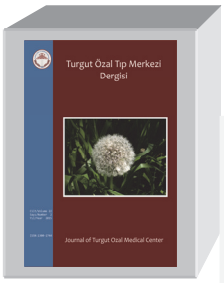

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Evaluation of Central Corneal Thickness Measurements by Optical Low Coherence Reflectometry and Contact Ultrasonic Pachymeter

Tolga Kocatürk[1], Erol Erkan[1], Harun Çakmak[1], İmran Kurt Ömürlü[2], Volkan Dayanır[1]

[1]Adnan Menderes University, Faculty of Medicine, Department of Ophthalmology, Aydın, Turkey
[2]Adnan Menderes University, Faculty of Medicine, Department of Biostatistics, Aydın, Turkey

Abstract

Objective: The aim is to compare the central corneal thickness measurements by optical low-coherence reflectometry and contact ultrasonic pachymeter in patients with pseudoexfoliation syndrome, pseudoexfoliation glaucoma, primary open-angle glaucoma as well as healthy subjects.

Materials and Methods: We have made a survey of the data of the patients with glaucoma who had been followed for ten years at the Department of Ophthalmology. 148 eyes of 76 patients who had central corneal thickness measurements with both optical low-coherence reflectometry and ultrasonic pachymeter during their follow-ups were included in the study. Central corneal thickness values were statistically analyzed.

Results: 46 of 76 patients (60.5%) were females, 30 patients (39.5%) were males, and the mean age was 69.1±6.06. Patients were divided into 4 groups; 36 eyes with pseudoexfoliative glaucoma (Group 1), 33 eyes with pseudoexfoliative syndrome (Group 2), 34 eyes with primary open angle glaucoma (Group 3), and 45 healthy eyes (Group 4). The mean central corneal thickness value was found to be 540.48±34.32 µm by ultrasonic pachymeter; it was 539.62±34.16 µm by optical low-coherence reflectometry. We did not observe any statistically significant difference between the mean central corneal thickness values (p=0.130).

Conclusion: The results of central corneal thickness measurements obtained by ultrasonic pachymeter and optical low-coherence reflectometry were found to be in strong correlation. We think that optical low-coherence reflectometry, which has an advantage in terms of patient comfort with its non-contact operating principle, may be a preferable alternative for central corneal thickness measurements.

Key Words: Glaucoma; Pseudoexfoliation Syndrome; Central Corneal Thickness; Optical Low-Coherence Reflectometry.

Optik Düşük Koherens Reflektometri ve Kontakt Ultrasonik Pakimetre ile Ölçülen Merkezi Kornea Kalınlığı Verilerinin Değerlendirilmesi

Özet

Amaç: Psödoeksfolyasyon sendromu, psödoeksfolyasyon glokomu, primer açık açılı glokomu olan hastalarda ve sağlıklı kişilerde, optik düşük-koherens reflektometri ve kontakt ultrasonik pakimetre ile ölçülen merkezi kornea kalınlığı verilerinin karşılaştırılması.

Gereç ve Yöntemler: Son 10 yılda üçüncü basamak bir göz hastalıkları kliniğinin glokom biriminde takip edilen hastaların dosyaları retrospektif olarak tarandı. Takiplerinde merkezi kornea kalınlıkları hem optik düşük-koherens reflektometri hem de kontakt ultrasonik pakimetre ile ölçülmüş olan hastalar tespit edildi. Çalışmaya 76 hastanın 148 gözüdahil edildi. Hastaların ölçülen merkezi kornea kalınlığı değerleri istatistiksel olarak analiz edildi.

Bulgular: 76 hastanın 46'sı (%60,5) kadın, 30'u (%39,5) erkek olup, yaşlarının ortalaması ise 69,1±6,06 idi. Hastalar 4 gruba ayrıldı; 36 psödoeksfolyasyon glokomlu göz (Grup 1), 33 psödoeksfolyasyon sendromlu göz (Grup 2), 34 primer açık açılı glokomu olan göz (Grup 3) ve 45 sağlıklı göz (Grup 4). Ultrasonik pakimetre ile ölçülen ortalama merkezi kornea kalınlığı 540,48±34,32 µm; optik düşük-koherens reflektometri ile ölçülen merkezi kornea kalınlığı ise 539,62±34,16 µm olarak bulundu. Merkezi kornea kalınlıklarının ortalamaları arasında istatistiksel olarak anlamlı bir fark görülmedi (p=0,130).

Sonuç: Merkezi kornea kalınlığı ölçümünde ultrasonik pakimetre ve optik düşük-koherens reflektometri ile elde edilen sonuçların birbiriyle yüksek oranda korele olduğu görüldü. Non-kontakt çalışma prensibi ile hasta konforu açısından bir avantaj oluşturan optik düşük-koherens reflektometrinin, merkezi kornea kalınlığı ölçümü için tercih edilebilir bir alternatif olabileceğini düşünmekteyiz.

Anahtar Kelimeler: Glokom; Psödoeksfolyasyon Sendromu; Merkezi Korneal Kalınlık; Optik Düşük-Koherens Reflektometri.

INTRODUCTION

Pseudoexfoliative material was first defined by John F. Lindberg in 1917 in a case series of glaucoma patients as the accumulation of whitish fibrillar material in the elements of the anterior segment and the angle (1). Pseudoexfoliative material is generally more prevalent in patients with Scandinavian roots while it is rare among African-American individuals (2). Its prevalence in the United States is 0.6% in individuals between 52 and 64, and 5% in individuals at 75-85 years of age.

The effect of central corneal thickness (CCT) on applanation tonometry in the intraocular pressure (IOP) measurement was first discussed by Goldmann (3). Goldmann argued that the corneal indentation tension is compensated by the surface resistance on the tear film. This recommendation applies in cases where CCT is 520µm, otherwise the measurement accuracy of applanation tonometry is severely damaged. This makes

corneal thickness an important parameter in IOP measuring. Corneal thickness is an important parameter especially in pseudoexfoliative patients. It is also a very important assessment criterion in the pre-refractive surgery period, follow-ups, and postoperative period. Especially after anterior segment operations of glaucoma patients, it is highly significant to measure corneal thickness correctly and with margin of error while determining corneal edema due to a decrease in endothelial function in corneal diseases, diagnosis of keratoconus and its in follow-up and treatment processes, and changes in corneal thickness taking place after contact lens use.

Ultrasonic pachymeter (UP) is regarded as the gold standard for measuring corneal thickness. Measurement with ultrasonic pachymeter requires contact with the cornea, which, in turn, requires topical anaesthesia. Recently, manufacturers have developed optics-based devices capable of measuring corneal thickness (optical laser interferometry, pentacam, specular microscopy, confocal slit lamp etc.). These systems allow rapid measurements without the need of topical anaesthetic drops. These measurements made without corneal contact provide reproducible values unaffected by potential human-origined errors.

Optical low-coherence reflectometry (OLCR) seems to be the most keen and objective non-contact pachymetry technique today. Measurements do not require corneal anaesthesia. As a non-invasive (820nm super luminescence diode laser beam) method, OLCR facilitates swift measurement and convenient examination both for the patient and doctor. OLCR can measure CCT in 1 µm spacing while the variability for the observer and among other observers is also quite low (1, 4-6).

In this study, we aim to compare the CCT measurements both in glaucomatous and non-glaucomatous patients with pseudoexfoliative materials by using OLCR and contact UP.

MATERIALS and METHODS

To this end, we went through the data files of patients without glaucoma from our outpatient clinic and those who had been followed by our glaucoma clinic for the last 10 years. At length, the study included 148 eyes of 76 patients. Prior to analysis, the patients were divided into subgroups according to the presence of pseudoexfoliation and glaucoma. 1st Group had 18 pseudoexfoliation glaucoma (PEG) patients while Group 2 had 17 pseudoexfoliation syndrome (PES) patients. Third group contained 17 patients with primary open angle glaucoma (POAG) and the last group had 24 healthy individuals without pseudoexfoliation or glaucoma. Patients with previous ocular surgery, corneal diseases, recent history of contact lens use, diabetic retinopathy, ocular traumas, ocular inflammations, and steroid use were excluded from the study. We obtained the approval of the ethics committee and carried out the study in accordance with the Helsinki Declaration on ethical principles.

During the detailed eye examination and after pupillary dilation with 10% phenylephrine hydrochloride, we decided whether the eyes had pseudoexfoliation material through a biomicroscopic examination of the anterior lens capsule or the pupillary border for exfoliation. Following the detailed ophthalmological examination of all patients, we made the pachymetry measurements with OLCR. The glaucoma diagnosis was decided by considering the appearance of the typical optic nerve head, high intraocular pressure, and/or visual field disorders. The visual fields were measured by a Humphrey Visual Field Analyzer (24-2 SITA standard) and assessed according to SAFE criteria (structure and function of the evaluation criteria for glaucomatous visual field loss) (7). Keeping in mind the possibility that UP may temporarily disrupt the corneal surface during measurement, we measured CCT first with non-contact OLCR pachymeter (OLCR-Slit lamp Pachymeter, Haag-Streit, Koeniz, Switzerland) and then with contact UP (Advent™ Ultrasonic Pachymeter, Mentor).

Optical low-coherence reflectometry is a device based on optical coherence tomography. Thanks to the simultaneous superposition of light waves caused by diode lasers, the reflectometer can measure corneal thickness. We did not apply any anaesthetic agents to the cornea prior to the OLCR measurements. The OLCR system was placed on the slit lamp. The OLCR measurements were performed in the normal corneal examination position as the patient was seated. Both eyes were open and focused on the measurement beam. We performed five individual measurements which were averaged by the OLCR software, which then automatically calculated the standard deviation.

By using high frequency sound waves, UP tries to identify highly reflective epithelial and endothelial surfaces. Determining the speed of sound waves on the corneal tissue, the distance between the two reflecting surfaces is calculated from the time difference between the reflected sound waves from the two surfaces. The cornea was anaesthetised with 0.5% proparacaine (Alcaine, Alcon, Belgium) for UP. Then the patient was asked to lay down facing up to fix the eyes on a distant object. We made the measurement so that the probe of the pachymeter was perpendicular to the corneal surface and could slightly flatten the cornea. We made three or four consecutive CCT measurements. To avoid false high results resulting from measurements taken from peripheral areas where cornea may be thicker, we only recorded the lowest values.

The compliance of the quantitative variables with the normal distribution was examined by using the Kolmogorov-Smirnov test. Since all quantitative variables had an even distribution, we applied the t test that matched the number and types of groups throughout the analysis while we adopted the t test and one-way variance analysis for the independent samples; defining statistics were shown as mean ± standard deviation. To

analyze the structure of relationships between variables, we used the Pearson correlation analysis. p<0.05 values were considered statistically significant.

RESULTS

The study was conducted on 148 eyes of 76 patients. 46 patients (60.5%) were females and 30 (39.5%) were males with an average age of 69.1±6.06. During the CCT measurements, the average value with UP was 540.48±34.32μm while this value was found to be 539.62±34.16μm with the OLCR measurements. There was no statistically significant difference between the CCT measurements with UP and OLCR (p=0.130). Control findings were consistent with pseudoexfoliative cases in terms of age and gender distribution. The gender distribution of CCT values of the patients are shown in Table 1. There was a negative, poor, and only slightly significant correlation between the CCT measurements (Table 1). Evaluating the 148 eyes of 76 patients, we detected pseudoexfoliation in 69 eyes of 35 patients. 36 of these had glaucoma (Group 1, PEG) while 33 were glaucoma-free (Group 2, PES). Among the 79 eyes of 41 patients without pseudoexfoliation material, 34 had POAG (Group 3) while 45 eyes were healthy (Group 4, control group). The subgroup-based analysis of average CCT values within each group is shown in Table 2. We determined a strong, positive, and statistically significant correlation in the CCT measurements of the groups (Figure 1-4).

Table 1. Sex and age based correlation of CTT values between OLCR and UP methods.

	Sex			Age	
	Female	**Male**	***p***	***r***	***p***
CCT by OLCR (μm)	539.51±37.04	539.80±29.28	0.961	-0.283	<0.001
CCT by UP (μm)	538.58±37.00	543.53±29.63	0.396	-0.307	<0.001
	p=0.205	p<0.001			

OLCR: Optical low-coherence reflectometry; UP: Contact Ultrasonic pachymeter; CCT: central corneal thickness.

Table 2. Comparison of CCT measurements by OLCR and UP between the groups.

Groups	**OLCR (μm)**	**UP (μm)**	**p**
PEG (n=36)	538.7±30.8	539.7±31.9	0.264
PES (n=33)	543.4±35.5	544.9±32.9	0.144
POAG (n=34)	536.3±35.0	536.1±35.0	0.909
Controls (n= 45)	540.0±36.0	541.1±38.0	0.367
	p>0.05	p>0.05	

PEG: pseudoexfoliation glaucoma; PES: pseudoexfoliation syndrome; POAG: primary open angle glaucoma; OLCR: Optical low-coherence reflectometry; UP: Contact Ultrasonic pachymeter.

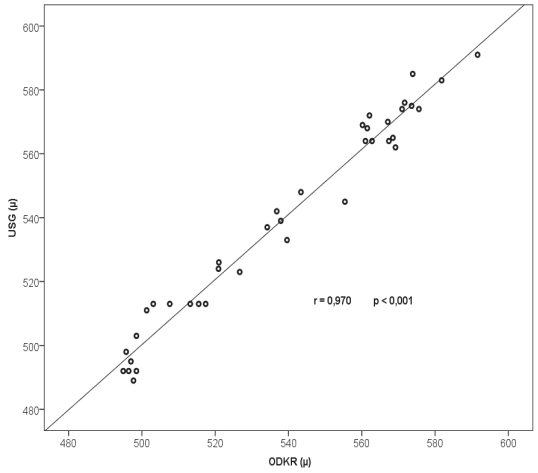

Figure 1. Correlation graph for CCT measurements in OLCR and UP devices in pseudoexfoliation syndrome group.

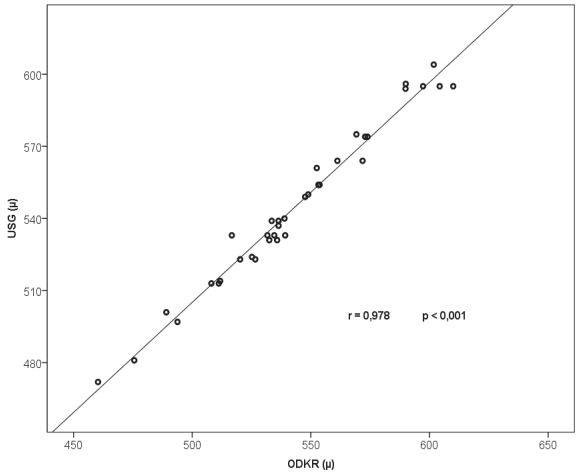

Figure 2. Correlation graph for CCT measurements in OLCR and UP devices in pseudoexfoliation glaucoma group.

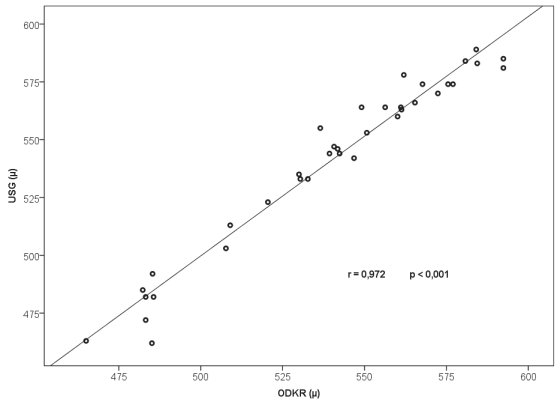

Figure 3. Correlation graph for CCT measurements in OLCR and UP devices in primary open angle glaucoma group.

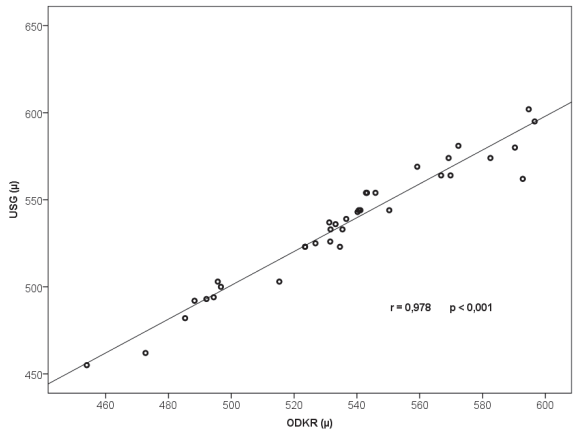

Figure 4. Correlation graph for CCT measurements in OLCR and UP devices in control group.

DISCUSSION

Corneal thickness measurement has an important place in clinical ophthalmology practices. Especially for glaucoma patients, CCT is a very essential parameter for the correct interpretation of IOP. Ehlers et al. have stated that each 10µm increase in CCT results in a 0.7mmHg of false high measurement of IOP (8). Kırgız et al. have reported that the low IOP measurement results due to thinner CCT in PES patients bring about delays in diagnosing glaucoma, which, in turn, leads to rapid progression of the disease (9). In this study, we have evaluated the CCT measurements by comparing the OLCR, a non-contact method, and the UP, which takes measurements by contacting the cornea. We have found that these two methods highly correlate with each other.

There are various methods to measure CCT. UP is still considered to be the gold standard in CCT measurement (10). Tai et al.'s study measuring the CCT of 184 eyes of 92 healthy patients by using non-contact specular microscopy, Pentacam rotating Scheimpflug photography system (Pentacam), OLCR, and UP devices have concluded that OLCR-UP and OLCR-Pentacam measurements are all comparable to each other and that these may be used interchangeably in clinical practices. It has also been reported that specular microscopy measures CCT lower than other methods (11).

Tuncer et al. (12) have argued for the presence of a statistically strong correlation between CCT measurements obtained with Scheimpflug imaging system (SGS) and optical coherence tomography devices. However, they have added that because SGS gives higher CCT measurement values, these two devices should not be used interchangeably (12).

In their study comparing CCT measurements using Stratus OCT and UP, Turk et al. have stated that results of the two devices vary with comparatively lower values measured by Stratus OCT. They have found the difference between the measurements made with these devices statistically significant. In this respect, they have advised against the interchangeable use of these two devices in clinical practices (13).

In another study conducted by using UP, OCT and Placido disc corneal topography, and combined Scheimpflug camera, the researchers have come up with the following average CCT measurement results: 544.12±33.89µm, 545.23±34.50µm, and 532.11±36.76µm, respectively. Although the differences between the devices were found to statistically notable, there was not a linear relationship between the measured CCT values in this study (14). Similar to the results of Turk et al.'s (14) study, this study also concludes that these devices should not substitute for one another in patient management.

Airiani et al. have evaluated the CCT measurements of 52 eyes of 26 healthy patients by using UP and OLCR. Comparing the results of the measurements, they have failed to observe a significant difference between the two methods despite the lower measurement results they have obtained with OLCR (15).

Gaujoux et al.'s study comparing the graft thickness of 41 patients who had undergone corneal graft after keratoplasty by using the UP and OLCR devices has calculated the mean, standard deviation, repeatability, and coefficient variation and examined the correlation between the two methods using Spearman regression. They have found the central corneal graft thickness similar in both measurement methods and, thus, a strong correlation between these two methods (rs: 0.96). They have concluded that both methods share comparable and high repeatability rates (10).

Kırgız et al.'s (9) study has compared the CCT values measured by UP between PES cases and healthy individuals. They have found that eyes with PES had thinner CCT (539.99±37.1µm) compared to the (558.62±30.67µm) controls. Subgrouping eyes with PES according to the presence of glaucoma, they have not found any statistically significant difference between the groups in terms of CCT thickness (541.94±29.32µm and 538.23±39.03µm, respectively with p=0.724).

Gillis et al.'s study has reported the CCT measurements of 50 eyes of 25 patients by using OLCR and UP and recorded the standard deviation and correlation between the figures. The standard deviation value of OLCR measurements was notably lower than the measurements made by UP (0.49µm and 4.71µm). They have noted an excellent correlation between the results of the two methods (r=0.99). In addition, analysing the variability of CCT measurements made with the OLCR they have found significantly less variability in comparison to UP results (16).

Analysing the differences in anterior segment parameters between PES patients and healthy individuals, Zengin et al.'s (17) OLCR-based study has put forward that PES patients had significantly shallow anterior chamber depth though there were no significant relation between these groups in terms of ordeal thickness and other biometrical parameters (17).

Through the course of our study, we have seen that UP and OLCR gave similar CCT measurement results and that they highly correlate with one another. We believe that OLCR, which is more advantageous in terms of patient comfort due to its non-contact operating principle, is a preferable alternative method for measuring CCT.

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Correspondence/İletişim

Tolga KOCATÜRK
Adnan Menderes Üniversitesi Tıp Fakültesi, Göz Hastalıkları Anabilim Dalı, AYDIN, TÜRKİYE
E-mail: tolgakocaturk@gmail.com

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