Repeatability of central corneal thickness and ocular anterior chamber depth measurements with the orbscan topography system

M.V. Sanhermelando[1], A. Lleó[1], L. Alonso[1], M.S. Rahhal[1], T. Hernández Gil de Tejada[2], F. Martínez Soriano[2] and J.A. Sanchis Gimeno[1,2]

1- Rahhal Ophthalmology Clinic, Valencia

2- Department of Anatomy and Human Embryology, Faculty of Medicine, University of Valencia

SUMMARY

The Orbscan topography system is a new anatomical noncontact system that allows study of central corneal thickness and ocular anterior chamber depth. It is currently important to know if there are significant differences among different observers when morphometric studies are carried out with the Orbscan System. Following on from this, the present work focuses on the repeatability of the new Orbscan Topography System II measurements.

At the Rahhal Ophthalmology Clinic and the Faculty of Medicine of Valencia (Spain), we carried out a prospective study involving 46 eyes of 46 healthy patients: 27 were women (58.59%) and 19 were men (41.30%). The mean age of the sample was 29.93 ± 6.6 years (range: 18-47 years). One physician carried out central corneal thickness and ocular anterior chamber depth measurements with the Orbscan Topography System II (Bausch & Lomb Surg, Barcelona, Spain), while a second physician measured the corneal thickness and ocular anterior chamber depth again. The means of two consecutive measurements were used. Only one eye per patient was considered for the statistical analysis. The repeatability of the Orbscan measurements was analysed by comparing the results obtained by physicians 1 and 2.

The mean central corneal thickness of the sample (mean ±SD) was 549.39 ±46.65 µm (physician 1) and 549.32 ±47 µm (physician 2). Thus, no significant differences were found between physicians (p=0.994). The mean ocular anterior chamber depth (mean ±SD) was 3.14 ±0.27 mm (physician 1) and 3.14 ±0.26 mm (physician 2). No significant differences were found between the physicians (p=0.978). Women had significantly greater corneal thickness values than men (p=0.003 for physician 1, and p=0.004 for physician 2). No significant differences between the sexes were found for ocular anterior chamber depth.

In sum, the Orbscan Topography System II offers a high degree of repeatability for central corneal thickness and ocular anterior chamber depth measurements. This situation should facilitate the study of corneal and ocular anatomy in vivo.

Key Words: Central corneal thickness – Anterior chamber depth – Morphometry – Noncontact – Repeatability

INTRODUCTION

Study of the in vivo ocular globe gained increasing importance in recent years due to the devel-

Submitted: January 30, 2002
Accepted: May 3, 2002

Correspondence to:
Dr. Juan Alberto Sanchis Gimeno. Dpto. Anatomía y Embriología Humana, Facultad de Medicina, Universidad de Valencia, Av/ Blasco Ibáñez 17, E-46010 Valencia, Spain. Phone: + 34 96 3864170; Fax: + 34 96 3864815. E-mail: juan.sanchis@uv.es

opment of new techniques in refractive surgery. Two of the most commonly used techniques are excimer laser in situ keratomileusis and bioptics.

Refractive surgery by means of the excimer laser in situ keratomileusis technique (LASIK) involves the photoablation of the corneal stroma under a flap of 160-180 µm (Tabbara et al., 2001; Balazsi et al., 2001). Bioptics is a surgical technique that combines excimer laser photoablation with intraocular lens implantantion (Zaldívar et al., 1999; Güell et al., 1999).

Before carrying out LASIK, it is necessary to carry out a preoperative central corneal thickness measurement in order to avoid the risk of postsurgical keratectasia (Wang et al., 1999; Schmitt-Bernard et al., 2000). In the case of the bioptics technique, apart from measuring the corneal thickness it is also necessary to have information about the ocular anterior chamber depth in order to successfully implant the intraocular lens. Furthermore, because of the different anatomical structures of myopic and hyperopic eyes ocular anterior chamber depth measurement is an important factor in refractive surgery (Vetrugno et al., 2000).

For several years, ultrasound pachymeters and ultrasound biometers have been used to study central corneal thickness (Longanesi et al., 1996; Bovelle et al., 1999; Price et al., 1999; Sanchis Gimeno et al., 2001a) and ocular anterior chamber depth (Midelfart and Aamo, 1994; Owens et al., 1998; Osuobeni, 1999, Hosny et al., 2000; Wong et al., 2001; Muñoz et al., 2001).

The Orbscan Topography System is a recently developed technique. This system was developed as a corneal topography analyser although recently the possibility of measuring ocular anterior chamber depth has been introduced (Vetrugno et al., 2000).

Currently, this new anatomical noncontact system permits study of central corneal thickness and ocular anterior chamber depth.

Morphometric studies by means of ultrasound must be carried out by the same physician due to the absence of repeatability among different observers. It is known that significant differences arise in the results of different observers when morphometric studies are carried out on the same sample (Bovelle et al., 1999) and this is one of the main disadvantages of ultrasound.

Thus, certain important issues remain to be resolved concerning the Orbscan Topography System. A striking example of this is whether there are significant differences among different observers when central corneal thickness and ocular anterior chamber depth measurements are performed using the Orbscan System.

On the light of above, we were prompted to study the repeatability of the Orbscan Topography System II by comparing the central corneal thickness and ocular anterior chamber depth results obtained by two different physicians examining the same sample.

MATERIALS AND METHODS

Prior procedures

At the Rahhal Ophthalmology Clinic and the Faculty of Medicine of Valencia (Spain) we carried out a prospective study involving 46 eyes of 46 healthy patients. The work was performed in accordance with the World Medical Association's Declaration of Helsinki and written informed consent was obtained from all patients.

The study included 27 women (58.59%) and 19 men (41.30%). The mean age of the subjects was 29.93 ± 6.6 years (range: 18-47 years). The women had a mean age of 30.14 ± 6.45 years and the men had a mean age of 29.63 ± 6.21 (range: 19-44 years).

All patients underwent an ophthalmic examination that included best-corrected visual acuity, manifest refraction (KR 7000-P Topcon Corp, Tokyo, Japan), slit-lamp examination (Haag Streit Biomicroscope 900, Bern, Switzerland), corneal topography (EyeSys Corneal Analysis System, Houston, TX), noncontact specular microscopy (Topcon SP-2000P noncontact specular microscope, Topcon Corp., Tokyo, Japan), gonioscopy, dilated fundus examination and repeated Humphrey 24-2 static threshold perimetry (Humphrey Systems, Dublin, CA).

Eyes that had previously undergone intraocular surgery or that had corneal disease, topographic alterations, or clinical corneal changes were excluded from the study. The eyes studied had no visual field loss and no optic disc cupping. Patients with systemic disease or corneal endothelial cell counts below 2.000 cells/mm^2, together with contact-lens wearers, were also excluded.

The mean manifest spherical equivalent refraction (mse) of the sample was -2.87 ± 0.85 diopters (range: -13.00 to +6.00 diopters). The women had a mse of -3.25 ± 4.21 diopters (range: -13.00 to +6.00 diopters) and the men had a mse of -2.17 ± 3.77 diopters (range: -11.50 to +4.00 diopters).

23 eyes (50.0%) had a best-corrected visual acuity (BCVA) of ≥20/22. 18 eyes (39.13%) had a BCVA of ≥20/20. 22 eyes (81.48%) from the women had a BCVA of ≥20/22 and 12 (44.44%) had a BCVA of ≥20/20. 13 eyes (68.42%) from the men had a BCVA of ≥20/22 and 8 (42.10%) had a BCVA of ≥20/20.

The mean tonometry for the whole of the sample was 15.89 ±1.67 mmHg (range: 12-20 mmHg). The women had a mean tonometry of 16.14 ±1.52 mmHg (range: 14-20 mmHg) and the men had 15.52 ±1.81 mmHg (range: 12-18 mmHg).

Central corneal thickness and ocular anterior chamber depth measurements

Central corneal thickness and ocular anterior chamber depth were measured by two different physicians. First, one physician carried out corneal thickness and ocular anterior chamber depth measurements. A second physician measured again corneal thickness and ocular anterior chamber depth. Both physicians obtained the means of two consecutive measurements of central corneal thickness and ocular anterior chamber depth. The second physician was not aware of the results obtained by physician 1.

Measurements were carried out with the Orbscan Topography System II (Bausch & Lomb Surg, Barcelona, Spain). To obtain corneal thickness and ocular anterior chamber depth measurements, the procedures recommended by the manufacturer were followed.

The principles and use of the Orbscan Topography System are well documented (Liu et al., 1999). Two scanning slit-lamps project beams at 45 degrees to the right or left of the instrument axis. 40 images –20 with slit beams projected from the left and 20 from the right– are obtained in two intervals, each lasting for 0.7 seconds. Surface data points are measured on the x, y, and z axes, thus creating colour-coded topographic maps.

During examination, the patient's chin was placed on the chin rest and the forehead was rested against the forehead strap. The subject was asked to look at a blinking red light coaxial to the imaging system. The tracking system measures involuntary eye movement during the examination.

Central corneal thickness is obtained showing the differences in elevation between the anterior and posterior surfaces of the cornea. Nevertheless, with the Orbscan system, the ocular anterior chamber depth is the distance from the anterior cornea to the anterior lens and not the distance from the posterior cornea to the anterior lens.

The repeatability of the central corneal thickness and ocular anterior chamber depth measurements obtained here was analysed by comparing the results recorded by physician 1 and 2.

Statistical method

All results were analysed statistically using the SPSS statistical software package (SPSS v10.0, SPSS Inc, Redmon, WA). The normality of data in each group was confirmed using normal probability plots. Differences between data sample means were determined by Student´s t-test and *p* values of less than 0.05 were considered statistically significant.

Although both eyes of the patients were analysed, only one eye was considered for the statistical analysis with a view to eliminating the possible intra-subject effect that might appear if both eyes of the same patient had been studied.

RESULTS

Results from physician 1

Table 1 shows the central corneal thickness and ocular anterior chamber depth results obtained by physician 1.

Table 1.- Central corneal thickness and ocular anterior chamber depth values obtained by physician 1.

	Central corneal thickness values (µm)		
	All	Women	Men
Mean	549.39	566.11	525.63
SD	46.65	38.77	45.03
Minimum	407	465	407
Maximum	644	644	611
	Ocular anterior chamber depth values (mm)		
	All	Women	Men
Mean	3.14	3.1	3.19
SD	0.27	0.26	0.24
Minimum	2.58	2.58	2.71
Maximum	3.68	3.61	3.68

The mean central corneal thickness of the subjects (mean ±SD) was 549.39±46.65 µm, with a minimum of 407 µm and a maximum of 644 µm. The women had higher mean central corneal thickness values than the men. The differences between the mean central corneal thickness values obtained for the women and those obtained for the men were significant (p=0.003; Student *t*-Test).

The mean ocular anterior chamber depth of the subjects (mean±SD) was 3.14 ±0.27 mm, with a minimum of 2.58 mm and a maximum of 3.68 mm. The men had higher mean ocular anterior chamber depth values than those observed in the women. These differences in mean ocular anterior chamber depth values between the sexes were not significant (p=0.254; Student *t*-Test).

Results from physician 2

Table 2 shows the central corneal thickness and ocular anterior chamber depth results obtained by physician 2.

The mean central corneal thickness of the subjects (mean ±SD) was 549.32 ±47 mm, with a minimum of 408 µm and a maximum of 646 µm. The mean central corneal thickness of the women (mean ±SD: 565.81 ±45.05 µm) was also significantly greater (p=0.004; Student *t*-Test) than that of the men (mean ±SD: 525.893 ±45.05 µm).

Table 2.- Central corneal thickness and ocular anterior chamber depth values obtained by physician 2.

	Central corneal thickness values (µm)		
	All	Women	Men
Mean	549.32	565.81	525.89
SD	47	45.05	45.05
Minimum	408	464	408
Maximum	646	646	611
	Ocular anterior chamber depth values (mm)		
	All	Women	Men
Mean	3.14	3.09	3.2
SD	0.26	0.24	0.23
Minimum	2.58	2.58	2.72
Maximum	3.7	3.65	3.7

The mean ocular anterior chamber depth of the subjects (mean ±SD) was 3.14 ±0.26 mm, with a minimum of 2.58 mm and a maximum of 3.65 mm.

As previously observed by physician 1, the men had higher mean ocular anterior chamber depth values than the women. The differences observed by physician 2 in mean ocular anterior chamber depth values between the women and men were not significant either (p=0.187; Student *t*-Test).

Analysis comparing the results of physician 1 and physician 2

After separate analysis of the results, the possible differences in the values of mean central corneal thickness between physician 1 (549.39 ±46.65 µm) and physician 2 (549.32 ±47 µm) were studied. No significant differences were observed (p=0.994; Student *t*-Test).

Likewise, the differences in mean ocular anterior chamber depth values between physician 1 (3.14 ±0.27 µm) and physician 2 (3.14 ±0.26) were not significant (p=0.978; Student *t*-Test).

DISCUSSION

The objective of this study was to determine the repeatability of the measurement of central corneal thickness and ocular anterior chamber depth using the Orbscan Topography System II.

Following on from this, we compared the central corneal thickness and ocular anterior chamber depth results obtained by two different physicians in the same sample.

Our results for the central corneal thickness and ocular anterior chamber depth measurements revealed that measurements carried out by two different observers did not differ significantly.

The Orbscan is an optical noncontact system and, in all likelihood, the absence of contact with the corneal surface is the reason for not detecting significant differences between the results of physician 1 and physician 2. With the IOLMaster, another new noncontact system, Lam et al., (2001) obtained mean ocular anterior chamber depth values of 3.60 ±0.25 mm (practitioner 1) and 3.60 ±0.24 mm (practitioner 2). No significant differences between practitioner 1 and practitioner 2 were found.

It is known that classical ultrasound measurements can be affected by several factors, such as the experience of the operator, the user´s technique, differences in probe handling, and the physical conditions in which the measurements are taken (Vetrugno et al., 2000).

The sum of these different factors must be the basis of the observed absence of repeatability when ultrasound morphometric studies are carried out by two different observers (Bovelle et al., 1999).

With the noncontact Orbscan, we avoided the globe compression associated with the shortening of the ocular globe during contact morphometric studies (Drexler et al., 1998; Haigis et al., 2000).

However, Solomon (1999) presented a study that was not in accordance with the principle of globe shortening during contact ultrasound measurements. The purpose of his study was to determine whether the indentation of the ultrasonic probe tip on the cornea during the time needed to obtain a thickness measurement might affect the measurement. In that study, indentation of the cornea with the ultrasonic probe-tip during a 10-second interval (contact time) did not significantly affect the measurements. As can be seen, this study presented results that cannot explain the differences noted in the study by Bovelle et al. (1999).

When carrying out ocular anatomical studies in vivo, it is very important to preserve normal physiological conditions because under physiological conditions the corneal thickness remains constant (Böhnke et al., 1998). Due to the absence of the use of corneal anaesthesia, and given that the Orbscan measurements are faster, we believe that corneal and ocular hydration during morphometric measurements are not affected and hence the measurements can be considered as valid.

Here, we report a mean central corneal thickness of 549.39 ±46.65 µm for physician 1 and 549.32 ±47 µm for physician 2. These results are very similar to those presented by us in a preliminary study employing the same Orbscan Topography System II (Sanchis Gimeno et al., 2000b).

Previously, different studies have shown a mean central corneal thickness ranging from 560 ±0.02 µm to 602 ±59 µm (Liu et al., 1999; Liu and

Pflugfelder, 1999; Liu and Pflugfelder, 2000; Marsich and Bullimore, 2000; Modis et al., 2001).

Furthermore, in our sample we detected that women had a significantly higher mean central corneal thickness as compared to men. This in accordance with results presented previously by us concerning hyperopic patients (Sanchis Gimeno et al., 2001a).

Here, the mean ocular anterior chamber depth value in the whole sample, by means of the Orbscan system, was 3.14 ±0.27 for physician 1 and 3.14 ±0.26 mm for physician 2. These results are very similar to those reported by Auffarth et al. (1997) also using the Orbscan System (3.23 ±0.55 mm). Nevertheless, more recently, another study employing the Orbscan System (Vetrugno et al., 2000) obtained a higher mean ocular anterior chamber depth value (3.51 ±0.25 mm) than those obtained by Auffarth et al. (1997) and by us.

As commented in the Material and Methods section, with the Orbscan system, ocular anterior chamber depth is the distance from the anterior cornea to the anterior lens and not the distance from the posterior cornea to the anterior lens. In other words, it is necessary to measure the central corneal thickness in order to obtain an ocular anterior chamber depth value. The ocular chamber depth values will be lower if the Orbscan measures the distance from the posterior cornea to the anterior lens. We deducted the central corneal thickness values in each patient and consequently the mean ocular chamber depth values were lower (Table 3).

Table 3.- Ocular anterior chamber depth values obtained after deducting central corneal thickness values in each patient (mm).

	Physician 1	Physician 2
Mean	2.59	2.59
SD	0.28	0.28
Minimum	2.04	2.04
Maximum	3.16	3.18

To sum up, the Orbscan Topography System is an efficient anatomical tool that enables central corneal thickness and ocular anterior chamber depth measurements to be carried out by different observers without there being any significant differences among them.

ACKNOWLEDGEMENTS

Supported by a grant from the University of Valencia (UV-3691).

The authors wish to thank John Vélez (B.A. University of Melbourne, Australia), translator and lecturer in English at *Universitat Jaume I*, Spain for the linguistic assessment of this paper. The authors of this study declare that they have received no financial assistance from any medical company, whose products, have been used and named in this work.

REFERENCES

AUFFARTH GU, TETZ MR, BIAZID Y and VOLCKER HE (1997). Measuring anterior chamber depth with Orbscan Topography System. *J Cataract Refract Sur g,* 23: 1351-1355.

BALAZSI G, MULLIE M, LASSWELL L, LEE PA and DUH YJ (2001). Laser in situ keratomileusis with a scanning excimer laser for the correction of low to moderate myopia with and without astigmatism. *J Cataract Refract Surg,* 27: 1942-1951.

BÖHNKE M, CHAVANNE P, GIANOTTI R and SALATHÉ RP (1998). Continuous non-contact corneal pachymetry with a high speed reflectometer. *J Refract Surg,* 14: 140-146.

BOVELLE R, KAUFMAN SC, THOMPSON HW and HAMANO H (1999). Corneal thickness measurements with the Topcon SP 2000P specular microscope and ultrasound pachymeter. *Arch Ophthalmol,* 177: 868-870.

DREXLER W, FINDL O, MENAPACE R, RAINER G, VASS C, HITZENBERGER CK and FERCHER AF (1998). Partial coherence interferometry: a novel approach to biometry in cataract surgery. *Am J Ophthalmol,* 126: 524-534.

GÜELL JL, VÁZQUEZ M, GRIS O, MULLER AD and MANERO F (1999). Combined surgery to correct high myopia: iris claw phakic intraocular lens and laser in situ keratomileusis. *J Refract Surg,* 15: 529-537.

HAIGIS W, LEGE B, MILLER N and SCHNEIDER B (2000). Comparison of immersion ultrasound biometry and partial coherence interferometry for intraocular lens calculation according to Haigis. *Graefe's Arch Clin Exp Ophthalmol,* 238: 765-773.

LAM AKC, CHAN R and PANG PCK (2001). The repeatability and accuracy of axial length and anterior chamber depth measurements from the IOLMaster™. *Ophthal Physiol Opt,* 21: 477-483.

LIU Z and PFLUGFELDER SC (1999). Corneal thickness is reduced in dry eye. *Cornea,* 18: 403-407.

LIU Z and PFLUGFELDER SC (2000). The effects of long-term contact lens wear on corneal thickness, curvature, and surface regularity. *Ophthalmology,* 107: 105-111.

LIU Z, HUANG AJ and PFLUGFELDER SC (1999). Evaluation of corneal thickness and topography in normal eyes using the Orbscan corneal system. *Br J Ophthalmol,* 83: 774-778.

LONGANESI L, CAVALLINI GM and TONI R (1996). Quantitative clinical anatomy of the human cornea in vivo. *Acta Anat,* 157: 73-79.

MARSICH MM and BULLIMORE MA (2000). The repeatibility of corneal thickness measures. *Cornea,* 19: 792-795.

MIDELFART A and AAMO B (1994). Ocular parameters in elderly in Norway. *Acta Ophthalmol (Copenh),* 72: 61-66.

MODIS JR L, LANGENBUCHER A and SEITZ B (2001). Scanning-slit and specular microscopic pachymetry in comparison with ultrasonic determination of corneal thickness. *Cornea,* 20: 711-714.

MUÑOZ MA, GONZÁLEZ F, NIETO A and SANZ JC (2001). Morphometric study of the hipermetrope eye. *Eur J Anat,* 5 (Suppl. 1): 65-66.

OSUOBENI EP (1999). Ocular components values and their intercorrelations in Saudi Arabians. *Ophthalmic Physiol Opt,* 19: 489-497.

OWENS H, GARNER LF, YAP MKH, FRITH MJ and KINNEAR RF (1998). Age dependence of ocular biometric measure-

ments under cycloplegia with tropicamide and cyclopentolate. *Clin Exp Optom,* 81: 159-162.

PRICE FW, KOLLER DL and PRICE MO (1999). Central corneal pachymetry in patients undergoing laser in situ keratomileusis. *Ophthalmology,* 106: 2216-2220.

SANCHIS GIMENO JA, SIMÓ GARCÍA C, CEGARRA M J and RUIZ TORNER A (2001b). A human study of corneal anatomy with the Orbscan Topography System. *Eur J Anat,* 5 (Suppl. 1): 66.

SANCHIS GIMENO JA, CASANOVA J, ALONSO L, LLEÓ PÉREZ A, RUIZ TORNER A and MARTÍNEZ SORIANO F (2001a). Morphometric study of the hyperopic central cornea. *Eur J Anat,* 5: 77-81.

SCHMITT-BERNARD CF, LESAGE C and ARNAUD B (2000). Keratectasia induced by laser in situ keratomileusis in keratoconus. *J Refract Surg,* 16: 368-370.

SOLOMON OD (1999). Corneal indentation during ultrasonic pachometry. *Cornea,* 18: 214-215.

TABBARA KF, EL-SHEIKH HF and ISLAM SM (2001). Laser in situ keratomileusis for the correction of hyperopia from +0.50 to +11.50 diopters with the Keracor 117C laser. *J Refract Surg,* 17: 123-128.

VETRUGNO M, CARDASCIA N and CARDIA L (2000). Anterior chamber depth measured by two methods in myopic and hyperopic phakic IOL implant. *Br J Ophthalmol,* 84: 1113-1116.

WANG Z, CHEN J and YANG B (1999). Posterior corneal surface topographic changes after laser in situ keratomileusis are related to residual corneal bed thickness. *Ophthalmology,* 106: 406-409.

WONG TY, FOSTER PJ, JOHNSON GJ, KLEIN BE and SEAH SK (2001). The relationship between ocular dimensions and refraction with adult stature: the Tanjong Pagar Survey. *Invest Ophthalmol Vis Sci,* 42: 1237-1242.

ZALDIVAR R, DAVIDORF JM, OSCHEROW S, RICUR G and PIEZZI V (1999). Combined posterior chamber phakic intraocular lens and laser in situ keratomileusis: bioptics for extreme myopia. *J Refract Surg,* 15: 299-308.