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Evaluation of the anterior chamber angle in keratoconus and normal subjects

M. Nilsson[a], W. Miller[b], A. Cerviño[c], J.P.G. Bergmanson[b], R.L. Brautaset[a,*]

[a] Unit of Optometry, Department of Clinical Neuroscience, Karolinska Institutet, Box 8056, 104 20 Stockholm, Sweden
[b] TERTC, University of Houston, College of Optometry, Houston, TX 77204-2020, USA
[c] University of Valencia, Valencia, Spain

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ABSTRACT

Purpose: To evaluate the anterior chamber angle in keratoconus eyes by use of the Visante™ OCT and Orbscan™ II.
Methods: Anterior chamber angle was measured with the Visante™ OCT and Orbscan™ II in 52 subjects, 26 KC subjects and 26 age and control subjects.
Results: When comparing the nasal and temporal angles obtained with the two techniques no correlation was found (R^2 always below 0.01) in either the control subjects or in the KC subjects. Despite this, there was an overall statistically significant difference in mean anterior chamber angles ($p < 0.001$) between Visante™ OCT and Orbscan™ II. There was no statistical difference ($p > 0.05$) between nasal and temporal anterior chamber angles when comparing controls and KC subjects with either of the two instruments. In general, the Visante™ OCT gave a smaller estimate of the anterior chamber angle.
Conclusion: The values from the Visante™ OCT and Orbscan™ II cannot be interchanged since the difference in measurement of the anterior chamber angle was significantly different between the two instruments.

1. Introduction

Little is known about the relationship between anterior chamber angles in normal patients and those patients who have keratoconus. The anterior chamber angle evaluation is an important diagnostic step to identify those patients with shallow angles who are at risk for angle-closure glaucoma [1,2]. It is also helpful to identify those patients prone to developing angle-closure as a result of pupillary dilation [3]. In assessing the chamber angle, the depth of the anterior chamber is measured as the distance from the posterior corneal surface to the anterior surface of the crystalline lens—this measurement is often referred to as the anterior chamber depth. However, clinically, it is the iridio-corneal angle that is estimated and this measurement is commonly graded using van Herrick's technique or by performing gonioscopy [4].

The accurate assessment of the iridio-corneal angle measurement is intended to determine who is at risk for angle closure during dilation, an important step in performing a comprehensive assessment of the retina, especially in eyes that are, more prone to peripheral retinal and posterior segment disease such as highly myopic patients. It has been reported that posterior segment disease is as common in patients with keratoconus (KC) as in the normal population [5]. Patients with KC may in some instances exhibit a greater level of posterior segment disease. A report by Cohen and Myers [6] found that patients with KC are more prone to develop glaucomatous optic neuropathy. A dilated pupil is necessary in order to fully binocularly evaluate the retina and optic nerve of keratoconic patients using a binocular indirect ophthalmoscope or indirect lenses with biomicroscopy. Current clinical measurements to evaluate the anterior chamber angle may be affected by the ectasia found in KC patients. Thus the biomicroscopic evaluation of the anterior chamber angle using the van Herrick's technique may yield an unreliable grade assessment in KC patients due to corneal ectasia. In addition, gonioscopy may be challenging and potentially traumatic to the fragile KC corneal surface.

Vigorous eye rubbing is associated with KC [7–9] and this could potentially be a risky activity in eyes with narrow angles. The possibility for angle closure as a result of excessive eye rubbing thereby compressing the anterior chamber has been previously reported [10] and is most likely to happen in individuals with shallow angles.

Recently it was established in vivo and histopathologically that the cornea peripheral to Fleischer ring is also affected by KC [11,12]. This research has, as a consequence, suggested that KC is a pan-corneal pathology and not a disease restricted to the region of

* Corresponding author. Tel.: +46 0 8 1232 3840; fax: +46 0 8 672 3846.
E-mail address: rune.brautaset@ki.se (R.L. Brautaset).

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Table 1
Demographic data over the study group. KC—keratoconus, SD—standard deviation, D—diopters. Peripheral corneal thickness measured in the 7–10 mm range.

	KC Patients	Controls
Number of subjects	26 (48 eyes)	26 (52 eyes)
Age (mean, years ± 1SD)	38.7 ± 13.2	36.9 ± 13.8
Spherical equivalent (D)	−8.80	−2.90
Visual acuity (log MAR)	0.33	0.03
Minimal corneal thickness Visante (μm ± 1SD)	427.79 ± 66.75	524.38 ± 30.58
Minimal corneal thickness Orbscan (μm ± 1SD)	415.66 ± 77.01	534.58 ± 49.24
Minimum peripheral corneal thickness Visante (μm ± 1SD)	505.58 ± 62.90	565.08 ± 36.40

the cone itself. It follows that peripheral structural alterations and changes in the corneal curvature may modify its relative relationship to the uvea. The corneal ectasia, as one would expect and as is well documented [13–15] will demonstrate an anterior chamber depth that increases with KC. However, this finding does not describe the changes that may occur in the peripheral regions of the cornea in KC. The data from Emre et al. [16] suggests that the anterior chamber angle may become narrower with increasing degree of KC. Based on the recent histopathological and reported anterior chamber angle findings, this study intended to explore potential alteration in the angle formed between the peripheral cornea and the uvea in patients with KC.

2. Methods

2.1. Subjects

Fifty-two subjects, 26 KC subjects with a mean age of 38.7 years (±13.2) and 26 control subjects, with a mean age of 36.9 years (±13.8) were recruited for this study from the University Eye Institute, University of Houston College of Optometry, and Houston, Texas, USA. For demographic details see Table 1. This study was part of a study focused to detail characteristics of KC [12].

2.2. Inclusion

To be included, a KC subject must manifest one or more of the following clinical signs: posterior stress lines (Vogt striae), Fleischer ring, external sign (Munson sign) together with a topography positive for KC (central corneal power superior to 48.7D, and an inferior superior asymmetry above 1.9 [17–19]). Exclusion criteria included: any previous ocular surgery, the use of any systemic or ocular medications and any chronic disorder that can affect the eye, currently being pregnant or a nursing mother, and participating in an ophthalmologic drug or device research study within 30 days prior to entering the present study. Biomicroscopic examination and topographic measurements were used to confirm or deny the presence of KC. The degree of KC was graded based on the CLEK grading scale using the greatest corneal curvature as determined with the Orbscan topographer [20]. Biomicroscopy was performed using a Haag Streit (BQ900) biomicroscope and the same investigator judged all subjects. The KC grading and distribution of clinical findings can be seen in Table 2. All contact lens wearers, except scleral lens wearers, were included in both groups since this was assumed not to affect the anterior chamber angle.

2.3. Instrumentation and angle measurements

The Orbscan™ II (at the time of purchase distributed by Bausch & Lomb Surgical, Orbtek Inc, Salt Lake City, Utah, USA) is a scanning optical slit topography imaging system that uses slit-beam images (entire corneal surface, 11 mm) to derive a three-dimensional anterior segment topography. The device is said to require clear reflections from epithelial and endothelial corneal surfaces and homogeneous composition of the optical media to obtain precise measurements [21,22]. The system measures over 9000 data points using 20 slits from the temporal and nasal position. The instrument provides information about the cornea, iris, and lens. Also incorporated in the Orbscan is a corneal angle estimate tool. This tool has been found to be capable of detecting significant differences in the numeric gonioscopy measurements according to Shaffers classification [23]. The Visante™ OCT (Carl Zeiss Meditec, Inc, Dublin, CA, USA) is an anterior segment optical coherence tomography (ASOCT) that obtains high-resolution, real-time, cross-sectional images of the cornea and anterior chamber [24–26]. The axial and transverse resolution is 18 and 60 μm, respectively, which use an infrared light source (1310 nm) to produce the cross-sectional images. It is also equipped with an angular calliper, which is useful in estimating the anterior chamber angle.

With the Orbscan the angles between the cornea and the iris along the 0° and 180° axis (nasal and temporal) were estimated. This was done by the using the corneal angle estimation tool with which the clinician subjectively identifies the apex of the anterior chamber angle and aligns a line tangential to the posterior surface of the cornea and the anterior surface of the iris. Using the Visante OCT the anterior chamber angle is calculated objectively using the angle calliper tool and displayed on the screen. As with the Orbscan, only the angles along the 0 and 180 meridians were assessed.

2.4. Statistical analysis

Only the nasal and temporal angles from both instruments were used for comparison. All statistics were performed using InStat™ (GraphPad) and Origin™ (Origin Lab) statistical software. The anterior chamber angle measurements were analysed by use One-Way ANOVA with post hoc tests. A regression analyze (linear correlation) was used to evaluate the relation between angles from the different techniques. Bland and Altman [27] plots were used for assessment of the level of agreement.

This research followed the tenants of the Declaration of Helsinki, was in accord with the Health Insurance Portability and Accountability Act of 1996, and was approved by the Committee for the

Table 2
KC grading and distribution of clinical findings. *K*-value—keratometry value, D—dioptres.

Eye	Sim *K*-value (Orbscan)				CLEK	
	Cyl (D)	Axis (°)	Max *K* (D)	Min *K* (D)	Category 1/2/3	
OD	−5.27	129.25	52.58	47.28	2/7/15	
OS	−4.77	60.65	51.18	49.80	4/12/9	
Biomicroscopic findings						
	Prominant nerve fibres	Fleischer ring	Vogt striae	Munson sign	Anterior corneal scarring	Posterior corneal scarring
OD	20	7	23	3	5	9
OS	19	8	24	0	4	12