



The Effects of Trabeculectomy on Ocular Pulse Amplitude in Patients with Glaucoma

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Abstract

Objectives: This study aimed to investigate whether trabeculectomy and its intraocular pressure (IOP)-lowering effect have an effect on ocular pulse amplitude (OPA) in glaucoma patients.

Methods: Thirty-five consecutive patients with glaucoma (70 eyes) who had undergone unilateral first-time trabeculectomy between April and November 2012 were enrolled in this retrospective study. Patients with intraoperative or postoperative complications were excluded from this study. The eye that underwent trabeculectomy was considered the study eye; the fellow eye was used as the control eye. OPA and IOP were measured by Pascal dynamic contour tonometry (DCT), IOP was measured by Goldmann applanation tonometry (GAT), and systolic and diastolic blood pressure and heart rate were measured before and one month after trabeculectomy. The change in the pre- and postoperative values was compared between the two eyes.

Results: The study sample included 17 male and 18 female patients with a mean age of 60.83 ± 13.46 years. The mean preoperative GAT, DCT and OPA values in the study eyes were 24.97 ± 8.26 , 31.23 ± 10.55 and 4.22 ± 1.77 mmHg, respectively. One month after trabeculectomy, the GAT, DCT and OPA values were 12.83 ± 4.35 , 20.28 ± 7.34 and 2.96 ± 1.66 mmHg, respectively. There was a significant decrease in OPA after filtration surgery in the study eyes ($p < 0.001$), but not in the control eyes ($p > 0.05$). Changes in OPA were positively correlated with changes in IOP ($p < 0.05$), and a significant association was found between OPA and IOP, and as measured by DCT (Regression coefficient = $0.093 [0.041-0.145]$) and GAT (Regression coefficient = $0.093 [0.013-0.173]$).

Conclusion: There was a significant decrease in OPA in the eyes that underwent trabeculectomy, and the change in OPA after surgery was significantly different in the study eyes in comparison to the change in OPA in the control eyes. The OPA changes were strongly correlated with the IOP changes in the study eyes.

Keywords: Dynamic contour tonometry, glaucoma, Goldmann applanation tonometry, ocular pulse amplitude, trabeculectomy.

Introduction

Glaucoma is one of the leading causes of blindness worldwide; it is characterised by a distinctive excavation of the optic nerve head and progressive visual field loss. Previous studies have identified many risk factors for glaucoma progression, including intraocular pressure (IOP), optic nerve ischemia, systemic hemodynamic disorder, optic disc haemorrhage, gender and vascular spasm (1–4). However, IOP is still the most important modifiable risk factor for the devel-

opment and progression of glaucoma (5–7). Trabeculectomy has long been considered to be the gold standard procedure for lowering IOP in patients with glaucoma (8–9). It involves draining aqueous humour from the anterior chamber into the subconjunctival spaces through a sclerotomy, and it requires full-thickness penetration of the anterior chamber under a partial-thickness scleral flap (10). Ocular perfusion and IOP are both affected by a trabeculectomy, and the ocular pulse amplitude (OPA) depends on these.

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Previous studies have suggested that OPA may play a role in the clinical course of glaucoma. The pulsatile component of ocular blood flow results in variations in IOP during the cardiac cycle. OPA is the difference between diastolic and systolic IOP, and it represents the magnitude of change in IOP with the ocular pulse. OPA is derived from the differences between the maximum and minimum IOP during the IOP measurement period (11–14).

The bulbus is subjected to pulsatile expansion generated by the rhythmic filling of the intraocular vessels. The fluctuation of the ocular volume causes variations in IOP. These can be recorded using dynamic contour tonometry (DCT) (Pascal, Swiss Microtechnology, Port, Switzerland), which is digital tonometry that claims to be relatively unaffected by corneal biomechanical properties. This non-applanation, slit-lamp-mounted, contour-matching contact tonometer produces minimal distortion of the cornea, and the IOP is the result of direct measurement by a sensor integrated into the centre of the device's tip. The tip of the tonometry has a concave surface, and it measures IOP when the cornea of patients matches the tip of the tonometry. The IOP and the quality of data (Q) are shown on a digital screen (15–17).

Goldmann applanation tonometry (GAT) is one of the devices most frequently used to measure IOP. GAT readings may be affected by many factors, such as central corneal thickness (CCT) and curvature, refractive errors, corneal edema, corneal surface disease, scleral rigidity and bulb dimensions. DCT was designed to function independently of the corneal structural properties (18).

The present study aimed to investigate whether trabeculectomy and its IOP-lowering effect, have an effect on OPA. Hence, we measured IOP and OPA using DCT before and one month after trabeculectomy surgery to assess the changes in OPA after trabeculectomy and to determine the association between changes in IOP and changes in OPA after surgery in patients with glaucoma.

Methods

This retrospective study was conducted at Beyoglu eye Training and Research Hospital among patients with glaucoma whose IOP was not adequately controlled by maximum medical treatment, and who were scheduled to undergo trabeculectomy between April and November 2012. This study included only those patients who underwent trabeculectomy surgery for the first time; patients who had intraoperative or postoperative complications were excluded. This study was conducted in accordance with the ethical standards of the Declaration of Helsinki, and this study was approved by the Institutional Ethics Committee after assuring that the data obtained from the study participants would only be used for the study and would be kept confidential.

All of the glaucoma-filtering surgeries were trabeculectomy with fornix-based conjunctival flaps, and all were performed using a similar surgical technique in all the patients. Anaesthesia was induced by a subtenon lidocaine injection. Corneal traction suture was placed with 8-0 silk. A fornix-based conjunctival flap was dissected. Tenon's capsule was separated by dissecting between the capsule and the episclera. The sclera was exposed, and haemostasis was achieved by bipolar diathermy. Mitomycin C 0.2 mg/ml was used as an adjuvant for 2 min under Tenon's capsule. A partial-thickness quadrangular scleral flap (3x4 mm) was prepared using lamellar dissection before entering the anterior chamber. Carbachol and viscoelastic materials were placed in the anterior chamber. Sclerotomy (1x2 mm) was done by removing a block of trabecular tissue at the sclerolimbic junction. Peripheral iridectomy was performed through the sclerotomy. The scleral flap was sutured with two-four fixed 10-0 nylon sutures. The conjunctiva and tenons were closed using 10-0 nylon sutures. Any intraoperative or postoperative complications associated with the procedure were noted.

Postoperative visual acuity using the Snellen chart, IOP via GAT, slit-lamp biomicroscopy and fundus examination were done on day 1, day 2, week 1, week 2 and week 4. All of the glaucoma medications were discontinued following surgery. Topical antibiotics and steroids (usually prednisolone) were given 5-times daily for the first week; steroids were slowly tapered and stopped six weeks after surgery. In addition to the full ophthalmological examination, OPA, blood pressure and heart rate measurements were performed before the trabeculectomy on the day of surgery and 30 days later. The eye that had trabeculectomy surgery was the study eye; the fellow eye was used as the control eye.

OPA was measured using a Pascal tonometer (Dynamic Contour Tonometer [DCT]; Ziemer Ophthalmic Systems, Port, Switzerland). IOP was measured by GAT and DCT. Up to three DCT measurements were performed to obtain one good-quality measurement (quality level 1–2). If, after three measurements, none of the measurements were of good quality, the data from the best-quality measurement were used for the analysis. Moreover, the following parameters were determined once in both eyes of each study patient. During any of the study visits, axial length, corneal curvature and anterior chamber depth were measured using an optical biometry system (IOL Master; Carl Zeiss AG, Feldbach, Switzerland). CCT was measured using ultrasonic pachymetry (Pachmate DGH 55; DGH Technology Inc., Exton, PA) placed on the central cornea over an undilated pupil. Blood pressure and heart rate were assessed using a calibrated sphygmomanometer (Omron Intell Sense M6 [HEM-7001-E] SN: 5306618L; Omron Health Care Co., Ltd., Kyoto, Japan).

Statistical Analysis

Statistical analysis was conducted using SPSS 16.0 for Windows software (SPSS Inc., Chicago, IL, USA). All the data were normally distributed according to the Shapiro-Wilk test, and the results were expressed as mean±standard deviation. The preoperative and postoperative parameters for each eye were compared using the paired t-test. The parameters between the study eyes and the control eyes were compared using an independent t-test. Pearson’s correlation coefficient test was used to investigate the correlation between the parameters. The association between the changes in IOP and the changes in OPA was evaluated using linear regression to determine the regression coefficient (95% confidence interval [CI]). A P-value <0.05 was considered to be statistically significant.

Results

There were about 35 study participants who met the selection criteria, of which 17 were male and 18 were female patients with a mean age of 60.83±13.46 years. About 57.1% of the 35 participants had primary open-angle glaucoma (Table 1). Table 2 shows the best-corrected visual acuity (BCVA), CCT and cup-to-disc (CD) ratio in the study eyes and the control eyes; the CD ratio was higher in the study group than the controls. No difference was found concerning preoperative and postoperative systolic blood pressure and diastolic blood pressure and heart rates (Table 3). Preoperative systolic blood pressure and diastolic blood pressure

were found to be negatively correlated with changes in the OPA values in Pearson’s correlation coefficient ($r = -0.313$, $p < 0.001$ and $r = -0.260$, $p = 0.03$, respectively).

The mean preoperative GAT, DCT and OPA was statistically significantly higher one month after trabeculectomy in the study eyes ($p < 0.00$ for each); there was no statistical difference in the control eyes for the same values (Table 4).

The changes in OPA were positively correlated with changes in IOP as measured by GAT ($\alpha = 0.38$, $p = 0.03$) and DCT ($\alpha = 0.54$, $p < 0.001$) in the study eyes, and there was a significant increase in OPA with an increase in IOP, as measured by DCT (Regression coefficient = 0.093 [0.041–0.145]) and GAT (Regression coefficient = 0.093 [0.013–0.173]) (Table 5).

Discussion

In the present study, we aimed to investigate whether trabeculectomy and its IOP-lowering effect, have an effect on OPA. Our results showed that the OPA changes were positively correlated with the IOP changes after trabeculectomy surgery. Due to the limited number of studies in the literature about the effects of surgery on OPA, the previously reported results were inconclusive. For example, Breusegem et al. (19) performed trabeculectomy in 48 eyes, and the nonsurgical eye was evaluated as the control group. In that study, the preoperative IOP results measured by DCT and OPA were 21.33 mmHg and 3.23 mmHg, respectively, and the 1-month postoperative values were 14.45 mmHg and

Table 1. Frequency distribution of baseline characteristics of the eyes of participants

Variable (n=70 eyes)	Number of eyes	Percentage (%)
Lens situation		
Phakic	56	80
Pseudophakic	14	20
Glaucoma type		
Pseudoexfoliative	14	20
POAG	40	57.1
PACG	16	22.8

POAG; primary open-angle glaucoma; primary angle closure glaucoma.

Table 2. Difference between parameters in the study eye and control eye

Variable	Study Eye (Mean±SD) n=35	Control Eye (Mean±SD) n=35	p*
BCVA (snellen)	0.45±0.33	0.62±0.37	0.04
CCT (µm)	535.71±32.32	536.06±28.69	0.96
CD ratio	0.87±0.19	0.65±0.30	0.00

BCVA: best-corrected visual acuity; CCT: central corneal thickness; CD: cup to disc ratio; SD: standard deviation; *Analysis was carried out using the independent t-test.

Table 3. Preoperative and postoperative systolic, diastolic blood pressures and pulse rates and p-values for the difference between two time points

	Baseline	Postoperative	Difference	p*
Systolic BP (mmHg)	138.80±14.98	140.17±14.12	1.37±15.80	0.467
Diastolic BP (mmHg)	80.80±9.28	79.71±6.03	-1.09±9.89	0.358
Heart rate (Per minute)	78.03±7.89	75.77±5.99	-2.26±8.81	0.060

*Analysis was carried out using paired t-test; BP: blood pressure.

Table 4. Difference between preoperative and postoperative parameters in control eye and study eye

	Study eye		p	Control eye		p
	Baseline	Postoperative		Baseline	Postoperative	
Q value	1.97±0.71	2.26±0.70	0.06	1.89±0.72	2.29±0.67	0.02
OPA	4.73±1.88	2.96±1.66	<0.001	3.70±1.50	3.35±1.34	0.10
DCT IOP	31.23±10.55	18.39±7.25	<0.001	22.48±7.58	22.16±7.03	0.77
GAT IOP	24.97±8.26	12.83±4.35	<0.001	16.71±5.64	16.80±5.56	0.93

*Analysis was carried out using paired test, OPA; ocular pulse amplitude, DCT; dynamic contour tonometry, GAT; Goldmann applanation tonometry, IOP; intraocular pressure.

Table 5. Association between change in OPA and change in IOP

	OPA Change in study eye (n=35)		OPA Change in control eye (n=35)	
	Pearson Correlation	Regression coefficient (95% CI)	Pearson Correlation	Regression coefficient (95% CI)
DCT IOP Change	$\alpha=0.54$ $p<0.001$	0.093 (0.041-0.145)	0.28 $p=0.10$	0.055 (-0.011-0.120)
GAT IOP Change	$\alpha=0.38$ $p=0.03$	0.093 (0.013-0.173)	0.33 $p=0.06$	0.072 (-0.002-0.146)

OPA: ocular pulse amplitude; DCT: dynamic contour tonometry; GAT: Goldmann applanation tonometry; IOP: intraocular pressure.

2.12 mmHg, respectively. The OPA values were found to be statistically significantly decreased in the eyes that underwent trabeculectomy in comparison to the control eyes. Von Schulthess et al. (20) researched the effects of trabeculectomy on OPA and reported that a decrease in the OPA values >2 mmHg in the early postoperative period after trabeculectomy might be a prognostic factor for the long-term success of the surgery. Similarly, in the present study, the mean preoperative OPA was 4.7±1.8 mmHg in the study eyes; one month after trabeculectomy, the OPA was 2.7±1.7 mmHg. There was a significant decrease in OPA after filtration surgery in the study eyes ($p<0.001$), but not in the control eyes ($p>0.05$), and the OPA changes were strongly correlated with the IOP changes.

Kaufman et al. (21) reported that the IOP readings were 0.8–2.7 mmHg higher when using DCT than when using GAT. Similarly, in our study, we found that the IOP measurements were higher when using DCT than when using GAT. The GAT and DCT values were 25.2±8.2, 31.3±0.4 mmHg, preoperatively, and 12.2±4.2, 18.2±7.5 mmHg, 1 month after the trabeculectomy surgery, respectively, in a study conducted by Kaufman et al. (19). In our study, the preoperative IOP values, measured by GAT and DCT, were 24.97±8.26 and 31.23±10.55 mmHg, respectively, and the

postoperative GAT and DCT values, measured one month after trabeculectomy, were 12.83±4.35 and 18.39±7.25, respectively.

It is difficult to prove the relationship between ocular perfusion and glaucoma progression. Although Galassi et al. (22) have shown that vascular pathologies play a role in glaucoma formation and progression, it is still unknown if glaucoma disturbs ocular blood flow or if ocular blood flow diseases cause glaucoma. There is no gold standard method to measure ocular blood flow. Nowadays, Doppler ultrasonography is usually used to measure ocular blood flow. However, this method cannot be used to measure some properties of blood flow, including the blood flow itself and the vascular diameter. Moreover, glaucoma takes years to progress. Thus, long-term patient follow-up and additional studies are needed. Additionally, using systemic or topical medications may affect the ocular blood flow. Schmidt et al. (23) demonstrated that topical dorzolamide increases the OPA and its IOP-lowering effect. Therefore, studies are limited due to these reasons. There are a few studies that have investigated the recovery of ocular hemodynamics after trabeculectomy surgery. In a study that included 30 patients, Berisha et al. (24) showed that optic nerve head blood flow and fundus pulsation amplitude increased after trabeculectomy surgery.

In our study, preoperative systolic blood pressure and diastolic blood pressure were found to be negatively correlated with changes in the OPA values. The difference between the pressure in the ciliary artery and IOP provides the pressure gradient sustaining ocular perfusion. By increasing the ciliary artery pressure, high blood pressure increases the aqueous humour of the ultrafiltration, thus increasing IOP (25). When systolic blood pressure increases, the pressure gradient between the arterial system and bulbus is elevated and OPA increases.

The strength of our study is that it is a novel investigation, and we measured IOP using both DCT and GAT. However, our study has some limitations. This study included a relatively low number of patients. We did not have the opportunity to correlate OPA alterations with choroidal Doppler ultrasound measurements, caffeine intake, smoking and exercise. This was a retrospective study, which might have led to interobserver bias. Moreover, the patient group consisted of people with different characteristics, including different types of glaucoma and lens status. Given that we did not perform a subgroup analysis, such as assessing different types of glaucoma and lens status, this is another limitation of the current study.

In conclusion, this study has shown that there was a significant decrease in OPA in the eyes that underwent trabeculectomy in comparison to the control eyes. The OPA changes were found to strongly correlate with IOP changes, overall, and IOP changes among the study eyes.

Disclosures

Ethics Committee Approval: The Ethics Committee of Beyoglu Eye Training and Research Hospital provided the ethics committee approval for this study (30-F/1).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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