

Evaluation of the Corneal Topographic Characteristics of Keratoconus With Orbscan II in Patients With and Without Atopy

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Purpose: To analyze the differences in corneal topography in keratoconus patients with and without atopy.

Methods: In the Beyoglu Eye Research and Training Hospital Refractive Surgery Department, corneal examination with the Orbscan II device (Bausch & Lomb) was done to all patients between May and June 2004 who were diagnosed as keratoconus with corneal topography findings and who did not have any surgical procedure. The atopy grading was done according to the criteria of the UK Atopy Study Group (1994). Patients were divided into 2 groups according to the presence of atopy. The Orbscan findings of the 2 groups were compared.

Results: Among 70 keratoconus patients, 33 patients had partial or full atopy. Sixty-six eyes of the 33 patients were classified as the atopic group, whereas 74 eyes of the remaining 37 patients were classified as the control group. The mean age of the patients was 27.7 ± 9.5 years in the atopic group and 26.9 ± 9.5 years in the control group. The central corneal thickness was 428.5 ± 37.1 μm in the atopic group and 491.8 ± 56.3 μm in the control group. There was a statistically significant difference between the mean central and thinnest corneal pachymetric readings, the distance of thinnest point to corneal center, anterior and posterior elevation values, distances of the anterior and posterior elevation to the central cornea, and irregularity indexes in the 2 groups ($P < 0.05$).

Conclusions: This study shows that corneal topographic and pachymetric characteristics of keratoconus may be different in atopic eyes from those in nonatopic eyes. Atopic keratoconus patients could possibly be evaluated as a separate entity in keratoconus disease.

Key Words: atopy, corneal topography, keratoconus, Orbscan

(*Cornea* 2007;26:945–948)

Keratoconus is a noninflammatory ectatic corneal disorder that presents later in the disease process, with central corneal thinning, corneal protrusion, and progressive irregular astigmatism.¹ Classically, the disease starts in adolescence and progresses through the third or fourth decades of life.² The incidence is reported to be 1 in 2000 eyes per year, with a prevalence of 54.4 per 100,000 eyes.² Although the etiology is not clearly known, atopy, eye rubbing, contact lens use, ocular trauma, cardiovascular diseases such as mitral valve prolapsus, collagen tissue diseases, pigmentary retinopathy, Marfan syndrome, and Down syndrome have been reported to be associated with keratoconus.²

The association of atopy with keratoconus has been discussed in many studies since the beginning of the 20th century. This association was first reported in 1937 by Hightner et al.³ Later, many studies contradicted this finding.^{4–7} In a controlled study, Lowell and Carroll⁸ reported that there was no statistically significant difference between the group of keratoconus patients and the control group with respect to the presence of atopy. Nevertheless, in 1965, Copman⁹ reported that, in the healthy population, 3% of the subjects had eczema, whereas in patients with keratoconus, 32% of the patients had eczema. Also, two thirds of those patients reported that they rubbed their eyes severely. Also, Gasset et al.¹⁰ reported that, in their controlled study of 162 keratoconus patients, the prevalence of asthma in the control group was 1%, whereas it was 17.9% in keratoconus patients. Because these previous studies reached different conclusions, we do not know if atopy or eye rubbing secondary to atopy are linked to keratoconus. The goal of this study was to determine any differences in corneal topography in keratoconus patients that did or did not have atopy. To our knowledge, this is the first study evaluating the Orbscan topographic characteristics of keratoconus eyes with and without atopy.

MATERIALS AND METHODS

In the Beyoglu Eye Research and Training Hospital, corneal examination with Orbscan II (Bausch & Lomb, Rochester, NY) was performed on patients diagnosed with keratoconus who had not previously undergone any form of ocular surgery. The diagnosis of keratoconus of the patients was established by the corneal topography findings.^{11,12}

Subjects were seated in the typical position that uses the chinrest; the patient was asked to keep both eyes open and to

Received for publication December 27, 2006; revision received April 25, 2007; accepted May 4, 2007.

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The authors state that they do not have any proprietary interest in the products named in this article.

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maintain steady fixation on the center of the fixation target without blinking. After appropriate alignment of the instrument, the operator triggered the acquisition sequence and scanned the cornea. During acquisition, the Placido disk is illuminated, and the mire's reflection from the anterior corneal surface is stored. Centration was achieved by correct alignment of the Orbscan image with the 2 half slits converging in the center of the Placido disk image. Subsequently, 20 slits from the right and 20 from the left are projected on the cornea at an angle of 45° to the instrument axis to construct the topographic image. Three Orbscan measurements were done for each eye, and the one with best centration and greatest corneal coverage area was included in the study.

From the Orbscan examinations, we recorded thinnest and central pachymetry readings, distance of the thinnest point to the corneal center, anterior and posterior best-fit sphere (BFS) powers, anterior and posterior elevation values, distance of the anterior and posterior elevation points from the corneal center, mean keratometry readings (K), astigmatic powers, and irregularity indexes. The BFS is a sphere that is altered by radius of curvature and position relative to the instrument axis to best fit the surface measured. The elevation maps are constructed by subtracting the calculated best-fit size against the eye surface. The anterior and posterior elevation values in this study were chosen as the maximum elevation points on the anterior and posterior BFS, respectively. The K value represented the mean of the minimum and maximum simulated keratometry readings of Orbscan for each patient.

The atopy classification was performed according to the criteria of the UK Atopy Study Group in 1994.¹³ For this purpose, keratoconus patients were asked whether they had any of the following findings, together with an itching skin history: itching in the skin creases in the body, history of asthma or frequent hay fever (or history of atopic disease in first-degree relatives), history of general dry skin in the previous years, or visible flexural eczema in the body.

Per these criteria, patients with a minimum positive response to 3 of the 4 criteria were classified as full atopic, and positive response to 2 or fewer of the 4 criteria was classified as partial or incomplete atopic. Those patients without any atopic findings were classified as the control group.

Patients were divided into 2 groups according to the presence or absence of atopy, and the Orbscan findings of the 2 groups were compared. The statistical analysis was done by using SPSS 11.5 (SPSS, Chicago, IL), with a *t* test with paired groups.

RESULTS

Of 70 patients (140 eyes) that were examined, 33 (66 eyes) had partial or full atopy according to the screening criteria. Seventy-four eyes from the remaining 37 patients were classified as the control group (Table 1). There were no statistically significant differences with respect to age and sex between the 2 groups ($P > 0.05$).

The central corneal thickness (Orbscan measured) was $428.5 \pm 37 \mu\text{m}$ in the atopic group and $491.8 \pm 56.3 \mu\text{m}$ in the control group ($P < 0.05$). There was a statistically significant difference between the mean corneal thinnest pachymetric

TABLE 1. Demographic Features

Variable	Atopy Group	Control Group	P
No. eyes (patients)	66 Eyes (33 patients)	74 Eyes (37 patients)	
Age (y)	27.7 ± 9.5	26.9 ± 9.5	0.653
Sex (M/F)	18/15	20/17	0.705

readings, distances of the thinnest point to the corneal center, anterior and posterior elevation values, distances of the anterior and posterior elevations to the corneal center, and irregularity indexes in the 2 groups ($P < 0.05$; Table 2).

There were no statistically significant differences between the 2 groups with respect to the anterior and posterior BFS values, mean K readings, and astigmatic powers ($P > 0.05$; Table 3).

DISCUSSION

It has been reported that, in keratoconus patients with atopy, the progression of keratoconus takes place more rapidly, the need for keratoplasty surgery appears earlier, and both refractive and immunologic complications are seen more frequently.¹⁴ These findings have led to the concern of whether atopic keratoconus patients should be evaluated as a separate entity in keratoconus disease.

Lapid-Gortzak et al¹⁵ have examined EyeSys video-keratography findings of children with vernal keratoconjunctivitis and compared them with those of healthy children. They have reported that more abnormal patterns were found among the vernal keratoconjunctivitis patients than expected compared with normal eyes. Also, they identified a subgroup of keratoconus suspect patients, as well as a trend of superior corneal steepening (superior keratoconus), with the anterior corneal characteristics displayed by the EyeSys system. To the best of our knowledge, there have been no reports on comparison of the anterior and posterior corneal morphologic characteristics of keratoconus patients with and without atopy. For this purpose, we examined the corneal morphologic characteristics with a slit-scanning corneal topography device.

The I, II, and IIz versions of the Orbscan device can provide the wide-field pachymetric values of the human cornea combined with the information of the anterior and posterior elevation of the cornea. Orbscan is a projection-based topography system that provides elevation data with respect to the reference plane. Orbscan II has also incorporated a Placido disk attachment in addition to slit-scanning beam projection on the cornea to obtain curvature measurements directly.¹⁶

An elevation map is calculated by fitting the corneal shape to a BFS, which is a sphere that could be altered by radius of curvature and position relative to the instrument axis to best fit the measured surface. The difference between the sphere and the eye surface is expressed in a radial way, from the center of the sphere. The deviation from that spherical surface helps to appreciate the true shape of the eye and its deviation from symmetry.

In a cornea with keratoconus, the apical point of the cone is the highest point on the cornea, and it can be easily

TABLE 2. Orbscan Parameters in the Atopy Group and the Control Group

Examined Parameter	Atopy Group	Control Group	P
Corneal thinnest pachymetry reading (μm)	387.23	468.28	0.001
Central pachymetry reading (μm)	428.54	468.28	0.001
Distance of the thinnest point to the center (mm)	1.05	0.78	0.001
Anterior elevation value (μm)	0.055	0.041	0.04
Posterior elevation value (μm)	0.113	0.082	0.03
Distance of the anterior elevation from the center (mm)	1.449	1.096	0.04
Distance of the posterior elevation from the center (mm)	1.269	1.034	0.005
Irregularity index (D)	5.283	3.937	0.001

determined from the elevation values. Reflection-based topographies detect only the change in corneal curvature with respect to the instrument axis or adjacent cornea. The maximum refractive power (smallest radius of curvature, maximum slope) is peripheral to the apical point. Therefore, reflection-based systems would err in the location of the cone in keratoconus.¹⁷ On the other hand, Orbscan can detect the highest corneal elevation point (ie, cone apex) by simultaneous elevation topography and pachymetry mapping. Therefore, although Orbscan accurately assesses the topographical properties in keratoconus, studies based on placido disk topographies could fail to show the differences between the atopic and nonatopic keratoconus patients.

However, Orbscan also has some limitations that could influence the accuracy of the results. Poor fixation or alignment of the patient would change the relative steepness of the superior and inferior cornea and lead to erroneous BFS detection and elevation data. Also, any decrease in acquired surface area coverage would cause loss of data from peripheral flatter areas of the cornea and result in increased radius of curvature of the calculated BFS to best fit the steeper more central region. This factor would directly affect the obtained elevation data.

In Orbscan examinations, posterior and anterior corneal elevations had been suggested to be indicators of keratoconus and suspected keratoconus.^{18–20} On the other hand, anterior/posterior BFS values and simulated keratometry readings were not found to be good diagnostic factors in discriminating between keratoconus suspects and normal eyes.²⁰ In this study, we found significantly different anterior and posterior elevation values between the 2 groups; however, the anterior and posterior BFS powers and mean K readings failed to show any significant difference in atopic and nonatopic keratoconus eyes. This finding is not surprising because the maximum elevation values are indicators of how much the shape of the cornea differs from a sphere, in favor of a more conical shape.

The anterior and posterior BFS values, on the other hand, do not provide any information about how much the corneal shape deviates from symmetry.

In this study, we evaluated the corneal thickness and the topographical characteristics. Today, the most widely accepted method of corneal thickness measurement is the ultrasonic pachymetry technique. The traditional ultrasonic pachymetry methods could measure only a limited area of the cornea. Measurements at multiple points on the cornea are needed to obtain information about the thickness of the whole cornea. Because optical pachymetry systems depend on measurements of reflected light beams through the corneal tissue, all factors altering the optical quality of the cornea could influence the results. Orbscan topography, compared with ultrasonic pachymetry, seems to display comparable corneal thickness readings in healthy eyes but disproportionately lower readings in thin corneas, corneas with haze, keratoconus, or previous keratoplasty operation.²¹ In this study, because the control group also included corneas with keratoconus, the possible systematic error in the comparison of the measurements would have been largely eliminated. The results showed that the central and thinnest corneal thicknesses were lower in keratoconus eyes with atopy than in keratoconus eyes without atopy in this study population.

The results of this study showed that atopic keratoconus eyes have steeper cones that appear to be thinner centrally, and both the thinnest point on the cornea and the cone are more peripherally located. Unlike in axial curvature maps, most apices in elevation maps are clustered in the inferotemporal quadrant.²² Corneal topography characteristics in keratoconus eyes with atopy are different from those in keratoconus eyes without atopy. Atopic keratoconus patients could be evaluated as a separate entity in keratoconus disease. In that case, the clinical approach to those patients has to be clarified by future research on this subject.

TABLE 3. Other Orbscan Parameters in the Atopy Group and the Control Group

Examined Parameter	Atopy Group	Control Group	P
Anterior BFS value (D)	44.422	44.219	0.618
Posterior BFS value (D)	55.866	55.155	0.262
Mean K value (D)	47.703	46.923	0.217
Astigmatic power (D)	4.3169	3.873	0.288

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