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Changes in Choroidal Thickness and Axial Length with Intraocular Pressure Changes After Trabeculectomy

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ABSTRACT
Background: Trabeculectomy is commonly performed in patients with chronic open angle glaucoma when medical therapy fails to control intraocular pressure (IOP).
Objective: The aim of the current work was to evaluate choroidal thickness (C.T) changes with Enhanced Depth Imaging-Optical Coherence Tomography (EDI-OCT) & axial length (AXL) with ophthalmic A-Scan ultrasound after reduction of intraocular pressure (IOP) following trabeculectomy.
Patients and Methods: The study was included 20 patients with open-angle glaucoma. The choroidal thickness was measured using enhanced depth imaging spectral domain optical coherence tomography (EDI-SD-OCT) and AXL of eye was measured using A-scan ultrasound before trabeculectomy and 1 month, 3 and 6 months postoperatively.
Results: The changes of choroidal thickness before and after 1, 3 and 6 months of the operation found to have high statistically significant increase in SFCT-V, SFCT-V, NCT, TCT, SCT and ICT in 1st month postoperative with mean (217.65±27.03, 218±21.09, 216.9±28.86, 190.35±34.3, 223.1±24.82 and 244.8 ± 23.77) respectively, then they decreased in the 3rd month with mean (198.85 ±27.8, 197.8±23.3, 200.15±27.5, 178.35 ±31.9, 208.75±23.3 and 233.5±21.05) respectively, but it was not less than preoperative, and continued in decreasing in the 6th month with mean (187.3 ± 29.02, 186.95 ± 25.82, 188.95±27.47, 166.45±26.38, 197.7± 23.05 and 223.5±22.66) respectively, but it was not also less than preoperative.
Conclusion: It could be concluded that intraocular pressure (IOP) reduction after trabeculectomy caused an increase in choroidal thickness (CT) this reduction of IOP was negatively correlated only with the increase in nasal, temporal, inferior and superior CT 3 mm away from the fovea.
Keywords: Axial Length, Choroidal Thickness, Intraocular Pressure Changes, Trabeculectomy

INTRODUCTION
The choroid is responsible for providing nutrition to retina, regulating ocular temperature, and contributing to growth of the sclera. Histologically the choroid can be subdivided into five layers: Bruch's membrane, choriocapillaris, two vascular layers (Haller's and Sattler's), and the suprachoroidal **(1)**. Glaucoma is the second most common cause of blindness worldwide and is the leading cause of irreversible blindness in the world. The prevalence of POAG for adults aged 40 and older in the United States was estimated to be about 2% **(2)**. Blindness due to glaucoma, and the problem is expected to increase as the population age **(3)**.

Glaucoma is a chronic, progressive optic neuropathy characterized by thinning of the neuroretinal rim of the optic disc **(4)**. It results in a characteristic appearance of the optic nerve head called cupping, and a corresponding loss of visual field. Importantly, the early symptoms of glaucoma can be quite subtle, and over half of individuals affected are not aware that they have the disease. Early recognition is important because the prognosis can be good if patients are diagnosed and treated appropriately early in the disease process, but if left untreated it can progress to irreversible blindness **(5)**. The major risk factors for glaucoma include advanced age, family history, African race, thin corneas, and high intraocular pressure (IOP). The only risk factor that is treatable is high IOP, and all current therapies for POAG are aimed at decreasing IOP **(2, 3)**.

Trabeculectomy is commonly performed in patients with glaucoma when medical therapy fails to control IOP, because this procedure appears to be the best surgical method for preventing optic disc damage and for preserving the visual field. Trabeculectomy is the most common type of filtrating surgery for IOP reduction in glaucoma **(6)**. Ocular changes such as shortening of axial length, shallowing of anterior chamber, reversal of lamina cribrosa displacement and increase of ocular blood flow have been observed in glaucomatous eyes after reduction of IOP following this type of surgery **(7, 8)**.

Prior to the advent of OCT, clinical evaluation of the choroid has involved fundus fluorescein angiography (FFA), indocyanine green (ICG) angiography, and ultrasound. While these methods are useful in detecting vasculature abnormalities, they do not provide cross-sectional anatomical information and poorly identify the depth of vascular pathology **(9)**. In addition, ICGA is a moderately invasive method and sometimes results in adverse reactions. Now, can use enhanced depth imaging-optical coherence tomography (EDI-OCT), which uses low signal strength and low resolution, to achieve greater depth on the conventional spectral domain (SD)-OCT, and thus acquire detailed cross-sectional images of the choroid as well as measure the choroid's thickness **(10)**.

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The aim of the current work was to evaluate choroidal thickness (C.T) changes with Enhanced Depth Imaging-Optical Coherence Tomography (EDI-OCT) & axial length (AXL) with ophthalmic A-Scan ultrasound after reduction of intraocular pressure (IOP) following trabeculectomy.

PATIENTS AND METHODS

This study included a total of 20 patients with open-angle glaucoma, attending at outpatient Ophthalmic Clinic, Menoufia University Hospital. This study was conducted between October 2018 to April 2020.

Ethical considerations:

After getting institutional approvals, The Research Ethics Committee has approved the protocol. The head of the department of Menoufia University were informed of the purpose of the study and its consequences with confirming confidentiality of data. The study was carried out in accordance with the Declaration of Helsinki and the nature of the study procedures was explained to all participants before enrollment. All patients signed a written informed consent.

The choroidal thickness was measured using enhanced depth imaging spectral domain optical coherence tomography and axial length of eye was measured using A-scan ultrasound before trabeculectomy and 1 month, 3 and 6 months postoperatively.

Inclusion criteria: Primary open angle glaucoma indicated trabeculectomy because of uncontrolled IOP by medical therapy, Refractive error between -5.00 & +3.00D of sphere, Clear media, no history of retinal diseases, any systemic abnormalities (vascular diseases, hypertension, diabetes mellitus) and no history of previous intraocular surgery except phacoemulsification with intraocular lens implantation.

Exclusion Criteria: History of intraocular surgery except phacoemulsification with intraocular lens, history of retinal disease and systemic abnormalities (vascular disease, hypertension and diabetes mellitus), media opacities due to sever cataract or low- quality image due to unstable fixation, high myopia or hyperopia greater than -5.00 or +3.00 diopter of sphere and secondary glaucoma (such as lens subluxation, uveitis, iris neovascularization, trauma, tumor).

For all patients complete ophthalmological examination was preformed included visual acuity assessment using landots chart and converted to decimal notation, slit lamp examination to assess anterior segment, cornea, IOP assessment using Goldmann applanation tonometer, Posterior segment evaluation to assess the retina, Axial Length Measurement by A-scan Sonomed 300AP (Sonomed Escalon, New York, USA).All eyes were assessed by OCT; the sub foveal choroidal thickness was obtained using SD-OCT with EDI modality (Heidelberg Engineering, Carlsbad, CA, USA).measurements of choroidal thickness were performed manually using the calipers provided by the Spectralis Heidelberg software at the fovea and 3 mm away from the fovea (nasaly, temporaly, inferiorely and superiorly). CT was measured from the outer limit of the retinal pigment epithelium to the choroidal-scleral junction.The technique of enhanced depth imaging (EDI) OCT is involved by placing the objective lens of the SD-OCT device closer to the eye such that an inverted image is obtained. By performing this maneuver, the deeper structures are placed closer to zero delay, allowing better visualization of the choroid.

All patients underwent a fornix-based trabeculectomy with mitomycin-c (MMC) by the three experienced surgeons (HM, AZ, ME).

Statistical Analysis

All data were subjected to revision and validation then description and analysis on IBM-compatible PC by using SPSS (Statistical Package for the Social Science) program version 22.0.0, Microsoft Office Excel 2007, and GraphPad Prism 6. Descriptive statistics were performed for all studied parameters in the three studied groups and were presented in the form of mean, median, standard deviation (SD), minimum, maximum, range, and percentages. The comparison between two paired groups with quantitative data and parametric distribution were done by using Paired t- test. $P < 0.05$ considered a significant level.

RESULTS

This study showed that there was high statistically significant decrease in IOP and AXL at 1st month with mean of (9.75 ± 1.29) and (24.8 ± 1.66) respectively, 3rd month (11.3 ± 1.08) and (24.88 ± 1.65) respectively and 6th month (12.45 ± 1.7) and (24.88 ± 1.6) respectively postoperative compared to preoperative (25.3 ± 2.83) and (25.08 ± 1.67) respectively (table 1).

Table (1): Comparison between IOP and AXL preoperative and 1, 3 and 6 months Postoperative.

		Preoperative	**1 month Postoperative**	**3 months Postoperative**	**6 months Postoperative**
		No.= 20	**No.= 20**	**No.= 20**	**No.= 20**
IOP	Mean ± SD	25.3 ± 2.83	9.75 ± 1.29	11.3 ± 1.08	12.45 ± 1.7
	Test value	–	29.041	26.261	21.757
	P-value	–	**0.000**	**0.000**	**0.000**
	Sig.	–	**HS**	**HS**	**HS**
AXL	Mean ± SD	25.08 ± 1.67	24.8 ± 1.66	24.88 ± 1.65	24.88 ± 1.6
	Test value	–	28.709	22.392	4.116
	P-value	–	**0.000**	**0.000**	**0.001**
	Sig.	–	**HS**	**HS**	**HS**

IOP: Intra ocular pressure AXL: Axial length *: Paired t-test

Also, we assessed the changes of choroidal thickness before and after 1, 3 and 6 months of the operation. Results showed that, there was high statistically significant increase in SFCT-V, SFCT-V, NCT, TCT, SCT and ICT in 1st month postoperative with mean (217.65 ± 27.03, 218 ± 21.09, 216.9 ± 28.86, 190.35 ± 34.3, 223.1 ± 24.82 and 244.8 ± 23.77) respectively, then they decreased in the 3rd month with mean (198.85 ± 27.8, 197.8 ± 23.3, 200.15 ± 27.5, 178.35 ± 31.9, 208.75 ± 23.3 and 233.5 ± 21.05) respectively, but it was not less than preoperative, and continued in decreasing in the 6th month with mean (187.3 ± 29.02, 186.95 ± 25.82, 188.95 ± 27.47, 166.45 ± 26.38, 197.7 ± 23.05 and 223.5 ± 22.66) respectively, but it was not also less than preoperative. While, the preoperative values were (169 ± 31, 166 ± 25.16, 164.3 ± 25.81, 147.8 ± 26.41, 173 ± 26.7 and 193.95 ± 28.97) respectively (table 2).

Table (2): Comparison between SFCT-H, SFCT-V, NCT, TCT, SCT and ICT preoperative and 1, 3 and 6 months Postoperative.

		Preoperative	**1 month Postoperative**	**3 months Postoperative**	**6 months Postoperative**
		No.= 20	**No.= 20**	**No.= 20**	**No.= 20**
SFCT-H	Mean ± SD	169 ± 31	217.65 ± 27.03	198.85 ± 27.8	187.3 ± 29.02
	Test value	–	-11.904	-11.371	-8.352
	P-value	–	**0.000**	**0.000**	**0.000**
	Sig.	–	**HS**	**HS**	**HS**
SFCT-V	Mean ± SD	166 ± 25.16	218 ± 21.09	197.8 ± 23.3	186.95 ± 25.82
	Test value	–	-24.940	-15.038	-6.404
	P-value	–	**0.000**	**0.000**	**0.000**
	Sig.	–	**HS**	**HS**	**HS**
NCT	Mean ± SD	164.3 ± 25.81	216.9 ± 28.86	200.15 ± 27.5	188.95 ± 27.47
	Test value	–	-21.967	-13.408	-8.746
	P-value	–	**0.000**	**0.000**	**0.000**
	Sig.	–	**HS**	**HS**	**HS**
TCT	Mean ± SD	147.8 ± 26.41	190.35 ± 34.3	178.35 ± 31.9	166.45 ± 26.38
	Test value	–	-13.739	-9.997	-7.764
	P-value	–	**0.000**	**0.000**	**0.000**
	Sig.	–	**HS**	**HS**	**HS**
SCT	Mean ± SD	173 ± 26.7	223.1 ± 24.82	208.75 ± 23.3	197.7 ± 23.05
	Test value	–	-23.871	-18.456	-10.507
	P-value	–	**0.000**	**0.000**	**0.000**
	Sig.	–	**HS**	**HS**	**HS**
ICT	Mean ± SD	193.95 ± 28.97	244.8 ± 23.77	233.5 ± 21.05	223.5 ± 22.66
	Test value	–	-11.808	-10.326	-7.491
	P-value	–	**0.000**	**0.000**	**0.000**
	Sig.	–	**HS**	**HS**	**HS**

*: Paired t-test
SFCT-H: Sub Foveal choroidal thickness – Horizontal SFCT-V: Sub Foveal choroidal thickness – Vertical
NCT: Choroidal thickness 3mm nasal to macula TCT: Choroidal thickness 3mm temporal to macula
SCT: Choroidal thickness 3mm superior to macula ICT: Choroidal thickness 3mm inferior to macula

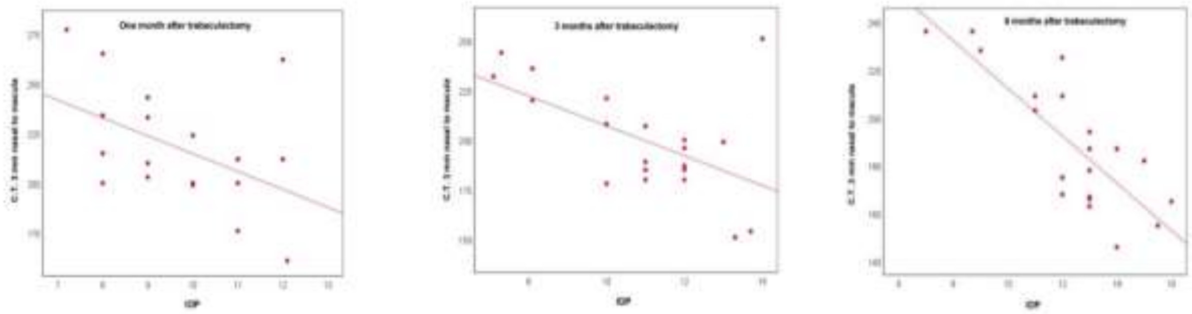
As regarding intra ocular pressure (IOP), there was statistically significant negative correlation with NCT, TCT, SCT and ICT preoperative and at the 1st, 3rd and 6th month postoperative. While, there was insignificant negative correlation with SFCT-H and SFCT-V. Concerning to axial length (AXL), there was statistically insignificant negative correlation with NCT, SCT, ICT, SFCT-H and SFCT-V preoperative and at the 1st, 3rd and 6th month postoperative. While, positive correlation was achieved regarding TCT (table 3).

Table (3): Correlation between NCT, TCT, SCT, ICT, SFCT-H and SFCT-V with IOP and AXL preoperative and 1, 3 and 6 months Postoperative.

	NCT		TCT		SCT		ICT		SFCT-H		SFCT-V	
	r	P-value	r	P-value	r	P-value	r	P-value	r	P-value	R	P-value
reoperative												
OP	-0.510*	0.022	-0.490*	0.028	-0.679**	0.001	-0.508*	0.022	-0.289	0.216	-0.142	0.551
XL	-0.310	0.183	0.085	0.720	-0.023	0.922	-0.403	0.078	-0.197	0.405	-0.180	0.477
month Postoperative												
OP	-0.452*	0.045	-0.521*	0.019	-0.447*	0.046	-0.518*	0.019	0.020	0.934	0.205	0.386
XL	-0.104	0.662	0.060	0.801	0.117	0.624	-0.167	0.482	-0.186	0.433	-0.175	0.462
months Postoperative												
OP	-0.467*	0.038	-0.553*	0.011	-0.474*	0.035	-0.465*	0.039	-0.296	0.205	-0.046	0.847
XL	-0.183	0.440	0.058	0.808	-0.002	0.992	-0.274	0.242	-0.074	0.756	-0.169	0.477
months Postoperative												
OP	-0.078**	0.000	-0.594**	0.006	-0.510*	0.022	-0.466*	0.038	-0.212	0.370	-0.261	0.266
XL	-0.148	0.535	-0.080	0.738	0.002	0.994	-0.327	0.159	-0.271	0.248	-0.293	0.210

IOP: Intra ocular pressure AXL: Axial length P-value >0.05: Non significant (NS);
P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

A



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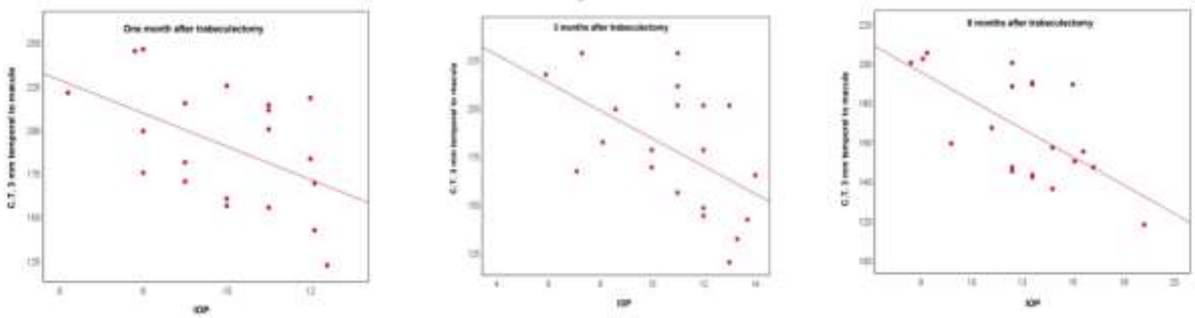

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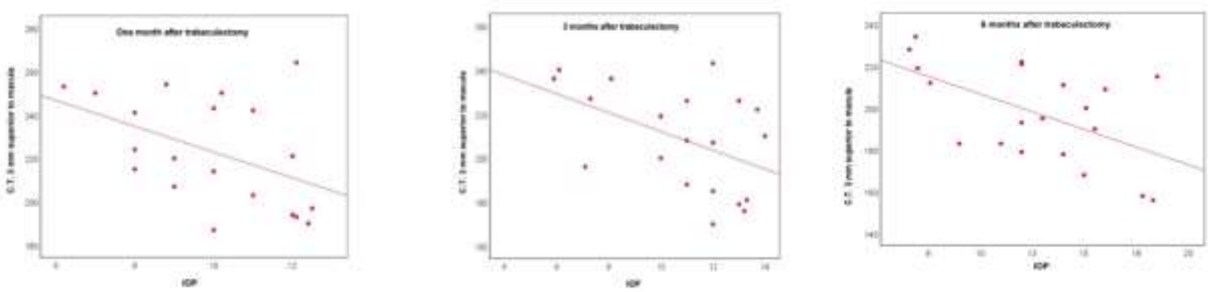

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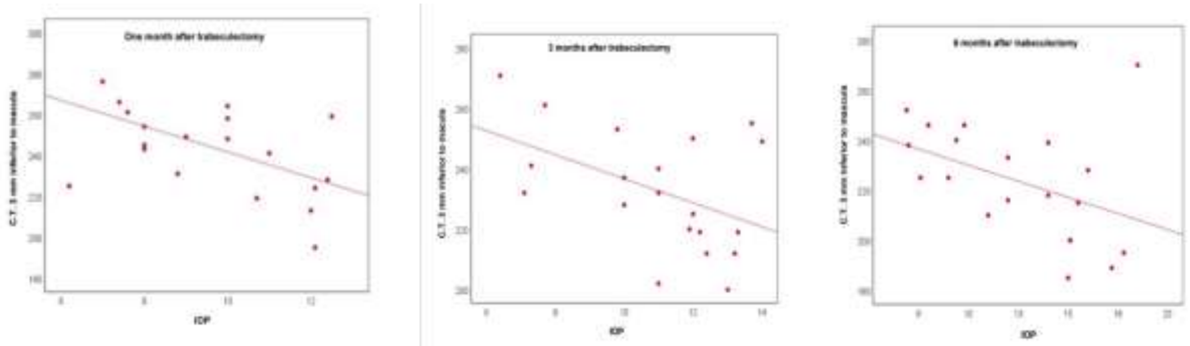

Figure 1: Correlation between IOP and choroidal thickness changes after trabeculectomy. (a). Changes in IOP and Choroidal thickness 3mm nasal to macula postoperative 1-month, 3-months and 6-months showed a significant negative correlation. (b). Changes in IOP and Choroidal thickness 3mm temporal to macula postoperative 1-month, 3-months and 6-months showed a significant negative correlation. (c). Changes in IOP and Choroidal thickness 3mm superior to macula postoperative 1-month, 3-months and 6-months showed a significant negative correlation**.** (d). Changes in IOP and Choroidal thickness 3mm inferior to macula postoperative 1 -month, 3-months and 6-months showed a significant negative correlation**.**

This study depicted that there was statistically significant Positive correlation Between IOP and AXL preoperative and 1, 3 and 6 months Postoperative (table 4).

Table (4): Correlation between IOP preoperative and AXL preoperative and 1, 3 and 6 months Postoperative.

AXL	**IOP**	
	R	**P-value**
Preoperative	0.543*	0.013
1month Postoperative	0.554*	0.011
3 months Postoperative	0.574**	0.008
6 months Postoperative	0.607**	0.005

IOP: Intra ocular pressure AXL: Axial length P-value >0.05: Non significant (NS);
P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

DISCUSSION

The choroid is a dynamic structure, whose thickness depends upon the intravascular blood volume of choroidal vessels and the extravascular choroidal space. The volume of the choroid is actively managed by mechanisms that help to produce emmetropia during early life **[11-12].** With the advent of OCT measurements of CT, we have become aware that the choroidal tissue is immediately responsive to changes in IOP and blood pressure most probably due to intravascular volume changes **[13].**

In trabeculectomy, a scleral flap guarded filtration procedure, a fistula that allows drainage of the aqueous humor into the subconjunctival/sub-Tenon space by a sclerostomy is obtained, thereby reducing the intraocular pressure. Though superior to unprotected surgeries, drainage control is not perfect, with the possibility of hyperfiltration and associated complications **[14].** Decompression and the resulting changes in the hydrostatic pressure gradient may lead to anatomical and functional alterations, such as reduced axial length, expansion of choroidal tissue and increased ocular perfusion pressure. It is also thought that choroidal thickness is a dynamic parameter, which may reflect vascular alterations related to intraocular pressure oscillations in the postoperative period **[15].**

In this study, we aimed to evaluate choroidal thickness changes and with enhanced depth imaging-optical coherence tomography (EDI-OCT) and axial length with ophthalmic A-Scan ultrasound after reduction of intraocular pressure following trabeculectomy. The study included 20 patients with open-angle glaucoma from the outpatient Ophthalmic Clinic of Menoufia University hospital. The choroidal thickness was measured using EDI-SD-OCT and AXL of eye was measured using A-scan ultrasound before trabeculectomy and 1 month, 3 and 6 months postoperatively.

In our study, the mean of age was 57.20 ± 8.51 years with the range between (40 to 73) years. there were 12 males represented the large portion (60%) and 8 females represented (40%) and mean spherical equivalent (S.E) -1.53 and ± 2.50 SD and range (-4.75 - 3.00). Our study showed that there was highly statistically significant difference between preoperative & 3 consecutive postoperative visits as regard IOP. Our study revealed that there was highly statistically significant difference between preoperative & 3 consecutive postoperative visits as regard AXL.

Cashwell and Martin [16] found a significant decrease in AXL at various times after trabeculectomy by using B-scan ultrasonography which supports our results**.**

Our study revealed that there was significant positive correlation between axial length decreases with a decrease in IOP after trabeculectomy. **Usui *et al.*** [17] measured CT and AL before and 6 days after trabeculectomy in 14 patients, Found the changes in IOP correlated positively with the changes in axial length after trabeculectomy which supports our results**.**

Our study revealed that there was non-significant correlation between axial length decreases with an increase in CT after trabeculectomy. Other studies **Kara *et al.*** [18]**, Saeedi *et al.*** [19] **and Kadziauskiene *et al.*** [20] demonstrated a significant correlation between the postoperative changes of CT and axial length shortening.

Our study revealed a highly statistically significant difference between preoperative & 3 consecutive postoperative visits as regard choroidal thickness. **Kadziauskiene *et al.*** [20] observed a significant increase in CT at all measured locations not only in the early postoperative period as reported by those mentioned authors but at least 6 months after the surgical IOP reduction which is the same of our study results.

Our study found the reduction of IOP was negatively correlated only with the increase in nasal, temporal, inferior and superior CT 3mm away from the fovea. While, there was insignificant negative correlation with SFCT-H and SFCT-V and there was non-significant negative correlation between AXL decreases and an increase in CT after trabeculectomy. **Kara *et al.*** [18] investigated the CT and AXL changes in relation to IOP reduction after trabeculectomy. They found that the CT increased significantly after trabeculectomy and that this increase correlated with changes in IOP, AXL, and OPP. The change in CT was negatively correlated with the change in IOP, negatively correlated with the change in AXL, and positively correlated with the change in OPP. However, **Usui *et al.*** [17] measured CT and AXL before and 6 days after trabeculectomy in 14 patients, they found that the sub foveal choroidal thickness increased significantly after trabeculectomy, compared with preoperatively. However, the increase in the choroidal thickness at the fovea was not correlated with either decreases in IOP or shortening of the axial length. Decrease in IOP was correlated with the increases in the choroidal thickness around the optic disc inferiorly and nasally, but not superiorly and temporally.

Several mechanisms for choroidal thickening after trabeculectomy can be considered. The IOP reduction affects the choroid directly as the force of the decreased IOP on the choroid is reduced. However, more important is the indirect effect of reduced IOP on sclera because subsequently scleral deformations are transmitted to compliant adjacent intraocular tissues [21]**.** The increase in ocular blood flow after trabeculectomy can also contribute to choroidal thickening [18, 22, 23]**.** Other hypotheses of CT changes after the surgery include the increased synthesis of osmotically active proteoglycans, growing number and size of the chorio-capillaries' fenestrations, altered trans-port of fluid from retina across the retinal pigment epithelium and change in the tonus of non-vascular smooth muscles that spans the choroid [1]**.**

CONCLUSION

It could be concluded that the CT increased significantly after trabeculectomy and that this increase correlated with changes in IOP. Our study found the reduction of IOP was negatively correlated only with the increase in nasal, temporal, inferior and superior CT 3 mm away from the fovea. While there was insignificant negative correlation with SFCT-H and SFCT-V. The change in IOP was positively correlated with the change in AXL.

REFERENCES

1. **Nickla D, Wallman J (2010):** The multifunctional choroid. Prog Retin Eye Res., 29: 144–168.
2. **Friedman D, Wolfs R, O'Colmain B *et al.* (2004):** Eye Diseases Prevalence Research Group. Prevalence of open-angle glaucoma among adults in the United States. Arch Ophthalmol., 122(4): 532-8
3. **Weinreb R, Khaw P (2004):** Primary open-angle glaucoma. The Lancet, 363(9422): 1711-1720.
4. **Kwon Y, Fingert J, Kuehn M *et al.* (2009):** Primary open-angle glaucoma. New England Journal of Medicine, 360(11): 1113-1124.
5. **Alward W (2000):** Open angle glaucomas. In: Alward WLM, editor. Glaucoma: the requisites in ophthalmology. Mosby: St. Louis, Pp. 128–140.
6. **Kirwan J, Lockwood A, Shah P *et al.* (2013):** Trabeculectomy in the 21st century: a multicenter analysis. Ophthalmology, 120(12): 2532–2539.
7. **Husain R, Li W, Gazzard G *et al.* (2013):** Longitudinal changes in anterior chamber depth and axial length in Asian subjects after trabeculectomy surgery. British Journal of Ophthalmology, 97(7): 852-856.
8. **Lee E, Kim T, Weinreb R *et al.* (2013):** Reversal of lamina cribrosa displacement after intraocular pressure reduction in open-angle glaucoma. Ophthalmology, 120(3): 553–559.
9. **Regatieri C, Branchini L, Fujimoto J *et al.* (2012):** Choroidal imaging using spectral-domain optical coherence tomography. Retina, 32(5): 865 -876
10. **Margolis R, Spaide R (2009):** A pilot study of enhanced depth imaging optical coherence tomography of the choroid in normal eyes. Am J Ophthalmol., 147: 811–815.
11. **Spaide R, Koizumi H, Pozzoni M (2008):** Enhanced depth imaging spectral-domain optical coherence tomography. Am J Ophthalmol., 146: 496–500.
12. **Moisseiev E, Loewenstein A, Yiu G (2016):** The suprachoroidal space: from potential space to a space with potential. Clin Ophthalmol., 10: 173-178.

13. **Sayin N, Kara N, Pekel G *et al.* (2015):** Choroidal thickness changes after dynamic exercise as measured by spectral-domain optical coherence tomography. Indian J Ophthalmol., 63(5): 445-450.
14. **Yu J, Nguyen C, Gallemore E *et al.* (2016):** Combined Scleral Flap with Donor Scleral Patch Graft for Anterior Tube Placement in Glaucoma Drainage Device Surgery. Case Rep Ophthalmol Med., 2016: 2124581.
15. **Zhang X, Cole E, Pillar A (2017):** The Effect of Change in Intraocular Pressure on Choroidal Structure in Glaucomatous Eyes. Invest Ophthalmol Vis Sci., 58(7): 3278-3285.
16. **Cashwell L, Martin C (1999):** Axial length decrease accompanying successful glaucoma filtration surgery. Ophthalmology, 106: 2307–2311.
17. **Usui S, Ikuno Y, Uematsu S *et al.* (2013):** Changes in axial length and choroidal thickness after intraocular pressure reduction resulting from trabeculectomy. Clinical Ophthalmology, 7: 1155–1161.
18. **Kara N, Baz O, Altan C *et al.* (2013):** Changes in choroidal thickness, axial length, and ocular perfusion pressure accompanying successful glaucoma filtration surgery. Eye, 27: 940–945**.**
19. **Saeedi O, Pillar A, Jefferys J *et al.* (2014):** Change in choroidal thickness and axial length with change in intraocular pressure after trabeculectomy. Br J Ophthalmol., 98: 976– 979.
20. **Kadziauskiene A, Kuoliene K, Asoklis R *et al.* (2016):** Changes in choroidal thickness after intraocular pressure reduction following trabeculectomy. Acta Ophthalmol., 94(6): 586–591.
21. **Sigal I, Flanagan J, Ethier C (2005):** Factors influencing optic nerve head biomechanics. Invest Ophthalmol Vis Sci., 46(11): 4189–4199.
22. **Berisha F, Schmetterer K, Vass C *et al.* (2005):** Effect of trabeculectomy on ocular blood flow. Br J Ophthalmol., 89(2): 185–188.
23. **Januleviciene I, Siaudvytyte L, Diliene V *et al.* (2015):** Effect of trabeculectomy on ocular hemodynamic parameters in pseudo exfoliative and primary open-angle glaucoma patients. J Glaucoma, 24: 52–56.