

## CENTRAL CORNEAL THICKNESS MEASURED BY THE OCULYZER, BIOGRAPH, AND ULTRASOUND PACHYMETRY

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Central corneal thickness (CCT) is an important parameter in selecting patients before any corneal refractive procedures and in postoperative follow-up, in monitoring the patients with corneal disorders such as keratoconus and Fuchs' dystrophy, as well as in adjusting the intraocular pressure according to central corneal thickness.

The aim of the paper was to compare the results of CCT measurements obtained by different measurement instruments: Oculyzer, BioGraph and ultrasound pachymetry.

CCT was measured in 64 eyes of 32 patients. The measurements were performed in a specialized Eye Hospital "Maja Clinic" in Niš, using the following instruments: WaveLight Allegro Oculyzer, WaveLight Allergo Biograph, ultrasound pachymeter DGH Pachette 3. The mean values of central corneal thickness obtained from different devices were compared.

The mean values of CCT ( $\pm$  standard deviation) obtained with Oculyzer were  $552.94 \mu\text{m} \pm 22.88 \mu\text{m}$ ,  $556.56 \pm 25.32 \mu\text{m}$  obtained with BioGraph, and  $559.46 \pm 26.0 \mu\text{m}$  measured by ultrasound pachymeter. There were no statistically significant differences among different measurement devices.

The CCT measurements with the Oculyzer, BioGraph, and ultrasound pachymetry do not show statistically significant differences, so the results of CCT measurements obtained by using any of these devices may be considered valid.

*Acta Medica Medianae 2019;58(2):33-37.*

**Key words:** corneal thickness, pachymetry, measurement devices

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### Introduction

Central corneal thickness (CCT) is an important parameter in general ophthalmology. Average central corneal thickness is about 540 microns. The cornea varies in thickness, it is the thickest at the limbus and thinnest in the central part.

In refractive surgery CCT is the most important factor in preoperative selection of patients in addition to corneal topography. Preoperative corneal thickness is a factor that guides a surgeon in making decision on performing the intervention, on diopter value to be safely corrected, as well as on the choice of surgical method (1, 2).

Keratoconus is a progressive disorder graded from stage 1 to 4, resulting in the thinning of the cornea and its changing to irregularly shaped conus. CCT is the most important parameter in grading this disease, as well as in making decision on therapeutic options. One of the revolutionary discoveries in ophthalmology is corneal crosslinking method that might stabilize the disease, prevent the disease progression, and avoid the need for corneal transplantation, but unfortunately it is suitable only in patients with CCT of more than 450 microns (3, 4).

Corneal thickness indirectly reflects corneal endothelial integrity. An increase in central corneal thickness can be seen in Fuchs' dystrophy because of corneal edema caused by endothelial decompensation.

Glaucoma is one of the leading causes of blindness nowadays. Central corneal thickness measurement is an important part of ophthalmic examinations in patients with glaucoma, with higher correction factor being associated with thinner cornea. Protocol deviations and not incorporating pachymetry in ophthalmic examination may result in unnecessary antiglaucomatous treatment in patients with CCT values above the average. Also, potential glaucomatous values may be underestimated in patients with thinner cornea (2, 5).

A correlation with refractive surgery can also be made, in fact with intraocular pressure values in patients after refractive surgery. After correction in moderate to high myopia where significant central thinning occurs, the values of intraocular pressure may be interpreted as hypotonic if correction factor is not used, or thinner cornea may underestimate the true IOP value regarding potential glaucomatous damage, which is far more dangerous.

Central corneal thickness can be measured with various instruments available, such as: Oculyzer, BioGraph, ultrasound pachymeter, or OCT. Each of these types of measurements is supposed to be accurate, safe, with high repeatability of results, reproducible, easy and quick to perform.

Ultrasound pachymeter measures central corneal thickness by using ultrasound waves and a probe. This method offers the advantages of being economical and easy to perform, but since it is a contact method its main limitations include tissue indentation, placement of the probe on the center of the cornea, and its requirements for topical anesthesia.

The BioGraph uses the optical low coherence reflectometry (OLCR) and thanks to highly sophisticated software it obtains data on anterior segment, including the CCT.

The Oculyzer is the most advanced and highly accurate device that allows a variety of diagnostic measures and enables obtaining a great deal of data on anterior chamber that are useful in making a final decision for a phakic intraocular lens implantation or refractive vision correction laser surgery. Its mechanism of action is based on improved Pentacam HR technology, non-contact measurement, and full analysis of the complete anterior eye segment (6).

### Aim of the paper

The aim of the paper was to compare the results of central corneal thickness measurements obtained by various devices (Oculyzer, Biograph, and Ultrasound pachymeter) and draw conclusion on their statistical significance.

### Material and methods

In this study, central corneal thickness (CCT) was measured in 64 eyes of 32 patients. Random

selection resulted in a sample of 15 male and 17 female patients of average age being  $33 \pm 4.03$  years. Patients with pathological changes that could affect corneal thickness and structure were excluded from the study. The voluntary, written informed consent for use of patients' data for medical and scientific purposes was obtained from each participant in the study.

The measurements were performed at the "Maja Clinic", a specialized hospital for eye diseases in Niš. The same patients underwent consecutive measurements on 3 different devices:

WaveLight Allergo Oculyzer, WaveLight Allergo Biograph and Ultrasound Pachymeter DGH Pachette 3.

All measurements were taken on the same day. First, the measurements were performed using non-contact methods (Oculyzer and Biograph), followed by a contact method – ultrasound pachymetry. Before each ultrasound pachymetry measurement, topical anaesthetic eye drop of 0.5 % tetracaine-hydrochloride was applied. To avoid subjective biased evaluation in ultrasound pachymetry measurement, five consecutive CCT measurements were performed in all 64 eyes by two examiners.

Upon the completion of measurements all the data were statistically grouped and analyzed (SPSS version 20, Student's t test), then mean values of central corneal thickness obtained from different devices were compared.

### Results

The obtained mean values of CCT ( $\pm$  standard deviation) were  $552.4 \pm 22.88$   $\mu\text{m}$  measured with Oculyzer,  $556.56 \pm 25.32$   $\mu\text{m}$  measured with Biograph, and  $559.46 \pm 26.0$   $\mu\text{m}$  measured with ultrasound pachymeter (Table 1). The measurement differences among the devices were not statistically significant ( $p > 0.001$ ). The greatest difference was registered between central corneal thickness measured with Oculyzer and ultrasound pachymetry, but still not statistically significant. The highest value measured with Oculyzer was 576  $\mu\text{m}$ , with Biograph it was 582  $\mu\text{m}$ , while the highest value measured with ultrasound pachymetry was 584  $\mu\text{m}$ .

**Table 1.** Mean values of CCT measured with three different instruments (Oculyzer, Biograph, ultrasound pachymetry)

Measurement device	CCT $\pm$ standard deviation ( $\mu\text{m}$ )
Oculyzer	552.94 $\pm$ 22.88
Biograph	556.56 $\pm$ 25.32
Ultrasound pachymeter	559.46 $\pm$ 26.00

## Discussion

According to technical differences between aforementioned devices, the values of CCT were believed to be significantly different. Still, the results were surprisingly similar. Mean CCT values ( $\pm$  standard deviation) were  $552.94 \pm 22.88 \mu\text{m}$  as measured with Oculyzer,  $556.56 \pm 25.32 \mu\text{m}$  measured with Biograph, and  $559.26 \pm 26.00 \mu\text{m}$  measured with ultrasound pachymeter.

Comparison between central corneal thickness measurements obtained by different devices has been the subject of many studies. Those worth mentioning include CCT measurement with the Pentacam, OCT device, and ultrasound probe by J. Barkana et al. (7), then a study on comparison between central corneal thickness measurements by pentacam and ultrasound pachymetry by H.S.Al-Mezaine et al. (8), and a study on measuring central corneal thickness with pentacam, OCT device, and ultrasound pachymetry by I. Piotrowiak (6). The results of our study show the extent of correlation with the results obtained in previously mentioned studies and how relevant each measurement obtained by different devices is in making decisions on further therapeutic procedures.

It is well-known that refractive surgery is a procedure that requires laser removal of about 15  $\mu\text{m}$  of corneal tissue per 1 diopter of vision corrected. The difference of 15  $\mu\text{m}$  or more at measurement may be crucial in making decision on performing the intervention. A lot of papers on this subject may be found in available literature data. A great number of studies compared CCT results measured with different devices. Our results and conclusions are consistent with the majority of them. A study entitled "Comparison between central corneal thickness measurements by oculus pentacam and ultrasonic pachymetry" by H.S.Al-Mezaine et al. (8) suggested that differences in CCT measurements were not statistically significant. On the contrary, both the Oculyzer and Ultrasonic pachymetry measurements showed high correlation. Y. Barkana et al. (7) published a paper on central corneal thickness measured with Pentacam, Ultrasound pachymetry and Biograph and concluded that the values obtained with these devices are highly correlated. Still, there are studies that observed statistically significant diffe-

rences between the results of CCT measurements obtained using the Pentacam, Ultrasound pachymetry, or OCT. Thus, it is recommended that different devices cannot be used interchangeably without using correcting coefficient, as I. Piotrowiak et al. (6) observed in their study. A thorough analysis of the first two studies revealed that there was no statistical significance in CCT measurements with different devices, but the Pentacam slightly overestimated the CCT in comparison to ultrasound pachymetry. In the third study that registered statistically significant difference, that relationship is reversal. The authors of the first two studies explain it by tissue indentation since the probe requires corneal contact, while the authors of the third study explain higher values measured with ultrasound probe by corneal edema after topical anaesthetic had been applied, as well as by placement of the probe on the corneal center that is operator-dependent.

Feizi et al. evaluated CCT measurements by ultrasound pachymetry, Scheimpflug analyzer, and Orbscan in normal and keratoconic eyes. They found no statistically significant difference in the values of normal eyes, unlike keratoconic eyes (9). The discrepancy between CCT measurements in the keratoconus was observed in other studies as well (10, 11).

Since normal physiological corneal thickness is about 540  $\mu\text{m}$ , the difference in the mean measurement values between the Oculyzer, BioGraph, and Ultrasound Pachymetry of only 6.32  $\mu\text{m}$  from the lowest to highest value obtained in our study had no statistical significance in making decisions on further diagnostic or therapeutic procedures.

## Conclusion

Based on the results of this study, it may be concluded that in healthy eyes there is no statistically significant difference in measurements obtained with WaveLight Allergo Oculyzer, WaveLight Allergo Biograph, and ultrasound pachymeter DGH Pachette 3. Each of these results may independently be considered valid and adequate in guiding therapeutic decisions. After all, each of these instruments has its place in ophthalmology, depending on the health status of the eye and further required procedures.

## References

1. Sadoughi M, Einollahi B, Einollahi N, Rezaei J, Roshandel D, Feizi S. Measurement of Central Corneal Thickness Using Ultrasound Pachymetry and Orbscan II in Normal Eyes. *J Ophthalmic Vis Res* 2015; 10(1): 4-9. [[CrossRef](#)] [[PubMed](#)]
2. Rashid RF, Farhood QK. Measurement of central corneal thickness by ultrasonic pachymeter and oculus pentacam in patients with well-controlled glaucoma: hospital-based comparative study. *Clin Ophthalmol* 2016; 10:359-64. [[PubMed](#)]
3. Sanctis U, Missolungi A, Mutani B, Richiardi L, Grignolo FM. Reproducibility and repeatability of central corneal thickness measurement in keratoconus using the rotating Scheimpflug camera and ultrasound pachymetry. *Am J Ophthalmol* 2007; 144:712-8. [[CrossRef](#)] [[PubMed](#)]
4. Aghazadeh Amiri M, Hashemi H, Ramin S, Yekta A, Taheri A, Nabovati P, et al. Corneal thickness measurements with Scheimpflug and slit scanning imaging techniques in keratoconus. *J Curr Ophthalmol* 2017; 29(1):23-7. [[CrossRef](#)] [[PubMed](#)]
5. Ramesh PV, Jha KN, Srikanth K. Comparison of Central Corneal Thickness using Anterior Segment Optical Coherence Tomography Versus Ultrasound Pachymetry. *J Clin Diagn Res* 2017; 11(8):NC08-11. [[CrossRef](#)] [[PubMed](#)]
6. Piotrowiak I, Soldanska B, Burduk M, Kaluzny B, Kaluzny. Measuring Corneal Thickness with SOCT, the Scheimpflug System, and Ultrasound Pachymetry. *ISRN Ophthalmology* 2012; 2012:869319. [[PubMed](#)]
7. Barkana Y, Gerber Y, Elbaz U, Schwartz S, Ken-Dror G, Avni I, et al. Central corneal thickness measurement with the Pentacam Scheimpflug system, optical low-coherence reflectometry pachymeter, and ultrasound pachymetry. *J Cataract Refract Surg* 2005; 31(9):1729-35. [[CrossRef](#)] [[PubMed](#)]
8. Al-Mezaine H, Al-Amro S, Kangave D, Sadaawy A, Wehaib T, Al-Obeidan S. Comparison between central corneal thickness measurements by oculus pentacam and ultrasonic pachymetry. *International Ophthalmology* 2008;28(5):333-8. [[CrossRef](#)] [[PubMed](#)]
9. Feizi S, Jafarinasab MR, Karimian F, Hasanpour H, Masudi A. Central and peripheral corneal thickness measurement in normal and keratoconic eyes using three corneal pachymeters. *J Ophthalmic Vis Res* 2014; 9(3):296-304. [[PubMed](#)]
10. Dutta D, Rao HL, Addepalli UK, Vaddavalli PK. Corneal thickness in keratoconus: comparing optical, ultrasound, and optical coherence tomography pachymetry. *Ophthalmology* 2013; 120(3):457-63. [[CrossRef](#)] [[PubMed](#)]
11. de Sanctis U, Missolungi A, Mutani B, Richiardi L, Grignolo F. Reproducibility and repeatability of central corneal thickness measurement in keratoconus using the rotating Scheimpflug camera and ultrasound pachymetry. *Am J Ophthalmol* 2007; 144(5):712-8. [[CrossRef](#)] [[PubMed](#)]

**Originalni rad****UDC: 617.713-07**  
**doi:10.5633/amm.2019.0206****CENTRALNA DEBLJINA ROŽNJAČE MERENA OCULYZEROM, BIOGRAFOM I ULTRAZVUCNIM PAHIMETROM**

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Centralna debljina rožnjače (CCT) je parametar bitan u selekciji bolesnika kod svih kornealnih refraktivnih procedura i u postoperativnom praćenju, u praćenju pacijanata sa bolestima rožnjače kao što su keratokonus i Fuksova distrofija, kao i u korekciji izmerenog intraokularnog pritiska.

Cilj rada bio je uporediti rezultate merenja CCT dobijene različitim instrumentima merenja: oculusom, biografom i ultrazvučnim pahimetrom.

Merena je CCT kod 32 bolesnika kod 64 očiju. Merenje je vršeno u specijalnoj očnoj bolnici "Klinika Maja" u Nišu na instrumentima: WaveLight Allegro Oculus, WaveLight Allegro Biograph, ultrazvučni pahimetar DGH Pachette 3. Upoređivane su srednje vrednosti CCT merene različitim instrumentima.

Dobijene srednje vrednosti CCT ( $\pm$  standardna devijacija) iznosile su  $552,94 \mu\text{m} \pm 22,88 \mu\text{m}$  mereno Oculusom,  $556,56 \pm 25,32 \mu\text{m}$  mereno Biografom i  $559,46 \pm 26,0 \mu\text{m}$  mereno ultrazvučnim pahimetrom, pri čemu dobijene razlike među različitim aparatima nisu statistički značajne.

Rezultati merenja CCT oculusom, biografom i ultrazvučnim pahimetrom ne pokazuju statistički značajne razlike, te se rezultati CCT dobijeni na bilo kom od ovih instrumenata mogu smatrati validnim.

*Acta Medica Medianae 2019;58(2):33-37.*

**Ključne reči:** debljina rožnjače, pahimetrija, instrumenti merenja