Preoperative and Postoperative Ocular Blood Flow in Cases with Cataract and Pseudoexfoliation Syndrome

Katarakt ve Psödoeksfoliasyon Sendromlu Hastalarda Operasyon Öncesi ve Sonrası Oküler Kan Akımı

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ABSTRACT Objective: To compare orbital blood flow parameters in patients having cataract with and without pseudoexfoliation syndrome before and after cataract surgery. **Material and Methods:** In this prospective study; 54 cases (79 eyes) taken into the study were monitored and treated in the 1st Ophthalmology Clinic and Radiology Clinic, Atatürk Training and Research Hospital. Of those, 31 cases (43 eyes) had cataract and pseudoexfoliation syndrome, 23 cases (36 eyes) had only cataract (control group). Color Doppler imaging was performed to measure ocular blood flow parameters preoperatively and 21 days after cataract operation in each case. Preoperative and postoperative values of resistive indices and pulsatility indices in the ophthalmic, central retinal and posterior ciliary arteries were compared. **Results:** When compared preoperatively with the control group, cases with pseudoexfoliation syndrome showed no statistically significant difference in the resistivity index values of the ophthalmic artery (0.77 ± 0.08; P= 0.356), the central retinal artery (0.80 ± 0.11; P= 0.711) or posterior ciliary arteries (0.79 ± 0.10; P= 0.097). Preoperative pulsatility index values of patients with pseudoexfoliation syndrom in the ophthalmic artery (1.72 ± 0.38; P= 0.548), the central retinal artery (1.85 ± 0.54; P= 0.269), or posterior ciliary arteries (1.81 ± 0.54; P= 0.074) were not statisticaly significantly different than control group. When compared postperatively with the control group, patients with pseudoexfoliation syndrome showed no statistically significant difference in the resistivity index values of the ophthalmic artery (0.78 ± 0.07; P= 0.126), the central retinal artery (0.83 ± 0.08; P= 0.225), posterior ciliary arteries (0.79±0.10; P=0.496) and in the pulsatility index values of the ophthalmic artery (1.69±0.38; P=0.356), the central retinal artery (2.05 ± 0.55; P= 0.364), posterior ciliary arteries (1.74 ± 0.47; P= 0.393). Cases with pseudoexfoliation syndrome showed no statisticaly significant difference between preoperative and postoperative values of resistive indices and pulsatility indices in the ophthalmic, central retinal and posterior ciliary arteries with the exception of pulsality index of central retinal artery having a higher postoperative (2.05 ± 0.55) than preoperative (1.85 ± 0.54) value (P= 0.043). On the other hand, preoperative and postoperative values of resistive indices and pulsatility indices in the ophthalmic, central retinal and posterior ciliary arteries were not significantly different in control group. **Conclusion:** In patients with pseudoexfoliation syndrome, all studied retroorbital blood flow parameters did not show any significant changes except an increase in postoperative pulsality index in the central retinal artery.

Key Words: Ultrasonography, Doppler, color; cataract; surgery; exfoliation syndrome

ÖZET Amaç: Psödoeksfoliasyon sendromu olan ve olmayan kataraktlı hastalarda katarakt ameliyatı öncesi ve sonrası retroorbital kan akımı parametrelerini karşılaştırmak. **Gereç ve Yöntemler:** Bu prospektif çalışmaya alınan 54 vaka (79 göz) Atatürk Eğitim ve Araştırma Hastanesi 1. Göz Kliniği ve Radyoloji Kliniği'nde tedavi ve takip edildi. Bunlardan 31 vakada (43 göz) katarakt ile birlikte psödoeksfoliasyon sendromu mevcut iken, 23 vakada (36 göz) yalnızca katarakt mevcut idi (kontrol grubu). Oküler kan akımı parametrelerini ölçmek için her vakada katarakt ameliyatı öncesi ve katarakt ameliyatından 21 gün sonra renkli Doppler görüntüleme yapıldı. Ameliyat öncesi ve sonrası oftalmik arter, santral retinal arter ve posterior silier arterlerdeki resitivite indeks ve pulsatilite indeks değerleri karşılaştırıldı. **Bulgular:** Psödoeksfoliasyon sendromu olan vakalar kontrol grubu ile ameliyat öncesi karşılaştırıldığında, oftalmik (0.77 ± 0.08; P= 0.356), santral retinal (0.80 ± 0.11; P= 0.711) ve posterior silier arterlerde (0.79 ± 0.10; P= 0.097) resitivite indeks değerleri istatiksel olarak anlamlı farklılık göstermedi. Psödoeksfoliasyon sendromu olan hastaların ameliyat öncesi oftalmik arter (1.72 ± 0.38; P= 0.548), santral retinal arter (1.85 ± 0.54; P= 0.269) ve posterior silier arterdeki (1.81 ± 0.54; P= 0.074) pulsatilite indeksi değerleri kontrol grubundan istatiksel olarak anlamlı farklı değildi. Psödoeksfoliasyon sendromu olan vakalar kontrol grubu ile ameliyat sonrası karşılaştırıldığında, oftalmik (0.77 ± 0.08; P= 0.356), santral retinal (0.80 ± 0.11; P= 0.711), posterior silier arter (0.79 ± 0.10; P= 0.097) resitivite indeks değerleri ve oftalmik (1.69 ± 0.38; P= 0.356), santral retinal (2.05 ± 0.55; P= 0.364), posterior silier arter (1.74 ± 0.47; P= 0.393) pulsatilite indeks değerleri istatiksel olarak anlamlı farklılık göstermedi. Psödoeksfoliasyon sendromu olan vakaların ameliyet öncesi ve sonrası oftalmik, santral retinal ve posterior silier arterlerdeki rezitivite indeks ve pulsatilite indeks değerleri, santral retinal arter pulsatilite indeks ameliyat sonrası (2.05 ± 0.55) değerinin ameliyat öncesi (1.85 ± 0.54) değerine göre yüksek olması (P= 0.043) dışında istatiksel olarak anlamlı farklılık göstermedi. Diğer taraftan, kontrol grubunda ameliyat öncesi ve ameliyat sonrası oftalmik, santral retinal ve posterior silier arterlerde resitivite indeks ve pulsatilite indeks değerleri istatiksel olarak anlamlı farklı değildi. **Sonuç:** Psödoeksfoliasyon sendromu hastalarında ameliyat sonrası santral retinal arter pulsatilite indeksinde saptanan artış dışında, incelen tüm retroorbital kan akımı parametreleri katarakt ameliyatı sonrasında anlamlı bir değişim göstermemiştir.

Anahtar Kelimeler: Renkli Doppler Ultrason; katarakt; cerrahi; eksfoliasyon sendromu

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PURPOSE

Pseudoexfoliation syndrome is a systemic disease characterized by the presence of dust like pseudoexfoliative material in ocular tissues.[1] Changes in ocular blood flow was reported in pseudoexfoliation syndrome.[2]

Although it was reported that some ocular blood flow changes observed in cataract patients in contrast to healthy controls, it is not clear how ocular blood flow changes after cataract operation.[3-4] This question is more controversial in cataract cases with pseudoexfoliation syndrome.

Color Doppler imaging is a safe and noninvasive method allowing evaluation of orbital blood flow parameters. It has been increasingly used in the assessment of many disorders that affect orbital hemodynamics.[5-9]

In this study, we investigated orbital blood flow parameters in patients having cataract with or without pseudoexfoliation syndrome. Blood flow resistive indices and pulsatility indices in the ophthalmic, central retinal, nasal posterior ciliary and temporal posterior ciliary arteries were assessed using color Doppler ultrasound (CDUS).

MATERIAL AND METHODS

In this prospective study; 54 cases, monitored in the 1. Ophthalmology Clinic taken into the study. Of those, 31 cases (43 eyes) had cataract and pseudoexfoliation syndrome, 23 cases (36 eyes) had cataract alone. This study was approved by the institutional ethical committee. The research followed the tenets of the Declaration of Helsinki. Written informed consent was also obtained from each participant before the study started.

Evaluation of visual acuity tests, biomicroscopy of the anterior segment, measurement of intraocular pressure with applanation tonometry, gonioscopy, and funduscopic examination using a Goldmann three-mirror contact lens were performed in all patients. Biomicroscopy and fundus examinations were repeated after mydriasis was achieved by application of phenylephrine HCL 2.5% (Mydfrin^{R} Eye Drop, Alcon) eye drops three times, five minutes apart. Pseudoexfoliation syndrome was defined as the presence of pseudoexfoliative material on the lens capsule or near the pupil or as the presence of transillumination defects near the pupil accompanied by normal optic disc findings and an intraocular pressure (IOP) less than 21 mmHg.[10,11] Previous or current history of any topical or systemic drug use was recorded. Patients with eye diseases other than cataract and pseudoexfoliation syndrome and those with diabetes mellitus or any other systemic and/or cardiovascular diseases and a history of transient ischemic attacks or stroke were excluded.

Color Doppler ultrasound was performed using a 7.5-14 MHz multifrequency linear array transducer (GE, Logic 9, Milwaukee, USA). All examinations were performed while the patients were in supine position with their eyes closed. At the beginning of each study, optic nerve that provides the most useful landmark for the identification of the retrobulbar vessels was located. The ophthalmic artery is situated above or below the optic nerve in the posterior orbit and passes forward into the nasal orbit in a horizontal plane slightly superior to that of the optic nerve. These vessels were examined approximately 25 mm behind the globe in the nasal orbit when the vessels were in a straight position at the site where the most reliable results could be obtained. The central retinal artery was detectable at approximately 10 mm behind the retrolaminar portion of the optic nerve, where it exhibited a straight course. The posterior ciliary arteries begin as trunks approximately 10 to 20 mm behind the globe, before they form multiple branches surrounding the optic nerve in its retrobulbar portion. This location was chosen as the most appropriate site for CDUS, at the point were it was possible to identify and assess reliably the nasal and temporal posterior ciliary arteries. In each artery resistivity index (RI) and pulsatility index (PI) were obtained.

Ultrasonographic evaluation was performed by the same radiologist (MG) who was unaware of the clinical diagnoses before the surgery.

Cataract surgery was performed using subtenon anesthesia comprising 2.5 ml lidocaine hydrochloride 2% (Jetocaine^{R} Adeka Inc, Samsun,

Turkey). A 3.2 mm wide clear corneal tunnel incision was made. After phacoemulsification, a flexible IOL (OcuFlex^{R}, Polymer Technologies Int. EOU, Gujarat, India) was implanted in the capsular bag. Sodium hyaluronate (Cohaerens^{R}, LCA Pharmaceutical, Chartres, France) was then thoroughly aspirated. Postoperative treatment consisted of prednisolone acetate (Predforte^{R},) and oflaxocin 0.3% (Exocin^{R}, Westport Co, Mayo, Ireland) eyedrops four times daily. Posterior capsule rupture or vitreus loss was not observed in any case. Postoperative color Doppler imaging examination was repeated in 21st postoperative day. CDUS examination was repeated in 21st postoperative day. A detailed ophthalmological examination including visual acuity assesment, biomicroscopic examination, fundus examination and IOP measurement were performed for all cases in the same visit.

The results were expressed as mean ± standard deviation. Using the NCSS 2007 statistical package, statistical analyses of continuous data were made through student unpaired t-test and paired t-test. Categoric data were analyzed by the chi-square test. A p value of less than 0.05 was considered statistically significant.

RESULTS

Patients were divided into two groups. First group was 31 patients who had both pseudoexfoliation syndrome and cataract. Second group was 23 patients with cataract alone. Mean age of patients was 72.2 ± 5.2 year in the first group and 69.8 ± 9.3 years in the second group (p= 0.01). Male/female ratio was 23/8 in pseudoexfoliation syndrome group however that ratio was 12/11 in control group. Although number of male cases was higher in pseudoexfoliation syndrome group, there was no significant difference between the groups (p= 0.094).

When both groups were compared with regard to preoperative CDUS measurement there were no statistically significant differences between two groups in any of the parameters. All preoperative values of PI and RI and significance of difference between group A (cataract patients with pseudoexfoliation syndrome) and group B (cataract patients) are shown in Table 1.

Preoperative central retinal artery measurements revealed very similar values for both RI and PI values in two groups. Lower mean pulsatility index value and higher mean resistivity index value in posterior ciliary artery were observed in group A. Cases in group A have a tendency to increased resistivity and decreased elasticity especially in small vessels, however the difference between two groups was not significant.

Comparison of group A and group B with regard to postoperative Doppler measurements revealed that both groups had similar values. Statistical analysis of all parameters between groups failed to show significant difference between groups. In Table 2 results of all CDUS measurements and p values are summarized.

TABLE 1: Preoperative resistivity index (RI) and pulsatility index values in group A* and group B**.

	Group A	Group B	p Value
Ophthalmic Artery			
Pulsatility Index	1.72±0.38	1.66±0.51	0.548
Resistivity Index	0.77±0.08	0.76±0.09	0.356
Central Retinal Artery			
Pulsatility Index	1.85±0.54	1.99±0.63	0.269
Resistivity Index	0.80±0.11	0.81±0.09	0.711
Posterior Ciliary Artery			
Pulsatility Index	1.81±0.54	1.61±0.42	0.074
Resistivity Index	0.79±0.10	0.75±0.10	0.097

* Patients with pseudoexfoliation syndrome and cataract.
** Patients with only cataract.

TABLE 2: Postoperative resistivity index and pulsatility index values in group A* and in group B**.

	Group A	Group B	p Value
Ophthalmic Artery			
Pulsatility Index	1.69±0.38	1.70±0.63	0.981
Resistivity Index	0.78±0.07	0.75±0.09	0.126
Central Retinal Artery			
Pulsatility Index	2.05±0.55	1.93±0.59	0.364
Resistivity Index	0.83±0.08	0.81±0.07	0.225
Posterior Ciliary Artery			
Pulsatility Index	1.74±0.47	1.64±0.50	0.393
Resistivity Index	0.79±0.10	0.77±0.11	0.496

* Patients with pseudoexfoliation syndrome and cataract.
** Patients with only cataract.

Preoperative tendency of lower PI and RI values in the central retinal artery and in the posterior ciliary arteries seemed to disappear postoperatively.

Preoperative and postoperative Doppler measurements changes in ophthalmic artery and posterior ciliary arteries were not significant in the cases with pseudoexfoliation syndrome. Although RI values were lower preoperatively in central retinal artery, the difference was not significant (p= 0.147). On the other hand, postoperative PI in central retinal artery was significantly higher (p= 0.043). All preoperative and postoperative CDUS measurements and p values are shown in Table 3.

In group B there was no significant difference between preoperative and postoperative CDUS measurements in ophthalmic artery, central retinal artery or posterior ciliary arteries. In Table 4, preoperative and postoperative PI and RI and p values are shown.

Intraocular pressure measurements were significantly different between pseudoexfoliation group and control group both preoperatively and postoperatively. On the other hand, both in pseudoexfoliation group and control group, preoperative mean IOP levels were not significantly different than postoperative mean IOP levels. Mean IOP measurements and p values after comparisons of groups are shown in Table 5.

TABLE 3: Preoperative and Postoperative Resistivity Index (RI) and Pulsatility Index (PI) Values in Group A*

	Preoperative	Postoperative	p Value
Ophthalmic Artery			
Pulsatility Index	1.72±0.38	1.69±0.38	0.617
Resistivity Index	0.77±0.08	0.78±0.07	0.782
Central Retinal Artery			
Pulsatility Index	1.85±0.54	2.05±0.55	**0.043**
Resistivity Index	0.80±0.11	0.83±0.08	0.147
Posterior Ciliary Artery			
Pulsatility Index	1.81±0.54	1.74±0.47	0.323
Resistivity Index	0.79±0.10	0.79±0.10	0.933

*Patients with pseudoexfoliation syndrome and cataract.

TABLE 4: Preoperative and Postoperative Resistivity Index (RI) and Pulsatility Index (PI) Values in Group B*

	Preoperative	Postoperative	p Value
Ophthalmic Artery			
Pulsatility Index	1.66±0.51	1.70±0.63	0.692
Resistivity Index	0.76±0.09	0.75±0.09	0.651
Central Retinal Artery			
Pulsatility Index	1.99±0.63	1.93±0.59	0.555
Resistivity Index	0.81±0.09	0.81±0.07	0.720
Posterior Ciliary Artery			
Pulsatility Index	1.61±0.42	1.64±0.50	0.759
Resistivity Index	0.75±0.10	0.77±0.11	0.359

* Patients with only cataract.

TABLE 5: IOP measurements in PEX and control groups preoperatively and postoperatively

	PEX	CONTROL	P*
PREOPERTIVE	16.3±2.4	14.2±3.1	0.001
POSTOPERATIVE	15.2±3.1	13.6±2.7	0.017
p**	0.069	0.384	

P*: P values as result of unpaired t- test comparision between PEX and control groups.
p**: P values as a result of paired t-test comparion of preoperative and postoperative IOP measurements both in PEX and control groups.

DISCUSSION

Cataract is the most common cause of reversible visual loss worldwide. Although cataract surgery is highly successful, some concomitant disorders like pseudoexfoliation syndrome may increase the risk of surgery. Cataract develops in most of the pseudoexfoliation cases. Pseudoexfoliation syndrome has been shown to be a systemic disorder with pronounced vascular damage.[10,11] Vascular alterations in pseudoexfoliation are associated with increased permeability, obstruction and loss of small vessels, neovascularization and elevated RI of the ophthalmic artery.[12] These changes are probably the results of accumulation of pseudoexfoliation material in the vessel walls.[12,13] These pseudoexfoliation fibers are consistently associated with fibroblasts, collagen and elastic fibers.[14] It has also been shown that pseudoexfoliative material is associated with elastosis in the vascular wall.[15] Pseudoexfoliation material is accumulated in the vascular endothelial cells,

smooth muscle cells and pericytes; all these cell types have a regulatory role in local microcirculation.[14]

Hollo et al. suggested that microcirculation is altered in pseudoexfoliation glaucoma and that this was a generalized process in the body.[16] In addition, Mitchell et al. showed that pseudoexfoliation may be associated with vascular disease or vascular risk factors.[15] It could be speculated that the decreased retrobulbar blood flow in patients with pseudoexfoliation syndrome could be contributed to pseudoexfoliation material accumulation in a vessel wall.

Our study showed that there were no statistically significant difference in most of the retrobulbar blood flow parameters according to CDUS measurements between isolated cataract cases and cataract cases with pseudoexfoliation. Only postoperative PI in central retinal artery was significantly higher in pseudoexfoliation group. PI and RI values give more reliable information about vascular flow pattern. RI is an indirect indicator of blood flow velocity. Both RI and PI are reliable indices for evaluation of end organ resistance. RI is an indicator of end organ resistance to blood flow but PI is more prone to changes in vessel elasticity and systemic blood pressure.[17]

Grieshaber et al. reported that lower local blood flow velocity in the ophthalmic artery seemed to be associated with the presence of cataracts.[18] Spraul et al. reported a decrease in pulsatile ocular blood flow measured with an ocular blood flow tonograph on the third day after cataract surgery.[19] A neural mechanism triggered by cataract extraction causing this temporary decrease was discussed. In principle, several factors could account for a change in ocular blood flow after cataract surgery. A postoperative increase in IOP may occur especially in the first 24 hours postoperatively.[20-22] This increase may lead to a concomitant decrease in ocular perfusion pressure. However, there is evidence that retinal vessels have autoregulation over a wide range of perfusion pressure.[23,24]

In case of an IOP increase that reduces ocular perfusion pressure beyond the lower level of autoregulation, ocular blood flow will certainly decrease. In patients with compromised autoregulation, this problem may be more severe. Anesthetic agents and other drugs can have local effects on choroidal and retinal blood flow.[25]

Our study indicates that blood flow measurements did not change postoperatively in isolated cataract cases. Doppler measurements in ophthalmic artery and posterior ciliary artery also did not change statistically significantly in cases with pseudoexfoliation syndrome group. PI was found to be higher postoperatively in central retinal artery. Postoperative RI had a tendency lower postoperatively. These two finding may be interpreted as a sign of positive effect of cataract surgery on orbital blood flow in cases with pseudoexfoliation syndrome. Several factors influence orbital blood flow measurement with color Doppler imaging, including age, systemic blood pressure, blood viscosity, and stenosis of the carotid artery.[26,27] Orbital blood flow velocities are also affected by increased intraocular pressure. In this study, there was no significant difference between preoperative and postoperative IOP measurements in either in pseudoexfoliation or control groups. For this reason we do not consider that IOP has a significant effect on changes in blood flow measurements. However, recent studies have shown that an artificially increased intraocular pressure affects the hemodynamics of posterior ciliary artery and central retinal artery while leaving the hemodynamics of the ophthalmic artery intact.[28,29]

Repeatibility of Doppler measurements are a concern in blood flow studies. Differences in the angle of measurement and location of probe may hinder repeatibility. Due to this concern for repeatibility, a possible difference among measurements in different time periods may be counted as a weakness for our study. However all Doppler measurements were done by the same investigator and with a standart method. That is why we suppose that variances among measurements do not cause a significant effect on the results. Another possible factor for variations among different measurements is the real time changes, in pulse or in systemic blood pressure, occuring during measu-

rements. Subjects were not monitored during Doppler examinations. Considering those two points, for repeatibility and real time circulatory status changes, our results must be evaluated carefully.

The findings of this study suggest that, in patients with pseudoexfoliation syndrome, cataract surgery does not make a significant change in retroorbital blood flow parameters except an increase in postoperetavie PI in the central retinal artery.

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