Human corneal thickness using a noncontact specular microscope

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SUMMARY

The aim of this work was to study the central corneal thickness values and interobserver variability using a noncontact specular microscope.

Methods: 62 eyes from 31 healthy subjects were studied with the Topcon SP-2000P noncontact specular microscope (Topcon Corp., Tokyo, Japan). 16 (51.61%) were females, and 15 (48.38%) were males. The mean age of the sample was 31.83±5.68 years. The mean of three consecutive measurements of the central corneal thickness was recorded by two investigators.

Results: Mean central corneal thickness was 497±53 μm for physician I and 497±51 μm for physician II (p=0.982). No significant differences were found between the left and right corneas (p=0.999), between females and males (p=0.756), between ≤ 29-years-olds and ≥ 30-years-olds (p=0.945) or between myopic and hyperopic eyes (p=0.994).

Conclusion: Noncontact specular microscopy is a recently introduced anatomical tool that can be used to study the human cornea in vivo.

Key Words: Cornea – corneal thickness – specular microscopy – noncontact – pachymetry

INTRODUCTION

The study of corneal anatomy has become the focus of several studies because refractive surgery by means of stromal photoablation with the excimer laser involves measuring central corneal thickness (Price et al., 1999).

Among the different techniques available, ultrasound pachymetry is possibly the most commonly used technique.

The advent of ultrasound pachymetry and other different techniques has opened up new possibilities to study corneal anatomy *in vivo*. One of these methods is noncontact specular microscopy.

Specular microscopy is the current technique for evaluating corneal endothelial morphology and is also reliable in measuring corneal thickness. Focusing on the corneal endothelium, the device provides specular images and gives the focal distance, which can be calculated as the corneal thickness (Modis et al., 2001a; Modis et al., 2002).

The most advanced noncontact specular microscopes do not require corneal contact and are equiped with auto-focus and image-analysis programs. However, there have only been a few studies on human corneal thickness using the recently developed noncontact specular microscopes (Bovelle et al., 1999; Cho and Cheung, 2000; Modis et al., 2001a,b; Modis et al., 2002).

Thus, certain important issues concerning the study of corneal thickness with noncontact specular microscopy must come under scrutiny.

A striking example of this is whether there are significant differences among different observers when central corneal thickness measurements are performed using noncontact specular microscopes.

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Following on from this, the aim of the present work was to study central corneal thickness (CCT) values and the interobserver variability of CCT measurements obtained with a noncontact specular microscope.

Materials and Methods

62 eyes from 31 patients were analysed in a prospective study. Participation was voluntary and informed consent was obtained after the subjects had been informed about the nature of the study.

Sixteen patients (51.61%) were female, and fifteen (48.38%) were male. The age of the patients ranged from 20 to 56 years, with a mean of 31.83±5.68 years. Spherical equivalent manifest refraction ranged from +2.50 to -11.50 diopters (D), with a mean of -5.77±2.75 D.

Selection criteria included an age of 20 years or older, stable refraction over the past years, and a spectacle-corrected visual acuity of 20/40 or better. The patients were tested using Goldmann applanation tonometry and those with an IOP value of over 21 mmHg were excluded. The patients had no corneal pathology and those using contact lenses were also excluded, as were patients with previous ophthalmic surgery or systemic diseases.

CCT measurements were carried out with a Topcon SP-2000P noncontact specular microscope (Topcon Corp., Tokyo, Japan) according to the instructions manual. The Topcon SP-2000P noncontact microscope provides specular images and gives the focal distance, which is interpreted as corneal thickness (Modis et al., 2001a; Modis et al., 2002).

This machine operates with both an automated and a manual imaging method. We used the automated mode and the calibration of the specular microscope was recorded according to the manufacturer's instructions.

CCT measurements were always performed in the same time interval (between 10 and 11 a.m.). Corneal thickness was measured using the Topcon SP-2000P specular microscope as described previously (Bovelle et al., 1999; Cho and Cheung, 2000; Modis et al., 2001a,b; Modis et al., 2002).

The mean of three consecutive measurements of central corneal thickness was recorded by one physician (JASG) while the patient focused on a fixation light in the instrument.

A few seconds later a second physician (A.L.), who was unaware of the results obtained by the first one, measured the CCT again. We analysed interobserver variability by comparing the results obtained by physicians 1 and 2.

The differences between data sample means were determined by a t-test and *P* values of less than 0.05 were considered statistically significant. The normality of the data in each group was confirmed using normal probability plots beforehand.

Results

The mean CCT of the subjects was 497±53 μm for physician 1, and was 497±51 μm for physician 2. No significant differences between the results of physician 1 and 2 were found (p=0.982).

Table 1 shows the CCT values obtained (μm±SD).

No significant differences were found (p=0.999) for the mean CCT between the left (n=31; mean±SD: 497±54 μm) and right corneas (n=31; mean±SD: 497±53 μm).

The corneal thickness of the female group (n=32) was not significantly different from that of the male group (p=0.756).

No statistically significant difference was found (p=0.945) between the mean CCT of patients with an age of 29 years old or under (n=32) and the mean CCT of patients with an age of 30 years old or over (n=30).

Table 1.– Central corneal thickness values obtained with noncontact specular microscopy in the present study (μm±SD)*

	All eyes		Left eyes		Right eyes		
	n	**mean±SD**	**n**	**mean±SD**	**n**	**mean±SD**	**p-value ‡**
Female	32	499±60	16	499±59	16	498±62	0.877
Male	30	495±46	15	494±45	15	495±45	0.659
≤ 29 years	32	496±49	16	497±48	16	496±51	0.967
≥ 30 years	30	497±58	15	497±60	15	498±58	0.826
Myopics	44	497±59	22	498±57	22	495±62	0.769
Hyperopics	18	497±37	9	493±46	9	500±29	0.227

* = Results obtained by physician 1; ‡ = Comparison between left and right eyes

The mean CCT value for the myopic eyes (n=44) was not significantly different (p = 0.994) from that of the hyperopic eyes (n=18).

Discussion

This study measured the CCT of healthy subjects using the Topcon SP-2000P noncontact specular microscope. Three important facts emerged from our study. First, our noncontact specular corneal thickness values were lower than those found using interferometric pachymetry (Hitzenberger *et al*., 1992), optical pachymetry (Herse and Yao, 1993; Hitzenberger et al., 1992), Orbscan pachymetry (Liu et al., 1999; Liu and Pfugfelder, 2000), ultrasound pachymetry (Longanesi et al., 1996; Lam et al., 1998; Bron et al., 1999; Price et al., 1999), and noncontact Scheimpflug photography (Eysteinsson et al., 2002).

Nonetheless, it has been reported that there are differences among noncontact specular pachymetry results and the values obtained with other pachymetric techniques when carrying out morphometric studies on the same sample (Bovelle et al., 1999; Modis et al., 2001a,b).

Bovelle et al. (1999) reported a difference of 31.6 μm while Modis et al. (2001a,b) reported a difference of 33 μm and 28 μm between noncontact specular pachymetry and ultrasound pachymetry results. Furthermore, noncontact specular microscopy afforded the lowest mean CCT values compared to optical and Orbscan pachymetry (Modis et al., 2001a). These authors also observed that with noncontact specular microscopy, the CCT values were 96 μm and 93 μm less than those obtained in the same sample when carrying out contact specular microscopy (Modis et al., 2001a,b).

The same group of researchers described another study (Modis et al., 2002) in which the differences in the CCT results between contact and noncontact specular pachymetry were analyzed. In that study, the noncontact microscope gave a thinner mean CCT value than the contact microscope, the diference in thickness (99±4 μm) between the two methods being significant.

Moreover, the results obtained in the present work were lower than those previously obtained by application of optical coherence tomography (Bechmann et al., 2000). Despite this, Feng et al., (2001) have recently presented their results on optical coherence tomography in healthy eyes. They reported a mean value for CCT of 498±11 μm, which is almost identical to the mean corneal thickness value obtained in the present study.

The second important observation is that our CCT values are lower than those previously obtained using the same microscope (Bovelle et al., 1999; Cho and Cheung, 2000; Modis et al., 2001a,b; Modis et al., 2002).

One explanation for the low values obtained could be that relatively few eyes were analysed and that patients with an intraocular pressure of over 21 mmHg were excluded, since it is known that CCT in these individuals is commonly thicker than the mean (Bron et al., 1999; Bechmann et al., 2000). Furthermore, so far there have only been a few studies on human corneal thickness using noncontact specular microscopes (Bovelle et al., 1999; Cho and Cheung, 2000; Modis et al., 2001a,b; Modis et al., 2002) and we believe that additional studies will be necessary to confirm our results.

Finally, in the present study the two sets of CCT values were almost identical: investigator 1 reported 497.24±53.45 μm and investigator 2 reported 497.47±51.95 μm. Similarly, Bovelle et al. (1999) and Cho and Cheung (2000) observed that the measurements made by two investigators were not significantly different either.

Conventional morphometric studies by means of contact ultrasound must be carried out by the same physician because, as is known, significant differences appear in the results of different observers when morphometric studies are carried out on the same sample (Bovelle et al., 1999) and this is indeed one of the main disadvantages of ultrasound.

Nevertheless, we assume that the results obtained by physician 1 and physician 2 in the present study were almost equal because the two investigators waited for seconds between taking the measurements.

In short, noncontact specular microscopy is an efficient instrument for studying central corneal anatomy *in vivo*.

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