Relationship Between Optical Coherence Tomography Signal Strength and Visual Acuity in Cataract Patients

Kataraktlı Hastalarda Optik Koherens Tomografi Sinyal Gücü ve Görme Keskinliği Arasındaki İlişki

Erdem DİNÇ[1], Mustafa VATANSEVER[2], Özer DURSUN[3], Gülhan Ö. TEMEL[4], Ayşe Ayça SARI[5], Ufuk ADIGÜZEL[5]

ABSTRACT

Purpose: To investigate the relationship between optical coherence tomography (OCT) signal strength and visual acuity in cataract patients and evaluate the effect of cataract on OCT measurements.

Materials and Methods: Twenty-one eyes of 18 patients with cataract were included in the study. Patients with other associated ocular pathology were excluded. After ophthalmologic examination, mydriasis was induced with 0.5% tropicamide and OCT images were acquired. The same assessment was conducted at 1 month after cataract surgery and obtained values were compared with baseline.

Results: Mean best corrected visual acuity (BCVA) of the study group was 0.15 ± 0.10 preoperatively and 0.84 ± 0.07 postoperatively and the difference was statistically significant (p<0.001). There was a significant positive correlation between preoperative BCVA and OCT signal strength (p<0.001). Similarly, significant positive correlations were observed between preoperative signal strength and central retinal thickness (CRT), macular volume (MV), and peripapillary nerve fiber thickness (PNFT) (p<0.001, p<0.001, p=0.005, respectively). In addition, CRT, MV, PNFT, and signal strength increased significantly postoperatively (p<0.001 for all). However, OCT signal strength was not correlated with postoperative BCVA, CRT, MV, or PNFT (p=0.85, p=0.99, p=0.89, and p=0.1, respectively).

Discussion: OCT signal strength can provide objective data such as visual acuity in patients planned for cataract surgery. However, the presence of cataract may seriously impact the accuracy of values obtained by OCT.

Keywords: Cataract, optical coherence tomography, signal strength, visual acuity.

ÖZ

Amaç: Kataraktlı hastalarda optik koherens tomografi (OKT) sinyal gücü ve görme keskinliği arasındaki ilişkiyi araştırmak ve kataraktın OKT ölçümleri üzerindeki etkisini değerlendirmek.

Materyal-Metod: Çalışmaya 18 hastanın 21 gözü dahil edildi. Katarakt dışında ön segment ya da arka segment patolojisi bulunan ve cerrahiye bağlı komplikasyon gelişen hastalar çalışma dışında bırakıldı. Hastaların oftalmolojik muayenesi yapıldıktan sonra %0.5'lik tropikamid ile pupilla dilatasyonu sağlandı ve OKT görüntüleri alınarak kaydedildi. Katarakt cerrahisini takiben aynı uygulama postoperatif 1. ayda tekrarlandı ve elde edilen veriler kaydedilerek cerrahi öncesi verilerle karşılaştırıldı.

Bulgular: Çalışmaya dahil edilen hastaların preoperatif en iyi düzeltilmiş görme keskinlikleri (EİDGK) 0.15 ± 0.10 iken postoperatif 0.84 ± 0.07 idi ve aradaki fark istatistiksel olarak anlamlıydı (p<0.001). Preoperatif EİDGK ile OKT sinyal gücü arasında anlamlı pozitif korelasyon mevcuttu (p<0.001). Benzer şekilde preoperatif sinyal gücü ile santral retinal kalınlık (SRK), maküla hacmi (MH) ve peripapiller sinir lifi kalınlığı (PSLK) arasında anlamlı pozitif korelasyon saptandı (sırasıyla p<0.001, p<0.001 ve p=0.005). Aynı zamanda SRK, MH, PSLK ve sinyal gücü postoperatif anlamlı artış gösteriyordu (Her bir parametre için p<0.001). Ancak postoperatif EİDGK, SRK, MH ve PSLK ölçümleri ile OKT sinyal gücü arasında anlamlı bir korelasyon yoktu (sırasıyla p=0.85, p=0.99, p=0.89 ve p=0.1).

Tartışma: OKT sinyal gücü katarakt cerrahisi planlanan hastalar için tıpkı görme keskinliği gibi objektif veri sağlayabilir. Ayrıca hastadaki katarakt varlığı OKT ile elde edilen sayısal verilerin doğruluğunu ciddi şekilde etkileyebilmektedir.

Anahtar Kelimeler: Katarakt, optik koherens tomografi, sinyal gücü, görme keskinliği.

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1- Yrd. Doç. Dr., Mersin Üniversitesi Tıp Fakültesi, Göz Hastalıkları Ana Bilim Dalı, Mersin

2- Uz. Dr., Toros Devlet Hastanesi, Göz Hastalıkları Kliniği, Mersin

3- Uz. Dr., Mersin Devlet Hastanesi, Göz Hastalıkları Kliniği, Mersin

4- Doç. Dr., Mersin Üniversitesi Tıp Fakültesi, Biyoistatistik Ana Bilim Dalı, Mersin

5- Prof. Dr., Mersin Üniversitesi Tıp Fakültesi, Göz Hastalıkları Ana Bilim Dalı, Mersin

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Yazışma Adresi / Correspondence Adress:
Erdem DİNÇ
Mersin Üniversitesi Tıp Fakültesi, Göz Hastalıkları Ana Bilim Dalı, Mersin

Phone: +90 324 241 0000
E-mail: erdem_dinc@hotmail.com

INTRODUCTION

Optical coherence tomography (OCT) was first developed in 1990 by Huang et al and provides objective data regarding the macula and optic nerve.[1] The first OCT devices used in the clinic were time domain OCT instruments. The following years saw the development of spectral domain OCT instruments, which allow faster scanning and provide higher resolution images compared to time domain OCT.[2-4] Image quality was described as signal-noise ratio in early devices, but in later models started to be expressed as signal strength. With each scan, the instrument displays the signal strength to the operator; as signal strength increases, image quality increases. Segal et al have suggested that a signal strength of 5 is clinically enough to evaluation of healthy subjects.[5] The instruments' user manuals also specify recommended minimum signal strength for image evaluation. Signal strength may be affected by operator technique, eye and head movements during scan acquisition, and anterior or posterior segment opacities in the eye.[6] Cataract is also an important and common factor that influences signal strength.[7] The aim of the present study was to investigate the relationship between OCT signal strength and visual acuity in cataract patients and evaluate the effect of cataract on OCT measurements.

MATERIALS AND METHODS

Twenty-one eyes of 18 patients who presented to Mersin University School of Medicine, Department of Ophthalmology with complaints of reduced vision and were diagnosed with cataract were included. Patients with any anterior or posterior segment pathology other than cataract were excluded. Best corrected visual acuity (BCVA) was evaluated by Snellen chart. After a complete ophthalmologic examination, mydriasis was induced with 0.5% tropicamide and OCT images were acquired by selecting the macula and optic nerve scan procedure on the instrument (Stratus OCT, Carl Zeiss Meditec, Dublin, CA, USA). In addition, signal strength was measured by OCT automatically. All patients in the study underwent phacoemulsification and intraocular lens implantation performed by the same surgeon with no complications. Patients were treated postoperatively with topical 0.5% moxifloxacin and 1.5% prednisolone. At postoperative 1 month, BCVA was reassessed and postoperative OCT images were acquired after pupil dilation as described above. All OCT scans were done by the same operator; scans were repeated in cases with movement-related artifacts. The relationship between pre- and postoperative values and visual acuity, and the effect of surgery on these values were statistically analyzed. Statistical Package for the Social Sciences (SPSS) version 11.5 software was used for statistical analysis. Distribution normality was tested for each parameter using the Shapiro-Wilks test. Pre- and postoperative values were compared using Wilcoxon test. Means and standard deviations were calculated for each parameter. Spearman's correlation coefficient (rho) was calculated to describe relationships between parameters. p values < 0.05 were accepted as statistically significant.

RESULTS

Mean BCVA of the study group was 0.15 ± 0.10 preoperatively and 0.84 ± 0.07 postoperatively; the difference was statistically significant ($p<0.001$). There was a significant positive correlation between preoperative BCVA and OCT signal strength ($p<0.001$). Similarly, significant positive correlations were observed between preoperative signal strength and central retinal thickness (CRT), macular volume (MV), and peripapillary nerve fiber thickness (PNFT) ($p<0.001$, $p<0.001$, $p=0.005$, respectively). BCVA was significantly correlated with CRT and MV ($p=0.01$ and $p=0.05$, respectively), but not with PNFT ($p=0.87$). CRT, MV, PNFT, and signal strength increased significantly postoperatively ($p<0.001$ for all) (Table 1). However, OCT signal strength was not correlated with postoperative BCVA, CRT, MV, or PNFT ($p=0.85$, $p=0.99$, $p=0.89$ and $p=0.1$).

DISCUSSION

Optical coherence tomography has become an indispensable tool for both diagnosing and monitoring macular diseases and glaucoma in current practice. With the widespread clinical use of these instruments, certain technical details of OCT have gained attention. One of these details is signal strength

Table 1. *Pre- and postoperative best corrected visual acuity, central retinal thickness, macular volume, peripapillary nerve fiber thickness and signal strength values are expressed as mean ± standard deviation.*

	Preoperative	Postoperative	p value
Best corrected visual acuity	0.15 ± 0.10	0.84 ± 0.07	<0.001
Central retinal thickness (micron)	149.62 ± 98.74	248.29 ± 49.60	<0.001
Macular volume (mm^3)	7.16 ± 3.34	9.60 ± 0.95	<0.001
Peripapillary nerve fiber thickness (micron)	55.95 ± 32.16	89.35 ± 20.49	<0.001
Signal strength	1.19 ± 1.17	3.52 ± 1.03	<0.001

(previously described as signal-to-noise ratio) and its close relationship with the image quality of acquired scans. A signal strength of 5 is clinically as efficient as a signal strength of 8 in healthy subjects to evaluate macular thickness.[5] Previous studies established that OCT measurements can be affected by factors like age and race, as well as signal strength.[6,8-15] Eye and head movements, improper scanning technique, and anterior or posterior segment opacities are known to affect signal strength.

Kim et al demonstrated that cataract can affect both signal quality and RNFT measurement.[8] In another study, Nakatani et al observed that in patients with cataract there was a correlation between signal quality and OCT measurements and cataract was responsible for segmentation errors.[16] Mwanza et al claimed that cataract surgery did not have an effect on retinal nerve fiber thickness measurements in patients with preoperative signal strength of 6 or higher.[17] In the present study, we observed a reduction in signal strength with cataract, and this reduction correlated with lower values for CRT, MV, and PNFT. In contrast to reports in the literature, we saw a significant correlation between signal strength and preoperative visual acuity in patients with cataract. This result may be evidence that OCT signal strength can provide objective data such as visual acuity in patients planned for cataract surgery. However, Na et al reported that there was no relation between cataract density and signal quality in patients with glaucoma. They attributed this result to their inclusion of many patients who were young and had less dense cataract.[18] In the present study, we also found that visual acuity was positively correlated with CRT and MV. This indicates that measurements obtained from cataract patients with low visual acuity are not reliable.

Previous studies have shown that signal strength can influence measurements not only in cataract patients, but also in healthy individuals. Cheung et al reported that retinal nerve fiber thickness measurements increased as signal quality increased in a study of healthy subjects.[9] In another study including healthy children, differences in macular measurements were nonsignificant, but optic nerve head values differed significantly between those with high and low signal strength.[10] In the present study, the positive correlations between visual acuity and MV, CRT, and PNFT that we observed preoperatively disappeared at the signal strengths obtained after cataract removal, and significant increases in all parameters were observed postoperatively. This result demonstrates that the relationship between measured values and signal strength does not persist after factors which reduce signal strength (such as cataract) are eliminated. Considering that none of the patients in our study had any ocular pathology other than cataract, this result differs from the study conducted by Cheung et al.

In summary, cataract significantly impacts signal strength and measurements obtained with OCT, which may make preoperative evaluation of cataract patients challenging. For this reason, measurements taken in patients with cataract cannot be considered reliable. However, the present study demonstrates that signal strength is correlated with preoperative visual acuity. This suggests that signal strength can provide objective data like visual acuity in these patients. Signal strength can give the clinician an idea about cataract density aside from physical examination and provide information about visual prognosis in patients with ocular pathology other than cataract. Considering that OCT is a noninvasive technique that can be used quickly and easily with patients of all ages, OCT evaluation of cataract patients prior to cataract surgery and taking signal strength into account is beneficial.

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