Comparison of Central Corneal Thickness Measurement with Pentacam and Ultrasound

Tamer Adel Refai, MD, FRCS.

Department of Ophthalmology, Refractive surgery unit, Research Institute of ophthalmology, Giza (Egypt) 2010.

Abstract: Purpose: The purpose of this study was to compare central corneal thickness (CCT) measurements obtained with a novel rotating Scheimpflug camera, ALLEGRO Oculyzer (Pentacam) Version 1074; Allergo, Germany with ultrasound pachymetry (Sonoscan model 4000AP, SONOMED, USA). Methods: CCT in 117 healthy eyes of 64 Egyptian patients seeking for refractive was measured with each modality by one observer. At least three measurements are taken for each eye and the average number for CCT is included in the study. For the rotating Scheimpflug camera, only images with Quality specification (QS): OK were included in the study. Results: The mean central corneal thickness by ultrasound pachymetry was 552.1 μ ± 43.96 μ standard deviation and by Pentacam 541.82 μ ± 39.87 μ standard deviation with correlation of 0.892 (P value < 0.01) implying a highly significant correlation but with slightly lower values (by about 8.60 μ ± 14.1) obtained by Pentacam with no significant difference attributed to age or sex of the patients. Conclusion: In the assessment of normal corneas, the Pentacam measured CCT values close to ultrasound pachymetry with tendency for slightly lower values without significant differences attributed to age or sex therefore, it is considered as valid in determining central corneal thickness as ultrasound pachymetry with other advantages over the ultrasound pachymetry.

Key words: Central corneal thickness, method comparison, Scheimpflug imaging, ultrasound pachymetry.

INTRODUCTION

Accurate assessment of central corneal thickness (CCT) is important for many reasons: For example, refractive surgery is routinely planned according to preoperative measurement of central corneal thickness (American Academy, 1999; Price et al., 1999) to avoid complications such as corneal ectasia. Also, CCT can be regarded as a correlate of the physiological condition of the corneal endothelium and used in the diagnosis of certain corneal diseases such as keratoconus and Fuchs dystrophy (Gherghel et al., 2004). Also for accurate determination of intraocular pressure, a modification has to be made according to the central corneal thickness (Doughty M.J., 2000; Stodtmeister R., 1998; Gordon M.O., 2002; Wolfs R.C., 1997; Herndon L.W., 1997; Argus W.A. 1995; Medeiros F.A., 2003).

Although ultrasound-based systems offer the advantages of relative ease of use, they experience relatively high errors in measurements, possibly as a result of difficulties in centration and alignment (McLaren et al., 2004; Doughty and Zaman, 2000; Thornton, 1984). The need for topical anesthesia and contact of the probe with the cornea has led to the search for noninvasive alternatives without the risk of epithelial lesions or transmission of infection. A novel apparatus capable of modeling the anterior chamber is the (Pentacam) Allergo, Germany. The system is based on a rotating Scheimpflug camera, which scans and measures the complete cornea and anterior chamber in approximately 2 seconds.

Its reproducibility and accuracy in assessing CCT compared with traditional modalities have to be established. The purpose of the present study was to compare CCT measurements obtained with the rotating Scheimpflug camera with ultrasound pachymetry to provide estimates for the average difference between measurements with the two different modalities and the validity of using the Pentacam as a good alternative for Ultrasound pachymetry prior to refractive surgery.

Corresponding Author: TAMER ADEL REFAI, MD, FRCS., Departments of Ophthalmology, Refractive surgery unit, Research Institute of ophthalmology, Giza (Egypt). E-mail: tamerrefaey@hotmail.com.
Methods:
117 eyes of (64 patients) seeking for refractive surgery; 72 female (F) eyes (of 38F patients) and 45 male (M) eyes (of 26 M patients ) with a mean age of 26.7 years ±5.6 years standard deviation were recruited for the study. All subjects had normal eyes without corneal abnormalities as verified by slit lamp examination. Softcontact lens wearers were included but were required not to wear contact lenses within 72 hours before the investigations. Their refractive error was measured with an autorefractometer model Topcon 5000, Japan. The mean spherical equivalent was -6.41D ± 3.76 standard deviation. Measurements were taken on one or both eyes according to patients demands for refractive surgery at least 3 hours after awakening.
Central corneal thickness was determined with 2 different modalities:
1- Pentacam (ALLEGRO Oculyzer)Version1074;Allergo,Germany
2- ultrasound pachymetry (Sonoscan model 4000AP,SONOMED,USA).
Each modality was carried out by the same observer. Ultrasound pachymetry was performed last to avoid influence of corneal microabrasions that might be induced by the ultrasound probe on the pentacam readings.

Rotating Scheimpflug Imaging:
Rotating Scheimpflug imaging was performed with the patient seated using a chinrest and forehead strap. The patient was asked to keep both eyes open and to fixate on a blue fixation target. The system uses a rotating Scheimpflug camera and a monochromatic slit light source (blue LED at 475 nm) that rotate together around the optical axis of the eye. Within 2 seconds, the system rotates 180° and acquires 25 images that contain 500 measurement points on the front and back corneal surfaces to draw a true elevation map. The software acquires the images as volume data, thus multiplanar reprojections allow the creation of sagittal and tangential maps (figure: 1). The thinnest value of corneal thickness was recorded as CCT. Only measurements with Quality Specification (QS) denoting OK were included in the study to avoid errors resulting from poor quality photos. At least three measurements are taken for each eye and the average number for CCT is included in the study.

Fig. 1: Pentacam printout showing corneal thickness in addition to further multiple measurements.

Ultrasound Pachymetry:
CCT was measured using Sonoscan model 4000AP,SONOMED,USA calibrated by the manufacturer. The cornea was anesthetized with topical 1%Bupivacaine. The patient was brought into a faceup position on the
examination chair and asked to fixate a target on the ceiling. The pachymeter probe was brought in light contact with the cornea centrally and perpendicularly. The central reading of at least 9 pachymetry readings in the printout is taken as the CCT (Fig:2) At least 3 measurements are taken for the CCT and the average number is included in the study.

![Ultrasound pachymetry printout showing the central and the other readings.](image)

**Fig. 2:** Ultrasound pachymetry printout showing the central and the other readings.

**Statistical Analysis:**

For the entire sample, central pachymetry for each patient by ultrasound and by Pentacam was subjected to statistical analysis including Mean value, Standard deviation, Minimum value, maximal value, Correlation of the measurements by both machines and Student “t” test for comparison of the measurements between both machines. To study the effect of sex on the measurements, the same statistical methods were applied to female and males groups under the study. To study the effect of age on the measurements, the same statistical methods were applied to two age groups (below 30y) & (above 30y) under the study.

**Results:**

The mean value for the central corneal thickness by ultrasound for the entire sample was 552.11μ ± 43.96 standard deviation with a minimum value of 471μ and a maximal value of 656μ while the mean value for
the central corneal thickness by Pentacam for the entire sample was 541.82μ ± 39.87standard deviation with a minimum value of 451μ and a maximal value of 629μ. The student “t”test shows a value of 0.081(P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines (table 1) & Pearson correlation shows a value of 0.892 (P value < 0.01 ) implying a highly significant correlation between mean central corneal thickness measurement by both machines (table 2 ). The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound ( see Chart 1)by about 8.60μ ± 14.1. To study the effect of sex on the measurements, patients eyes were divided into two groups: A-Female group: 72 female (F) eyes (of 38F patients) & B-Male group:45 male (M) eyes(of 26 M patients). For Females, the mean value for the central corneal thickness by ultrasound was 554.71μ ± 46.14 standard deviation with a minimum value of 471μ and a maximal value of 656μ while the mean value for the central corneal thickness by Pentacam was 549.94μ ±36.94 standard deviation with a minimum value of 462μ and a maximal value of 629μ. The student “t”test shows a value of 0.523 (P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines for females (table 3) & Pearson correlation shows a value of 0.876 (P value < 0.01 ) implying a highly significant correlation between mean central corneal thickness measurement by both machines for females (table 4). The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound for females (see Chart 2 and Graph 1).

For males, the mean value for the central corneal thickness by ultrasound was 548.18μ ±41.32standard deviation with a minimum value of 482μ and a maximal value of 646μ while the mean value for the central corneal thickness by Pentacam was 529.23μ ±41.87standard deviation with a minimum value of 451μ and a maximal value of 629μ. The student “t”test shows a value of 0.042 (P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines for males (table 3) & Pearson correlation shows a value of 0.931 (P value < 0.01 ) implying a highly significant correlation between mean central corneal thickness measurement by both machines for males (table 4). The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound (see Chart 2 & Graph 1). Inspite of slightly higher values by both machines for the female group(that is probably related to the larger size of the female group i.e 72 female (F) eyes compared to 45 male(M) eyes) yet no statistically significant difference between measurements by both machines was attributed to sex of the patient. To study the effect of age on the measurements ,patients eyes were divided into two age groups: Age Group A (<30y):87 eyes (of 49 patients) & Age Group B (>30y):30 eyes (of 17 patients). For age group below 30y, The mean value for the central corneal thickness by ultrasound was 558.36μ ± 44.90 standard deviation with a minimum value of 489μ and a maximal value of 656 μ while the mean value for the central corneal thickness by Pentacam was 545.3μ ± 37.26 standard deviation with a minimum value of 462μ and a maximal value of 609μ.

Chart 1: Mean value for the central corneal thickness for the entire sample by ultrasound and pentacam
Chart 2: Mean value for the central corneal thickness for females by ultrasound and pentacam.

The student “t” test shows a value of 0.094 (P => 0.05) which reveals a non-significant difference between mean central corneal thickness measurement by both machines for patients below 30y (table 5) & Pearson correlation shows a value of 0.869 (P value < 0.01) implying a highly significant correlation between mean central corneal thickness measurement by both machines. (table 6). The values for the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound (see Chart 3 and Graph 2).
Chart 3: Mean value for the central corneal thickness for according to age by ultrasound and pentacam.

Graph 2: Mean value for the central corneal thickness for according to age by Ultrasound and pentacam.

For age group above 30y, the mean value for the central corneal thickness by ultrasound was 541.63μ±32.80 standard deviation with a minimum value of 490μ and a maximal value of 585μ while the mean value for the central corneal thickness by Pentacam was 535.86μ±24.71 standard deviation with a minimum value of 505μ and a maximal value of 566μ. The student “t” test shows a value of 0.71 (P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines for patients above 30y (table 5) & Pearson correlation shows a value of 0.953 (P value < 0.01) implying a highly significant correlation between mean central corneal thickness measurement by both machines. (table 6).

The values for the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound (see Chart 3 and Graph 2). Inspite of slightly higher values by both machines for age group <30y (that is probably related to the larger size of age group <30y i.e 87 eyes (of 49 patients) compared to 30 eyes (of 17 patients) for the age group >30y, yet no statistically significant difference between measurements by both machines was attributed to age of the patient.
Table 1: Comparison of Mean value and standard deviation for the central corneal thickness for the entire sample by ultrasound and pentacam by t-test.

<table>
<thead>
<tr>
<th>Item</th>
<th>CCT By ultrasound</th>
<th>CCT By Pentacam</th>
<th>t test</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean value for central corneal thickness (CCT)</td>
<td>552.11± 43.96</td>
<td>541.82± 39.87</td>
<td>0.081</td>
<td>&gt;0.05</td>
<td>Non significant</td>
</tr>
</tbody>
</table>

Table 2: Mean value and standard deviation for the central corneal thickness for the entire sample by ultrasound and pentacam and their correlation.

<table>
<thead>
<tr>
<th>Item</th>
<th>CCT By ultrasound</th>
<th>CCT By Pentacam</th>
<th>Correlation</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean value for central corneal thickness (CCT) for females</td>
<td>554.71± 46.14</td>
<td>549.94± 36.94</td>
<td>0.892498</td>
<td>&lt;0.01</td>
<td>Highly significant</td>
</tr>
</tbody>
</table>

Table 3: Comparison of Mean value and standard deviation for the central corneal thickness by ultrasound and pentacam by t-test for males and females.

<table>
<thead>
<tr>
<th>Item</th>
<th>CCT By ultrasound</th>
<th>CCT By Pentacam</th>
<th>t test</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean value for central corneal thickness (CCT) for females</td>
<td>548.18± 41.32</td>
<td>529.23± 41.87</td>
<td>0.042</td>
<td>&gt;0.05</td>
<td>Non significant</td>
</tr>
</tbody>
</table>

Table 4: Mean value and standard deviation for the central corneal thickness for males and females by ultrasound and pentacam and their correlation.

<table>
<thead>
<tr>
<th>Item</th>
<th>CCT By ultrasound</th>
<th>CCT By Pentacam</th>
<th>Correlation</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean value for central corneal thickness (CCT) for males</td>
<td>554.71± 46.14</td>
<td>549.94± 36.94</td>
<td>0.876</td>
<td>&lt;0.01</td>
<td>Highly significant</td>
</tr>
</tbody>
</table>

Table 5: Comparison of Mean value and standard deviation for the central corneal thickness by ultrasound and pentacam by t-test for patients below and above 30 years.

<table>
<thead>
<tr>
<th>Item</th>
<th>CCT By ultrasound</th>
<th>CCT By Pentacam</th>
<th>t test</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean value for central corneal thickness (CCT) for &lt;30y</td>
<td>558.36±44.90</td>
<td>545.30±37.26</td>
<td>0.094</td>
<td>&gt;0.05</td>
<td>Non significant</td>
</tr>
</tbody>
</table>

Table 6: Mean value and standard deviation for the central corneal thickness for patients below and above 30 years by ultrasound and pentacam and their correlation.

<table>
<thead>
<tr>
<th>Item</th>
<th>CCT By ultrasound</th>
<th>CCT By Pentacam</th>
<th>Correlation</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean value for central corneal thickness (CCT) for &lt;30y</td>
<td>558.36±44.90</td>
<td>545.30±37.26</td>
<td>0.869</td>
<td>&lt;0.01</td>
<td>Highly significant</td>
</tr>
</tbody>
</table>

Discussion:

As previously mentioned, accurate measurement of corneal thickness is an important issue for a variety of reasons; including prior to refractive surgery (to decrease the incidence of ectasia), for proper measurement of intraocular pressure and as an indirect indication for the endothelial cell function. Although ultrasound pachymetry is considered the traditional way for measurement of corneal thickness, yet nowadays Pentacam is increasingly used for this purpose being easy, fast, non-contact way in addition to the ability of performing further measurements like anterior, posterior corneal topography in addition to anterior chamber depth all are of importance in refractive surgery. In this study, I compared the central corneal thickness measurements by ultrasound pachymetry (Sonoscan Model 4000 AP, Sonamed, USA) and by Pentacam (ALLEGRO Oculyzer Version 1074; Allergo, Germany). I found that the "mean value for the central corneal thickness by ultrasound" for the entire sample was 552.11 ± 43.96 standard deviation while the "mean value for the central corneal thickness by Pentacam" for the entire sample was 541.82 ± 39.87 standard deviation. The student "t" test shows a value of 0.081 (P > 0.05) which reveals a non significant difference between mean central corneal...
thickness measurement by both machines & Pearson correlation shows a value of 0.892 (P value < 0.01) implying a highly significant correlation between mean central corneal thickness measurement by both machines.

The values for the the mean central coneal thickness by Pentacam were slightly lower than that obtained by ultrasound by about 8.60μ ± 14.1μ. Yaniv Barkana, MD &al in 2005 had reported that central corneal thickness measurements obtained by the Pentacam Scheimpflug device were highly correlated with those of the US pachymeter. Pentacam and US measurement differed by a mean of only 6 mm. Therefore, it seems that for most practical purposes, measurements with these instruments can be used interchangeably (Yaniv Barkana.)

While Birgit Lackner, MD etal 2005 reported that in the present collective of 60 eyes of healthy European volunteers, CCT determined with with rotating Scheimpflug imaging (Pentacam)was on average 13 μ (2.4%)thinner than with ultrasound pachymetry. They conclude that Pentacam can be regarded as valid in determining CCT in eyes with normal cornea as the other modalities (Birgit et al., 2005). To study the effect of sex on the measurements, patients eyes were divided into two groups: A-Female group: 72 female (F) eyes (of 38F patients) & B-Male group:45 male(M) eyes (of 26 M patients).

For Females, the mean value for the central corneal thickness by ultrasound was 554.71μ± 46.14 standard deviation while the mean value for the central corneal thickness by Pentacam was 549.94μ±36.94 standard deviation. The student ‘t’ test shows a value of 0.523 (P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines for females & Pearson correlation shows a value of 0.876 (P value < 0.01) implying a highly significant correlation between mean central corneal thickness measurement by both machines for females.

The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound for females.

For Males, the mean value for the central corneal thickness by ultrasound was 548.18μ±41.32 standard deviation while the mean value for the central corneal thickness by Pentacam was 529.23μ±41.87 standard deviation. The student ‘t’ test shows a value of 0.042 (P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines for males & Pearson correlation shows a value of 0.931 (P value < 0.01) implying a highly significant correlation between mean central corneal thickness measurement by both machines for males.

The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound.

In spite of slightly higher values by both machines for the female group (that is probably related to the larger size of the female group i.e 72 female(F) eyes compared to 45 male(M) eyes), yet no statistically significant difference between measurements by both machines was attributed to sex of the patient. To study the effect of age on the measurements, patients eyes were divided into two age groups: Age Group A(<30y):87eyes (of 49 patients) & Age Group B(>30y):30 eyes (of 17 patients).

For age group below 30y, the mean value for the central corneal thickness by ultrasound was 558.36μ±44.90 standard deviation while the mean value for the central corneal thickness by Pentacam was 545.3μ±37.26 standard deviation.

The student ‘t’ test shows a value of 0.094(P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines for patients below 30y & Pearson correlation shows a value of 0.869 (P value < 0.01) implying a highly significant correlation between mean central corneal thickness measurement by both machines. The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound.

For age group above 30y, the mean value for the central corneal thickness by ultrasound was 541.63μ±32.80 standard deviation while the mean value for the central corneal thickness by Pentacam was 535.86μ±24.71 standard deviation. The student ‘t’ test shows a value of 0.71(P=>0.05) which reveals a non significant difference between mean central corneal thickness measurement by both machines for patients above 30y & Pearson correlation shows a value of 0.953 (P value < 0.01) implying a highly significant correlation between mean central corneal thickness measurement by both machines.

The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound. In spite of slightly higher values by both machines for age group <30y (that is probably related to the larger size of age group <30y i.e 87eyes (of 49 patients) compared to 30 eyes (of 17 patients) for the age group >30y, yet no statistically significant difference between measurements by both machines was attributed to age of the patient.
Conclusion:
In the assessment of normal corneas, the Pentacam measured CCT values close to ultrasound pachymetry with tendency for slightly lower values by about 8.60μ ± 14.1μ without significant differences attributed to age or sex therefore, it is considered as valid in determining central corneal thickness as ultrasound pachymetry with other advantages over the ultrasound pachymetry.

REFERENCES