Clinical Experience With the Tracey Technology Wavefront Device

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ABSTRACT

PURPOSE: In refractive surgery, measuring the total ocular profile of refraction gives more vital information than measuring the cornea alone. We report the first clinical experiments with spatially resolved refractometry using ray tracking principles. Tracey technology was developed in Ukraine by the Institute of Biomedical Engineering in cooperation with the Vardinoyannion Eye Institute of Crete.

METHODS: The Tracey-1 device was evaluated in comparison with conventional videokeratoscopes. Seven pseudophakic eyes of 7 patients and two phakic eyes were measured thirty (30) consecutive times (consecutively) each to test reproducibility. Measurements were provided in zones 0 to 5 (6) mm. For each zone, parameters of astigmatism were calculated and mean value and standard deviation were derived.

RESULTS: Standard deviation on the order of 0.14 D was derived.

CONCLUSION: The Tracey Technology wavefront device provides information on the refraction distribution at the first principal plane of the ocular optical system. For the instrument to provide measurements that are directly applicable to clinical practice, the data should be transposed to the corneal plane. The Tracey device can be utilized for the measurement of accommodative amplitude and range. Further development of the instrument is requred to increase its accuracy. [*J Refract Surg* 2000;16:S588-S591]

Corneal topography is an essential tool for the clinical evaluation of refractive errors contributed by the cornea for patients undergoing refractive surgery. It is important also for the evaluation of corneal surface irregularities following trauma, dystrophy, keratoplasty, cataract surgery, and complicated refractive surgery.[1-2] However, placido-based corneal topography systems actually measure the geometry of the anterior surface of the cornea. An instrument capable of measuring ocular refraction in a spatially resolved manner and taking into account the optical contribution of all refractive media of the eye could provide more information about total ocular optical performance. To measure refraction on a spatially resolved basis requires the ability to look at the wavefront aberrations of the eye on a point by point basis. A new instrument has been developed to measure the wave aberration of the eye. The aim of this study was to perform a preliminary evaluation of the functionality of this new instrument.

PATIENTS AND METHODS

Instrument

Tracey is a new instrument developed in the Institute of Biomedical engineering (IBME) in Kiev, Ukraine, in cooperation with VEIC, University of Crete, for the evaluation of refraction throughout the pupillary area, taking into account corneal, lenticular, and fundus shape related (eg, staphyloma) refraction.

Tracey utilizes a 0.9 mW diode laser (wavelength, 650 nm) to scan the pupil. Laser exposure levels comply with international safety standards.[3] During scanning, the laser beam is laterally displaced but remains parallel to the visual axis of the eye examined. The eye at a particular point on the retina focuses the laser beam. Lateral displacement (with respect to the visual axis of the eye examined) of this point on the retina is proportional to the total ametropia of the eye along the optical path corresponding to the specific entry pupil point. The position of the spot on the retina is recorded at a position sensitive detector (PSD) (Fig 1).

Refraction data from a number of different entry points (16 to 256) as recorded during the sampling

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Ioannis G. Pallikaris and Vasyl V. Molebny have a proprietary interest in the materials presented.

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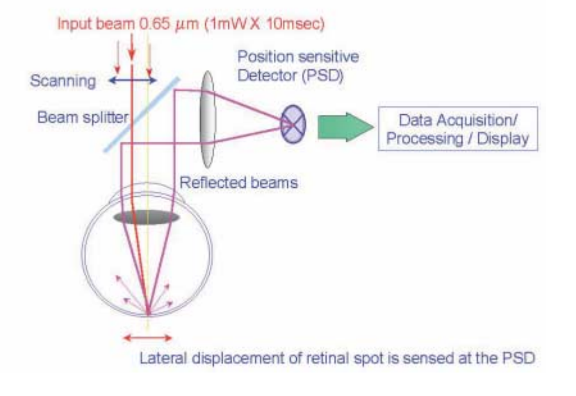

Figure 1. Schematic diagram of Tracey.

phase are automatically processed with a computer program that constructs a color map representing total ametropia at different points of the pupil. For each eye in this study, the laser beams were positioned in the predetermined site points (64 entry points, five times each).

Ametropia distribution as presented in Tracey maps is rendered to the first principal plane of the eye. Current Tracey configuration has a measurement range of 6 diopters (D) (+3.00 to -3.00 D from emmetropia). To examine patients with ametropias higher than this range, standard trial lenses must be inserted into a special receptacle of the instrument.

Testing

Instrument calibration was carried out using a specially designed ghost eye consisting of a cavity (25 mm axial length) filled with distilled water with a spherical front window. A 20 D intraocular lens (IOL) can be placed either perpendicular or tilted in respect to the ghost eye's optical axis. The latter induces a predetermined astigmatism-like aberration.

The present study included 7 pseudophakic eyes with clear corneas and no visible fundus irregularities. The IOL was centered and aligned in all cases. Pseudophakic eyes were included in the reproducibility study to exclude accommodation related refractive changes. Thirty consecutive measurements of each eye were performed with Tracey to test the instrument's reproducibility. Head positioning and eye alignment were performed for each examination separately.

Table 1
Tracey Reproducibility Data for Pupil-scanning Zone: 6 mm, 64 Datapoints/Measurement, Scanning Time of 15 ms

Eye No.	Angle° SD (mean)	Steep Axis SD (mean)	Astigmatism SD (mean)
1	1.8 (164.42)	0.23 (0.53)	0.21 (1.38)
2	3.2 (132.35)	0.08 (-0.80)	0.09 (0.38)
3	3.6 (82.76)	0.11 (0.66)	0.09 (0.17)
4	3.01 (17.86)	0.14 (0.67)	0.09 (1.02)
5	3.82 (22.27)	0.11 (-0.76)	0.1 (1.17)
6	4.46 (110.3)	0.23 (-1.38)	0.25 (1.85)
7	6.51 (94)	0.14 (0.85)	0.12 (0.55)
Average SD	3.77	0.15	0.14

Two of the seven pseudophakic eyes and two phakic eyes were included in a comparative study of astigmatism. Astigmatism was measured with EyeSys (dK), Technomed C-Scan, Canon R-30 Autorefractometer, and Tracey-1.

The topographic maps from these eyes are presented in Figures 2 to 5.

RESULTS

Reproducibility tests in seven pseudophakic eyes are presented in Table 1. For each case the astigmatic value as well as the steep axis with the respective axis (angle) are presented. The values (standard deviation [SD] and average value [mean]) were derived from the 30 consecutive measurements for each eye. These tests revealed that Tracey at its current configuration can measure refraction values with a standard deviation of 0.14 D.

When comparing the astigmatism measured in two pseudophakic eyes and 2 phakic eyes using Tracey, EyeSys, Technomed C-scan, and Canon R-30 Autorefractometer, the magnitude and axis most closely matched the manifest refraction more frequently with Tracey (Tables 2, 3).

DISCUSSION

This study proved the functionality of this device in a clinical setting. Obviously certain weaknesses can be attributed to the study mainly due to the lack of an adequate number of patients and therefore lack of statistical analysis of the results. Technical problems during the study arose from the prototype nature of the device. These initial technical problems have been addressed and further development

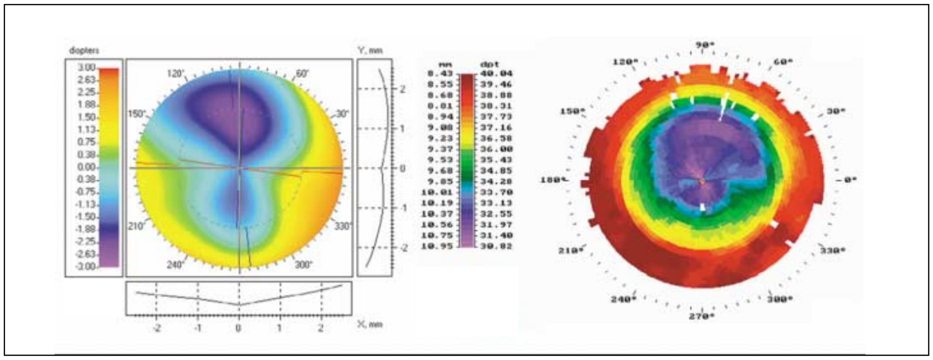

Figure 2. Left) Tracey map for pseudophakic eye #6, and **Right)** C-Scan (Technomed) color map of the same eye.

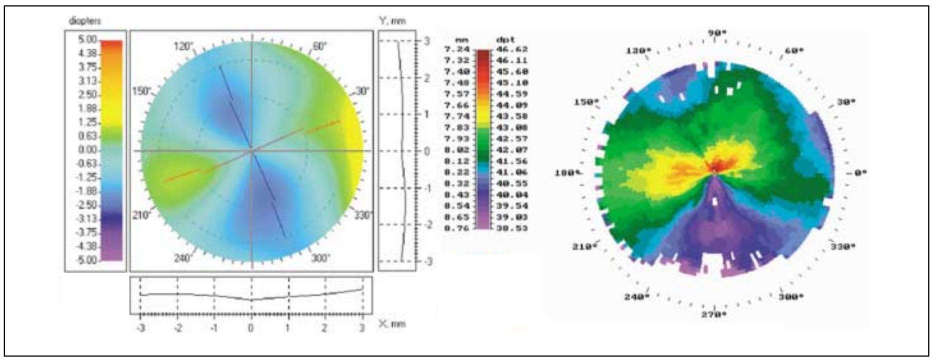

Figure 3. Left) Tracey map of pseudophakic eye #7, and **Right)** C-Scan (Technomed) color map for the same eye.

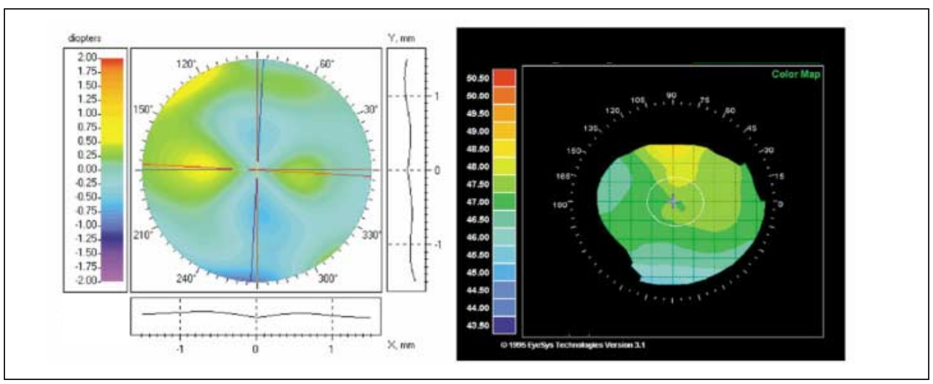

Figure 4. Left) Tracey map of phakic eye #1, and **Right)** EyeSys map for the same eye.

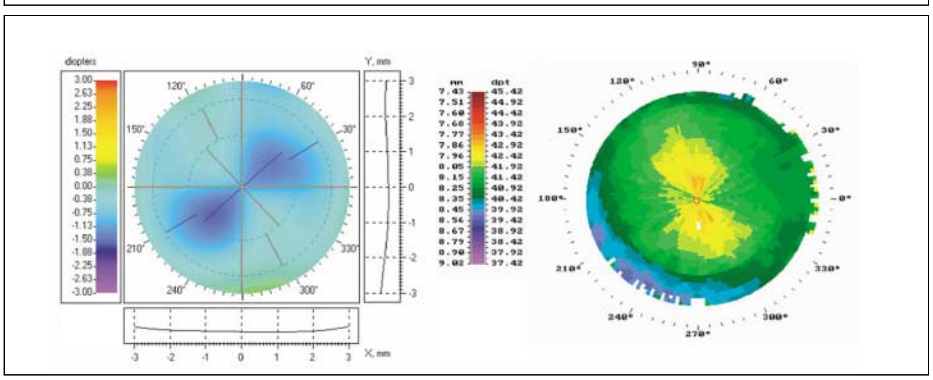

Figure 5. Left) Tracey map of phakic eye #2, and **Right)** C-Scan (Technomed) color map for the same eye. Refractive patterns appear to be similar.

Table 2
Data for Comparative Study of Pseudophakic Eyes #6 and 7

	Astigmatism (D)	Axis (°)
Eye #6		
Manifest refraction (D)		
+1.00 -1.75 x 100°		
EyeSys	-1.74	98
C-Scan	-2.37	104
Refractometry	-2.25	101
Tracey	-1.85	110
Eye #7		
Manifest refraction (D)		
+3.00 -0.50 x 90°		
EyeSys	-0.40	150
C-Scan	-0.17	147
Refractometry	-1.00	55
Tracey	-0.55	94

Table 3
Data for Comparative Study of Phakic Eyes #1 and 2

	Astigmatism (D)	Axis (°)
Eye #1		
Manifest refraction (D)		
Cyl -1.50 x 40°		
EyeSys	-0.69	15
C-Scan	-0.65	31
Refractometry	-1.25	26
Tracey	-1.39	37
Eye #2		
Manifest refraction (D)		
-2.00 -1.75 x 90°		
EyeSys	-0.60	90
C-Scan	-1.46	95
Refractometry	-1.25	90
Tracey	-1.68	91

of the instrument is currently underway. Future developments of TRACEY technology include utilization of an accommodation target for the dynamic measurement of accommodative aberrations and range of refraction, and increase of measurement dioptric range to at least 10 D (-5 to 5 D).

Although further improvements are necessary, Tracey technology seems to be effective in the measurement of refraction distribution throughout the pupillary area. Direct retinal ray tracing ensures refraction measurement with the contribution of all refractive media of the optical path.

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