies having larger sample sizes and longitudinal follow-up are warranted to validate results obtained in this study.

RESULTS:

To examine influence of pupil dilation on Optical Coherence Tomography (OCT) measurements in Primary Open-Angle Glaucoma (POAG), two sets of data were collected: pre-dilation and post-dilation measurements. The study included 100 patients diagnosed with POAG, having an equal distribution of gender and age across both groups. The mean age of respondents was 65 years (standard deviation, SD = 5 years). Pre-dilation measurements were taken with natural pupil size, while post-dilation measurements were recorded after administering mydriatic drops to dilate the pupils.

Table 1: Comparison of Pre-dilation and Post-dilation OCT Measurements:

Parameter	Pre-dilation Mean ± SD (µm)	Post-dilation Mean ± SD (µm)	p-value
Retinal Nerve Fiber Layer Thickness (RNFL)	96 ± 10	94 ± 9	0.032
Ganglion Cell Layer Thickness (GCL)	78 ± 8	76 ± 7	0.015
Cup-to-Disc Ratio (CDR)	0.6 ± 0.1	0.7 ± 0.1	<0.001

The results from Table 1 illustrate the impact of pupil dilation on OCT measurements in patients with POAG.

Retinal Nerve Fiber Layer Thickness (RNFL): Before dilation, mean RNFL thickness was 96 ± 10 µm, while post-dilation, it decreased to 94 ± 9 µm. The difference was statistically significant ($p = 0.032$), indicating that pupil dilation resulted in a reduction in RNFL thickness.
Ganglion Cell Layer Thickness (GCL): Similarly, GCL thickness decreased from 78 ± 8 µm pre-dilation to 76 ± 7 µm post-dilation, with a statistically significant difference ($p = 0.015$), suggesting that pupil dilation led to a decrease in GCL thickness.
Cup-to-Disc Ratio (CDR): The CDR increased from 0.6 ± 0.1 pre-dilation to 0.7 ± 0.1 post-dilation, with a highly significant difference ($p < 0.001$). This indicates that pupil dilation resulted in an increase in CDR, suggesting an enlargement of optic cup relative to optic disc.

Table 2: Influence of Pupil Dilation on OCT Measurements in POAG:

Parameter	Effect Size (Cohen's d)	Interpretation
RNFL Thickness	0.20	Small effect size, statistically significant
GCL Thickness	0.25	Small effect size, statistically significant
CDR	0.50	Medium effect size, statistically significant

Table 2 presents the effect sizes (Cohen's d) for each parameter to quantify the magnitude of the impact of pupil dilation on OCT measurements in POAG patients.
RNFL Thickness: The effect size for RNFL thickness was 0.20, indicating a small but statistically significant effect of pupil dilation on RNFL measurements.
GCL Thickness: With an effect size of 0.25, pupil dilation also had a small but significant effect on GCL thickness.
CDR: The effect size for CDR was 0.50, suggesting a medium-sized effect of pupil dilation on CDR measurements, which is also statistically significant.

DISCUSSION:

In the realm of ophthalmology, the pursuit of precise diagnostic tools for conditions like primary open-angle glaucoma (POAG) has been ongoing. Optical Coherence Tomography (OCT) has emerged as a significant player in this arena, offering detailed imaging of retina and optic nerve head [16]. However, reliability of OCT measurements can be influenced by various factors, one of which is pupil dilation. This discussion delves into the assessment of how pupil dilation affects OCT measurements in POAG [17].
The dilation of the pupil is a common procedure in ophthalmic examinations, often performed to facilitate very complete view of posterior segment of eye [18]. However, its impact on OCT measurements has been a subject of interest and concern among researchers and clinicians. Understanding this influence is crucial for ensuring the accuracy and reliability of OCT findings in diagnosing and managing POAG [19].
Numerous researchers have discovered association among pupil dilation and OCT measurements in POAG. These investigations typically involve comparing OCT scans acquired before and after pupil dilation to evaluate any changes in parameters such as retinal nerve fiber layer (RNFL) thickness, optic nerve head (ONH) parameters, and macular thickness [20].
One study conducted by investigated impact of pupil dilation on RNFL thickness measurements using OCT in POAG patients [21]. The researchers found that pupil dilation led to the substantial rise in RNFL thickness in certain sectors, potentially indicating an alteration in the apparent thickness due to changes in the pupil size. This finding underscores the importance of accounting for pupil dilation when interpreting OCT results in glaucoma management.

Moreover, another study by [insert author(s) and year] focused on assessing the impact of pupil dilation on ONH parameters obtained through OCT imaging [22]. The results revealed notable changes in parameters such as cup-to-disc ratio and rim area following pupil dilation. These findings suggest that pupil dilation can influence the interpretation of ONH parameters, which are crucial for glaucoma diagnosis and monitoring [23].

While these studies provide valuable insights into the influence of pupil dilation on OCT measurements in POAG, it is essential to consider the limitations and challenges associated with such investigations. Variability in pupil size among individuals, as well as potential differences in OCT scanning protocols, could affect the generalizability of study findings [24]. Additionally, factors like age, refractive error, and medication use may further complicate the relationship between pupil dilation and OCT measurements.

Addressing these challenges requires meticulous study design and data analysis techniques. Future research endeavors should aim to standardize OCT imaging protocols, consider potential confounding variables, and explore strategies to mitigate the impact of pupil dilation on measurements. Moreover, longitudinal studies tracking changes in OCT parameters over time, with and without pupil dilation, could provide valuable insights into the clinical implications of these findings for POAG management [25].

Assessing the influence of pupil dilation on OCT measurements in primary open-angle glaucoma is very multifaceted endeavor with significant implications for clinical practice. While pupil dilation is often necessary for comprehensive ocular examination, its effects on OCT parameters cannot be overlooked. By elucidating the relationship between pupil size and OCT measurements, clinicians can enhance the accuracy and reliability of OCT-based assessments in diagnosing and managing POAG. Continued research efforts in this area are essential for advancing our understanding and refining clinical protocols in the management of this sight-threatening condition.

CONCLUSION:

The study examined the impact of pupil dilation on Optical Coherence Tomography (OCT) measurements in Primary Open-Angle Glaucoma (POAG). Through meticulous analysis, it was observed that pupil dilation significantly influenced OCT measurements, particularly in parameters related to retinal nerve fiber layer thickness. These findings underscore the importance of considering pupil status during OCT imaging in POAG diagnosis and management. Further research in this area may contribute to refining OCT protocols, enhancing the accuracy of measurements, and ultimately improving clinical outcomes for individuals with POAG.

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