Turkish Journal of Medical Sciences

http://journals.tubitak.gov.tr/medical/

Research Article

Turk J Med Sci
(2016) 46: 1773-1778
© TÜBİTAK
doi:10.3906/sag-1506-122

The effect of deep sclerectomy on ocular blood flow: a 6-month clinical trial

Arzu ÖZSOY[1,*], Murat Sinan SARICAOĞLU[2], Mehtap ÇAVUŞOĞLU[1]
[1]Department of Radiology, Ankara Numune Training and Research Hospital, Ankara, Turkey
[2]Department of Ophthalmology, Ankara Numune Training and Research Hospital, Ankara, Turkey

Received: 26.06.2015 • **Accepted/Published Online:** 20.03.2016 • **Final Version:** 20.12.2016

Background/aim: To investigate the effect of deep sclerectomy on retrobulbar blood flow.

Materials and methods: This prospective study included 20 eyes of 20 patients with open angle glaucoma. Color Doppler imaging (CDI) examinations were performed before and 2, 12, and 24 weeks after deep sclerectomy. Peak systolic velocity (PSV), end diastolic velocity (EDV), and resistance index (RI) were measured for the ophthalmic artery (OA), central retinal artery (CRA), and temporal and nasal short posterior ciliary arteries (SPCAs) at each examination and the results were compared.

Results: A significant decrease was determined in intraocular pressure (IOP) ($P < 0.001$) and a significant increase in ocular perfusion pressure (OPP) ($P < 0.001$) at all postoperative examinations. The EDV in OA increased significantly ($P < 0.001$), but the change in RI was not statistically significant ($P = 0.67$). EDV increased and RI decreased significantly in CRA and SPCA ($P < 0.001$).

Conclusion: Deep sclerectomy decreases IOP and increases OPP significantly. Retrobulbar blood flow was seen to improve after deep sclerectomy.

Key words: Color Doppler imaging, nonpenetrating surgery, deep sclerectomy, intraocular pressure, retrobulbar hemodynamics

1. Introduction

Although elevated intraocular pressure (IOP) has been identified as a major risk factor for glaucoma progression, there is also increasing evidence that disturbed ocular blood flow (OBF) is a primary and independent risk factor for glaucoma progression. Therefore, the aim of glaucoma therapy is to decrease the damage by lowering IOP and improving ocular blood flow (1).

The concept of shifting to nonpenetrating surgery in the management of uncontrolled open-angle glaucoma has been recently considered. The idea behind the development of this technique was to avoid ocular entry in order to limit postoperative complications. In 1990, Fyodorov et al. and Kozlov et al. recommended the procedure of nonpenetrating deep sclerectomy (2,3). Various subsequent modifications of this procedure have also been reported (4,5).

The application of ultrasound technology to the study of vascular tissue in the eye has resulted in a greater understanding of ocular hemodynamics, and color Doppler imaging (CDI) has become an important tool. CDI is an ultrasonic imaging modality that provides a display of blood flow velocity imposed over a conventional gray-scale B-mode ultrasound image (6).

The effect of trabeculectomy on ocular blood flow has been studied and on CDI examination IOP has been reported to be significantly decreased and ocular blood flow to be increased (6–8).

To date there has been a limited number of reports on the effect of deep sclerectomy on ocular blood flow (9). The aim of the present study was to investigate the effects of deep sclerectomy on IOP, ocular perfusion pressure (OPP), and retrobulbar blood flow.

2. Patients and methods

Approval for the study was granted by the Local Ethics Committee (Decision no: 779). All patients included in this study had a diagnosis of open angle glaucoma (OAG). Patients were fully informed about the details of the study protocol and written informed consent was obtained from all subjects at the beginning of the study in accordance with the Declaration of Helsinki principles and the good clinical practice guidelines. Twenty eyes of 20 patients with open angle glaucoma were enrolled in a prospective trial and the patients were scheduled for deep sclerectomy. Of the enrolled patients, 11 had primary OAG and 9 had pseudo-exfoliative glaucoma. The mean age of the study population was 58 years (range 35–78 years).

* Correspondence: arzu.ozsoy@hotmail.com

None of the patients suffered from hypertension, diabetes mellitus, or any other cardiovascular disease. The primary exclusion criteria included previous ocular surgery, argon laser trabeculoplasty (ALT), other types of glaucoma such as angle closure glaucoma and neovascular and uveitic glaucoma, and evidence of any other retinal or choroidal vascular disease.

Before surgery, all patients underwent a complete ophthalmic examination, including a review of the medical history, best-corrected visual acuity, biomicroscopy, gonioscopy, fundoscopy with optic disc measurements, and IOP measurement using Goldmann applanation tonometer. For the glaucoma diagnosis, visual field tests were performed with the full-threshold program 30-2 of the Humphrey field analyzer. All the parameters were again evaluated at the follow-up examinations. Deep sclerectomy was performed in accordance with the technique described by Mermoud et al. (10). Surgical treatment was used in all patients without receiving maximal medical treatment.

2.1. Surgical technique

Following retrobulbar anesthesia, a traction suture was inserted in the superior rectus muscle with a 5–0 silk suture. A limbus-based conjunctival incision was made and electrocautery was applied for a short time. A scleral flap, 5 × 5 mm in size and of thickness equal to one third of the sclera, was raised as far as 1 mm clear cornea. A second scleral flap was marked at 1 mm inside the bed of the first scleral flap in the shape of a triangle. The deep flap was excised towards the cornea leaving a thin scleral tissue, exposing the choroidal tissue underneath. At this time aqueous was seen to filtrate from the excised roof of the Schlemm canal. The trabeculo-Descemet's membrane (TDM) was checked and the deep flap was excised including a small part of the anterior corneal stroma. The superficial scleral flap was sutured from two corners with 10–0 nylon sutures and the conjunctiva was sutured continuously with 7–0 vicryl suture. For the first week, dexamethasone eye drops were applied 5 times a day and gentamicin eye drops 4 times a day in all patients. Topical steroid treatment with a gradually tapering dose was administered for the first 2 months postoperatively.

2.2. Color Doppler imaging (CDI)

Retrobulbar blood flow was investigated with CDI. CDI examinations were performed before and 2, 12, and 24 weeks after deep sclerectomy. The same physician performed CDI at the same time of day (between 1400 and 1600) in order to minimize the diurnal hemodynamic variations. All CDI examinations were performed after a 20-min rest in a supine position with GE Logiq 9 (General Electric, Milwaukee, WI, USA). A 7.5-MHz linear array transducer was applied over the closed eyelid**.** The OA was examined approximately 20 mm behind the globe. Temporal and nasal SPCAs were examined approximately 5–10 mm behind the globe and the results were averaged. CRA was examined 5–10 mm behind the globe. Peak systolic velocity (PSV), end diastolic velocity (EDV), and resistance index (RI) [RI = PSV – EDV/PSV] were measured for each case.

Systolic and diastolic blood pressure and heart rate values were recorded during the CDI examinations before and after the operation. OPP was calculated according to the formula OPP = 2/3 [BPd + 1/3 (BPs – BPd)] – IOP, where BPd and BPs are diastolic and systolic brachial blood pressure values, respectively. According to the Hodapp classification, glaucomatous damage was in the middle stage in 16 patients and in the advanced stage in 4 patients (11).

2.3. Statistical analysis

Statistical comparisons of the preoperative and postoperative parameters were made with repeated measures of ANOVA. Pairwise comparisons with Bonferroni adjustment were applied when the change over time was found to be significant. A value of $P < 0.05$ was considered statistically significant.

3. Results

No statistically significant difference was determined between the baseline and postoperative systolic blood pressure levels (Table 1).

Mean IOP was 26.4 ± 1.7 mmHg before DS, 12.3 ± 2.2 mmHg at 2 weeks, 13.4 ± 2.1 mmHg at 12 weeks, and

Table 1. Blood pressure (BP), heart rate, intraocular pressure (IOP), and ocular perfusion pressure (OPP) before and 2, 12, and 24 weeks after deep sclerectomy.

	Preop.	2 weeks	12 weeks	24 weeks	P value
IOP (mmHg)	26.4 ± 1.7	12.3 ± 2.2	13.4 ± 2.1	13.5 ± 2	P < 0.001
OPP (mmHg)	34.4 ± 4.1	47.4 ± 4	47.8 ± 3.8	46.7 ± 7.1	P < 0.001
Systolic BP	115.5 ± 10.7	113.2 ± 9.5	118 ± 8.9	120 ± 6.1	P = 0.12
Diastolic BP (mmHg)	79.3 ± 5.2	77.8 ± 8	78.6 ± 6.9	78.8 ± 5.6	P = 0.88
Heart rate (pulse/min)	71.9 ± 6	71.5 ± 5.8	69.2 ± 6.4	72 ± 4.7	P = 0.35

13.5 ± 2 mm Hg at 24 weeks. None of the patients required antiglaucomatous drugs postoperatively and no laser goniopuncture was applied to any patient. Mean OPP was 34.4 ± 4.1 mmHg before DS, 47.4 ± 4 mmHg at 2 weeks, 47.8 ± 3.8 mmHg at 12 weeks, and 46.7 ± 7.1 mm Hg at 24 weeks. Taking the three measurements into account, the decrease in IOP and increase in OPP were found to be statistically significant ($P < 0.001$) (Table 1) (Figures 1 and 2).

There was no statistically significant difference between PSV measurements of OA ($P = 0.16$). The mean EDV in OA was 10.6 ± 2.3 cm/s before DS, 10.9 ± 2.2 cm/s at 2 weeks, 11.1 ± 2.3 cm/s at 12 weeks, and 11 ± 2.3 cm/s at 24 weeks. The increase in EDV was statistically significant in three measurements ($P < 0.001$). There was no statistically significant difference between the three measurements ($P = 0.91$). The change in RI was not statistically significant ($P = 0.67$).

There was no statistically significant difference between PSV measurements ($P = 0.21$). Mean EDV in CRA was 3.5 ± 1.1 cm/s before DS, 4.5 ± 1.2 cm/s at 2 weeks, 4.7 ± 1 cm/s at 12 weeks, and 4.5 ± 0.9 cm/s at 24 weeks. The increase in EDV was statistically significant in three postoperative measurements ($P < 0.001$) (Figure 3). There was no statistically significant difference between the three measurements ($P = 0.27$). Mean RI was 0.64 ± 0.07 before DS, 0.59 ± 0.06 at 2 weeks, 0.58 ± 0.05 at 12 weeks, and 0.58 ± 0.07 at 24 weeks. The decrease in RI after DS was statistically significant in three measurements ($P < 0.001$) (Figure 4). There was no statistically significant difference between the three measurements ($P = 0.25$).

The change in PSV in SPCAs was not statistically significant ($P = 0.65$). Mean EDV in SPCA was 5.3 ± 1.8

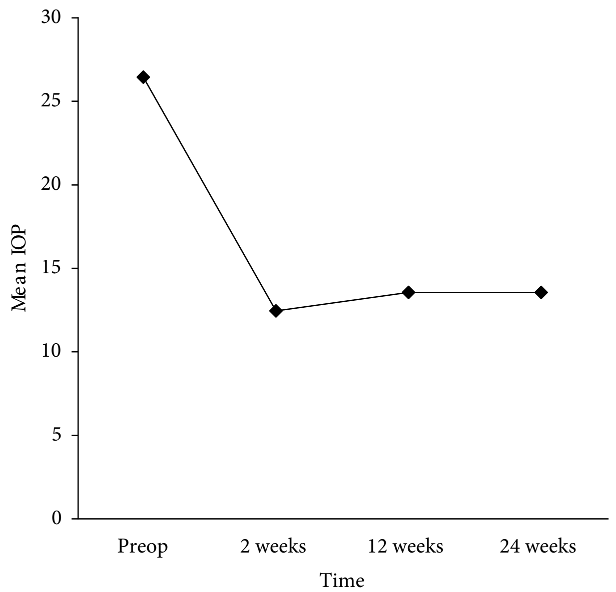

Figure 1. IOP changes after deep sclerectomy ($P < 0.001$).

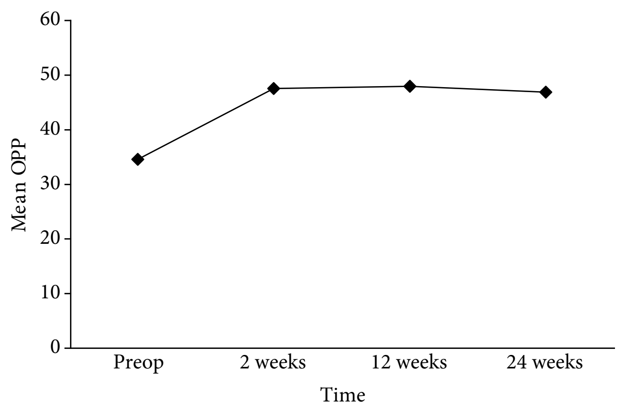

Figure 2. OPP changes after deep sclerectomy ($P < 0.001$).

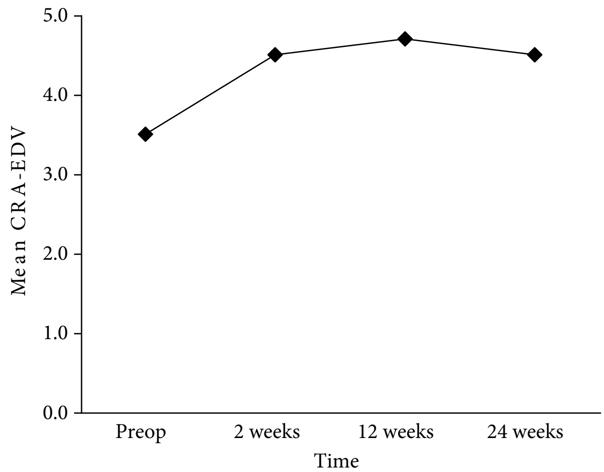

Figure 3. Mean EDV of central retinal artery ($P < 0.001$).

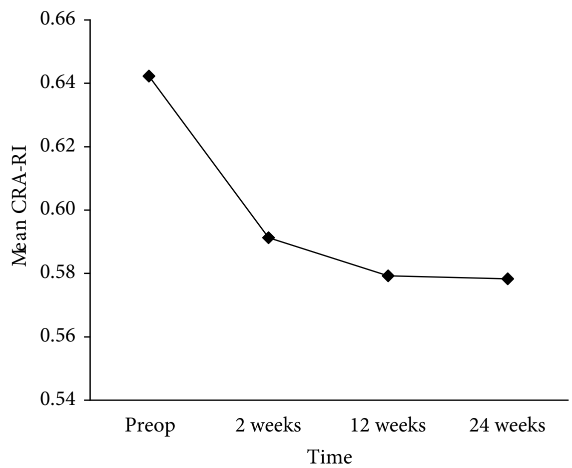

Figure 4. Mean RI of central retinal artery ($P < 0.001$).

cm/s before DS, 6.2 ± 1.5 cm/s at 2 weeks, 6.3 ± 1.7 cm/s at 12 weeks, and 6.2 ± 1.6 cm/s at 24 weeks. The increase was statistically significant in three postoperative measurements (P < 0.001) (Figure 5). There was no statistically significant difference between the three measurements (P = 0.96). Mean RI was 0.64 ± 0.09 before DS, 0.57 ± 0.07 at 2 weeks, 0.57 ± 0.08 at 12 weeks, and 0.57 ± 0.08 cm/s at 24 weeks. The decrease in RI was statistically significant in three postoperative measurements (P < 0.001) (Figure 6) (Table 2). There was no statistically significant difference between the three measurements (P = 0.99).

4. Discussion

In this prospective study, the early effects of deep sclerectomy were evaluated on IOP, OPP, and retrobulbar blood flow in patients with high tension OAG. To the best of our knowledge, this is the second study to evaluate the effect of nonpenetrating deep sclerectomy on ocular blood flow.

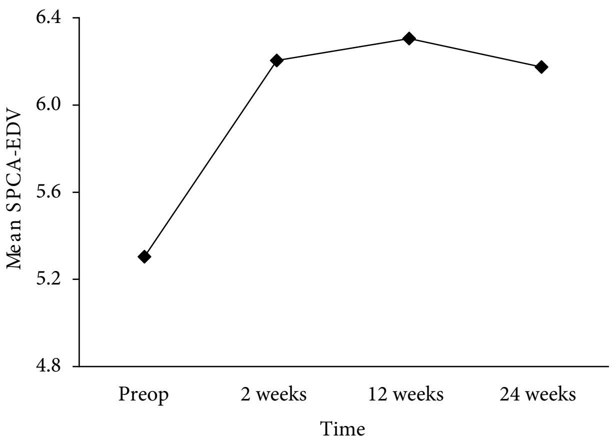

Figure 5. Mean EDV of short posterior ciliary artery (P < 0.001).

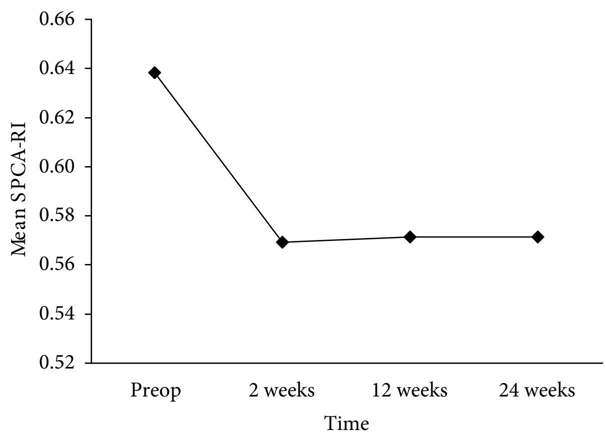

Figure 6. Mean RI of short posterior ciliary artery (P < 0.001).

Flow velocities of CRA and of the central retinal vein are significantly correlated with the size of the neuroretinal rim of the optic disc in POAG. Flow velocities decrease with increasing optic disc damage in glaucoma. EDVs of the OA, CRA, and PCA have been reported to be reduced and RIs to be increased in patients with POAG compared to control subjects (6). In the current study, a decrease was observed in IOP, an increase in OPP, and a significant improvement in retrobulbar blood flow in the measurements taken in postoperative weeks 2, 12, and 24. EDV in OA, CRA, and SPCAs increased significantly and RI in CRA and SPCA decreased significantly. There was no statistically significant difference between the three postoperative examinations with respect to the increase in EDV or the decrease in RI. This is an important finding showing that the improvement in ocular blood flow lasts up to 6 months after deep sclerectomy.

Table 2. Retrobulbar hemodynamic parameters before and 2, 12, and 24 weeks after deep sclerectomy.

Parameter	Preop.	2 weeks	12 weeks	24 weeks	P value
Ophthalmic artery					
PSV (cm/s)	33.9 ± 8.2	35.9 ± 8.1	34.4 ± 8.4	34.6 ± 8.1	P = 0.16
EDV (cm/s)	10.6 ± 2.3	10.9 ± 2.2	11.1 ± 2.3	11 ± 2.3	P < 0.001
RI	0.67 ± 0.09	0.66 ± 0.08	0.67 ± 0.08	0.67 ± 0.08	P = 0.67
Central retinal artery					
PSV (cm/s)	10.5 ± 3.9	11 ± 4.2	11.2 ± 3.4	11.1 ± 3.8	P = 0.21
EDV (cm/s)	3.5 ± 1.1	4.5 ± 1.2	4.7 ± 1	4.5 ± 0.9	P < 0.001
RI	0.64 ± 0.07	0.59 ± 0.06	0.58 ± 0.05	0.58 ± 0.07	P < 0.001
Posterior ciliary artery (mean)					
PSV (cm/s)	14.5 ± 3	14.2 ± 2.7	14.6 ± 3.1	14.5 ± 3.2	P = 0.65
EDV (cm/s)	5.3 ± 1.8	6.2 ±1.5	6.3 ± 1.7	6.2 ± 1.6	P < 0.001
RI	0.64 ± 0.09	0.57 ± 0.07	0.57 ± 0.08	0.57 ± 0.08	P < 0.001

The effect of trabeculectomy on ocular blood flow has been investigated in previous studies and positive results have been recorded. Trible et al. performed trabeculectomy in 20 patients with chronic glaucoma and found an increase in mean velocity and EDV in CRA and SPCA and a statistically significant decrease in RI on CDI measurements. A statistically significant increase was determined in EDV in OA while the change in RI was not significant (6).

The results of the current study are similar to the findings of Trible et al. They suggested that the cause of the positive effect on retrobulbar blood flow after trabeculectomy might be the decrease in external compression on retinal vessels and choroid (6). Deep sclerectomy is nonpenetrating, filtrating glaucoma surgery similar to trabeculectomy. It may also improve retinal and choroidal circulation by effectively decreasing the IOP. In the current study, no change in PSV in CRA or SPCA was determined in relation to optic nerve circulation and a significant increase in EDV and a significant decrease in RI were observed.

A significant increase in OPP was determined in the current study. James reported an increase in pulsatile ocular blood flow (POBF) and OPP in a study on the effect of trabeculectomy on ocular blood flow (7). Poinoossawmy et al. reported that POBF was significantly increased in 23 patients in the surgical group in a retrospective study evaluating the effects of medical and surgical treatment on IOP and POBF in patients with normal tension (12). Following trabeculectomy in 30 open angle glaucoma cases, Berisha et al. found a statistically significant increase in optic nerve head blood flow (ONHBF), OPP, and fundus pulsation amplitude (FPA) and noted that trabeculectomy caused a significant improvement in ocular blood flow in association with the decrease in IOP in chronic open angle glaucoma cases (8). The current study finding of a significant increase in OPP after surgery supports the positive effect of DS on ocular blood flow.

In a study by Galassi et al. (9), one group of patients were treated with deep sclerectomy (n = 22) and another group (n = 19) with trabeculectomy (9). The effects of the treatment methods on blood flow were evaluated at the end of 3 months. Similar improvements were reported in both groups in terms of retrobulbar blood flow. These results were similar to the findings of the current study, where the follow-up period was 6 months. Furthermore, in the current study, the increase in EDV in the central retinal artery and short posterior ciliary artery was more significant. The preoperative and final end diastolic velocities in the ophthalmic arteries were higher in the current study than the results of Galassi et al. (9). It can be speculated that the differences might have resulted from the selection of the reference points for the measurements of PSV and EDV. In the current study, all the measurements were taken approximately 5–10 mm behind the globe. However, there are no details about the measurement method used by Galassi et al. (9).

There are also some studies that have reported results contrary to those mentioned above. Tamaki et al. reported that OPP increased significantly in association with a decrease in IOP after trabeculectomy and needling, but when the laser speckle technique was used the change in ONHBF was minimal (13). Cantor reported that there was no significant change in ocular hemodynamics after trabeculectomy at 3, 6, and 12 months although there was a significant decrease in IOP (14). That is the only report in which it is noted that the antiglaucoma medications were discontinued just before surgery irrespective of the washout period, but in some cases the period without medication was prolonged for up to 4 weeks, which would seem to be very risky in this progressive disease.

Reports related to the effect of topical hypotensive agents on ocular blood flow are also contradictory (15). Most of the current study patients were using a prostaglandin analogue in the preoperative period. It is interesting that there is no consensus on the effects of prostaglandin analogues on ocular blood flow (16–19). In addition, the differences in previous studies with respect to materials, methods, and inclusion and exclusion criteria should be taken into account.

This study had some limitations resulting from CDI. This imaging technique determines the velocity of blood flow at a specific part of a given vessel. Since the diameter of orbital vessels cannot be measured due to the small dimensions, CDI provides information about blood flow velocity. The resistance of the vessels can then be calculated. There is a good correlation between blood volume and blood flow velocity. As the statistical analysis revealed significant differences in EDV and RI between the times examined, the present study could be used as a pilot study for larger consecutive series in the future. Subgroup analysis could not be applied in this study because of the low number of cases in each group. There is a need for further studies with a larger number of cases to analyze the possible differences between subgroups.

In conclusion, the results of this study have shown that deep sclerectomy causes a significant improvement in retrobulbar blood flow in association with a decrease in IOP and an increase in OPP in the early postoperative period. Further studies will be helpful to clarify the effects of deep sclerectomy on ocular hemodynamics in patient with OAG.

References

1. Satilmis M, Orgul S, Doubler B, Flammer J. Rate of progression glaucoma correlates with retrobulbar circulation and intraocular pressure. Am J Opthalmol 2003; 135: 664-669.
2. Fyodorov SN, Kozlov VI, Timoshkina NT. Non-penetrating deep sclerectomy in open angle glaucoma. IRTC Eye Microsurgery. Moscow: RSFSR Ministry of Public Health 1989; 3: 52-55.
3. Kozlov VI, Bagrov SN, Anisimova SY. Non penetrating deep sclerectomy with collagen. IRTC Eye Microsurgery. Moscow: RSFSR Ministry of Public Health 1989; 3: 44-46.
4. Kozobolis VP, Christodoulakis EV, Tzanakis N, Zacharopoulos I, Pallikaris IG. Primary deep sclerectomy versus primary deep sclerectomy with the use of mitomycin C in primary open-angle glaucoma. J Glaucoma 2002; 11: 287-293.
5. Ravinet E, Bovey E, Mermoud A. T-Flux implant versus Healon GV in deep sclerectomy. J Glaucoma 2004; 13: 46-50.
6. Trible JR, Sergott RC, Spaeth GL, Wilson RP, Katz LJ, Moster MR, Schmidt CM. Trabeculectomy is associated with retrobulbar hemodynamic changes. A color Doppler analysis. Ophthalmology 1994; 101: 340-351.
7. James CB. Effect of trabeculectomy on pulsatile ocular blood flow. Br J Ophthalmol 1994; 78: 818-822.
8. Berisha F, Schmetterer K, Vass C, Dallinger S, Rainer G, Findl O, Kiss B, Schmetterer L. Effect of trabeculectomy on ocular blood flow. Br J Ophthalmol 2005; 89: 185-188.
9. Galassi F, Giambene B, Corvi A, Falaschi G, Menchini U. Retrobulbar hemodynamics and corneal surface temperature in glaucoma surgery. Int Ophthalmol 2008; 28: 399-405.
10. Mermoud A, Schnyder CC. Nonpenetrating filtering surgery in glaucoma. Curr Opin Ophthalmol 2000; 11: 151-157.
11. Hodapp E, Parrish HRK, Anderson DR. Clinical Decision in Glaucoma. St Louis, MO, USA: Mosby Comp. 1993; pp. 52-61.
12. Poinoosawmy D, Indar A, Bunce C, Garway-Heath DF, Hitchings RA. Effect of treatment by medicine or surgery on intraocular pressure and pulsatile ocular blood flow in normal pressure glaucoma. Graefes Arch Clin Exp Ophthalmol 2002; 240: 721-726.
13. Tamaki Y, Araie M, Hasegawa T, Nagahara M. Optic nerve head circulation after intraocular pressure reduction achieved by trabeculectomy. Ophthalmology 2001; 108: 627-632.
14. Cantor LB. The effect of trabeculectomy on ocular hemodynamics. Trans Am Ophthalmol Soc 2001; 99: 241-252.
15. Costa VP, Harris A, Stefansson E, Flammer J, Krieglstein GK, Orzalesi N, Heijl A, Renard JP, Serra LM. The effects of antiglaucoma and systemic medications on ocular blood flow. Prog Retin Eye Res 2003; 226: 769-805.
16. Seong GJ, Lee HK, Hong YJ. Effects of 0.0005% latanoprost on optic nerve head and peripapillary retinal blood flow. Ophthalmologica 1999; 213: 355-359.
17. Akarsu C, Yılma S, Taner P, Ergin A. Effect of bimatoprost on ocular circulation in patients with open angle glaucoma or ocular hypertension. Graefes Arch Clin Exp Ophthalmol 2004; 242: 814-818.
18. Akarsu C, Bilgili YK, Taner P, Unal B, Ergin A. Short-term effect of latanoprost on ocular circulation in ocular hypertension. Clin Experiment Ophthalmol 2004; 32: 373-377.
19. Martinez A, Sanchez M. Retrobulbar haemodynamic effects of the latanoprost/timolol and the dorzolamide/timolol fixed combinations in newly diagnosed glaucoma patients. Int J Clin Pract 2007; 61: 815-825.