

The effect of trabeculectomy on contrast sensitivity, corneal topography and aberrations

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Abstract

Purpose To investigate the effect of trabeculectomy on corneal topography, corneal sensitivity and aberrations.

Methods Twenty-four eyes of 24 subjects with open-angle glaucoma who required glaucoma filtration surgery were assessed. The evaluation of corneal topography, corneal sensitivity and aberrations were done before the trabeculectomy procedure, 1 week and 1 month after the trabeculectomy.

Results There were significant differences in cylindrical power ($P = 0.02$), contrast sensitivity at 12 cycle/degree spatial frequency ($P = 0.04$) as well as high order aberration ($P = 0.04$) and high order without spherical component ($P = 0.02$) following trabeculectomy. However, significant differences were found for keratometric results and Fourier index

in 3 and 6 mm pupil diameters between pre- and post-trabeculectomy ($P > 0.05$).

Conclusions According to the findings of the current study, trabeculectomy affects contrast sensitivity at 12 cycle/degree spatial frequency, higher-order aberration and higher order without spherical component 1 month after trabeculectomy. Being knowledgeable about these changes may lead to some advancement in post-surgical management of patients particularly in early stages following trabeculectomy.

Keywords Trabeculectomy · Corneal topography · Contrast sensitivity · Aberrations

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Introduction

Glaucoma is the second leading cause of blindness worldwide [1]. Its treatment could be applied either pharmacologically or surgically. In cases that medications and laser treatment are ineffective in intraocular pressure (IOP) decrease, surgery is performed [2].

Trabeculectomy is currently the most common surgical option for the treatment of glaucoma and was first introduced in 1968 [3–6]. It reduces the IOP by creating a fistula, protected by a superficial scleral flap, to allow aqueous outflow from the anterior chamber to the sub-Tenon space [7]. However, several post-surgical complications such as deterioration in visual acuity have been reported by previous studies [8].

It was stated that the trabeculectomy operation induces changes in corneal keratometry, astigmatism and topography that results in visual acuity decline [8–10].

Contrast sensitivity as well as corneal aberrations influences the visual function such as reading and driving, especially at night that affect the quality of life [11]. Hence, assessment of corneal topography and contrast sensitivity following trabeculectomy in order to investigate the changes of these factors seems inevitable. The results might be helpful in post-surgical management of patients with angle-open glaucoma particularly in early stages following trabeculectomy.

The aim of the current study was to investigate the effect of trabeculectomy on contrast sensitivity and corneal topography and aberrations.

Methods

In this prospective clinical study, patients attended the Khatamolanbia Eye Hospital, Mashhad, Iran, were evaluated. The study was approved by human ethics committee in Mashhad University of Medical Sciences and followed the recommendation of the Declaration of Helsinki 2008 for ethical standards.

Twenty-four eyes of 24 subjects with open-angle glaucoma who required glaucoma filtration surgery were evaluated. After a brief explanation about the nature, benefits and possible complications of the trabeculectomy procedure, written informed consent was obtained from all participants.

All the subjects underwent a thorough ophthalmic examination comprised: taking history, best corrected visual acuity (Snellen E chart and Topcon KR-8800, Topcon Corporation, Tokyo, Japan), contrast sensitivity [CSV1000E chart in photopic condition (285 cd/m)], corneal topography (Tomey TMS-4, Tomey, Erlangen, Germany), ocular aberrometry (Zywave, Bausch & Lomb), slit lamp biomicroscopy, intraocular pressure measurement (Goldmann Applanation Tonometer, Haag-Streit, Köniz, Switzerland). The measurements were done before the treatment, 1 week and 1 month after the trabeculectomy.

The inclusion criterion was the presence of drug resistance uncontrolled open-angle glaucoma detected by an experienced ophthalmologist. Those with any history of ocular surgery or ocular diseases except

mild cataract (all LOCS III grade of ≤ 2 [12]) were excluded from this study.

Limbus-based trabeculectomy was performed for all patients by one glaucoma specialist.

Pre-operative and post-operative IOP were measured with standard Goldmann applanation tonometer. A glaucoma specialist performed all of the surgeries using the same method. This procedure was explained in a previous study [13].

Contrast sensitivity

Contrast sensitivity was measured monocularly (in treated eyes) with best spectacle correction using CVS1000E chart (Vector Vision, Arcanum, OH) in calibrated luminance of 85 cd/m² at 2.5 m testing distance. This test comprises sinoidal grated patches for 4 frequencies including: 3 cpd (threshold range 0.70–2.08), 6 cpd (threshold range 0.91–2.29), 12 cpd (threshold range 0.61–1.99) and 18 cpd (threshold range 0.17–1.55). The results of pre- and post-operative assessments were reported as logarithm 10.

Corneal topography

Corneal topography was performed using the Tomey TMS-4 to measure the pre- and post-operative astigmatism and its meridian. Furthermore, Fourier analysis map was taken for all participants and Fourier indices including: spherical component, regular astigmatic component, asymmetry, irregularity and high-order components in 3 and 6 mm pupil diameters were measured before and after trabeculectomy.

Aberrometry

Wave front aberration data were measured by Zywave (Bausch & Lomb). Zywave is a Hartmann–Shack system. The measurements were performed in 5 mm pupil diameter. The coefficient of Zernike polynomials is shown as the root mean square (RMS) that indicates the wave front aberrations.

Statistical analysis

Statistical analyses were performed using the SPSS software version 11.5 (SPSS Inc, Chicago, IL, USA). For description of data, mean \pm standard deviation (SD) with 95% confidence interval was used. Data for

all parameters were normally distributed according to Shapiro–Wilk test. The one-way analysis of variance test was used for statistical analysis of the parameters. The P value of less than 0.05 ($P < 0.05$) was considered statistically significant.

Results

Twenty-four eyes of 24 patients, 11 female (45.83%) and 13 male (54.17%) were recruited. The mean age of patients was 62.38 ± 20.18 years. The comparisons between pre- and post-operative mean cylindrical power are indicated in Table 1. There was a significant difference in cylindrical power pre- and post-operation ($P = 0.02$).

Keratometric results obtained with corneal topography are presented in Table 2. There were no significant differences in keratometric measurements between different time intervals. The analysis showed no significant differences for keratometric results ($P > 0.05$).

Tables 3 and 4 present the Fourier indices measured in 3 and 6 mm pupil diameters by Tomey TMS-4 topographer. No significant difference was found in

Fourier index between pre- and post-trabeculectomy ($P > 0.05$).

Assessment of contrast sensitivity changes in 3, 6, 12 and 18 cycle/degree spatial frequencies following trabeculectomy (Table 5) showed a significant difference in 12 cycle/degree spatial frequency ($P = 0.04$).

The results of wave front aberrations are indicated in Table 6. There were significant differences in high order and high order without spherical component parameters following trabeculectomy ($P < 0.05$).

Discussion

Trabeculectomy usually causes some changes in visual function in the early postoperative period that might be distressing to the patient. A previous study showed that 1 week after trabeculectomy, a change in uncorrected visual acuity occurred in 94% of their subject and corrected visual acuity change in 43% of patients [14]. It was stated that the source of the decline in visual function might be the induced alterations in corneal contour, axial length, anterior chamber depth and lens thickness [15–19] by trabeculectomy. The increase in corneal astigmatism following trabeculectomy as a result of the scleral flap

Table 1 Refractive errors changes following trabeculectomy

Refraction	Mean \pm SD			
	Pre-operation	One week after trabeculectomy	One month after trabeculectomy	P value
Cylindrical power (Diopter)	-1.00 ± 0.87	-2.44 ± 1.84	-1.91 ± 1.91	0.022*
Cylindrical axis (Degree)	68.89 ± 34.66	83.75 ± 56.08	85.53 ± 57.37	0.55

*Difference statistically significant ($P < 0.05$)

Table 2 Keratometric results before and after trabeculectomy

Keratometric parameters	Mean \pm SD			
	Pre-operation	One week after trabeculectomy	One month after trabeculectomy	P value
Steep power (Diopter)	45.34 ± 2.78	46.02 ± 2.45	46.13 ± 2.28	0.50
Steep axis (Degree)	66.13 ± 58.29	97.33 ± 49.30	85.00 ± 50.48	0.13
Flat power (Diopter)	43.79 ± 1.64	43.38 ± 2.10	43.69 ± 2.14	0.75
Flat axis (Degree)	93.52 ± 42.08	67.33 ± 55.61	100.00 ± 56.48	0.07
Average power (Diopter)	44.57 ± 1.96	44.70 ± 2.08	44.91 ± 1.96	0.84
Cylinder power (Diopter)	1.55 ± 2.35	2.64 ± 1.89	2.44 ± 2.05	0.16

Table 3 Fourier index in 3 mm pupil diameter

Fourier indices in 3 mm pupil	Mean \pm SD			P value
	Pre-operation	One week after trabeculectomy	One month after trabeculectomy	
Spherical	44.53 \pm 1.90	44.56 \pm 1.90	44.77 \pm 1.88	0.89
Regular astigmatism	0.83 \pm 1.09	1.30 \pm 0.95	1.11 \pm 0.79	0.23
Axis	76.97 \pm 58.55	93.55 \pm 49.67	88.07 \pm 53.75	0.56
Asymmetry	0.62 \pm 0.58	0.74 \pm 0.68	0.88 \pm 0.90	0.46
Axis	186.77 \pm 108.56	153.34 \pm 125.85	209.54 \pm 109.20	0.24
High order	0.22 \pm 0.14	0.34 \pm 0.18	0.35 \pm 0.38	0.13

Table 4 Fourier index in 6 mm pupil diameter

Fourier indices in 6 mm pupil	Mean \pm SD			P value
	Pre-operation	One week after trabeculectomy	One month after trabeculectomy	
Spherical	44.31 \pm 1.91	44.31 \pm 1.91	44.44 \pm 1.85	0.94
Regular astigmatism	1.21 \pm 0.77	1.21 \pm 0.77	0.99 \pm 0.67	0.11
Axis	110.87 \pm 66.14	110.87 \pm 66.14	89.58 \pm 54.24	0.16
Asymmetry	0.89 \pm 0.67	0.89 \pm 0.67	1.01 \pm 0.93	0.63
Axis	190.56 \pm 115.87	190.56 \pm 115.87	190.21 \pm 112.20	0.34
High order	0.39 \pm 0.16	0.39 \pm 0.16	0.39 \pm 0.30	0.13

Table 5 Contrast sensitivity changes in different spatial frequencies following trabeculectomy

Spatial frequency (cycle/degree)	Contrast sensitivity Mean \pm SD			P value
	Pre-operation	One week after trabeculectomy	One month after trabeculectomy	
3	0.41 \pm 1.27	0.45 \pm 1.20	0.45 \pm 1.29	0.729
6	0.46 \pm 1.47	0.40 \pm 1.22	0.48 \pm 1.38	0.161
12	0.51 \pm 1.12	0.38 \pm 0.80	0.43 \pm 0.98	0.043*
18	0.51 \pm 0.62	0.39 \pm 0.43	0.45 \pm 0.58	0.349

*Difference statistically significant ($P < 0.05$)

Table 6 Zernike RMS changes following trabeculectomy

Zernike RMS in 5 mm	Mean \pm SD			P value
	Pre-operation	One week after trabeculectomy	One month after trabeculectomy	
HO	0.52 \pm 0.26	0.77 \pm 0.28	0.68 \pm 0.35	0.041*
HO W/O	0.45 \pm 0.27	0.73 \pm 0.28	0.64 \pm 0.35	0.020*
Total	1.60 \pm 1.06	2.33 \pm 1.47	1.92 \pm 1.26	0.225

HO higher-order aberrations, HO W/O higher-order aberrations without spherical aberration

*Difference statistically significant ($P < 0.05$)

sutures and utilizing the cautery on sclera [15, 17] was also indicated. In the present study, the results showed an induced astigmatism 1 week after trabeculectomy that declined after 1 month but did not reach the pre-operative level. The amount of induced astigmatism was 0.91 D after 1 month that was lower than the results of previous studies [15, 20]. They found 1.5 to 2.5 D induced astigmatism 3 months after trabeculectomy. These differences might be as a result of the manipulation in cornea, flap size, cautery and tightened suture.

Contrast sensitivity evaluation by CVS1000E chart showed that the contrast sensitivity in 3, 6, 18 cycle/degree spatial frequencies insignificantly decreased 1 week after trabeculectomy and improved gradually by 1 month. These findings were in agreement with the results of Dietze et al. [9] study. They measured the spatial frequency equivalent to 20/20 Snellen acuity and found that contrast sensitivity was not affected by trabeculectomy. They expressed that regarding to visual acuity deterioration, contrast sensitivity changes may occurred in other spatial frequencies [9]. However, in our study the change in contrast sensitivity was significant in 12 cycle/degree spatial frequency and improved gradually after 1 month. It should be noted that the post-operative data were measured only 1 month after trabeculectomy, and longitudinal investigation was not conducted. The longer term assessment of changes in contrast sensitivity seems significant which should be addressed in future studies.

Since ocular surgeries are believed to boost the ocular and corneal higher-order aberrations, and consequently influence the post-operative visual function [15, 20], being knowledgeable about the effect of ocular surgeries on ocular and corneal higher-order aberrations is of great importance. In the current study, the analysis demonstrated that although corneal aberration did not change by trabeculectomy, ocular higher-order aberration and higher order without spherical component aberration increased. These findings were consistent with the results of a preceding study [20]. Their study indicated that ocular coma-like and total aberrations significantly increased 1 month after trabeculectomy. However, they reported that the increase in aberrations returned to normal by 3 months. So these outcomes suggested that there must be changes in the internal optics, such as crystalline lens, that lead to the rise in higher-order

aberration and higher order without spherical component aberration at 1 month post-trabeculectomy. In a previous report, the change in the thickness and position of the crystalline lens were introduced as the key parameters for the alteration of higher-order aberrations [20]. Further researches to study the correlation between the parameters of the crystalline lens and higher-order aberrations seem inevitable. One suggested assumption is that the temporary edema in ciliary body after trabeculectomy altered the anterior chamber depth as well as thickness and position of the lens and thus deteriorate the ocular higher-order aberrations.

Based on our findings in this study, it is concluded that trabeculectomy affects contrast sensitivity at 12 cycle/degree spatial frequency, higher-order aberration and higher order without spherical component aberration 1 month after trabeculectomy. Being well-informed about these alterations may result in some advancements (such as providing appropriate explanation about the process of changing and the source of the changes for the patients) in post-surgical management of patients, especially in early stages following trabeculectomy. Further studies are required with longer follow-up to achieve better understanding of these changes. Furthermore, assessment of changes in internal optical components of the eye such as crystalline lens and anterior chamber depth will help in better eliciting of the changes in visual function.

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Compliance with ethical standards

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership or other equity interest; and expert testimony or patent-licensing arrangements) or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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