# Comparison of Ultrasonic Pachymetry and Optical Coherence Tomography for the Measurement of Central Corneal Thickness

## Santral Kornea Kalınlığının Ölçümünde Ultrasonik Pakimetri ve Optik Koherens Tomografinin Karşılaştırılması*

*Sebile ÜSTÜN ÇOMÇALI[1], Raşit KILIÇ[1], Serdar BAYRAKTAR[1], Yasin ÇAKMAK[1], Zeliha YAZAR[2], Hafize SEZER[3], Ayhan DURSUN[4]*

**ABSTRACT**

**Purpose:** The aim of this study was to compare the results of ultrasonic pachymetry (UP) and optical coherence tomography (OCT) for central corneal thickness measurement in healthy individuals in the general population.

**Materials and Methods:** We measured the central corneal thicknesses of the right eyes of 60 healthy subjects consecutively with ultrasonic pachymetry (Sonomed 300P PacScan) and optical coherence tomography (SD-Nidek RS-3000 Advance). Ultrasonic pachymetry measurement results were specified as group UP and optical coherence tomography measurement results as group OCT and the compared with each other. The t test and the Bland-Altman plot were used as the statistical methods.

**Results:** The study was conducted on 60 subjects consisting of 33 (55%) males and 27 (45%) females. The mean age was 36.7±15.8 (10-76) years for all subjects, 37.4±13.9 (16-76) years for the males and 35.9±18.1 (10-68) for the females. Mean UP measurement for all subjects was 544±33.6 μm (467-616) while the mean OCT measurement was 533.9±30 μm (457-600). The difference between the results was statistically significant (p=0.001) with mean OCT measurements 10.1 μm lower than mean UP measurements. There was a high degree of agreement between the two methods with the Bland-Altman plot.

**Conclusion:** Mean central corneal thickness measurements with optical coherence tomography were approximately 10 μm lower than ultrasonic pachymetry measurements. Further studies on larger series are needed.

**Key Words:** Central corneal thickness, glaucoma, pachymetry.

**ÖZ**

**Amaç:** Normal populasyondaki sağlıklı bireylerde, santral kornea kalınlığının ölçümünde ultrasonik pakimetri (UP) ve optik koherens tomografi (OKT) sonuçlarını karşılaştırmaktır.

**Gereç ve Yöntem:** Sağlıklı 60 olgunun sağ gözlerinin santral kornea kalınlığı ardışık olarak OKT (Nidek RS-3000 Advance) ve UP (Sonomed 300P Pacscan) ile ölçüldü. Ultrasonik pakimetri ölçüm sonuçları UP grubu, OKT ölçüm sonuçları OKT grubu olarak değerlendirildi ve sonuçlar iki grup arasında karşılaştırıldı. İstatistiksel yöntem olarak T testi ve Bland Altman testi kullanıldı.

**Bulgular:** Çalışma 33 (%55) erkek ve 27 (%45) kadın olmak üzere toplam 60 olgudan oluştu. Erkek olguların yaş ortalaması 37.4±13.9 (16-76) yıl, kadın olguların yaş ortalaması 35.9±18.1 (10-68) yıl ve tüm olguların yaş ortalaması 36.7±15.8 (10-76) olarak bulundu. Toplam 60 olguda UP ölçüm sonuçları ortalaması 544±33.6 μm (467-616) ve OKT ölçüm sonuçları ortalaması 533.9±30 μm (457-600) olarak tespit edildi. Sonuçlar arasındaki bu farklılık istatistiksel olarak anlamlı bulundu (p=0.001). OKT ölçümleri, UP ile yapılan ölçümlerden ortalama 10.1 μm daha düşük olduğu tespit edildi. Bland Altman testi ile iki yöntem arasında yüksek uyum tespit edildi.

**Sonuç:** Optik koherens tomografi ile yapılan ölçümlerin, ultrasonik pakimetri ölçümlerinden yaklaşık 10 μm daha düşük olduğu saptanmıştır. Bu konuda geniş serilerle yapılan çalışmalara gereksinim vardır.

**Anahtar Kelimeler:** Glokom, pakimetri, santral kornea kalınlığı.

***Bu çalışma kısmen TOD 47. Ulusal Oftalmoloji Kongresi'nde (Antalya 2013) poster olarak sunulmuştur.***

1- M.D. Sivas Numune Training and Research Hospital, Eye Clinic, Sivas/TURKEY
USTUN COMCALI S., sebileustun@gmail.com
KILIC R., kilicrasit@gmail.com
BAYRAKTAR S., serdarbayratktar@gmail.com
CAKMAK Y., yasincakmak111@mynet.com
2- M.D. Professor, Ankara Numune Training and Research Hospital, Eye Clinic, Ankara/TURKEY
YAZAR Z., zelihayazar@gmail.com
3- M.D. Professor, Cumhuriyet University Faculty of Medicine, Department of Biostatistics, Sivas/TURKEY
SEZER H., hafize.sezer@gmail.com
4- M.D. Asistant Professor, Cumhuriyet University Faculty of Medicine, Department of Biostatistics, Sivas/TURKEY
DURSUN A., dursunayhan01@gmail.com

**Geliş Tarihi - Received:** 10.05.2015
**Kabul Tarihi - Accepted:** 08.09.2015
*Glo-Kat 2016;11:93-96*

**Yazışma Adresi / Correspondence Adress:** M.D. Sebile USTUN COMCALI
Sivas Numune Training and Research Hospital, Eye Clinic, Sivas/TURKEY

**Phone:** +90 505 253 81 18
**E-mail:** sebileustun@gmail.com

## INTRODUCTION

Central cornea thickness (CCT) is an important measurement for the correct evaluation of intraocular pressure. CCT has been found to be higher in cases with ocular hypertension without optic nerve damage than the control group and other glaucoma cases but lower in normotensive glaucoma patients.[1-3] Almost all intraocular pressure (IOP) measurement methods including applanation tonometry and air puff tonometers are affected from CCT.[4-7] The correct measurement of CCT and obtaining consistent results is extremely important as the measurement of central corneal thickness has become significant in the follow-up of patients with glaucoma and ocular hypertension and for the estimation of the glaucoma development and progression risk.

The measurement of CCT is commonly used in glaucoma, corneal diseases, clinical follow-up of contact lens users, and in preoperative and postoperative refractive surgery periods. CCT plays an important role for selecting the ablation amount and diameter to be used and the laser surgical method to be employed in refractive surgery.[8]

Ultrasonic pachymetry (UP) is a gold standard method for central corneal thickness measurement in terms of reliability and accuracy. It is a contact test performed with topical anesthesia. Optical coherence tomography (OCT) is a new technique for CCT measurement and is a non-contact method. There are many studies comparing UP and various OCT devices for CCT measurement but there is no previous study that compares the SD-Nidek RS-3000 Advance OCT device with ultrasound pachymetry as far as we are aware. The aim of this study was therefore to investigate the differences between UP and OCT in CCT measurement and to evaluate the reliability of data obtained with the non-contact SD-Nidek RS-3000 Advance OCT device.

## MATERIAL AND METHOD

The study was planned in accordance with the Helsinki Declaration. Adult subjects who presented to the Eye Clinic and where no ocular pathology was found as a result of the examination were informed about the study. The right eyes of the 60 subjects who agreed to volunteer were evaluated within the scope of the study. Those who had undergone any ocular surgery or had a systemic disease were excluded. The measured IOP of the subjects was between 10.0 and 20.0 mmHg.

The central corneal thickness of the right eyes of all subjects was measured by the same physician. SD-Nidek RS-3000 Advance was used as an OCT device in the study. The device is capable of a scan speed of 53 000 A-scans per second and by averaging images provides 4 μm OCT digital resolution. Cornea measurement provides thickness of cornea apex, thickness of any two sites, and corneal thickness map using an anterior segment module. Scan pattern with the anterior segment module uses cornea line, cross and radial (6 lines/12 lines) scan for the corneal measurement. The device is also able to provide the central corneal thickness automatically without the need to make a manual measurement.

CCT was first measured three times consecutively with OCT while the subject was in the sitting positioın and looking at the fixation point. Measurements with the UP (Sonomed 300P Pacscan) were performed afterwards since contact ultrasonographic pachymetry can affect the corneal structure. The probe end was disinfected with 70% alcohol before each measurement. A drop of 0.5% proparacaine hydrochloride (Alcaine, Alcon) was administered to the eye for anesthesia and 5 consecutive measurements were taken by touching the probe gently to the center of the cornea at a right angle while the subject was looking at the fixation point in the sitting position. The average of 3 measurements performed with optical coherence tomography was accepted as the CCT value with OCT. Similarly, the average of 5 measurements taken with ultrasonic pachymetry was accepted as the CCT value with UP.

Ultrasonic pachymetry measurement results were accepted as the UP group and optical coherence tomography measurement results as the OCT group and the results were compared between the two groups. The data were analyzed with the Bland-Altman test and the t test. A p value smaller than 0.05 was accepted as statistically significant.

## RESULTS

The 60 subjects included in the study consisted of 33 males (55%) and 27 females (45%). The mean age was 36.7±15.8 (10-76) for all subjects, 37.4±13.9 (16-76) years for the males and 35.9±18.1 (10-68) years for the females with no significant difference between the mean ages of the male and female subjects (p=0.717). The mean UP measurement was 544±33.6 (467-616) μm and the mean OCT measurement was 533.9±30 (457-600) μm (Table). The mean result was approximately 10 μm thinner with OCT than UP and this difference was statistically significant (p=0.001).

***Table:*** *Central corneal thickness measurement results in the subjects.*

| **Central corneal thickness μm** | **In female subjects n:27** | **In male subjects n:33** | **P** | **In all subjects n:60** |
|---|---|---|---|---|
| Mean measurement with OCT | 540.9±29.9 | 528.2±29.4 | 0,106 | 533.9±30 |
| Mean measurement with UP | 552.2±33.8 | 537.2±32.4 | 0,085 | 544±33.6 |
| P | 0.001* | 0.001* | | 0.001* |

N; number of subjects, OCT; Optical Coherence Tomography, UP; Ultrasonic Pachymetry. *statistically significant.

The mean UP measurement was 537.2±32.4 (467-591) μm, and the mean OCT measurement 528.2±29.4 (457-576) μm in males while the respective measurements were 552.2±33.8 (476-616) μm and 540.9±29.9 (472-600) μm in females. The difference between OCT and UP measurement results was statistically significant both in female and male subjects (p=0.001 for both). The difference between females and males for UP measurements or OCT measurements was not statistically significant (p=0.085 and p=0.106 respectively) (Table).

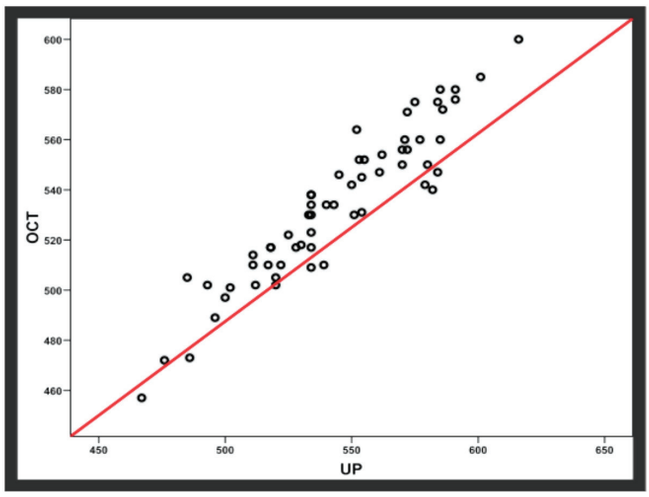
UP and OCT measurement results are presented around the equality line in graphic 1. OCT measurement results are seen to be within acceptable limits in the Bland-Altman 95% agreement plot that was used to evaluate the agreement between the two methods (Graphic 2).

## DISCUSSION

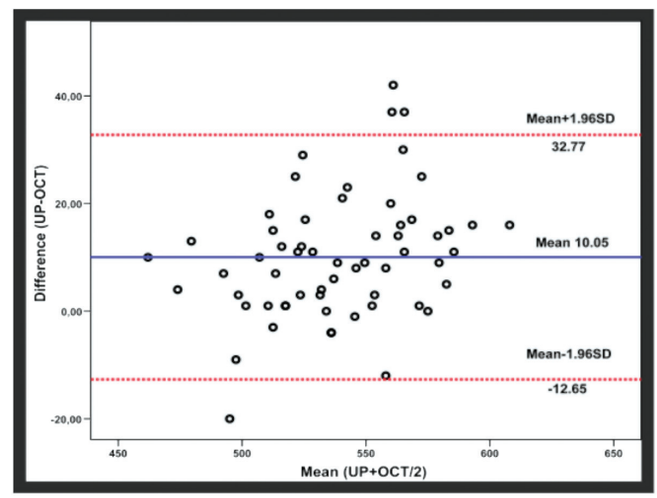
Central corneal thickness plays an important role in the diagnosis and treatment of corneal diseases. CCT can be measured with ultrasound biomicroscopy, slit-lamp pachymetry, non-contact specular microscopy, scanning-slit corneal topography (Orbscan), confocal microscopy, OCT and UP.[9-14]

The most commonly used CCT measurement method at present is ultrasonic pachymetry and it is accepted as the gold standard. However, the requirement for topical anesthesia, large variability in repeat measurements and the cross-contamination risk are disadvantages of this contact method.[15] The experience of the person performing the measurement, placement of the probe, and fixation losses of the patient also limit the reliability of the technique.

Optical coherence tomography is commonly used to investigate retinal layers and provides high-resolution sections to evaluate the anterior and posterior segment; it can also be used to measure the cornea thickness.[16] There is no contact with the eye and therefore no contamination risk. There is also less variability in repeated measurements as the patient's head is stable while the patient looks at the fixation point. CCT measurement with OCT has therefore become increasingly popular. However, there are no standardized data regarding the accuracy of CCT measurement with OCT and the agreement with UP measurements, which are still commonly used. CCT values measured with OCT have been reported to be higher than those measured with UP by Leung et al.,[17] Keskin et al.,[18] measured mean CCT as 528.55±35.11 μm with OCT and 530.47±33.39 μm with UP and the difference was not statistically significant. However, Acar et al.,[19] measured the mean CCT value as 536±37 μm with OCT and 559±36 $\mu$m with UP, with the mean CCT about 22 μm lower with OCT and a statistically significant difference between the two methods. Vollmer et al.,[20] found OCT measurements about 12 $\mu$m lower than UP measurements and also stated that repeated OCT measurements showed less variability than UP. Mean CCT with OCT was reported to be 16 $\mu$m lower than the mean measurement performed with UP by Northey et al.,[21] Garcia-Medina et al.,[22] also found the mean CCT measured with OCT to be 17 μm lower than the values measured with UP. CCT with OCT was reported to be lower than UP measurements in all these studies.[19-22] Similarly, mean CCT measured with OCT was found to be 10.1 μm lower than the mean values measured with UP in our study and this difference was statistically significant It is possible to accurately detect the central cornea with OCT but not with UP, making it possible to inadvertently obtain paracentral corneal measurements with UP.[23] In addition, the effect of topical anesthetics, the site of the reflection from the cornea posterior surface not being completely clear, and the reflection location between Descemet's membrane and the anterior chamber instead of the posterior surface of the cornea were stated as the other reasons for the higher CCT measurements with the ultrasonic method in some studies.[24,25] We believe that the thicker central corneal measurements with UP are due to the inability to accurately determine the central cornea, the reflections from beyond the Descemet's membrane, and the effect of topical anesthetic drops.




***Graphic 1:*** *The distribution of central cornea thickness measurements with UP and OCT around the equality line.*
*UP; Ultrasonic Pachymetry, OCT; Optical Coherence Tomography.*




***Graphic 2:*** *Scatter plot of the difference between the mean measurements with the UP and OCT methods.*
*UP; Ultrasonic Pachymetry, OCT; Optical Coherence Tomography.*

Correlation analysis is usually used in studies conducted to evaluate the degree of agreement between two methods.[26] However, correlation analysis is the test of the hypothesis that there is no relationship between the two methods and it is unnecessary to test whether two methods designed to measure the same value are related. Two different methods can show a high degree of correlation despite weak agreement. The degree of correlation depends on the distribution width of the sample results. The correlation is higher in samples with big distribution width than those with narrow distribution width.[26] We thought the Bland-Altman method was more appropriate as an alternative as it reveals the measurement differences between two methods objectively and leaves the interpretation of the acceptability level of the differences to the clinician.[26] The data of this study were evaluated with the Bland-Altman analysis and a high degree of agreement was found between the OCT and UP methods.

In conclusion, central corneal thickness measurements can also be performed reliably with the SD-Nidek RS-3000 Advance OCT device. OCT can be an alternative method to ultrasonic pachymetry due to advantages such as not requiring topical anesthesia, not requiring contact with the eye, easy applicability and lower variability with repeated measurements. However, it should be kept in mind that central cornea thickness measurements can be lower with optical coherence tomography than ultrasonic pachymetry. This difference may not be significant for glaucoma specialists but could be quite important for refractive surgeons. More detailed studies on larger series are required to clarify the matter.

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