Kristina Sander *) , Wilfried Bißmann **)

A study of the effect of the tear film on keratometric measurements with the IOLMaster™

0. Introduction

The IOLMaster™ is used to calculate the thickness of the intraocular lens on the basis of measurements of the axial length, corneal radii and sometimes the anterior chamber depth (depending on the biometric formula used).
Nowadays, the axial length can be measured very accurately by optical biometry using the PCI (part coherent interferometry) method, so that deviations from the target refraction caused by errors in the measurement of the axial length are no greater than approximately 0.1 D. The standard deviations of axial length measurements found in a number of clinical studies[1,2,3,4)] are less than 30 µm, corresponding to a deviation from the target refraction of less than 0.1 D in an eye of average length.
Therefore, in considering the measurement of corneal radii with the IOLMaster™, the focus of attention has now shifted to the accuracy with which the corneal radii (or refractive power of the cornea) themselves are determined. This study was conducted to determine the effect of the tear film.
A deviation in the radius measurement of 20 µm leads, in typical eyes, to a deviation from the target refraction of 0.1 D.
Since the clients for intraocular lens implants frequently have dry eyes, we examined whether administering tear replacement fluid improved the accuracy and reproducibility of keratometric measurements.
To minimize error, the IOLMaster with the software version V3.01 has algorithms intended to prevent measuring inaccuracies due to additional reflexes (caused by tear film problems) and imprecise images of the test target (caused by eyelashes or eyelids).

1. Purpose

The IOL Master™ measures the central corneal radii by projecting an image of a test target with six measuring points onto the cornea.
The keratometer module of the IOL Master™ projects images of six LEDs onto the cornea at a certain angle. A camera seeks the brightest points of the individual round illuminated areas on the cornea in order to analyze these as points, and then measures the distances between the points. These distances will depend on the curvature of the cornea, and they can therefore be used to determine the corneal radii. The most important prerequisite for precise measuring is that the software must recognize the brightest point correctly. This is easiest if the point images on the cornea are sharply defined and circular. When dry eyes are measured, the test targets may be distorted or distracting reflexes may occur if the tear film is torn. The camera may then determine the brightest point of light within the round areas incorrectly. As a logical consequence, the distances between the points will be wrongly measured, and the calculation of the corneal radii will be inaccurate.
The purpose of the study was to determine whether the tear film of the eye affected the keratometric measurement, and if so, in what way.
Our task was to check the correctness, accuracy and reproducibility of the measuring results obtained in several measurements, depending on the tear film.
In its measuring procedure, the keratometer module records five individual measurements and calculates a mean value from them.

*) Jena College of Applied Sciences, Faculty of Ophthalmic Optics
**) Carl Zeiss Meditec AG

In addition, observations were to be made of the effect of the tear film on the conduct of the measuring procedure, taking note of possible measuring difficulties caused by changes in it.

2 Equipment used

2.1 Instruments used

- The IOL Master™ from Carl Zeiss Jena GmbH
- The Keratograph from Oculus

2.2 Tear replacement fluids used

- Opti Tears Free from Alcon
- Optisoak from Alcon

3. Method

2.1. Test subjects

This was a random study of 26 eyes in 13 test subjects. The eyes of the test subjects were not required to fulfill any specific criteria.
The test subjects were between 19 and 29 years of age.

2.2. Procedure

The study was conducted in two basic steps:
– the central keratometric values were measured without the administration of tear replacement fluid
– the same measurement was then performed after the administration of tear replacement fluid.

In the first step, the central keratometric values of both eyes of all test subjects were measured with the IOLMaster, without administering tear replacement fluids. These measurements were then repeated with the Oculus Keratograph. All measurements were performed three times on every eye.
In the second step, tear replacement fluid was administered and the measurements were taken with the IOLMaster only.
Opti Tears Free (low viscosity) was dropped into the eyes of the test subjects and the eyes were measured. The corneal radii were subsequently measured after administration of Optisoak (high viscosity). Here, too, all measurements were performed three times on every eye.

4. Results and analysis

The standard deviation was determined for all radii measured (horizontal and vertical) and then displayed in graphs (see Graphs 1 …4).
The graphs are sorted by right and left eye and by the corresponding horizontal and vertical radii. The y axis of every graph plots the standard deviation ***s*** and the x axis the different tests conducted in this study. Each graph contains 14 colored curves, one for each of the 13 test subjects and one for the mean standard deviation.

The measurements using the Oculus keratograph serve for comparison with the IOLMaster™ in the measurement of the central corneal radii without tear replacement fluid. The graphs show that the standard deviation in this test is of the same order of magnitude for both instruments, with the mean actually slightly less using the IOLMaster™. Comparing the measurements with the IOLMaster™ with or without tear replacement fluid, we find that there is more scatter in the measuring values when the low-viscosity tear replacement fluid is administered than without it, the standard deviation increases. If a high-viscosity tear replacement fluid is administered to the eye before measuring, the values obtained vary substantially, the standard deviation increases by a multiple.
This is clearly shown by the curves of the mean values. The individual curves of the 13 test subjects vary slightly from one another, but the curve of the mean standard deviation tends to be similar in all four graphs. It becomes steeper when a low-viscosity tear replacement fluid is administered, and shows an additional increase when a high-viscosity tear replacement fluid is used.
The subjective impression was that the measurements of the central corneal radii using the IOLMaster™ without tear replacement fluid were most accurate and required the least time. Both

types of tear replacement fluid caused more or less significant reflexes at the 6 measuring points on the cornea and the points appeared blurred and distorted at times. This made measurement more complex and difficult.

5. Conclusion

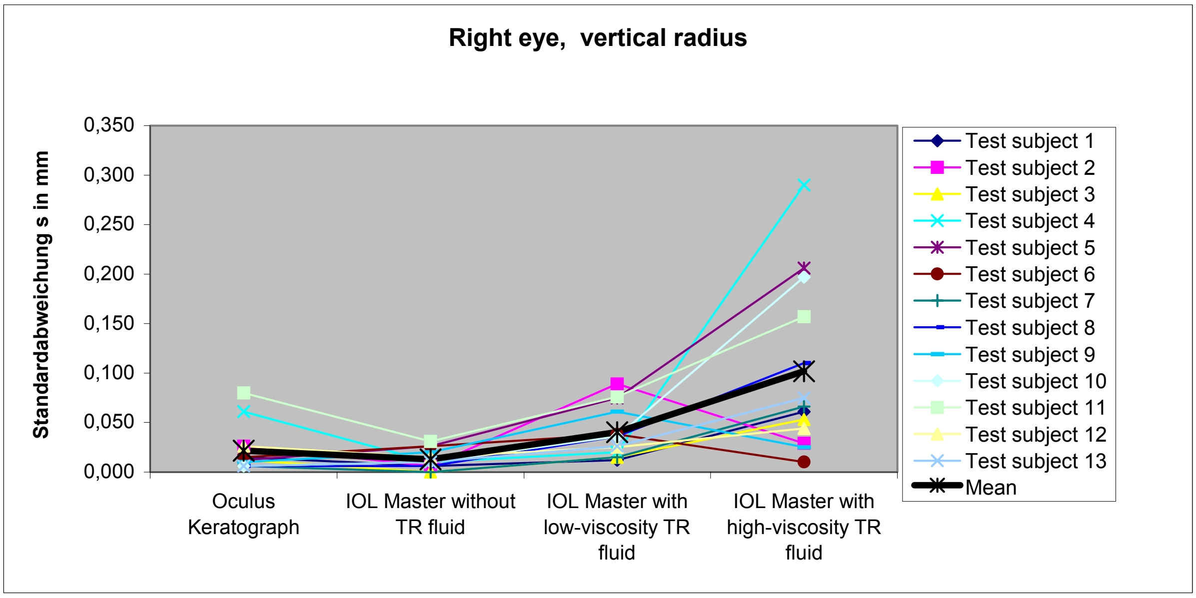
In accordance with the values we obtained, we recommend performing the measurements without administering a tear replacement fluid in normally healthy eyes.
Because of the small number of test subjects, who in addition were young people without pathologically dry eyes, this study can only indicate a trend.

6. Literature

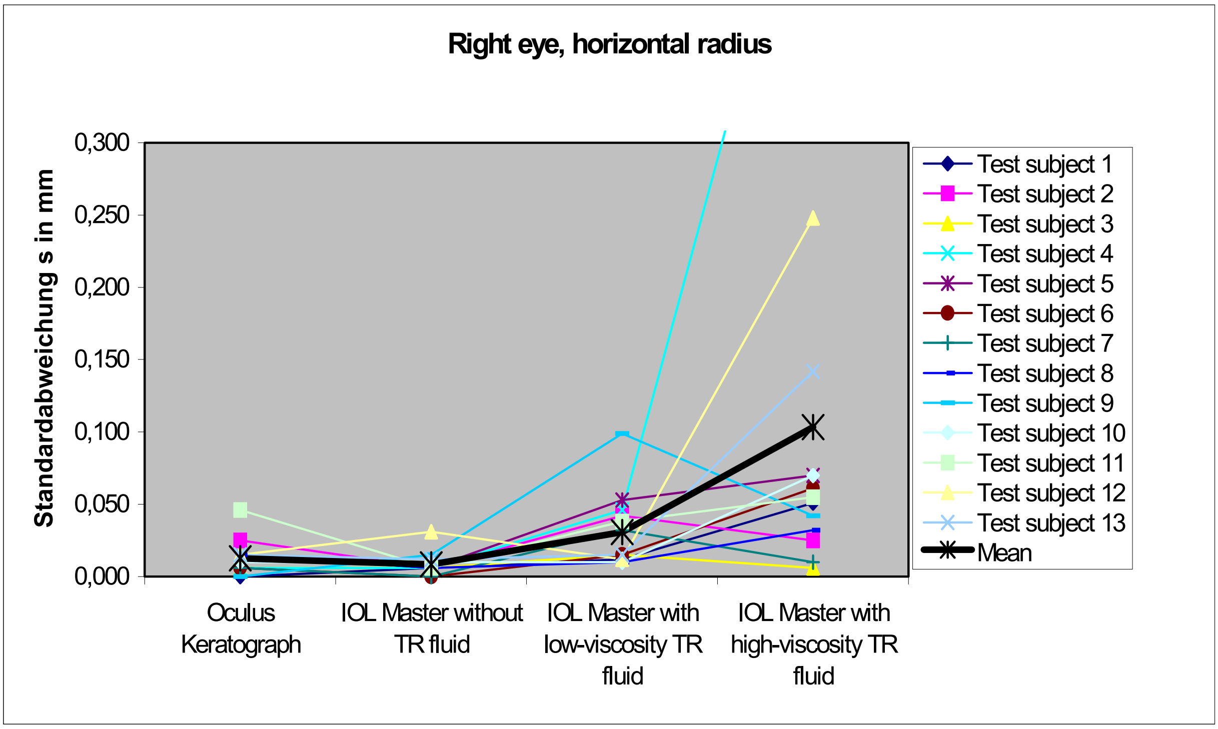
1) Wolfgang Haigis, Würzburg University Eye Hospital, Optical Coherence Biometry; in Kohnen, T (ed): Modern Cataract Surgery. Dev Ophthalmol. Basel, Karger, 2002, vol 34, pp119-130
2) Kenneth Rosenthal, Great Neck, N.Y. USA, Correction of Presbyopia – The IOLMaster and the AMO Array Multifocal. A Partnership in Refractive Surgery; Special Print CZM
3) Warren Hill, Mesa, Arizona, The new Role of Optical Biometry in Cataract Surgery; in Geriatric Ophthalmology, May 2002, vol1 no1.
4) Annette Vogel, Burkhard Dick, Frank Krummenauer, Norbert Pfeiffer, Mainz University Eye Hospital, Reproducibility of MeasurementResults in Optical Biometry: Intraobserver and Interobserver Variability; Special Print CZM

	No 1	No 2	No 3	No 4	No 5	No 6	No 7	No 8	No 9	No 10	No 11	No 12	No 13	Mean
Oculus Keratograph	0,000	0,025	0,006	0,006	0,015	0,006	0,006	0,015	0,000	0,010	0,046	0,015	0,015	0,013
IOL Master without TR fluid	0,006	0,006	0,006	0,006	0,006	0,000	0,000	0,006	0,015	0,010	0,006	0,031	0,012	0,008
IOL Master with low-viscosity TR fluid	0,012	0,042	0,015	0,046	0,053	0,015	0,032	0,010	0,099	0,010	0,038	0,012	0,015	0,031
IOL Master with high-viscosity TR fluid	0,051	0,025	0,006	0,532	0,070	0,061	0,010	0,032	0,042	0,070	0,055	0,248	0,142	0,103
	No 1	No 2	No 3	No 4	No 5	No 6	No 7	No 8	No 9	No 10	No 11	No 12	No 13	Mean
Oculus Keratograph	0,012	0,030	0,012	0,031	0,035	0,015	0,023	0,026	0,023	0,006	0,050	0,006	0,015	0,022
IOL Master without TR fluid	0,017	0,127	0,000	0,044	0,006	0,006	0,000	0,006	0,010	0,006	0,010	0,012	0,010	0,020
IOL Master with low-viscosity TR fluid	0,045	0,115	0,049	0,151	0,098	0,031	0,015	0,015	0,065	0,038	0,032	0,044	0,085	0,060
IOL Master with high-viscosity TR fluid	0,040	0,146	0,006	0,256	0,035	0,031	0,035	0,036	0,114	0,075	0,065	0,060	0,040	0,072
	No 1	No 2	No 3	No 4	No 5	No 6	No 7	No 8	No 9	No 10	No 11	No 12	No 13	Mean
Oculus Keratograph	0,015	0,026	0,012	0,061	0,012	0,015	0,006	0,006	0,010	0,006	0,080	0,026	0,006	0,022
IOL Master without TR fluid	0,006	0,006	0,000	0,010	0,026	0,026	0,000	0,006	0,020	0,010	0,031	0,015	0,010	0,013
IOL Master with low-viscosity TR fluid	0,012	0,089	0,015	0,020	0,075	0,038	0,015	0,036	0,061	0,036	0,076	0,025	0,026	0,040
IOL Master with high-viscosity TR fluid	0,061	0,029	0,053	0,290	0,206	0,010	0,066	0,110	0,025	0,197	0,157	0,044	0,075	0,102
	No 1	No 2	No 3	No 4	No 5	No 6	No 7	No 8	No 9	No 10	No 11	No 12	No 13	Mean
Oculus Keratograph	0,026	0,026	0,010	0,026	0,021	0,062	0,006	0,010	0,017	0,017	0,083	0,026	0,006	0,026
IOL Master without TR fluid	0,006	0,006	0,006	0,012	0,035	0,010	0,006	0,000	0,021	0,038	0,061	0,010	0,006	0,017
IOL Master with low-viscosity TR fluid	0,023	0,089	0,067	0,193	0,115	0,006	0,049	0,015	0,099	0,021	0,053	0,046	0,032	0,062
IOL Master with high-viscosity TR fluid	0,121	0,029	0,062	0,040	0,026	0,057	0,040	0,110	0,096	0,092	0,196	0,081	0,081	0,079

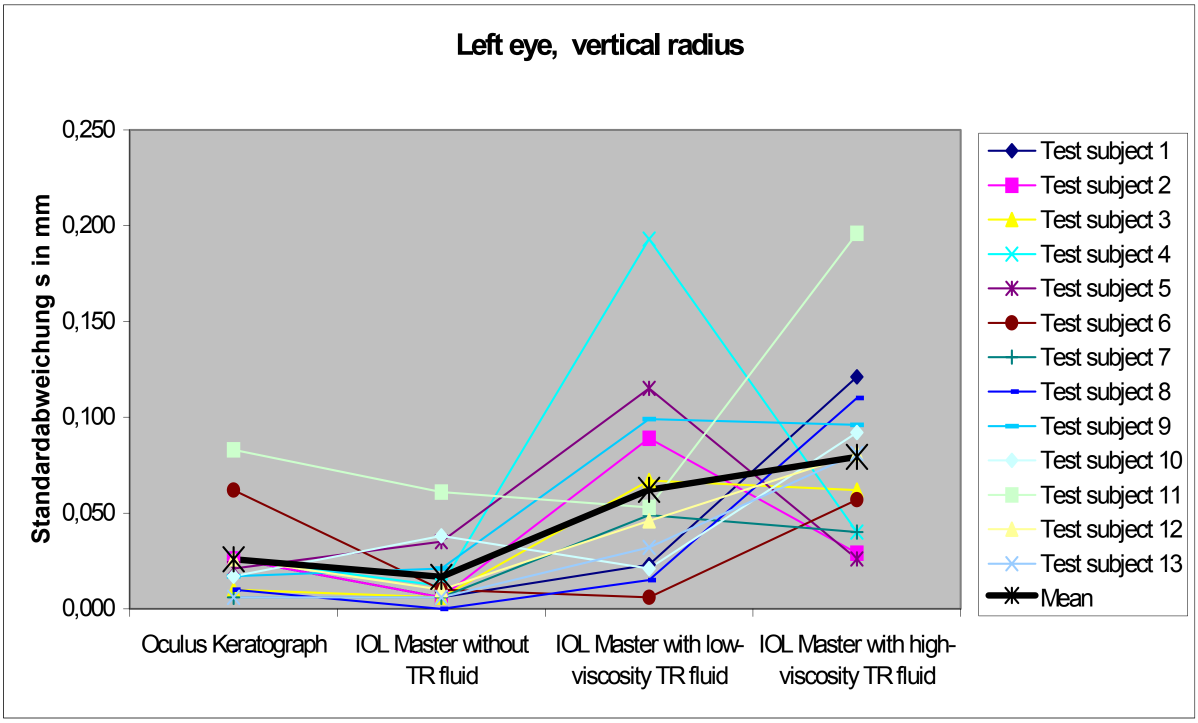
Table:
Standard deviations of measurements of the test subjects with the Oculus Keratograph and the IOLMaster with and without tear replacement fluid



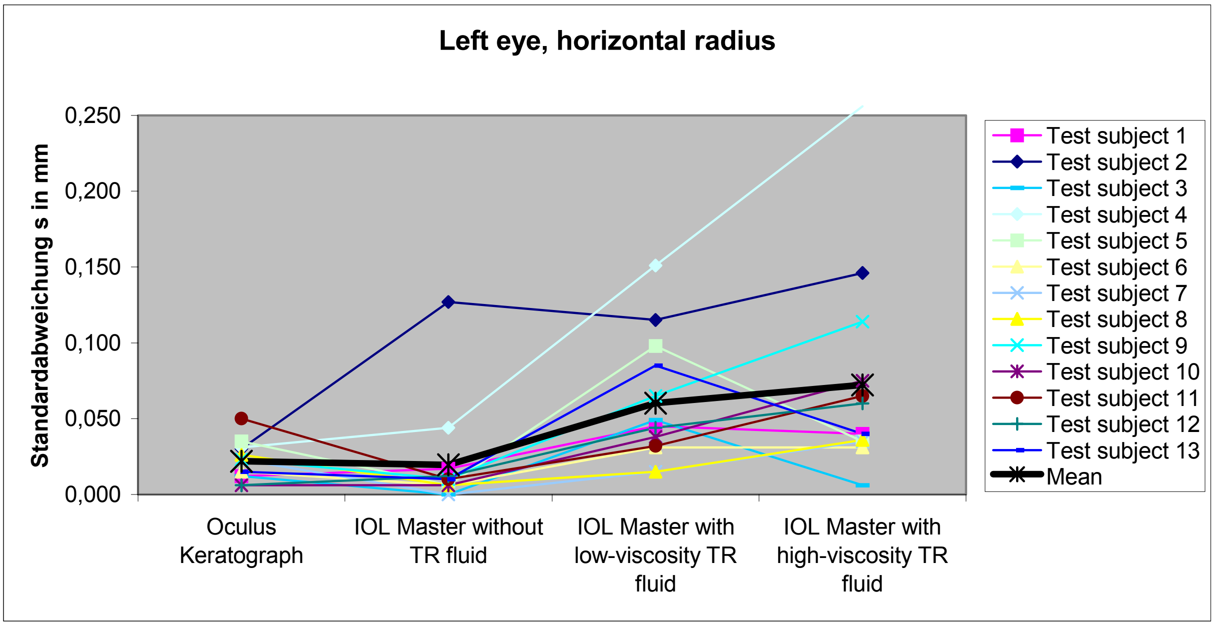
Graph 1:
Standard deviation of measurements of the right eye, vertical radius with and without tear replacement



Graph 2:
Standard deviation of measurements of the right eye, horizontal radius with and without tear replacement



Graph 3:
Standard deviation of measurements of the left eye, vertical radius with and without tear replacement



Graph 4:
Standard deviation of measurements of the left eye, horizontal radius with and without tear replacement