Quantitative corneal anatomy in emmetropic subjects

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PURPOSE. *Currently there is little information available about the corneal thickness values of healthy emmetropic subjects. Therefore, the authors decided to analyze the corneal thickness in healthy emmetropic subjects.*
METHODS. *The authors analyzed the difference in thickness values between the thinnest corneal site and the central and paracentral cornea in 124 eyes of 124 healthy emmetropic white subjects.*
RESULTS. *The mean difference between the thinnest site of the cornea and the thickness values obtained in the areas analyzed was as follows: 12±6 μm center; 140±19 μm superonasal; 133±23 μm nasal; 117±26 μm inferonasal; 122±19 μm superotemporal; 89±22 μm temporal; and 99±29 μm inferotemporal (p<0.001; one way analysis of variance test).*
CONCLUSIONS. *In healthy emmetropic white subjects the thinnest site of the cornea is statistically lower than the central and paracentral cornea. (Eur J Ophthalmol 2006; 16: 235-8)*

KEY WORDS. *Corneal anatomy, Corneal thickness, Emmetropia, Orbscan*

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INTRODUCTION

To date, the most widely accepted method of measuring corneal thickness has been ultrasound pachymetry (1). However, with conventional ultrasound pachymetry it is not possible to obtain the thinnest site value of the entire cornea.

Orbscan pachymetry, which was more recently introduced (2), made it possible to measure the corneal thickness of the central and paracentral corneal areas as well as to detect the corneal site with the minimum thickness value.

Assessment of the corneal thickness values and their main variations has become fundamental since the introduction of excimer laser refractive surgery techniques, and its use to correct refractive errors (i.e., myopia, hyperopia, and astigmatism). Modification of the corneal anatomy and thus the refractive properties of the cornea is the basis of these techniques. The thickness of the cornea limits the degree of correction of refractive errors, as there is a relatively fixed amount of refractive correction that occurs for each micron of cornea ablated. The corneal thinning out after excimer laser photoablation makes it necessary to determine the corneal thickness first in order to have an acceptable safety margin after surgery (3).

Although several corneal thickness studies have been carried out with Orbscan pachymetry (2, 4-10), to our knowledge no study, including those carried out specifically in emmetropic subjects (9), has analyzed the quantitative differences in corneal thickness values between the thinnest site of the cornea and the central and paracentral cornea in emmetropic eyes.

Following from this, and in order to increase the knowledge of the quantitative corneal anatomy in emmetropic eyes, we aimed to analyze the quantitative differences in thickness values between the thinnest site and the central and paracentral cornea in emmetropic eyes.

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METHODS

We carried out a prospective study on 124 eyes of 124 healthy white emmetropic subjects: volunteers with manifest sphere and manifest cylinder of ±0.5 diopters and of an age that ranged from 18 to 39 years (mean ± SD, 26.70±5.24). 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 means of five consecutive measurements of the corneal thickness were obtained with the Orbscan Corneal Topography System II (Orbscan Inc., Salt Lake City, UT). The corneal thickness is calculated by the Orbscan System by measuring the distance in elevation between the anterior and posterior surfaces of the cornea. In this case the measurements were averaged in a 2-mm-diameter circle in the center of the cornea and at six 2-mm-diameter circles located 3 mm from the visual axis in the midperipheral cornea (temporal, superotemporal, inferotemporal, nasal, inferonasal, and superonasal). The minimum thickness of the entire corneal surface was also recorded. Orbscan System II was used in all patients with an acoustic equivalent factor of 0.92 as recommended by the manufacturer.

Only one eye per subject was analyzed. The choice of either the right or the left eye was random. The Kolmogorov-Smirnov test and the one-way analysis of variance (ANOVA) test were applied. P values less than 0.05 were considered to be statistically significant.

RESULTS

Table I shows the corneal thickness values obtained in the study. The central value was lower than all the paracentral areas analyzed ($p<0.001$; one way ANOVA test). The differences in corneal thickness values among the paracentral areas analyzed (nasal, superonasal, inferonasal, temporal, superotemporal, and inferotemporal) were significant ($p<0.001$; one way ANOVA test).

The differences between the lowest value of the entire cornea and the central, superonasal, nasal, inferonasal, superotemporal, temporal, and inferotemporal values were statistically significant ($p<0.001$; one way ANOVA test). Table II presents the quantitative differences between the minimum thickness of the entire cornea and the central and paracentral corneal thickness values.

DISCUSSION

To our knowledge this is the first study that has analyzed the quantitative differences between the thinnest site of the entire cornea and the central and paracentral corneal thickness in human emmetropic eyes.

Conventional ultrasound pachymetry and Orbscan pachymetry can measure the corneal thickness at different positions. However, during ultrasound pachymetry the physician must place the ultrasonic probe subjectively over the ocular surface and take the center of the pupil as a reference point; furthermore the pressure must be very delicate when placing the probe on the ocular surface (9). It also needs topical anesthesia, which can modify corneal thickness values (11), and, in addition, central and paracentral corneal thicknesses cannot be measured simultaneously. Moreover, during ultrasound pachymetry it is difficult to locate the same points of measurement accurately in serial examinations (4), and it is not possible to locate the thinnest site of the entire cornea.

The interobserver and intraobserver variability of Orbscan pachymetry measurements has been analyzed before (8). Rainer et al (8) obtained correlation coefficients for the intraobserver variability between 0.985 and 0.991 for Orbscan pachymetry. The correlation coefficients for the interobserver variability were between 0.987 and 0.989 for Orbscan pachymetry. It seems that the accuracy of ultrasound and Orbscan pachymetry was acceptable when measuring CCT in normal corneas (8), and moreover, Marsich and Bullimore (5) detected that the Orbscan System was the most repeatable instrument for measuring corneal thickness among optical, ultrasound, and Orbscan pachymetry. On the other hand, it seems that the repeatability of peripheral measurements of pachymetry by Orbscan is poorer than that of central measurements (1).

To date there are conflicting studies about the accuracy of Orbscan pachymetry when compared to the more frequently used ultrasound pachymetry (1). Cairns and McGhee (1) in a review study that analyzed 91 relevant peer-reviewed publications that used the Orbscan System observed that Orbscan measurements of central and peripheral pachymetry were determined to be 15 and 95 µm greater than ultrasound pachymetry. In order to minimize the differences between Orbscan and ultrasound measurements the manufacturers of the Orbscan devices introduced the acoustic equivalent factor of 0.92 used in this study. Consequently, studies using the acoustic equivalent factor show a close agreement between pachymetry val-

TABLE I - CORNEAL THICKNESS VALUES OBTAINED IN THE STUDY (μm)

	MT	CCT	SN	N	IN	ST	T	IT
Mean ± SD	519±17	531±17	659±21	653±25	636±25	641±20	608±22	614±24
Minimum	481	501	631	613	593	603	563	567
Maximum	551	561	716	705	682	683	680	657

MT= Minimum thickness of the entire cornea; CCT = Central corneal thickness; SN = Superonasal thickness; N = Nasal thickness; IN = Inferonasal thickness; ST = Superotemporal thickness; T = Temporal thickness; IT = Inferotemporal thickness

TABLE II - QUANTITATIVE DIFFERENCES BETWEEN THE MINIMUM THICKNESS VALUE OF THE ENTIRE CORNEA AND THE VALUES OBTAINED IN THE CENTRAL AND PARACENTRAL CORNEA (μm)

	MT vs C	MT vs SN	MT vs N	MT vs IN	MT vs ST	MT vs T	MT vs IT
Mean ± SD	12±6	140±19	133±23	117±26	122±19	89±22	99±29
Minimum	6	96	95	75	68	32	60
Maximum	30	174	188	191	160	139	171

MT = Minimum thickness of the entire cornea; C = Central thickness; SN = Superonasal thickness; N = Nasal thickness; IN = Inferonasal thickness; ST = Superotemporal thickness; T = Temporal thickness; IT = Inferotemporal thickness

ues for Orbscan II and ultrasound when assessing central pachymetry in normal corneas. However, the use of a single correction factor across the entire cornea and population must be accepted with reservations when a constant linear relationship between ultrasound and Orbscan pachymetry has not been found (1).

We analyzed exclusively healthy emmetropic subjects. Cosar and Sener (6), using Orbscan pachymetry, obtained a mean central corneal thickness value of 513.7±68.5 μm in a reduced sample of emmetropic eyes. On the other hand, Sanchis-Gimeno et al (9), in a large sample of young emmetropic subjects, obtained a mean central corneal thickness value of 554±16 μm. In the present study the mean central corneal thickness value was 531±17 μm.

Cosar and Sener (6) did not analyze the paracentral corneal thickness values of their emmetropic subjects but they detected that these subjects had lower central corneal thickness values (513.7±68.5 μm) than myopic (536.1±35.4 μm) and hyperopic subjects (551.3±40.2 μm).

The paracentral corneal thickness values obtained in the present study were similar to those obtained previously (9) with the exception of the nasal values (653±25 vs 641±17). Nevertheless, in the two emmetropic studies the differences in corneal thickness values between the paracentral areas analyzed and between the central and the paracentral areas were significant.

Liu et al (4) in a study carried out on 94 non-emmetropic eyes observed that the thinnest site in the entire cornea was 550±30 μm thick. Modis et al (7) in another study carried out on 88 non-emmetropic eyes obtained a mean thinnest value of 578±50 μm. We found that the thinnest site of the emmetropic cornea was 519±17 μm thick, and we believe this is the first report that has located and quantified the thinnest site of the cornea in emmetropic eyes.

Recently the quantitative differences between the central and the paracentral cornea (9) in emmetropic subjects have been demonstrated and these differences are corroborated in this study. Nevertheless, the present study has observed that the emmetropic central cornea is 12±6 μm thicker than the thinnest site of the entire cornea.

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