

Assessing Mean Change in Retinal Nerve Fiber Layer Thickness on Optical Coherence Tomography in Glaucoma Patients after Trabeculectomy

Khizir Hayat¹, Muhammad Younis Tahir¹, Muhammad Ajmal Chaudhary²,
Adeel Ahmad Siddiqui³, Sadia Haneef⁴

Department of Ophthalmology¹, Quaid e Azam Medical College, Bahawalpur, Department of Pediatric Ophthalmology, Sheikh Zayed Medical College, Rahim Yar Khan², Department of Ophthalmology³, Nishtar Hospital, Multan, Sahiwal Medical College⁴, Sahiwal.

Abstract

Background: Glaucoma leads to changes in visual fields, optic nerve head (ONH) and retinal nerve fiber layer (RNFL). It is important to detect glaucomatous damage to avoid visual impairment and initiate treatment. Reversal of glaucomatous damage after intraocular pressure (IOP) lowering treatments has been reported in glaucoma patients. ONH and RNFL imaging by optical coherence tomography (OCT) are important to evaluate anatomical changes in glaucoma patients.

Objective: To assess the mean change in retinal nerve fiber layer thickness (RNFLT) on optical coherence tomography (OCT) in glaucoma patients after trabeculectomy.

Study type, settings & duration: This quasi-experimental study (pre-post intervention) was carried out in the Department of Ophthalmology, Bahawal Victoria Hospital, Bahawalpur from August 2022 to February 2023.

Methodology: A total of 30 patients of either gender undergoing trabeculectomy, having a duration of glaucoma >03 months, between the ages of 30-60 years were included. Patients having media opacity, or previous intraocular surgery and/or patients with history of trauma were excluded. After taking history, ophthalmic examination was carried out. OCT was done to measure the baseline and 03 months post-operative RNFLT.

Results: There were 63.3% males and 36.7% females, the mean age was 51.83±16.24 years, and the mean duration of disease was 16.50±10.46 months. Mean pre-operative and post-operative RNFLT was 48.56±9.46 µm and 58.03±16.81 µm respectively, and the mean RNFLT change after trabeculectomy was 24.43±18.61 µm which was statistically significant ($p < 0.004$).

Conclusion: This study showed significant increase in RNFLT after trabeculectomy which is a good prognostic factor in the control of glaucoma.

Key words: Glaucoma, trabeculectomy, retinal nerve fiber layer thickness, optical coherence tomography.

Introduction

After cataracts, glaucoma is the most common ophthalmic disease mentioned in the

literature leading to irreversible blindness and is considered an important public health problem across the globe.¹⁻³ With a global prevalence of 2.20%, about 57.50 million world's population is suffering from primary open angle glaucoma (POAG). In Europe, 7.8 million people are affected by POAG with a cumulative prevalence of 2.51%. POAG is more prevalent in the United Kingdom, affecting 2% of adults over 40 years of age and 10% of adults over the age of 75 years.³ Glaucoma particularly the POAG is a disorder of progressive neurodegeneration⁴ of retinal ganglion cells (RGCs) and retinal nerve fiber layers (RNFL)³ resulting in poor quality of life, visual impairment, and blindness. Glaucoma can lead to certain structural changes in the optic nerve head (ONH) and RNFL along with progressive loss of visual fields. This functional and

Corresponding Author:

Muhammad Ajmal Chaudhary

Department of Pediatric Ophthalmology

Sheikh Zayed Medical College, Rahim Yar Khan.

Email: ajmal15571@hotmail.com

Received: 22 December 2023, Accepted: 16 January 2025

Published: 11 February 2025

Authors Contribution

KH conceptualized the project. KH & MYT did the data collection. MAC & AAS did the literature search. SH performed the statistical analysis. Drafting, revision & writing of manuscript were done by MAC & SH.

Copyright © 2024 The Author(s). This is an Open Access article under the CC BY-NC 4.0 license.

structural damage is highly variable among all glaucoma patients. It is also important to detect this glaucomatous damage to avoid serious visual impairment and initiate appropriate treatment.⁵

Conventional automated visual field (VF) analysis is routinely used in glaucoma evaluation and its progression. Now a days ONH and RNFL imaging by optical coherence tomography (OCT) are getting popular to evaluate anatomical changes in glaucoma patients.^{5,6} OCT is a reliable, convenient imaging tool for the diagnosis and monitoring of retinal disorders. By utilizing infrared light,⁷ OCT provides us a tomographical three dimensional (3-D) study with quantitative and repeatable measures of the optic nerve head (ONH), macular, and RNFL parameters. Reversal of ONH and RNFL glaucomatous damage after intraocular pressure (IOP) lowering treatments has been reported in primary congenital glaucoma and infantile glaucoma in children and primary open angle glaucoma (POAG) in adults.⁸ Analyses of ONH/RNFL and confocal scanning laser ophthalmoscopy (CSLO) on experimental models and humans showed reversal of ONH and RNFL parameters after IOP reduction by medical or surgical treatment.^{8,9} Changes in the neuro retinal rim area and the cup volume of the optic disc are also documented by stereoscopic disc photographs.⁷ The effects of IOP reduction on peripapillary RNFL is conflicting and still not clear. Earlier studies showed increased RNFLT after trabeculectomy surgery¹⁰ but certain later studies mentioned no change in the thickness of RNFL after IOP lowering surgery.⁸

The gradual and progressive degeneration of the retinal ganglion cell complex is the hallmark of POAG. VF defects on standard automated perimetry are seen when structural damage up to 40% has already occurred. Detecting early structural changes and their progression in the RNFL and ONH is very crucial in the management of POAG. The purpose of our study is to assess the mean RNFLT change by using OCT after trabeculectomy in POAG patients. Previously no local data was available on this topic, so our study will not only provide local statistics but will also encourage clinicians to intervene early and timely in these patients to prevent them from developing advance glaucomatous damage and VF defects in future. Our study will improve the existing knowledge of ophthalmologists and will provide ideas for further future research.

Methodology

This quasi experimental study (pre-post intervention) using non-probability purposive

sampling technique was carried out in the Department of Ophthalmology, Bahawal Victoria Hospital, Bahawalpur from August 2022 to February 2023. By using open epi software, the calculated sample size was 30 patients with 5% level of significance, 80% power of study and taking preoperative RNFLT as $52.56 \pm 17.40 \mu\text{m}$ and postoperative RNFLT as $58.48 \pm 20.20 \mu\text{m}$.¹⁰

Patients of either gender with an age of 30-60 years undergoing trabeculectomy and having duration of glaucoma >03 months were included. Patients with previous history of trauma, glaucoma or intraocular surgery, having media opacity (corneal opacity, dense cataract etc), and patients having OCT scan signal strength index < 8 were excluded. After getting informed consent, every patient was given a through explanation of the entire procedure. A detailed medical and ophthalmic history was taken, and through examination of the anterior and posterior segments was carried out including visual acuity (VA), best corrected visual acuity (BCVA), slit lamp examination, IOP measurement by applanation tonometry with its correction according to central corneal thickness (CCT), CCT by ultrasound pachymetry, anterior chamber angle examination by three mirror gonioscopy lens, dilated fundus examination of optic nerve and retina using +90 diopter lens, and 30-2° visual field (VF) analysis by automated perimetry. A prototype OCT 3000 (three circular scans, each scan having 3.4mm diameter centered on the optic disc) was done in all patients to measure the baseline RNFLT in microns (μm), then each patient underwent standard trabeculectomy procedure and after 03 month of surgery OCT was done in each patient to measure the postoperative RNFLT. All the findings and other variables like age, gender, duration of disease were documented on an already developed questionnaire.

The Statistical Package for Social Science (SPSS) version 22.0 was used to analyze all the data. The quantitative data like age, duration of disease and changes in RNFLT (pre-operative, post-operative) was presented as mean and standard deviation (SD) whereas the qualitative variables like gender was presented by frequency and percentage. Paired sample t-test was applied to compare pre-operative and post-operative RNFLT measurement at 95% CI. Through stratification, effect modifiers like age and duration of disease were controlled by applying independent sample t-test to measure their effect on RNFLT. A P-value of ≤ 0.05 was regarded as statistically significant.

The ethical approval was obtained from the Institutional Ethical Review Board of Quaid-e-Azam Medical College, Bahawalpur vide letter no. 1801/DME/QAMC.

Results

Out of 30 patients, 63.3% (n=19) were males and 36.7% (n=11) were females with a mean age of 51.83±16.24 years and a mean duration of disease 16.50±10.46 months. There were 33.3% (n=10) patients between 30-45 years and 66.7% (n=20) were between 46-60 years of age. Duration of disease was 04-15 months in 56.7% (n=17) patients and 16-45 months in 43.3% (n=13) patients. The mean pre-operative and post-operative RNFLT of these patients was 48.56±9.46 µm and 58.03±16.81 µm respectively. (Table), and the mean change in RNFLT was 24.43±18.61 µm which was statistically significant ($p < 0.004$). The statistically insignificant difference was seen with stratified age and duration of disease (Table).

Table: Comparison of various characteristics of study participants.

Variables		Mean± SD (µm)	p value
RNFLT (µm)	Pre-operative (n=30)	48.56±9.46	0.004
	Post-operative (n=30)	58.03±16.81	
Age	30-45 years (n=10)	22.20±17.07	0.650
	46-60 years (n=20)	25.55±19.65	
Disease Duration	4-15 months (n=17)	25.71±19.93	0.676
	16-45 months (n=13)	22.76±17.37	

Discussion

Glaucoma, in its early stage, has no apparent symptoms and signs¹¹ and is known as a silent killer of human sight. Patients with advance stage glaucoma are usually symptomatic having only central tunnel¹² vision and eventually irreversible damage leading to permanent blindness occurs. Measurement of IOP and cup-disc ratio (CDR), examination of VF, and OCT analysis of RNFL and ONH are important components in the diagnosis of glaucoma. OCT is an optical biopsy¹² of the retina to evaluate the structural anatomy of the optic nerve and it is the best tool¹³ to detect the progression of glaucomatous damage.

According to a 2004 survey of Pakistan's national blindness and visual impairment, POAG is considered as a third most common (7.1%) cause of irreversible blindness in Pakistan.^{14,15} More than 1.8 million people in Pakistan have glaucoma and half of them had permanent vision loss prior to the diagnosis.¹² In Pakistan, few studies have been carried out to find out the effects of trabeculectomy on RNFLT in POAG patients. Latif S et al.¹⁵ in their

study in Pakistan, reported that mean pre-treatment RNFLT was 0.072 (72 µm)±0.0049 µm which was increased to 0.080 (80 µm)±0.0048 µm three months after trabeculectomy. In a study conducted in POAG patients by Rafique A et al.¹⁶ in Pakistan, mean increase in RNFLT three months after trabeculectomy was 0.028±0.012 µm. Amjad A et al.¹⁷ and Shahid M et al.⁶ from Pakistan in their studies showed that a significant increase in mean RNFLT is also seen after phacoemulsification cataract surgery.

In a study conducted by Sarkar KC et al.¹⁰ the mean preoperative RNFLT was 52.56±17.40 µm, the mean postoperative RNFLT was 58.48±20.20 µm and the mean change (5.94±8.70 µm) was statistically significant ($p < 0.0001$). Our study results are almost similar to this study. Chang PT et al.¹⁸ studied 21 glaucomatous eyes of 21 patients, all patients received IOP lowering medical/surgical treatment. No obvious overall change in RNFLT on OCT was seen in this study. This difference could be due to the intervention variation in their study as opposed to our study in which we did trabeculectomy only. Raghu N et al.⁸ studied 17 glaucomatous patients post trabeculectomy. They observed a significant increase in the average ($p = 0.019$) RNFLT after 01 week of surgery but values reverted to baseline after 03 months of surgery. The initial results of this study were similar to that of our study but later variations in their study might be due to differences in their sample population. Variation in results might also be due to the advance glaucoma stage in these studies as previous studies have shown that the reversal of glaucomatous damage is more likely seen in the early stages of glaucoma.

Ali Aydin et al.¹⁹ reported a statistically significant increase in mean RNFLT after trabeculectomy procedure ($p < 0.0001$). The mean thickness increase in RNFL (0.5 µm / mm Hg IOP decrease) was much correlated with IOP reduction ($r = -0.41$; $p = 0.03$). A similar significant overall mean RNFLT increase was found in our study as well. The findings of our study are in agreement with the findings of a study conducted by Sharma Y et al.²⁰, which reported a statistically significant increase in RNFLT in all four quadrants after trabeculectomy surgery. A recent study conducted by Koenig SF et al.²¹ also showed a significant increase in RNFLT after filtration surgery as seen in our study.

The results of our study showed a statistically significant link between RNFLT and glaucoma and RNFLT can be used as an important parameter in glaucoma assessment particularly at an early stage. The results of this study in the local population will complement the national and international research evidence on this important

subject that has already been published.

Our sample size was limited and follow-up was limited to three months, a large sample size with longer follow-up is required to study the effects of RNFLT in such glaucoma patients. The effects of trabeculectomy on retinal ganglion cells (RGCs) is also an important predictor in glaucoma progression which should also be included in future studies. Our study is imperative and can be used for further clinical research in future.

Our study concluded that trabeculectomy has a beneficial effect on RNFLT and there was significant increase in RNFLT after trabeculectomy surgery which is a good prognostic factor in the control of glaucoma in these patients. RNFLT is an important indicator of documenting early glaucoma and monitoring progression to improve quality of life and to prevent from development of advanced glaucomatous damage in these patients.

The results of our study can be generalizable in Pakistan and other developing countries. OCT is currently available in almost all hospitals in Pakistan and can be utilized for routine monitoring of glaucoma patients to prevent advanced glaucomatous VF defects and future blindness.

Conflict of interest: None declared.

References

1. Leffler CT, Schwartz SG, Stackhouse R, Davenport B, Spetzler K. Evolution and impact of eye and vision terms in written English. *JAMA Ophthalmol* 2013; 131 (12): 1625-31.
2. Casson RJ, Chidlow G, Wood JP, Crowston JG, Goldberg I. Definition of glaucoma: clinical and experimental concepts. *Clin Exp Ophthalmol* 2012; 40 (4): 341-9.
3. Allison K, Patel D, Alabi O. Epidemiology of glaucoma: the past, present, and predictions for the future. *Cureus* 2020; 12 (11): e11686.
4. Chiarini LB, Petrs-Silva H, Linden R. Novel approaches to glaucomatous neurodegeneration, based on the integrated stress response. *Mol Ther Nucleic Acids* 2023; 33: 845-7.
5. O'Leary N, Artes PH, Hutchison DM, Nicolela MT, Chauha BC. Rates of retinal nerve fibre layer thickness change in glaucoma patients and control subjects. *Eye* 2012; 26 (12): 1554-62.
6. Shahid M, Saleem Z, Malik TG, Farqaleet M. Comparison of changes in retinal nerve fiber layer thickness and intraocular pressure between glaucoma and non-glaucoma patients after phacoemulsification. *Pak J Med Sci* 2023; 39 (1): 232-5.
7. Jewariya P, Sharma M, Parwal S, Khilnani K. Ability of Optical Coherence Tomography in Early Detection of Primary Open Angle Glaucoma. *J Clin of Diagn Res* 2021; 15 (8): NC01-NC05.
8. Raghu N, Pandav SS, Kaushik S, Ichhpujani P, Gupta A. Effect of trabeculectomy on RNFL thickness and optic disc parameters using optical coherence tomography. *Eye* 2012; 26 (8): 1131-7.
9. Medeiros FA, Zangwill LM, Anderson DR, Liebmann JM, Girkin CA, Harwerth RS, et al. Estimating the rate of retinal ganglion cell loss in glaucoma. *Am J Ophthalmol* 2012; 154 (5): 814-24.
10. Sarkar KC, Das P, Pal R, Shaw C. Optical coherence tomographic assessment of retinal nerve fiber layer thickness changes before and after glaucoma filtration surgery. *Oman J Ophthalmol* 2014; 7 (1): 3-8.
11. Khalil T, Akram MU, Raja H, Jameel A, Basit I. Detection of Glaucoma using Cup to Disc Ratio from Spectral Domain Optical Coherence Tomography Images. *IEEE Access* 2018; 6: 4560-76.
12. Shehryar T, Akram MU, Khalid S, Nasreen S, Tariq A, Perwaiz A, et al. Improved automated detection of glaucoma by correlating fundus and SD-OCT image analysis. *Int J Imaging Syst Technol* 2020; 1-20.
13. Ghita AM, Iliescu DA, Ghita AC, Ilie LA, Otobici A. Ganglion Cell Complex Analysis: Correlations with Retinal Nerve Fiber Layer on Optical Coherence Tomography. *Diagnostics* 2023; 13(2): 266.
14. Mahar PS, Butt NH, Ali SI. Role of OCT in Diagnosis and Progression of Glaucoma. *Pak J Ophthalmol* 2018; 34 (3): 207-20.
15. Latif S, Riaz R, Qamar A, Anjum M., Bibi I, Shoukat T, et al. Comparison of mean retinal nerve fiber layer thickness on optical coherence tomography (OCT) in patients of primary open angle glaucoma (POAG) after trabeculectomy vs anti glaucoma medication. *Pak J Health Sci* 2023; 4(5): 233-8.
16. Rafique A, Khan AA, Shaheer M. Changes in retinal nerve fiber layer thickness on Heidelberg retinal tomography in patients of primary open angle glaucoma after trabeculectomy versus anti glaucoma medication. *Khyber Med Univ J* 2020; 12(3): 211-5.
17. Amjad A, Shaheer M, Rafique A. Retinal Nerve Fiber Layer Thickness Changes after Phacoemulsification with Intraocular Lens Implantation. *J Coll Physicians Surg Pak* 2018; 28 (12): 919-22.
18. Chang PT, Sekhon N, Budenz DL, Feuer WJ, Park PW, Anderson DR. Effect of lowering intraocular pressure on optical coherence tomography measurement of peripapillary retinal nerve fiber layer thickness. *Ophthalmology* 2007; 114(12): 2252-8.
19. Aydin A, Wollstein G, Price LL, Fujimoto JG, Schuman JS. Optical coherence tomography assessment of retinal nerve fiber layer thickness changes after glaucoma surgery. *Ophthalmology* 2003; 110(8): 1506-11.
20. Sharma Y, Sharma V, Sharma K, Pandey ML. Retinal nerve fiber layer and visual field changes in patients undergoing trabeculectomy at Sub-Himalayan Region. *Sudanese J Ophthalmol* 2019; 11: 19-24.
21. Koenig SF, Hirreiss CW. Changes of Neuroretinal Rim and Retinal Nerve Fiber Layer Thickness Assessed by Optical Coherence Tomography After Filtration Surgery in Glaucomatous Eyes. *Clin Ophthalmol* 2021; 15: 2335-44.