

# Comparison of Central Corneal Thickness Measurements with Pentacam, Orbscan II, and Ultrasound Pachymeter

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## Abstract

**Purpose:** To compare thickness of central cornea measured using Pentacam, Orbscan II, and ultrasound pachymeter

**Methods:** Patients with no history of corneal diseases or systemic diseases affecting eyes, who did not wear contact lens or use eye medications, and who with no previous history of corneal surgery were selected for this study. Central corneal thickness (CCT) was measured by three methods using Pentacam, Orbscan II, and ultrasound pachymeter.

**Results:** Comparison of ultrasound and Orbscan CCT measurements showed a relatively high correlation between these two devices ( $P<0.001$ ;  $r=0.891$ ). The 95% limits of agreement (LoA) between these two devices were -42.44 to 20.18  $\mu\text{m}$ . There was also a high correlation between the results obtained through ultrasound and Pentacam ( $P<0.001$ ;  $r=0.932$ ). The 95% LoA of CCT with ultrasound and Pentacam were -13.35 to 24.16  $\mu\text{m}$ . There was also a high correlation between CCT measurements carried out by Orbscan and Pentacam ( $P<0.001$ ) and the 95% LoA were -12.14 to 45.19  $\mu\text{m}$ .

**Conclusion:** The findings of the present study demonstrated high agreements between the CCT readings measured with Orbscan, Pentacam, and ultrasound. The agreement between the Pentacam and ultrasound measurements was higher than that of between Orbscan and ultrasound, making Pentacam a better substitute for ultrasound.

**Keywords,** Central Corneal Thickness, Orbscan, Pentacam, Ultrasound, Agreement

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## Introduction

The central corneal thickness (CCT) provides specialists with a valuable biometric parameter in different fields of ophthalmology and optometry.<sup>1</sup> Surgeries for the correction of myopia and astigmatism are planned according to the preoperative CCT.<sup>2,3</sup> Accurate measurement of CCT is also important in orthokeratology, evaluating edema in contact lens wear, diagnosis of corneal pathologies, and assessment of glaucoma.<sup>4,5</sup>

Eye clinics today are equipped with a variety of tools to measure the CCT. Among these, the ultrasound pachymeters, recognized as the gold standard device, are more commonly in use compared to other devices and their repeatability in measuring the CCT has been studied by researchers.<sup>6,7</sup> When using an ultrasonic pachymeter to measure the CCT, the ultrasound probe needs to be placed perpendicularly on the center of the cornea. Impression by the probe may lead to underestimations and measurements done away from the center of cornea lead to overestimated CCT readings.<sup>1,2</sup> Other disadvantages of contact methods include less patient cooperation due to local anesthesia and a burning sensation, in addition to risk of infection.<sup>1,2</sup>

In recent years, new noncontact methods have been introduced; Pentacam and Orbscan II are among the most important ones. With Pentacam (Oculus), a rotating Scheimpflug camera is used to image the anterior segment of the eye, and light is used instead of sound waves to measure the corneal thickness. Imaging is done in about 2 seconds, during which data on 25000 is captured and used in analyses to determine the topography, thickness, and curvature of the cornea, in addition to the anterior chamber depth and angle.<sup>1,2</sup> The Orbscan II is a system based on the optical method of measuring the central and peripheral thickness of the cornea. In this system, a slit light scans the cornea while a video camera records them to measure the corneal thickness. Considering the measuring technique, clear reflections from the epithelium and endothelium of the cornea are required. This device measures the corneal thickness from the surface of the tear film, air, and the posterior corneal surface. Several studies have investigated the

agreement in measurements made with contact and noncontact methods.<sup>2,4,6,9,11</sup>

These three systems are usually not available in a clinical setting, and some surgical centers use only one device. In this study we investigate and discuss the agreement of CCT measurements made with Orbscan, Pentacam, and an ultrasound pachymeter. Obtained results will enable us to determine whether anyone of these devices can be substituted as the other one or not for measuring CCT.

## Methods

In this prospective study, 75 candidates between 19 and 27 years of age, who wished to have laser refractive correction for astigmatism or myopic astigmatism, were consecutively selected and enrolled. After explaining the process of the study, and completing consent forms, patients had complete Haag Streit slit lamp examinations by an ophthalmologist. Exclusion criteria were corneal or systemic disease affecting the eye, use of contact lenses or eye medication, keratoconus, and history of ophthalmic surgery. The CCT was first measured with the Orbscan II (Bausch and Lomb) followed by the Pentacam (Oculus) and an ultrasonic pachymeter (Nidek 1000), respectively. Patients were given a two-minute break between measurements. Two minutes before making ultrasound measurements, 0.5% tetracaine was instilled in the eyes for anesthesia. Then the patient was asked to sit and gaze at the light target. The ultrasound probe was perpendicularly positioned on the center of the cornea and five consecutive measurements and their mean values were recorded. All measurements were made between 9:00 AM and 2:00 PM, at least two hours after waking up. The Orbscan measurements were recorded without any correction.

All examinations were done by a single skilled technician. To test the reliability of the CCT measurements with Orbscan and Pentacam compared to ultrasound, paired T-test was applied. Correlations between the devices were assessed through the Pearson test, and the 95% limits of agreement (LoA) were calculated. The 95% LoA is computed from the mean difference between paired

measurements  $\pm 1.96 \times$  standard deviation of these differences, and will be demonstrated in Bland Altman graphs.

To predict the accuracy of results with Orbscan and Pentacam in comparison to ultrasound, linear regression models were used. For all three devices, the corneal thickness was defined as the distance between the anterior and posterior corneal surfaces.

## Results

As in similar studies, we took data of both eyes of each patient, and so a total of 150 eyes were evaluated. Among the participants, 57.3% were male and 42.7% were female. The mean CCT was 549.5, 560.9, and 544.3  $\mu\text{m}$  with ultrasound, the Orbscan, and Pentacam, respectively (Table 1).

Comparison of The ultrasound and Orbscan CCT measurements showed relatively high correlations between these two devices ( $P<0.001$ ; Pearson correlation coefficient=0.891; mean difference= $-11.12 \pm 15.98 \mu\text{m}$ ) and the 95% confidence intervals (CI) were  $-13.7$  to  $-8.55 \mu\text{m}$ . The 95% LoA between these two devices were  $-42.44$  to  $20.18 \mu\text{m}$  (Figure 1).

The Ultrasound and Pentacam measurements were highly correlated as well ( $P<0.001$ ; Pearson correlation coefficient=0.932). The mean difference between the measurements

made with these two devices was  $5.4 \pm 9.6 \mu\text{m}$  (CI, 3.86 to 6.95). The 95% LoA of the CCT measurements with ultrasound and Pentacam were  $-13.35$  to  $24.16 \mu\text{m}$  (Figure 2).

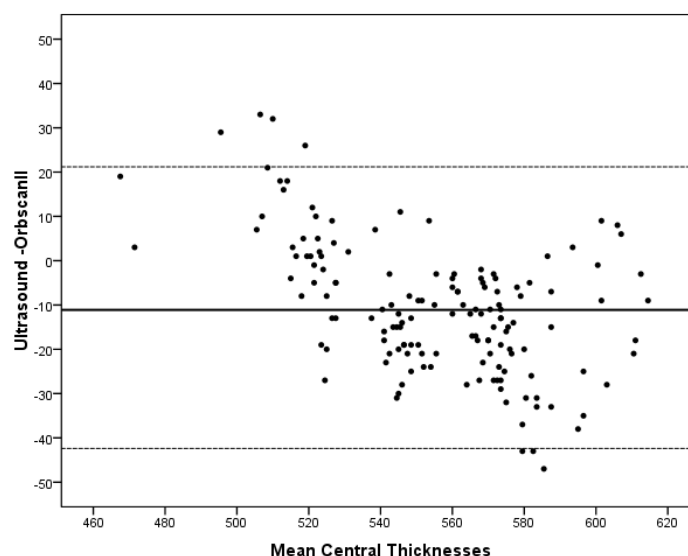
The Orbscan and Pentacam CCT measurements showed a high correlation ( $P<0.001$ , Pearson correlation coefficient=0.912). The 95% CI for the mean difference between measurements made with these two devices was 14.17 to 18.9  $\mu\text{m}$  and the 95% LoA were  $-12.14$  to 45.19  $\mu\text{m}$  (Figure 3). Using the linear regression model and ultrasound readings as the dependant variable, the following equations were achieved to calculate ultrasound equivalent values from the Orbscan and Pentacam readings:

Equation 1: (Orbscan CCT  $\times 0.677$ ) + 170.224 = Ultrasound equivalent

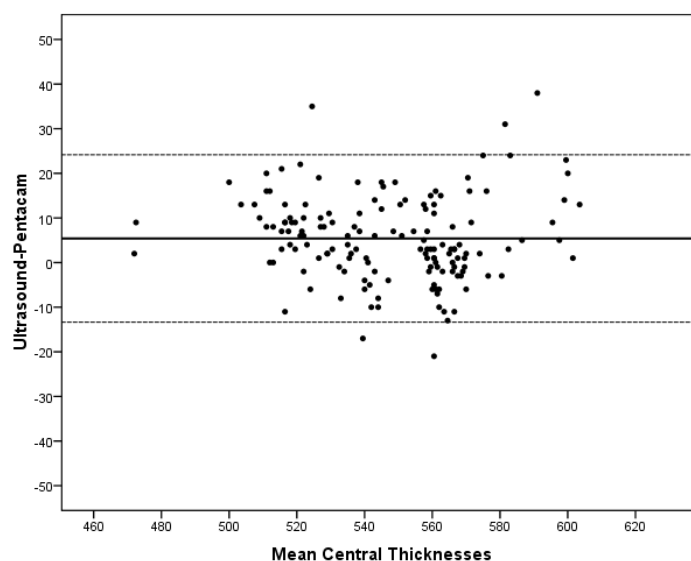
Equation 2: (Pentacam CCT  $\times 0.918$ ) + 49.97 = Ultrasound equivalent

**Table 1.** Mean central corneal thickness (CCT) readings measured with the ultrasound, the Orbscan and the Pentacam in microns

	Mean	SD	MIN	MAX
Ultrasound	549.76	25.66	473	611
Orbscan	560.89	33.78	458	631
Pentacam	544.35	26.03	468	601

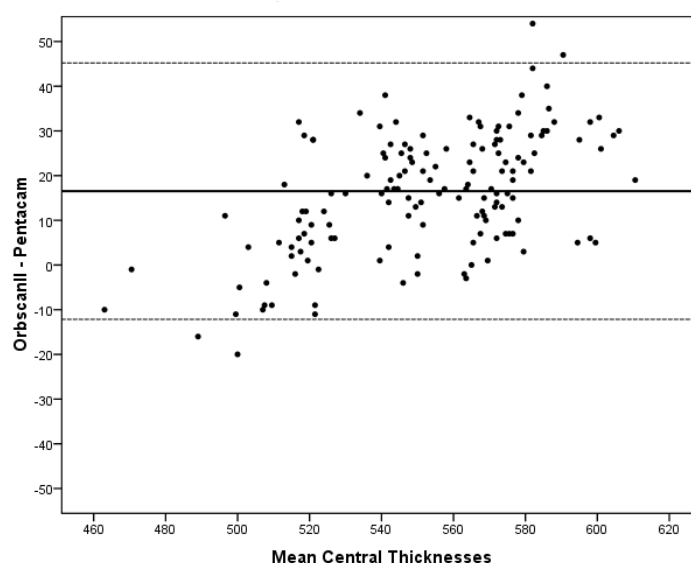


**Figure 1.** Agreement between the ultrasound and Orbscan measurements of the central corneal thickness (CCT). The middle line indicates the mean difference and the two dashed side lines show the 95% limits of agreement.



**Figure 2.** Agreement between the ultrasound and Pentacam measurements of the central corneal thickness (CCT)

The middle line indicates the mean difference and the two dashed side lines show the 95% limits of agreement.



**Figure 3.** Agreement between the Pentacam and Orbscan measurements of the central corneal thickness (CCT)

The middle line indicates the mean difference and the two dashed side lines show the 95% limits of agreement.

## Discussion

Different devices available for measuring the corneal thickness are based on a variety of techniques and each has its own advantages and disadvantages. The ultrasonic

pachymetry technique is known as the gold standard, and often used as the reference for evaluating other systems. Knowledge of the agreement between noncontact devices, such

as Orbscan and Pentacam and ultrasonic method in measuring the corneal thickness can help specialists use the former ones when the latter is not possible. Orbscan and Pentacam also have the advantage of presenting other information about the anterior segment of the eye which can be of use to the refractive surgeon, and so their use may be more cost-effective as well.<sup>11-14</sup>

The findings of the present study indicated high correlations between the ultrasonic and Pentacam readings with a Pearson correlation coefficient of 0.932. Other studies have confirmed such a high correlation between ultrasound and Pentacam measurements of the CCT. O'Donnell et al<sup>2</sup> (Table 2) compared CCT measurements with ultrasound and the Pentacam in normal corneas and reported high correlations between these two devices. Barkana et al<sup>15</sup> found very little difference between ultrasound and Pentacam readings of the CCT, and stated that Pentacam is a valuable diagnostic tool. Results of the study by Amano et al<sup>16</sup> also verified these findings. Agreement in measuring the CCT between these devices has been demonstrated by Al-Mezaine<sup>19</sup> as well (Table 2). In another study, He<sup>20</sup> showed that pachymetry readings with Pentacam, compared to ultrasound, was an acceptable device and their difference, as shown in table 2, was small.

In the present study, we found a mean

CCT of 549.8  $\mu\text{m}$  with the ultrasonic pachymeter and 544.3  $\mu\text{m}$  with the Pentacam. The CCT readings Pentacam were invariably lower than those with ultrasonic pachymeter, which is in agreement with other studies. As summarized in table 2, some studies have found higher readings with Pentacam. This could be the effect of corneal thickness range examined in the study. Some systems have been shown to overestimate the thickness in thicker corneas and underestimate them in thinner ones.

Another finding of the present study was a mean CCT of 560.9  $\mu\text{m}$  with Orbscan and a high correlation between this device and ultrasonic pachymeter. This also has been reported by other researchers (Table 2).<sup>9,17,18</sup> As demonstrated in Table 1, the mean CCT measured by Orbscan was 11  $\mu\text{m}$  higher than the measurement of ultrasound; a finding which has been indicated in previous reports. Higher readings is probably occurred because the Orbscan measures the corneal thickness from the tear and air interface to the posterior corneal surface, while ultrasound technique does not include the tear film layer and measures the thickness down to the reflection between the Descemet's membrane and the anterior chamber. It is for this reason that an acoustic equivalent correction factor is needed to compensate for the overestimation with Orbscan.

**Table 2.** Central corneal thickness measurement by different devices in the literature

AUTHERS	Number of eye	Pentacam	Orbscan II	Ultrasound
Matsuda <sup>21</sup>	48	413	434	
Rosa <sup>22</sup>	91			
Hashemi <sup>12</sup>	60	548	580	555
		468	474	478
Ho[13]	103	430.66	435.17	438.2
Al-Mezaine <sup>19</sup>	984	552.4		544.1
Fujioka <sup>23</sup>	135	559.49		553.01
Lackner <sup>24</sup>	30	542	576	552
O'Donnell <sup>2</sup>	21	534		528
Li EY <sup>25</sup>	70		553.22	553.5
Basmak <sup>26</sup>	356		562.95	580.39
Haque <sup>27</sup>	20	433.5	438.6	494.2
He YL <sup>20</sup>	433	538.08		537.26

Comparisons of the CCT readings with Orbscan and Pentacam showed high agreements between them. This has been confirmed by other studies. Our Orbscan readings were higher than Pentacam. This could be due to usage of crude readings and not applying an acoustic factor. Similar results have been reported previously (Table 2). It is believed that applying the acoustic factor can minimize the differences between Orbscan and the gold standard

method (i.e. ultrasound).<sup>13</sup>

### Conclusion

The findings of the present study determined agreement between the CCT readings measured with Orbscan, Pentacam and ultrasound. The agreement between Pentacam and ultrasound was higher than that of between Orbscan and ultrasound, making Pentacam a better substitute for ultrasound.

### References

1. Patwardhan AA, Khan M, Mollan SP, Haigh P. The importance of central corneal thickness measurements and decision making in general ophthalmology clinics: a masked observational study. *BMC Ophthalmol* 2008;8:1.
2. O'Donnell C, Maldonado-Codina C. Agreement and repeatability of central thickness measurement in normal corneas using ultrasound pachymetry and the OCULUS Pentacam. *Cornea* 2005;24(8):920-4.
3. Javaloy J, Vidal MT, Villada JR, et al. Comparison of four corneal pachymetry technique's in corneal refractive surgery. *J Refract Surg* 2004;20(1):29-34.
4. Pflugfelder SC, Liu Z, Feuer W, Verm A. Corneal thickness indices discriminate between keratoconus and contact lens-induced corneal thinning. *Ophthalmology* 2002;109(12):2336-41.
5. Herndon LW, Weizer JS, Stinnett SS. Central corneal thickness as a risk factor for advanced glaucoma damage. *Arch Ophthalmol* 2004;122(1):17-21.
6. Lackner B, Schmidinger G, Pieh S, et al. Repeatability and reproducibility of central corneal thickness measurement with Pentacam, Orbscan, and ultrasound. *Optom Vis Sci* 2005;82(10):892-9.
7. Fishman GR, Pons ME, Seedor JA, et al. Assessment of central corneal thickness using optical coherence tomography. *J Cataract Refract Surg* 2005;31(4):707-11.
8. Medeiros FA, Sample PA, Weinreb RN. Corneal thickness measurements and visual function abnormalities in ocular hypertensive patients. *Am J Ophthalmol* 2003;135(2):131-7.
9. Wong AC, Wong CC, Yuen NS, Hui SP. Correlational study of central corneal thickness measurements on Hong Kong Chinese using optical coherence tomography, Orbscan and ultrasound pachymetry. *Eye* 2002;16(6):715-21.
10. Miglior S, Albe E, Guareschi M, et al. Intraobserver and interobserver reproducibility in the evaluation of ultrasonic pachymetry measurements of central corneal thickness. *Br J Ophthalmol* 2004;88(2):174-7.
11. Kim SW, Byun YJ, Kim EK, Kim TI. Central corneal thickness measurements in unoperated eyes and eyes after PRK for myopia using Pentacam, Orbscan II, and ultrasonic pachymetry. *J Refract Surg* 2007;23(9):888-94.
12. Hashemi H, Mehravaran S. Central corneal thickness measurement with Pentacam, Orbscan II, and ultrasound devices before and after laser refractive surgery for myopia. *J Cataract Refract Surg* 2007;33(10):1701-7.
13. Ho T, Cheng AC, Rao SK, et al. Central corneal thickness measurements using Orbscan II, Visante, ultrasound, and Pentacam pachymetry after laser in situ keratomileusis for myopia. *J Cataract Refract Surg* 2007;33(7):1177-82.
14. Lackner B, Schmidinger G, Pieh S, et al. Repeatability and reproducibility of central corneal thickness measurement with Pentacam, Orbscan, and ultrasound. *Optom Vis Sci* 2005;82(10):892-9.

15. Barkana Y, Gerber Y, Elbaz U, 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.
16. Amano S, Honda N, Amano Y, et al. Comparison of central corneal thickness measurements by rotating Scheimpflug camera, ultrasonic pachymetry, and scanning-slit corneal topography. *Ophthalmology* 2006;113(6):937-41.
17. Chakrabarti HS, Craig JP, Brahma A, et al. Comparison of corneal thickness measurements using ultrasound and Orbscan slit-scanning topography in normal and post-LASIK eyes. *J Cataract Refract Surg* 2001;27(11):1823-8.
18. Suzuki S, Oshika T, Oki K, et al. Corneal thickness measurements: scanning-slit corneal topography and noncontact specular microscopy versus ultrasonic pachymetry. *J Cataract Refract Surg* 2003;29(7):1313-8.
19. Al-Mezaine HS, Al-Amro SA, Kangave D, et al. Comparison between central corneal thickness measurements by oculus pentacam and ultrasonic pachymetry. *Int Ophthalmol* 2008;28(5):333-8.
20. He YL, Li XX, Bao YZ, et al. Measurement of central corneal thickness in myopic eyes with ultrasound and Pentacam scheimpflug system. *Zhonghua Yan Ke Za Zhi* 2006;42(11):985-8.
21. Matsuda J, Hieda O, Kinoshita S. Comparison of central corneal thickness measurements by Orbscan II and Pentacam after corneal refractive surgery. *Jpn J Ophthalmol* 2008;52(4):245-9.
22. Rosa N, Lanza M, Borrelli M, et al. Comparison of central corneal thickness measured with Orbscan and Pentacam. *J Refract Surg* 2007;23(9):895-9.
23. Fujioka M, Nakamura M, Tatsumi Y, et al. Comparison of Pentacam Scheimpflug camera with ultrasound pachymetry and noncontact specular microscopy in measuring central corneal thickness. *Curr Eye Res* 2007;32(2):89-94.
24. Lackner B, Schmidinger G, Pieh S, et al. Repeatability and reproducibility of central corneal thickness measurement with Pentacam, Orbscan, and ultrasound. *Optom Vis Sci* 2005;82(10):892-9.
25. Li EY, Mohamed S, Leung CK, et al. Agreement among 3 methods to measure corneal thickness: ultrasound pachymetry, Orbscan II, and Visante anterior segment optical coherence tomography. *Ophthalmology* 2007;114(10):1842-7.
26. Basmak H, Sahin A, Yildirim N. The reliability of central corneal thickness measurements by ultrasound and by Orbscan system in schoolchildren. *Curr Eye Res* 2006;31(7-8):569-75.
27. Haque S, Simpson T, Jones L. Corneal and epithelial thickness in keratoconus: a comparison of ultrasonic pachymetry, Orbscan II, and optical coherence tomography. *J Refract Surg* 2006;22(5):486-93.