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ORIGINAL ARTICLE

Correlation of Corneal Thickness Measurements Between Tono-pachymeter and Scheimpflug-Placido Topography

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ABSTRAK

Pengukuran ketebalan kornea pusat (CCT) adalah penting untuk diagnosis, rawatan dan perancangan pembedahan dalam oftalmologi. Tujuan kajian ini adalah untuk melihat sama ada pengukuran CCT yang diambil dengan Tono-pachymeter dan Topografi Scheimpflug-Placido mempunyai sebarang perbezaan yang signifikan. Pengukuran Tono-pachymeter dan CCT topografi telah diambil (n=400). Persetujuan antara pengukuran ditentukan menggunakan analisis Plot Bland-Altman. Kumpulan umur juga dibahagikan kepada kumpulan 1 (berumur 18-50 tahun, 94 lelaki, 106 perempuan) dan kumpulan 2 (umur >51 tahun, 100 lelaki, 100 perempuan). Min CCT diukur dengan Tonopachymeter dan topografi adalah 563.77 ± 26.43 dan 560.88 ± 26.341 mikron. Analisis Plot Bland-Altman menunjukkan secara keseluruhan, 13 melebihi had atas dan 5 di bawah had minimum persetujuan dengan analisis regresi tidak menunjukkan hubungan yang signifikan (p=0.213). Kumpulan 1 mempunyai 7 di atas dan 2 di bawah dari had persetujuan. Kumpulan dua mempunyai 9 di atas dan 2 di bawah dari had persetujuan. Kedua-dua kumpulan menunjukkan perbezaan yang tidak signifikan (p=0.07 dan p=0.86). Tono-pachymeter dan Topografi Scheimpflug-Placido memberikan hasil CCT yang boleh dipercayai antara satu sama lain. Walau bagaimanapun, oleh kerana had julat persetujuan masih boleh mempengaruhi penilaian seseorang pesakit, kami mengesyorkan klinik yang menggunakan kedua peralatan ini untuk tidak menukar pengukuran semasa penggunaan.

Kata kunci: pachymetri kornea, kornea, teknik diagnostik oftalmologi, topografi kornea

ABSTRACT

Central corneal thickness (CCT) measurements are important for diagnosis,

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treatment, and surgery planning in ophthalmology. The purpose of this study was to see whether CCT measurements taken with Tono-pachymeter and Scheimpflug-Placido Topography had any significant differences. Tono-pachymeter and topography CCT measurements were taken (n=400). Inter-measurement agreement between them was determined using Bland-Altman Plot analysis. Age groups were also formed as group 1 (aged 18-50 years, 94 males, 106 females) and group 2 (age >51 years, 100 males, 100 females). Mean CCTs measured by Tono-pachymeter and topography were 563.77 $\pm$ 26.43 and 560.88 $\pm$ 26.341 microns. Bland-Altman Plot analysis showed in total, 13 were above the upper limit and 5 were under the minimum limit of agreement with regression analysis showing no significant relationships (p=0.213). Group 1 had 7 above and 2 below from the limits of agreement. Group two had 9 above and 2 below from the limits of agreement. Both groups showed insignificant differences between devices (p=0.07 and p=0.86). Tono-pachymeter and Scheimpflug-Placido Topography give reliable CCT results within each other. However, since the limit of agreement ranges can still affect one-to-one patient evaluations, we recommend clinics that use these devices to not interchange measurements in practice.

Keywords: corneal pachymetry, corneal topography, cornea, ophthalmological diagnostic techniques

INTRODUCTION

Central corneal thickness (CCT) measurements are important for diagnosis, treatment, and surgery planning in ophthalmology. Many techniques are used to measure CCT, each of which having direct influence over the measurement (Çelebi & Mirza 2014).

Automated optical pachymeters like Kerato-refractometer tono-pachymeters are pivotal in terms of enabling CCT measurements to be used as screening tools in daily practice. Replacing the need to take separate measurements, this method measures intra-ocular pressure, autorefraction, and keratometry in addition to CCT.

Scheimpflug imaging is commonly used for clinical evaluation of corneal pathologies and can also measure corneal thickness at any point of the cornea. By using a rotating Scheimpflug camera it provides a three-dimensional model of the anterior segment including the elevation maps of the corneal surfaces and pachymetry maps. Kerato-refractometer tono-pachymeters use automated, noncontact techniques using optical pachymetry to determine CCT. The illuminated slit is measured, and corneal thickness is calculated using trigonometry (Polat et al. 2016)

There are previous studies comparing different CCT measurement methods within each other. Given that these previous studies showed statistical differences between measurements

taken with Scheimpflug and automated optical pachymetry, we expected to find differences in CCT measurements taken by topographer and Kerato-refractometer tono-pachymeter. (Wells et al. 2013). Thus, the purpose of this study was to discover whether the Sirius topographer (Sirius,CSO,Italy) and Topcon TRK-2P (Topcon, USA) CCT results are within each other's limits of agreement and can be used interchangeably.

MATERIALS AND METHODS

Subjects and Methods

This study received approval from the Hitit University ethics committee (decision no. 2019-07) and adhere to the principles of the Declaration of Helsinki. A total of 400 patients without significant refractive errors (between the spherical equivalents of -2 and +2 diopters) participated in the study. Patients over the age of 50 were taken in the study only if best corrected vision were 20/25, as were patients who had had previous non-complicated cataract surgery.

Measurement was performed with the Topcon TRK-2P first, per the normal screening method, which was followed by a complete ophthalmological examination and topography. All measurements were taken by the same technician. The Topcon TRK-2P was used in automatic mode, in which CCT is measured multiple times and an average calculated.

Study descriptives were expressed as mean standard deviation, in addition to minimum and maximum values. Inter-measurement agreement between the devices was determined using Bland-Altman Plot analysis, followed by linear regression using IBM Statistical Package for the Social Science (Version 24.0). P-value below 0.05 was considered to be statistically significant. The Bland-Altman plot was presented as a scatter plot in which the x axis represents the average of the measurements [(TRK-2P + Sirius)/2] and the y axis shows the difference between the two paired measurements (TRK-2P - Sirius). The limits of agreement are shown as the horizontal lines within which 95% of all the points fall on either side of the bias [Mean Value $\pm$ (1.96 x the standard deviation)] (Bland & Altman 1999).

In addition to collective analysis, the groups were also formed by age. Group 1 consisted of patients between the ages of 18 and 50 years. Group 2 was formed by subjects over 51 years of age.

RESULTS

A total of 194 males and 206 females were taken in the study. Of these, 94 males and 106 females were in group 1. Group 2 had equal number of male and female subjects. The gender of the patients between the age groups were statistically insignificant ($p = 0.78$).

Mean corneal thicknesses as measured by TRK-2P and Sirius topography were 563.77 $\pm$ 26.43 and 560.88 $\pm$ 26.341 microns. Descriptives of the groups are shown in Table 1.

Bland-Altman Plot analysis and scatter graph were constructed to find the limits of agreement. This showed

Table 1: Descriptives for the groups. The columns show the Tono-pachymeter (Topcon TRK-2P Kerato-refractometer tono-pachymeter) and Scheimpflug Topography (Sirius Scheimpflug-Placido Topography). Corneal Thickness row shows the minimum and maximum CCT values and their means for each group. Difference between measurements are shown in the second row, with minimum and maximum difference for each group and their mean values. The minimum and maximum ages and means of the age groups are shown in the last row

	Tono-pachymeter	**Scheimpflug Topography**	**Tono-pachymeter**	**Scheimpflug Topography**	**Tono-pachymeter**	**Scheimpflug Topography**
Corneal Thickness (Microns)						
Min/Max	469/624	468/630	469/624	468/630	498/612	495/610
Mean±SD	561.83±27.98	559.13±28.12	559.89±29.39	557.38±29.69	563.77±26.43	560.88±26.41
Difference Between Measure-ments (Microns)						
Min/Max	(-6) /(+20)		(-6) /(+20)		(-3)/(+9)	
Mean±SD	2.70±2.16		2.51±2.36		2.89±1.92	
	TOTAL SUBJECTS Min – Max age: 18-75 years Mean age: 48.92±16.16		GROUP 1 Min – Max age: 18-50 years Mean age: 35.01±8.82		GROUP 2 Min – Max age: 51-75 years Mean age: 62.83±7.57	

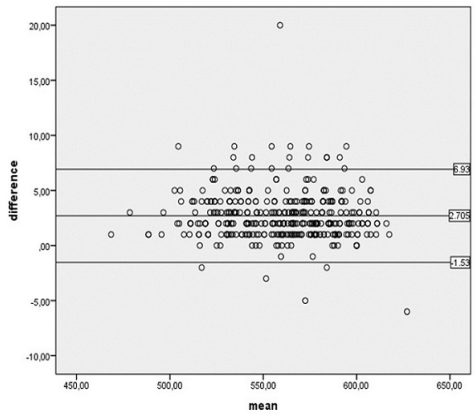

Figure 1: Bland-Altman Plot analysis for all subjects. The average of the two measurements is plotted along the horizontal axis and the difference between the two methods is plotted along the vertical axis. The mean difference, upper and lower limits of agreement values are shown on their respective horizontal lines. The regression analysis for this group is -0.0048, with the p value of 0.21.

that in all of the results, most fell between the limits of agreement. Of the 400 patients, 13 measurements were above the upper limit of agreement, and 5 were under the minimum limit of agreement. Regression analysis showed no significant relationship with the p value of 0.213. Scatter graph is shown in Figure 1.

In group 1 of the 200 patients 7 results were above and 2 result were below the upper and lower limits of agreement respectively. Regression analysis showed no significant relationship with the p-value of 0.07. Scatter graph is shown in Figure 2.

In the 200 subjects forming the second group, 9 were above and 2 were below the upper and lower limits of agreement, respectively. Regression

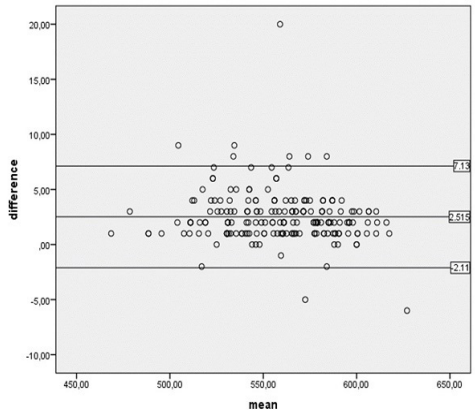

Figure 2: Bland-Altman Plot analysis for group 1 (ages between 18 and 50 years). The average of the two measurements is plotted along the horizontal axis and the difference between the two methods is plotted along the vertical axis. The mean difference, upper and lower limits of agreement values are shown on their respective horizontal lines. The regression analysis for this group is -0.01, with the p value of 0.07.

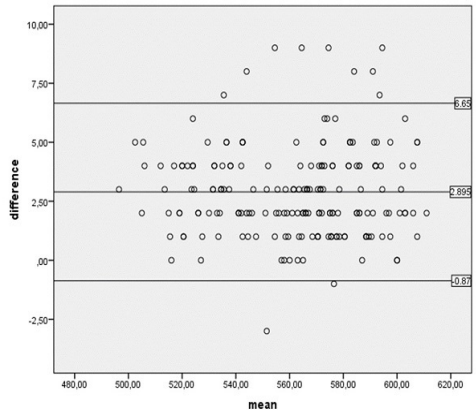

Figure 3: Bland-Altman Plot analysis for group 2 (ages between 51 and 75 years). The average of the two measurements is plotted along the horizontal axis and the difference between the two methods is plotted along the vertical axis. The mean difference, upper and lower limits of agreement values are shown on their respective horizontal lines. The regression analysis for this group is 0.001, with the p value of 0.86.

analysis showed no significant relationship with the p-value of 0.86. Scatter graph is shown in Figure 3.

DISCUSSION

CCT measurement interchangeability between multiple devices keep being compared within each other every time a new device is introduced to ophthalmology practices. The gold standard of measurement remains contact ultrasound pachymetry (USP), and many studies have shown that non-contact methods are not clinically interchangeable with it (Li et al. 2007). The major conclusion reached by CCT measurement studies is that current non-contact measurement methods, although sometimes comparable, result in significantly different measurements both from each other and from USP (Chen et al. 2012; González-Pérez et al. 2018; O'Donnell et al. 2012). However, USP has its own drawbacks, such as non-central placement of the probe, epithelial edema due to the use of topical anesthesia, and probe pressurization (Chen et al. 2012). Previous studies have shown different results using a variety of technologies. In one study, Scheimpflug imaging has been found statistically comparable to CCT measurement with USP (Huang et al. 2011). Doğan et al. (2019) found that Sirius topographer and USP were within each other's limit of agreement. Bayhan et al. (2014) showed that Scheimpflug-Placido topographer significantly underestimated the corneal thickness compared with USP measurements. In contrast to this overestimation, Çağlar et al. (2017) reported that Sirius device results are higher than when measured

by optical biometry.

On the pachy-tonometer front, Lee et al. (2011) found no statistically significant difference between measurements taken with the NT-530P (Nidek, Japan), Tonopachy, and Pentacam topography. Wells et al. (2013) found that the Topcon TRK-1P underestimated CCT when compared with anterior segment optical coherence tomography and USP and explained this difference by the local anesthetic swelling effects on the cornea. Özyol and Özyol (2017) found that the Pentacam Scheimpflug system in their study overestimated CCT measurements compared to TRK-2P).

Our study demonstrated that Sirius Topographer and TRK-2P has an insignificant difference when measuring the CCT, with only 18 results in the total of 400 eyes out of the limits of agreement. here was also no difference for these over/under results between age groups. However, although not statistically significant, the mean TRK-2P values were higher, as seen in Table 1. So Özyol and Özyol's results are in contrast to our findings. Kocamis and Kilic (2019) found that significantly lower measurements were found when Lenstar 900 was compared with Topcon TRK-2P, which is similar to our results. In addition to this, the scatter graph of group 2 shows that the results are within the limits of agreement, but not consistently on the mean value, rather all over between the upper and lower limits. The reason for this "scattered" values is unclear. Both measurement techniques require good fixation, and it is possible that elderly patients found it harder to stay fixated while undergoing topography. Dry eye, which increases with age, has also been shown to be factor in CCT measurements, but we would have expected it to affect both measurements.

There are a few limitations to this study. First, all the measurements were achieved by the same technician. This may have introduced a bias in the measurements, however it is also realistic in the environment of our clinic, where measurements are taken by only one person in practice. Intra-examiner repeatability could have not been checked for the same reason.

CONCLUSION

In conclusion, we have found TRK-2P tono-pachymeter and Sirius Scheimpflug-Placido Topography give CCT results in agreement within each other. However, since the limit of agreement ranges can still affect one-to-one patient evaluations, we recommend clinics that use these devices to not interchange CCT measurements during actual practice.

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