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Original Article

Optic Nerve Head, Retinal Nerve Fiber Layer and Ganglion Cell Complex Changes after Successful Subscleral Trabeculectomy

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ABSTRACT

Background: The utilization of optical coherence tomography [OCT] has demonstrated its efficacy in the identification and assessment of glaucomatous impairment.

The Aim of the work: The objective of this study is to evaluate and compare the alterations in Optical Coherence Tomography measurements, specifically the Optic Nerve Head, Retinal Nerve Fiber Layer Thickness, and Ganglion Cell Complex, in patients diagnosed with primary open-angle glaucoma before and after undergoing subscleral trabeculectomy surgery.

Patients and Methods: This study included 25 eyes having primary open angle glaucoma scheduled for subscleral trabeculectomy at Al-Azhar university hospital, Damietta**.** Ethical approval was obtained from ethics committee of Al-Azhar university, faculty of medicine. A written informed consent was obtained from all patients included in the study after nature and possible consequences of the procedure has been explained. The patients were evaluated by Topcon 3D OCT 2000 device. Standard resolution scans captured the temporal and nasal quadrants [nasal-temporal 0° -180°] before subscleral trabeculectomy operation and was evaluated at 1 week, 1 month and 3 months post operatively

Results: According to the total RNFL, it was 60.7 ± 13.9 µm preoperatively, and significantly increased to 71.9 ± 14.3 µm at 1 month postoperative and also, increased to 74.7 ± 13.6 µm at 3 months postoperative [P value = 0.001 for both]. According to the total GCC, it was 65.5 ± 14.9 µm preoperatively, and significantly increased to 74.1 ± 13.9 µm at 1 month postoperative and also, increased to 76.2 ± 13.5 µm at 3 months postoperative [P value = 0.001 for both]. In terms of IOP, it was significantly decreased from 35.5 ± 5.5 mmHg to 13.7 ± 1.4 at 1 month postoperative [P value = 0.001], and also, decreased to 13.9 ± 1 mmHg at 3 months postoperative [P value = 0.001].

Conclusion: Sub scleral trabeculectomy is an effective surgical procedure for the treatment of Open angle glaucoma.

Keywords: Optic Nerve Head; Retinal Nerve Fiber Layer; Ganglion Cell Complex.

INTRODUCTION

Glaucoma stands as the primary etiology behind the occurrence of permanent visual impairment. The estimated global prevalence of glaucoma among individuals aged 40 to 80 years is 3.5%. Given the increasing demographic shift towards an aging population, it is anticipated that by the year 2040, approximately 111.8 million individuals will be affected by glaucoma [1].

Open-angle glaucoma is a chronic and irreversible optic neuropathy that affects both eyes. It is a multifactorial condition characterized by an elevation in intraocular pressure and an open angle of the anterior chamber. This condition is associated with changes in the optic nerve head, a gradual decline in peripheral vision, and subsequent loss of central visual field [1, 2]. Glaucoma, a prevalent cause of permanent blindness on a global scale, is characterized by the gradual degeneration of the optic nerve and subsequent depletion of retinal ganglion cells [3].

The procedure of subscleral trabeculectomy involves the creation of a novel route for the flow of aqueous humor between the front chamber of the eye [known as the anterior chamber or AC] and the space beneath the conjunctiva, beneath a flap in the sclera. Consequently, in order to prevent obstruction of the aqueous outflow through the fistula, it is imperative that the undersurface of the partial thickness scleral flap, the edges of the scleral wound, and the region between the episclera and conjunctiva remain devoid of any healing or scarring following iridectomy and sclerectomy procedures [4].

The identification of disease progression is a critical and complex aspect of managing glaucoma. The utilization of optical coherence tomography [OCT] has demonstrated its significance in the identification of glaucomatous impairment. Due to its exceptional resolution and established capacity for reproducible measurements, optical coherence tomography [OCT] possesses the potential to identify the advancement of glaucomatous damage. This discussion aims to present an overview of the existing literature on the clinical performance of OCT [5].

The aim of this study is to compare the Optical Coherence Tomography [Optic Nerve Head, Retinal Nerve Fiber Layer Thickness and Ganglion Cell Complex] changes in patients with primary open angle glaucoma preoperative and postoperative subscleral trabeculectomy.

PATIENTS AND METHODS

This study included 25 eyes having primary open angle glaucoma scheduled for subscleral trabeculectomy at Al-Azhar university hospital, Damietta**.** Ethical approval was obtained from ethics committee of Al-Azhar university, faculty of medicine. A written informed consent was obtained from all patients included in the study after nature and possible consequences of the procedure has been explained.

Inclusion criteria

Patients diagnosed with open angle glaucoma who are characterized by the following: [1] Patients age from 40 to 60 years, [2] Patients not controlled on anti-glaucoma medications, and [3] IOP of 22 mm Hg or higher under full antiglaucoma treatment.

Exclusion criteria

[1] Patients with other types of glaucoma, [2] Patients with diabetic retinopathy, [3] Patients with hypertensive retinopathy, [4] Patients who had previous glaucoma or posterior segment intraocular eye surgeries, [5] High myopic patients, [6] Non glaucomatous patients with optic disc diseases, and [7] Patients with failed sub scleral trabeculectomy.

Data collection

Full detailed systemic history including medical history of chronic diseases, personal habits may affect visual acuity as alcohol, smoking and its duration. Full detailed ophthalmic history including: medical and surgical ophthalmic history and history of trauma, history of previous intraocular surgery. All patients underwent complete ophthalmologic examinations, including: [1] Measurement of best corrected visual acuity [BCVA], [2] Measurement of intraocular pressure [IOP] with air puff tonometer and applanation tonometry, [3] Slit lamp biomicroscopy, [4] Gonioscopic Examination of angle, and [5] Dilated fundus evaluation using a 90 D lens.

The following investigations were done for every patient: [1] OCT: The patients were evaluated by Topcon 3D OCT 2000 device. Standard resolution scans captured the temporal and nasal quadrants [nasal-temporal 0° -180°] before subscleral trabeculectomy operation and was evaluated at 1 week, 1 month and 3 months post operatively, and [2] Visual field evaluation.

Postoperative evaluation

Evaluation of patients was done after 1 week, 1 month and 3 months post-operative by The Topcon 3D OCT 2000 device. Standard resolution scans captured the temporal and nasal quadrants [nasal-temporal 0° -180°] with participants looking straight ahead. All the images will be taken with the patients in a sitting position. After several scans, we will select the best image.

Statistical analysis

We analyzed our data by SPSS version 26. Quantitative data was described as Mean ± SD, and the comparison between the paired data regarding it was done by repeated measures ANOVA followed by pairwise comparison between each 2 follow up periods. Qualitative data were presented as numbers and percentages. P value was considered significant if < 0.05.

RESULTS

This study included 18 patients [25 eyes] with diagnosed with open angle glaucoma and submitted for sub scleral trabeculectomy**.** The mean age of the studied patients was 55.5 ± 4.3 with a range of 42 – 60. According to the gender distribution of the patients, the male percentage was higher than female [72.2%, and 27.8% respectively] [Table 1].

In terms of the C/D ratio, either vertical or horizontal C/D ratio we found no statistically significant change in it all over the follow up periods [P value = 0.5 for vertical, and 0.07 for horizontal] [table 2].

According to the total RNFL, it was 60.7 ± 13.9 µm preoperatively, and significantly increased to 71.9 ± 14.3 µm at 1 month postoperative and also, increased to 74.7 ± 13.6 µm at 3 months postoperative [P value = 0.001 for both] [Table 3].

According to the total GCC, it was 65.5 ± 14.9 µm preoperatively, and significantly increased to 74.1 ± 13.9 µm at 1 month postoperative and also, increased to 76.2 ± 13.5 µm at 3 months postoperative [P value = 0.001 for both] [Table 4].

In terms of IOP, it was significantly decreased from 35.5 ± 5.5 mmHg to 13.7 ± 1.4 at 1 month postoperative [P value = 0.001], and also, decreased to 13.9 ± 1 mmHg at 3 months postoperative [P value = 0.001] [table 5].

In this study the percentage change of RNFL, GCC, and IOP were 24.9 ± 11.5%, 17.3 ± 6.2%, -59.7 ± 7.1% respectively [Table 6].

Spearman correlation analysis between the Percentage change of IOP and RNFL and GCC revealed no significant correlation was detected between each of them [Table 7].

Table [1]: Demographic characteristics of the studied patients

Variables		Findings
Age [years]	Mean ± SD	55.5 ± 4.3
	Range	42 - 60
Gender, No. [%]	Male	13 [72.2%]
	Female	5 [27.8%]

Table [2]: C/D ratio of the studied patients over the follow up periods

C/D ratio	Pre-operative	1 wk. Post-operative	1 mo. Post-operative	3 mo. Post-operative	P value within follow up periods [a]	P value between each 2 follow up [b]
Vertical	0.87 ± 0.1	0.87 ± 0.1	0.87 ± 0.1	0.87± 0.1	0.5	P1= 1 P2= 1 P3= 1
Horizontal	0.87 ± 0.1	0.88 ± 0.1	0.88 ± 0.1	0.88 ± 0.1	0.07	P1= 1 P2= 1 P3= 0.2

a: Repeated measure ANOVA. **b:** Pairwise comparison between each 2 follow up periods. **ONH:** Optic verve head. **P1:** Comparison between preoperative and 1-week post-operative. **P2:** comparison between the preoperative and 1 month postoperative. **P3:** comparison between the preoperative and 3 months postoperative.

Table [3]: RNFL of the studied patients over the follow up periods

RNFL µm	Pre-operative	1 wk. Post-operative	1 mo. Post-operative	3 mo. Post-operative	P value within follow up periods [a]	P value between each 2 follow up [b]
Total	60.7 ± 13.9	60.7 ± 13.9	71.9 ± 14.3	74.7 ± 13.6	0.001*	P1= 1 P2= 0.001* P3= 0.001*
Superior	61.6 ± 15.8	61.8 ± 15.9	71.5 ± 18.1	73.5 ± 17.2	0.001*	P1= 0.4 P2= 0.001* P3= 0.001*
Inferior	65.1 ± 14.1	65.2 ± 14.2	76.4 ± 15.2	80.2 ± 14.1	0.001*	P1= 1 P2= 0.001* P3= 0.001*

a: Repeated measure ANOVA. **b:** Pairwise comparison between each 2 follow up periods. **ONH:** Optic verve head. **P1:** Comparison between preoperative and 1-week post-operative. **P2:** comparison between the preoperative and 1 month postoperative. **P3:** comparison between the preoperative and 3 months postoperative.

Table [4]: GCC of the studied patients over the follow up periods

GCC µm	Pre-operative	1 wk. Post-operative	1 mo. Post-operative	3 mo. Post-operative	P value within follow up periods [a]	P value between each 2 follow up [b]
Total	65.5 ± 14.9	65.5 ± 15	74.1 ± 13.9	76.2 ± 13.5	0.001*	P1= 1 P2= 0.001* P3= 0.001*
Superior	65.1 ± 14.1	65.5 ± 18.9	74.2 ± 13.4	76.5 ± 13	0.001*	P1= 1 P2= 0.001* P3= 0.001*
Inferior	64.3 ± 18.4	64.5 ± 18.4	74.8 ± 16.5	77.1 ± 16.4	0.001*	P1= 1 P2= 0.001* P3= 0.001*

a: Repeated measure ANOVA. **b:** Pairwise comparison between each 2 follow up periods. **ONH:** Optic verve head. **P1:** Comparison between preoperative and 1-week post-operative. **P2:** comparison between the preoperative and 1 month postoperative. **P3:** comparison between the preoperative and 3 months postoperative. **GCC:** ganglion cell complex

Table [5]: IOP of the studied patients over the follow up periods

IOP [mmHg]	Pre-operative	1 wk. Post-operative	1 mo. Post-operative	3 mo. Post-operative	P value within follow up periods [a]	P value between each 2 follow up [b]
Mean ± SD.	35.5 ± 5.5	11.7 ± 1.7	13.7 ± 1.4	13.9 ± 1	**0.001***	**P1= 0.001*** **P2= 0.001*** **P3= 0.001***
Range	27 - 46	9 - 15	10 - 17	12 – 16		

a: Repeated measure ANOVA. **b:** Pairwise comparison between each 2 follow up periods. **ONH:** Optic verve head. **P1:** Comparison between preoperative and 1-week post-operative. **P2:** comparison between the preoperative and 1 month postoperative. **P3:** comparison between the preoperative and 3 months postoperative. **IOP:** Intraocular pressure.

Table [6]: Percentage change of the study RNFL, GCC, and IOP between preoperative and postoperative

Variables	Percentage change
RNFL	24.9 ± 11.5
GCC	17.3 ± 6.2
IOP	-59.7 ± 7.1

Table [7]: Correlation analysis between the IOP reduction and RNFL and GCC improvement

Variables	IOP	
	r	**P value**
RNFL	-0.025	0.93
GCC	-0.027	0.91

DISCUSSION

This prospective study set out to evaluate the effect of uncomplicated subscleral trabeculectomy on the OCT parameters from the optic disc, RNFL and ganglion cell complex, provided by the commercial software, in patients with open-angle glaucoma.

As regards the C/D ratio changes, we found no statistically significant change in the C/D ratio all over the follow up periods. This is in agreement with **Elghonemy et al.** [6], who evaluated the C/D ratio in 36 eyes with advanced glaucoma who underwent trabeculectomy, and found no change in the C/D ratio after the surgery. Another study was done by **Vessani et al.** [7], evaluated the optic disc changes after IOP reduction surgeries in 29 eyes with primary open angle glaucoma and found that no significant change in the linear and vertical C/D ratio all over the follow up periods which is consistent with our findings. However a study was done by **Figus et al.** [8] found non-significant reduction in the C/D ratio after the surgery, and the mechanism was elucidated as an anterior displacement of the lamina cribrosa. Following glaucoma filtering surgery, a decrease in intraocular pressure [IOP] would lead to the anterior repositioning of the lamina cribrosa, which had previously been displaced posteriorly. Simultaneously, there would be a restoration of the neuroretinal tissue. Previous research studies have documented a decrease in cupping subsequent to the reduction of intraocular pressure [IOP] following surgical interventions for glaucoma. The observed phenomenon can be attributed to a straightforward alteration in anatomical structures, rather than the process of recovery or reversal of damage. When the intraocular pressure [IOP] decreases, there is a reduction in the tension exerted on the lamina cribrosa of the optic nerve head. This likely leads to the restoration of the laminar surface to its original position, which had been altered due to the elevated IOP-induced deformation. The postoperative outcome may be characterized by a reduction in the area of the cup [6, 9].

In terms of the RNFL, in the present study we found a significant increase in the total thickness postoperatively to a degree of 24.9 ± 11.5 % from the baseline thickness [P value = 0.001]. Also, the superior and inferior thickness were significantly increased postoperatively [P value = 0.001]. This results agreed with **Aydin et al.** [10], who included thirty-eight eyes of 31 glaucoma patients who underwent trabeculectomy, and found significant increase in the RNFL thickness. Also, **Figus et al.** [8] showed an increase in the RNFL thickness postoperatively. In **Raghu et al.** [11] study, they found that RNFL thickness was significantly increased at 1 week post-operative. However, they noticed that it was decreased at 1 and 3 months postoperatively. They explained this immediate increase in RNFL thickness postoperatively by the reversal or rebound of the physical compressive effect on the RNFL by the elevated pre intervention IOP, leading to a recovery of normal shape and size by the retinal ganglion cell axons. In contrary to our results **Vessani et al.** [7] reported no significant change in the RNFL thickness postoperatively. Also, **Gietzelt et al.** [12] who did trabeculectomy for 88 patients found that the RNFL thickness didn’t change post-operatively. Another study by **Chang et al.** [13], examined 21 eyes of which 8 had IOP reduction with eye drops only while the rest received a trabeculectomy or tube shunt placement. They did not find any RNFL thickness difference after trabeculectomy. The difference between these studies and our study may be explained by the differences in the resolution of OCT imaging platforms may affect the reliability of RNFL measurements.

As regards the IOP changes, we found a significant reduction in the IOP to a percentage of more than 50%, which is in agreement with previous studies [7–10, 14].

According to the GCC, the present study showed significant increase in its thickness postoperatively [P value = 0.001]. which disagree with **Vessani et al.** [7] who found no significant change in the GCC all over the follow up periods.

In our study we didn’t find correlation between the reduction in the IOP and the changes increased thickness in the RNFL or the GCC. This agreed with the finding of **Raghu et al.** [11] who reported no significant correlation between the IOP changes and the RNFL thickness. Although in our study the correlation between the IOP changes and the improvement in the RNFL or GCC was not significant, the correlation needs further larger studies with larger sample size in the future to be proved or to determine the factors which is responsible for this improvement.

Conclusion: Sub scleral trabeculectomy is an effective surgical procedure for the treatment of Open angle glaucoma. RNFL thickness and GCC thickness are significantly improved after sub scleral trabeculectomy.

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