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Comparison between Measurement of Central Corneal Thickness by Non-Contact Clinical Specular Microscope and Ocular Coherence Tomography

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Abstract: ***Comparison between measurement of Central Corneal Thickness by Clinical Specular Microscopy and OCT. Purpose: To study the difference between central corneal thickness measurements, acquired by Clinical Specular Microscopy and OCT and infer whether one instrument gives consistently higher readings as compared to other. Materials and Methods: An observational, cross-sectional study was carried out in 2000 eyes of 1000 patients coming to the out-patient department. Patients having corneal pathology, pterygium, those wearing contact lenses, those having undergone corneal surgical procedures and those having a history of previous corneal trauma were excluded from the study. Basic ophthalmological and systemic history was recorded followed by a thorough anterior and posterior segment examination done with the help of Slit lamp and Ophthalmoscope. Central Corneal Thickness was calculated by Non-contact Clinical Specular Microscope and AS-OCT, taking three readings of each eye with each instrument. Results: Non-contact Clinical Specular Microscope (NCSM) and Anterior Segment Ocular Coherence Tomography (AS-OCT) showed strong positive correlation in the measurements of Central Corneal Thickness (CCT) (r= 0.97, p < 0.01). NCSM measured the CCT consistently higher than AS-OCT, the mean difference being 6.51+6.53 µm. A mean CCT of 536 µm was found in males as compared to 531 µm in females when measured by OCT. A mean CCT of 542 µm was found in males as compared to 539 µm in females when measured by Specular Microscope. A mean CCT of 543 µm was found in Diabetics compared to 533 µm in non-diabetics when measured by OCT. NCSM showed a mean CCT of 552 µm in diabetics as compared to 540 µm in non-diabetics. Hypertensive patients showed a mean CCT of 533 µm, compared to non-hypertensive showing 532 µm by NCSM. With OCT, the means were found to be 526 µm in the hypertensive, compared to 527 µm in non-hypertensive. Conclusion: NCSM and OCT show a strong positive correlation in their measurements of CCT. But the difference between their readings is statistically significant. Although they cannot be used interchangeably for research purposes, their readings can be compared for clinical assessment since we know that NCSM measures the CCT 6.51+6.53 µm higher than OCT.***

Keywords: Central corneal thickness, Ocular Coherence Tomography, Specular microscope

1. Introduction

The central corneal thickness (CCT) of a normal and healthy cornea ranges from 450 to 650 µm. It can be thinner in ectatic corneal diseases such as keratoconus, pellucid marginal degeneration, and iatrogenic keratectasia and after surgical tissue ablation. CCT is increased in case of corneal edema, in cases of cornea plana, and other corneal dystrophies and post-keratoplasty (1, 2).

Corneal thickness can mask an accurate reading of eye pressure, causing doctors to treat patients for elevated intra-ocular pressure that may not really exist or to treat them unnecessarily when are normal. Patients with thin corneas (less than 555 µm) show artificially low IOP readings. On the contrary, those patients with thicker CCT may show a higher reading of IOP than what actually exists (1, 3).

Measurement of the corneal thickness is called pachymetry (4). With the advent of technology, we as ophthalmologists have various methods of measuring the corneal thickness at our disposal (5) –

Ultrasonic techniques
1) Conventional ultrasonic pachymetry (6)
2) Ultrasound Biomicroscopy (7)

Optical techniques
1) Manual optical pachymetry (8)
2) Specular microscopy (9, 10)
3) Scanning Slit Technology (11)
4) Optical Coherence Tomography (OCT) (12)
5) Optical Low Coherence Interferometry (13, 14)
6) Confocal Microscopy (15)
7) Laser Doppler Interferometry (16)

Alternative Measurements
1) Pentacam (17)

Optical pachymetry is based on the measurement of the apparent thickness of an optical section of the cornea (18). The ultrasonic pachymeter is based on traditional A-scan ultrasonography, where the recording is in one dimension only, as compared with B-scan instruments, which provide a two-dimensional view of the eye. Currently it is considered as the gold standard for clinical evaluation of corneal thickness. Anterior-segment OCT provides non-contact topographic corneal thickness measurements and has been extensively used to report central and peripheral total corneal thickness (19). AS-OCT also permits the measurement of corneal thickness with a contact lens in situ, making it an accessible procedure for monitoring corneal swelling in contact lens wearers. Clinical Specular microscope projects the light on the surface of the cornea at

nearly normal incidence and images the light reflected specularly from the interface between corneal endothelium and aqueous humor and also air and corneal epithelium. By determining the distance between these two interfaces, it measures the corneal thickness (20).

Corneal thickness is an important parameter to be measured before and after refractive surgeries, to measure the corneal edema in post-operative patients after intraocular surgeries, during glaucoma evaluation to rule out over or underestimation of Intraocular pressure and also as a risk factor for developing glaucoma. It is thus, important for clinicians to have knowledge about different methods and instruments used, and have an idea about their comparative results. The comparison between measurements of central corneal thickness by AS-OCT and Non-contact Clinical Specular Microscopy (NCSM) is done in this study. Central corneal thickness can be influenced by various patient factors like Age, gender, presence of Diabetes mellitus, Hypertension. An analysis of these is also done in this study.

2. Objectives

1) To study the difference between central corneal thickness measurements, acquired by Clinical Specular Microscopy and OCT. to infer whether one instrument gives consistently higher readings as compared to other.
2) To infer whether one instrument gives consistently higher readings as compared to other.

3. Methods and Materials

This was an observational, cross-sectional study carried out in 1000 patients, selected on the basis of inclusion and exclusion criteria discussed below, and conducted after approval from the Institutional Ethics Committee during the period from December 2018 to August 2020. A written informed consent was obtained from all the patients before participating in the study.

Inclusion Criteria

- Patients coming to the OPD
- Patients admitted in the ward
- Adult patients

Exclusion Criteria

- Patients with corneal pathology
- Patients with pterygium
- Patients wearing contact lenses
- Patients having undergone corneal surgery
- Patients with a history of ocular trauma.

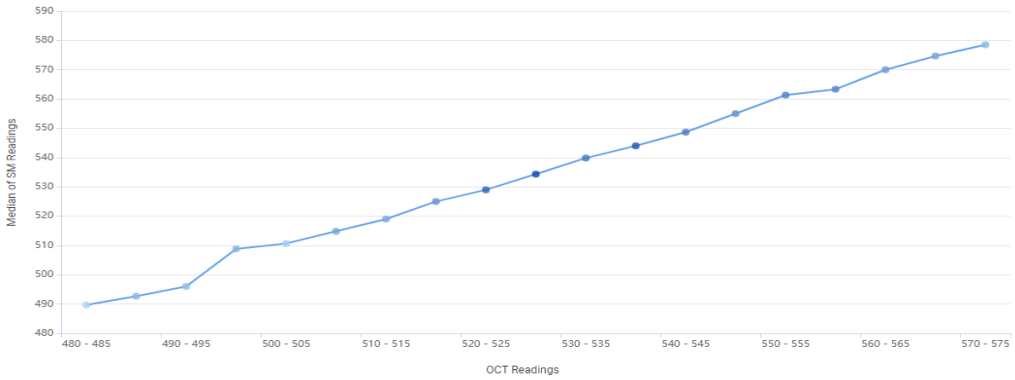
Evaluation

1) Patient's basic details like age, sex and registration number of patient's outdoor case were recorded, followed by a basic ocular history and history of systemic illnesses, specifically Diabetes Mellitus (DM) and Hypertension (HTN).
2) Patient's visual acuity and Pinhole Vision were recorded with each eye separately, followed by a detailed anterior segment examination by Slit Lamp Biomicroscopy and fundus evaluation with an ophthalmoscope.
3) Central corneal thickness was measured by two instruments – OCT and Non-contact Clinical Specular microscope. Three readings of each eye with each instrument were taken.

Readings from the study were compared with the data gathered about the patients i.e. age, sex, presence or absence of systemic diseases (DM and HTN). Readings from both instruments were compared with each other and correlation analysis was done.

4. Results and Analysis

The mean CCTs of the population under study were found to be 533.71± 21.55 µm by OCT and 540.23±21.99 µm by NCSM. A strong positive correlation ($r = 0.97$ with $p < 0.01$) was found between OCT and NCSM readings as shown in the graph below.



NCSM consistently showed higher readings as compared to AS-OCT measurements with the difference between them being 6.51±6.53 µm. This was statistically significant ($p<0.01$).

Age	OCT Means	Specular microscope means
15 -19	574.66	585.83
20-24	563.18	570.13
25-29	557.76	564.29
30-34	555.42	560.80
35-39	547.43	554.31
40-44	538.14	545.27
45-49	534.45	539.19
50-54	531.78	539.62
55-59	528.01	535.94
60-64	524.04	531.03
65-69	520.94	527.71
70-74	504.13	510.46
75-79	502.99	509.30
80-84	491.10	500.13
85-90	493.54	498.83

The CCT readings measured by AS-OCT and NCSM both show a strong negative correlation with age ($r = -0.87$, $p < 0.01$). The table above contains the means for different age groups.

A mean CCT of 536 µm was found in males as compared to 531 µm in females when measured by OCT. A mean CCT of 542 µm was found in males as compared to 539 µm in females when measured by Specular Microscope.

A mean CCT of 543 µm was found in Diabetics compared to 533 µm in non-diabetics when measured by OCT. NCSM showed a mean CCT of 552 µm in diabetics as compared to 540 µm in non-diabetics. Hypertensive patients showed a mean CCT of 533 µm, compared to the non-hypertensive showing 532 µm by NCSM. With OCT, the means were found to be 526 µm in the hypertensive compared to 527 µm in the non-hypertensive.

5. Discussion

Our study found a mean CCT of 533.71± 21.55 µm by OCT and 540.23±21.99 µm by NCSM. These results were similar to other studies conducted in an Indian population by Ramesh et al. (21) (532.42±29.71 µm) and an Asian population by Badr et al. (3) (539.29±34.1 µm). Our study comprised of a mixed urban and rural population from Gujarat and showed a higher mean CCT as compared to central rural Indian population studied by Nangia et al (514±33 µm) (22).

The CCT readings measured by OCT and SM both show a strong negative Spearman correlation with age ($r = -0.87$, $p < 0.01$). This was stronger than the correlation inferred by Galgauskas et al. in the Lithuanian population ($r = -0.26$, $p <0.05$) (23) and Hashmani et al. ($r = -0.05$, $p < 0.01$). Most of the studies have showed a negative correlation but some outliers and contradictors do exist. A uniform strength of correlation between age and CCT cannot be expected in all populations but we can expect it to be negative. The results however are significantly influenced by race and locality.

The mean of CCT readings in males was higher by 4.3 µm as compared to that of females in our study. This finding is comparable to Hwang et al in the Korean population, where males showed a CCT 5.7 µm higher than females (24). No statistically significant difference in the CCT measurements of males and females was found in the studies conducted by Galgauskas and Herse et al. in New Zealanders (23, 25, 26).

In our study, the mean CCT of Diabetics was found to be 10 µm higher than that of those without Diabetes, which correlated with the studies conducted by Su et al. in Singapore (6.5 µm thicker in Diabetics), ($p < 0.01$) and Luo et al in a multiethnic Asian population (4.9 µm thicker in Diabetics) ($p < 0.05$) (27, 28). Diabetes causes intrinsic abnormality of the epithelial basement membrane complex and interferes with epithelial and endothelial barrier function (29). This causes the corneas of Diabetics to be in a state or relative swelling as compared to those without Diabetes.

Our study showed no association of CCT with presence or absence of hypertension similar to Habib et al and Li et al (30).

However, the goal of our study was to compare the readings taken in individuals by two instruments – AS OCT (Anterior Segment Ocular Coherence Tomography) and NCSM (Non-contact Clinical Specular Microscope). A very strong positive Spearman Correlation ($r = 0.97$) was obtained between readings of the instruments. Overall the mean difference between NCSM and AS OCT was 6.51±6.53 µm. ($p<0.01$) with NCSM showing higher values consistently.

Very few studies of comparison between these two instruments have been carried out in a population size comparable to ours. Our results, though similar with such studies e.g. Scotto et al (12), are more accurate for the Indian population. The difference between the two instruments is statistically significant and thus readings of both cannot be used interchangeably for research purposes. However we have an idea that NCSM measures corneas thicker by 6.51±6.53 µm as compared to AS OCT and this can be clinically used to compare the results if readings by one of the instruments are available, since they show a very strong positive correlation.

This is of a practical importance because not all clinicians have multiple or dedicated instruments for measuring CCT due to feasibility and affordability issues. OCT, however, is used widely for diagnosing and managing retinal disorders and has become a common tool in the armamentarium of ophthalmologists worldwide. Like in our setup, a NCSM too, is being used by many, for measuring ECC (endothelial

cell count) values in all patients being posted for intraocular surgeries, pre and postoperatively. So it is highly likely that one of the two instruments will be available with most of the ophthalmologists in small as well as large institutional setups. Our study thus provides them with a solid data as a reference point to manage patients, keeping in mind the limitations of the resources available at their disposal. In this age of refractive surgeries, CCT value is of pivotal importance in planning the choice of refractive procedure to be employed. It is important in deciding the safety and also influences the outcome of the procedure drastically. This study also helps refractive surgeons in comparing values if prior readings by only one of the two instruments are available. CCT also influences the intra-ocular pressure measurements by applanation tonometry. Applanation tonometry, being the gold standard for measurement of IOP is universally used in diagnosing and following up glaucoma patients. In thin corneas, the IOP is underestimated, which can make ophthalmologists miss the diagnosis of glaucoma or have a false reassurance of achieving the target IOP during follow-ups. An accurate CCT measurement with a NCSM/ AS-OCT can help them in such cases for getting the corrected IOP for relatively thin/thick corneas.

6. Conclusion

Non contact Specular Microscope (NCSM) and Anterior Segment Ocular Coherence Tomography (AS-OCT) show a strong positive correlation in the measurement of Central Corneal Thickness (CCT), Pearson correlation coefficient (r) being 0.97. NCSM measures the CCT consistently higher than AS-OCT, a finding which can be very helpful while comparing values clinically. Overall the mean difference between NCSM and OCT is 6.51±6.53 µm. The difference is statistically significant and thus these instruments cannot be used interchangeably for research purposes.

The CCT readings measured by OCT and NCSM both show a strong negative correlation with age ($r = 0.87$) with a p-value of < 0.01. Older people have thinner corneas as compared to the young. Males show slightly higher CCT values than females. On an average Central Corneas of Diabetics are 10 µm thicker than non-diabetics. There is no association of CCT with HTN.

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