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Comparison of Central Corneal Thickness Measurement with Pentacam and Ultrasound

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Abstract: *Purpose:*Thre 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 includedin the study. *Results:*The mean central corneal thickness by ultrasound pachymetry was 552.1 μ ± 43.96μ standard deviation and by Pentacam 541.82 μ ± 39.87 μstandard deviation with correlation of 0.892 (P value < 0.01) implying a hightly significant correlation but with slightly lower values (by about 8.60μ ± 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 pachymery 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 noninvasivealternative solutions 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 thecomplete 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 measurementsobtained with the rotating Scheimpflug camera with ultrasound pachymetry to provideestimates 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.

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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. There fractive error was measured with an autorefractometer model

Topcon 5000, Japan. The mean spherical equivalentwas -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 tokeep 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 aroundthe optical axis of the eye. Within 2 seconds, the system rotates180° and acquires 25 images that contain 500 measurement pointson the front and back corneal surfaces to draw a true elevation map. The software acquires the images as volume data, thus multiplan arreprojections 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.

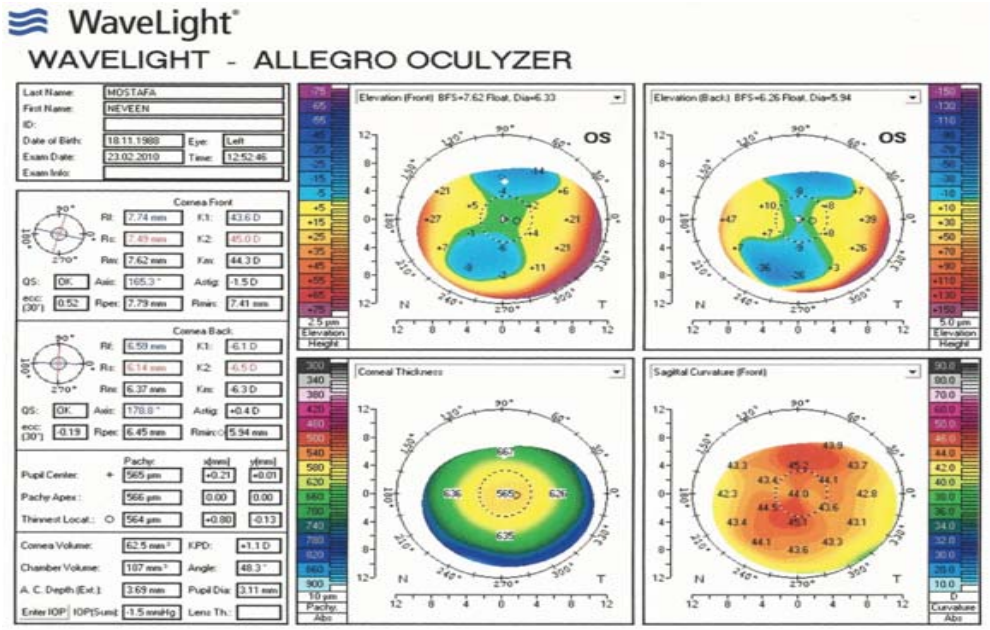


Fig. 1: Pentacam printout showing corneal thickness in addition to further multiple measurements.

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.

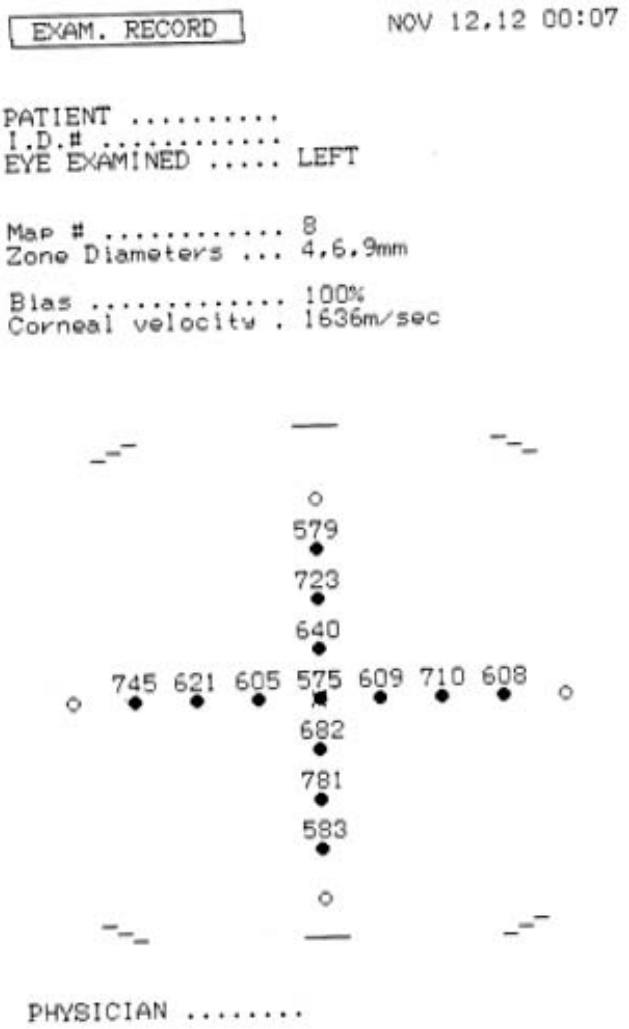


Fig. 2: Ultrasound pachymetry printout showing the central and the other readings.

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 sudy. *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 hightly 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 hightly 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 hightly 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):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 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.

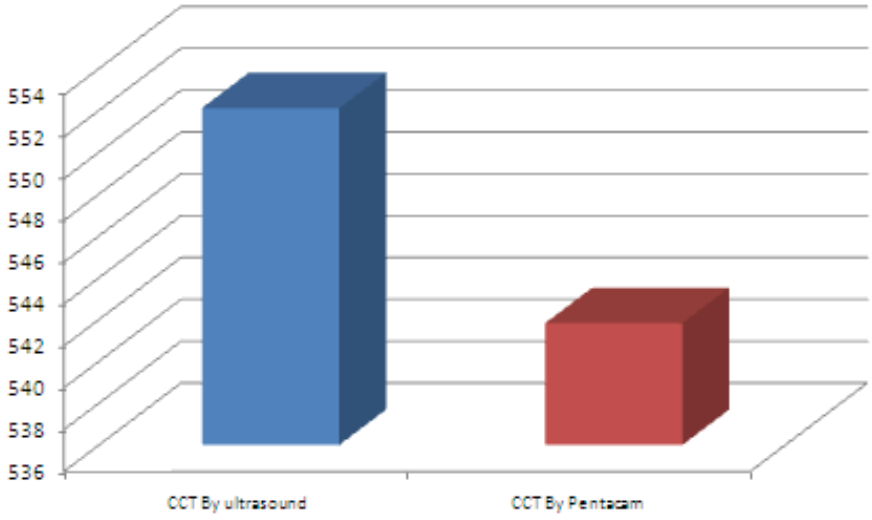


Chart 1: Mean value for the central corneal thickness for the entire sample by ultrasound and pentacam

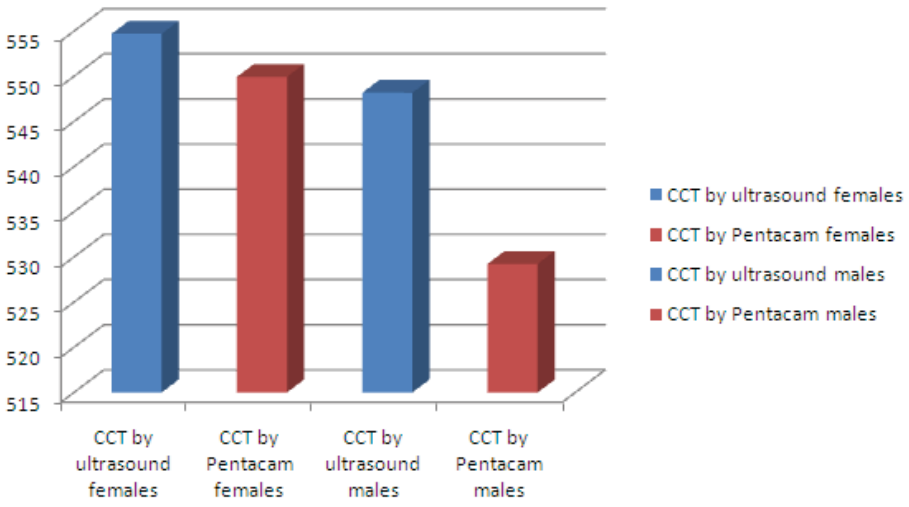
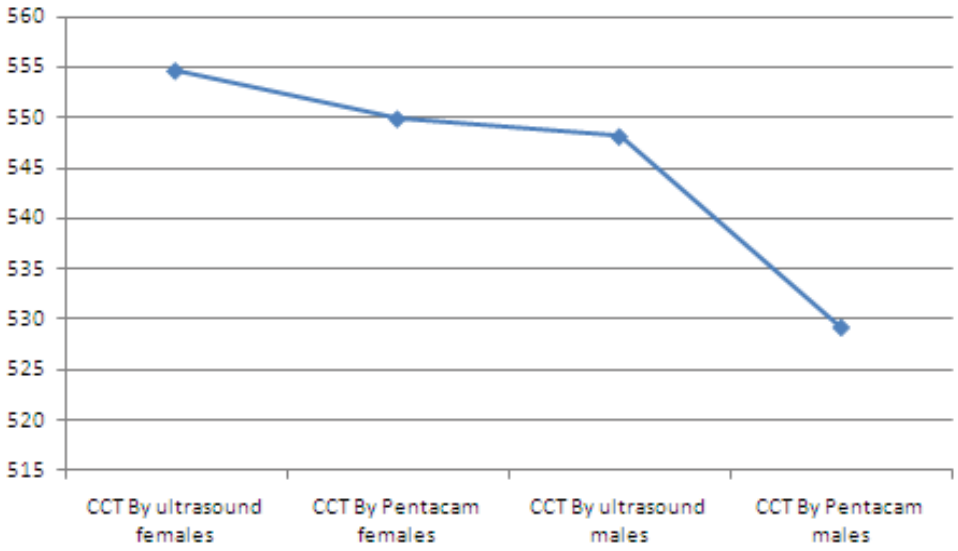


Chart 2: Mean value for the central corneal thickness for females by ultrasound and pentacam.



Graph.1: Mean value for the central corneal thickness for females and males 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 hightly significant correlation between mean central corneal thickness measurement by both machines. (table 6). The values for the the mean central corneal thickness by Pentacam were slightly lower than that obtained by ultrasound (see Chart 3 and Graph 2).

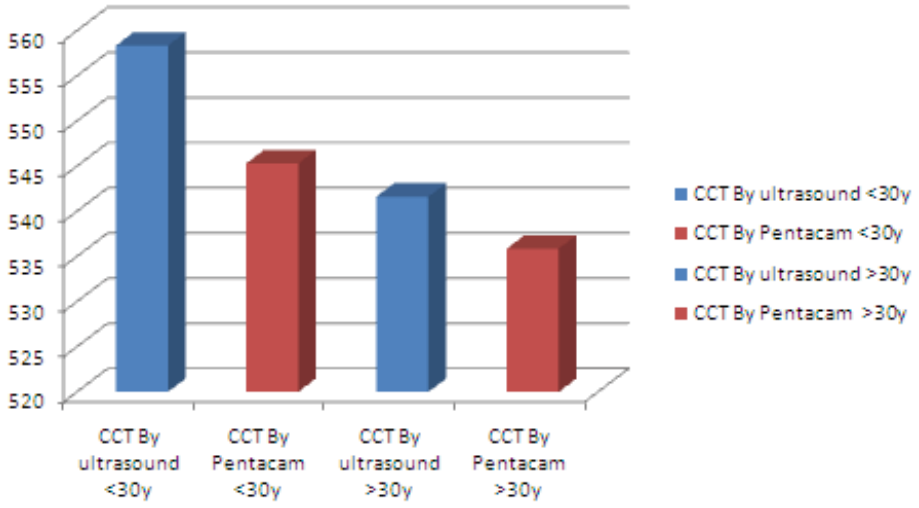
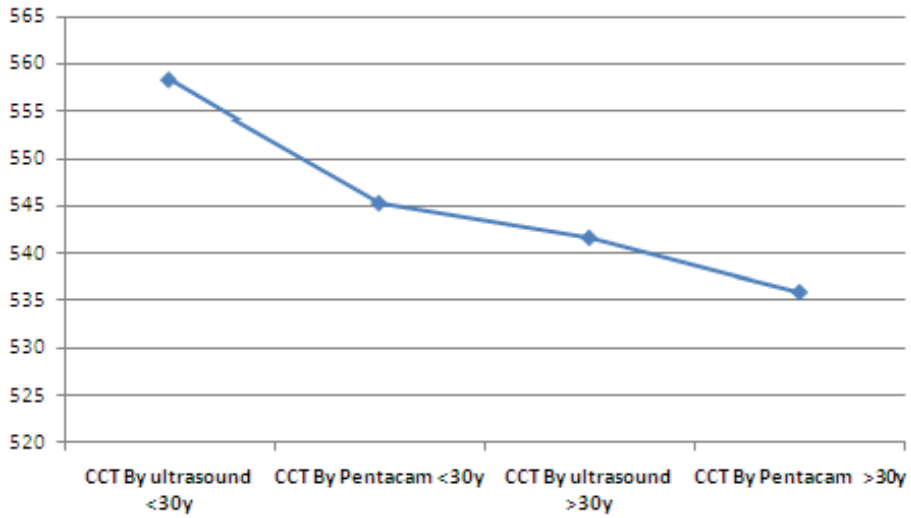


Chart 3: Mean value for the central corneal thickness for according to age by ultrasound and pentacam.



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± 32.80standard deviation with a minimum value of 490µ and a maximal value of 585 µ while the *mean value for the central corneal thickness by Pentacam was* 535.86µ± 24.71standard 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 hightly significant correlation between mean central corneal thickness measurement by both machines. (table 6).

The values for the 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 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.*

Table 1: Comparison of Mean value and standard deviation for the central corneal thickness for the entire sample for the etire sample by ultrasound and pentacam by t- test.

Item	CCT By ultrasound	CCT By Pentacam	t test	Probability	Significance
Mean value for central corneal thickness (CCT)	552.11± 43.96	541.82± 39.87	0.081	>0.05	Non significant

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

Item	CCT By ultrasound	CCT By Pentacam	Correlation	Probability	Significance
Mean value for central corneal thickness (CCT)	552.11± 43.96	541.82± 39.87	0.892498	<0.01	Highly significant

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

Item	CCT By ultrasound	CCT By Pentacam	t test	Probability	Significance
Mean value for central corneal thickness(CCT) for females	554.71± 46.14	549.94± 36.94	0.523	>0.05	Non significant
Mean value for central corneal thickness(CCT) for females	548.18± 41.32	529.23± 41.87	0.042	>0.05	Non significant

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

Item	CCT By ultrasound	CCT By Pentacam	Correlation	Probability	Significance
Mean value for central corneal thickness(CCT) for females	554.71± 46.14	549.94± 36.94	0.876	<0.01	Highly significant
Mean value for central corneal thickness(CCT) for males	548.18± 41.32	529.23± 41.87	0.931	<0.01	Highly significant

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.

Item	CCT By ultrasound	CCT By Pentacam	t test	probability	Significance
Mean value for central corneal thickness(CCT) for <30y	558.36±44.90	545.30±37.26	0.094	>0.05	Non significant
Mean value for central corneal thickness(CCT) for for >30y	545.07±32.80	535.86±24.71	0.710	>0.05	Non significant

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

Item	CCT By ultrasound	CCT By Pentacam	correlation	probability	Significance
Mean value for central corneal thickness(CCT) for <30y	558.36±44.90	545.30±37.26	0.869	<0.01	Highly significant
Mean value for central corneal thickness(CCT) for for >30y	541.63± 32.80	535.86±24.71	0.953	<0.01	Highly significant

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 measuement 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,noncontact 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 *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± 39.87standard 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 hightly 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, MDetal 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 hightly 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±41.32standard deviation while the *mean value for the central corneal thickness by Pentacam* was 529.23µ±41.87standard 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 hightly 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.

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):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 hightly 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± 32.80standard deviation while the *mean value for the central corneal thickness by Pentacam was* 535.86µ± 24.71standard 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 hightly 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 .*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* 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 pachymery 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.

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