Variations in keratometric values (K-value) after administration of three different eye drops: effects on the intraocular lens calculations in relation to cataract surgery

Jensen, Mia N.; Søndergaard, Anders Peter; Pommerencke, Claus; Møller, Flemming

Published in:
Acta Ophthalmologica

DOI:
10.1111/aos.14408

Publication date:
2020

Document version:
Accepted manuscript

Citation for published version (APA):

Go to publication entry in University of Southern Denmark's Research Portal

Terms of use
This work is brought to you by the University of Southern Denmark. Unless otherwise specified it has been shared according to the terms for self-archiving. If no other license is stated, these terms apply:

- You may download this work for personal use only.
- You may not further distribute the material or use it for any profit-making activity or commercial gain.
- You may freely distribute the URL identifying this open access version.

If you believe that this document breaches copyright please contact us providing details and we will investigate your claim. Please direct all enquiries to puresupport@bib.sdu.dk

Download date: 14. Sep. 2023
Variations in keratometric values (K-value) after administration of three different eye drops - effects on the intraocular lens calculations in relation to cataract surgery

Authors: Jensen MN, MS¹, Søndergaard A, MD, Ph.D.¹, Pommerencke C, MD¹ and Møller F, MD, DmSci¹

Institution: ¹Department of Ophthalmology, Vejle Hospital, Denmark

Corresponding author: Flemming Møller, MD, Ph.D., DmSci., associated professor
Department of Ophthalmology, Vejle Hospital, Denmark, Beriderbakken, 7100 Vejle
E-mail: Flemming.moller2@rsyd.dk
Telephone: +45 7940 6450
Abstract

Purpose: To investigate the variance in keratometric (K) values after administration of different eye drops (3 tested), and the effects on intraocular lens (IOL) power calculations in relation to standard cataract surgery.

Methods: A prospective intervention study (pilot study) on 38 participants (22 women, 16 men, 58–88 years) undergoing 57 cataract surgeries. Three keratomeries on each eye were performed: a
baseline (‘standard’) keratometry about nine weeks pre-operatively, and two on the operation day; a ‘dry’-measurement before interventions and a ‘wet’-measurement after applying one of three eye drops (saline, Systane Ultra®, or Systane Complete®). All standard cataract operations were uneventful. Variabilities in K-values, spherical equivalents (SEQs) for IOL power calculations (Barrett TK Universal II), and subjective manifest refractions (SRs) 6 weeks post-operatively were compared between groups.

**Results:** The ‘wet’ K-values had a similar variability to those of the ‘standard’ and ‘dry’ K-values (P > 0.05, ANOVA on ranks). The mean paired differences in K-measurements between groups ranged within a small interval from −0.0107 mm to 0.0096 mm. After comparing SEQ predictions with SR-measurements, the most precise IOL calculation was achieved after administration of a saline eye drop, but the precision was not statistically improved compared to the other drop modalities.

**Conclusion:** The variability in keratometric values was not significantly changed by administration of any of the different eye drops tested, suggesting that artificial eye drops do not impact keratometry or IOL power prediction.

**Key words:** keratometry; cataract; tear film; dry eyes; eye drop; IOL power calculation; spherical equivalent; refraction

**Introduction**
Cataract remains the leading cause of blindness worldwide; it caused more than 30% of the blindness in adults 50 years and older in 2015 (Flaxman et al., 2017, Khairallah et al., 2015). The number of people affected by cataract is anticipated to increase as the population increases and ages. Currently, approximately 50,000 cataract procedures are performed yearly in Denmark (Sundhedsstyrelsen, 2014).

Expectations from patients undergoing cataract surgery have changed during the past 20 years. Previously, a post-operatively improved corrected visual acuity was accepted. Today, cataract surgery is also a refractive procedure, and many patients expect spectacle independence as well as improved visual acuity (Allen and Vasavada, 2006, Panagioto-poulou et al., 2018). In order to achieve this goal, an uneventful cataract phacoemulsification as well as precise intraocular lens (IOL) calculations is needed.

The three main sources of intraocular lens power prediction errors are incorrect measurements of axial length (AL), corneal power (K-values), and estimation of post-operative anterior chamber depth (ACD) accounting for 36%, 22% and 42% of the errors, respectively (Olsen, 2007).

The IOL Master device (700 version 5.2, Advanced Technology) provides AL and ACD measurements with accuracies of 0.06 and 0.2 mm, respectively (Shammas and Chan, 2010), limiting errors in IOL calculations to approximately 0.16 and 0.3 dioptres (D), respectively (Olsen, 2007).

The interface between air and tear film on the corneal curvature accounts for two-thirds (40 D) of the overall refraction in the optic eye, and according to Olsen (2007) a 0.1 mm error in K-values corresponds to a refractive error of about 0.57 D in the spectacle plan. Accordingly, unprecise K-readings may influence pre-operative IOL calculations.

Artificial eye drops may stabilise the tear film. However, to our best knowledge, whether administration of an artificial eye drop influences the precision of IOL calculations has never been investigated.

The purpose of the present study was to investigate the precision of pre-operative IOL calculations after administration of one of 3 eye drops (saline, Systane Ultra® ALCON, Fort Worth, Texas USA and Systane Complete® ALCON, Fort Worth, Texas USA) and compare these calculations to an IOL calculation without the use of an artificial eye drop. The prediction of the spherical equivalent (SEQ) from all IOL calculations were compared to the spherical equivalent as measured by subjective manifest refraction (SR) approximately 6 weeks after the cataract surgery.
Materials and methods

Setting

A prospective intervention study (a pilot-study) performed at the Department of Ophthalmology, Vejle Hospital, Denmark.

The study follows the Tenets of the Declaration of Helsinki. The Regional Ethical Committee waived the requirement for an approval because the study was qualitative in nature and without risks for the patients.

Participants

Forty sequential patients scheduled for cataract surgery on an out-patient basis from the 1st of January to the 28th of February, 2019, were included.

Pre-examination and surgery procedure

Non-mydriatic standard (“standard”) biometric measurements were obtained with the IOLMaster 700 v. 1.80.6.60340 (© Carl Zeiss Meditec AG) for each patient about 9 weeks prior to surgery. A trained technician evaluated the measurements and repeated them if needed. On the day of surgery, additional two IOLMaster 700 biometric measurements were made approximately 30 minutes prior to the surgery. One without intervention (‘dry’) and identical to the ‘standard’ one, and the second (‘wet’) after assigning the patients consecutively to one of three eye drops to be tested (saline, Systane Ultra® or Systane Complete®). The second measurements were performed 1 minute after the ‘dry’-measurements.

The Barrett TK Universal II formula for IOL power-calculation was used for all patients, and the predicted post-operative outcome reported as the spherical equivalent (SEQ).

A speciality registrar or a consultant surgeon performed the uneventful standard cataract operations with implantation of a TECNIS ITEC® preloaded IOL (Model PCB00) through a 2.4-mm temporal corneal incision.

The post-operative standard medication consisted of dexamethasone eye drops thrice a day (Maxidex®, NOVARTIS, Basal, Switzerland) for 2 weeks and diclofenac eye drops (Voltabak, THEA, Clermont-Ferrand, France) thrice a day for 4 weeks.

Post-examination protocol
A subjective manifest refraction (SR) using plus principle was performed 6 weeks after surgery and best corrected visual acuity was measured using ETDRS visual acuity charts. Refraction was reported as SR (post-operative SEQ) and calculated as, \( SR = \text{sphere} + (0.5 \times \text{cylinder}) \)

**Statistical analysis**

Excel v. 16.24 (Microsoft®, USA) and SigmaPlot v. 14 (Systat Software Inc., USA) were used in the statistical analysis.

Data was handled as suggested by Bland and Altman (Bland and Altman, 1999). In brief, the standard deviation (SD) of the three repeated measurements for each subject was plotted against the mean to assess independence of the magnitude of the measurements and their differences. The 95% limits of agreement (LoA) were defined as the mean ± 1.96 SD. One-way analysis of variance (ANOVA) on ranks (Shapiro-Wilk Normality Test failed in some groups, \( P < 0.05 \)) was used to compare medians with 25–75% interquartile ranges (IQRs) between intervention groups. P-values \( \leq 0.05 \) was considered statistically significant.
Results

Data completion

The cataract operation was cancelled on three eyes leaving 57 cataract surgeries on 38 participants for analysis. Four K-values obtained on the day of surgery were not available due to technical difficulties. Accordingly, we had data from 72 eyes for K-value analysis. Fourteen eyes from 9 patients were not available for the 6-week follow-up analysis: 5 patients were not able to attend (8 eyes), 5 eyes from 3 patients were excluded due to incomplete data, and one eye from one patient was excluded due to a visual acuity of counting fingers at 1 metre, and not being able to perform a SR. Thus, 43 of the operated eyes were available for the final SEQ analysis (21 right eyes and 22 left eyes). Table 1 shows patient demographics.

Table 1 shows patient demographics.

| Table 1 over here |

Keratometry

We found no significant differences in keratometric outcomes between the ‘standard’, ‘dry’ and ‘wet’ groups (p = 0.989 and p = 0.927 on right and left eyes, respectively, ANOVA on ranks). In addition, we found no statistically significant differences between subgroups of ‘wet’ K-measurements alone (right eyes, p = 0.760; left eyes, p = 0.539; ANOVA on ranks). Table 2 shows the keratometric outcomes for right and left eye pooled values. We pooled all ‘wet’ K-measurements and compared them to ‘standard’ and ‘dry’ K-measurements using Bland-Altman plots.

Figure 1A-C shows the Bland-Altman plots of differences in ‘standard’, ‘dry’ and ‘wet’ K-measurements. The means of the paired differences ranged between -0.0107 mm (‘standard’ and ‘dry’ comparison, Fig. 1A) and 0.0096 mm (‘dry’ and ‘wet’ comparison Fig. 1C). The majority of measurements were within the 95% LoA [Mean ± 1.96 SD]. The 95% confidence intervals for paired differences were -0.1785 mm to 0.1572 mm, -0.1938 mm to 0.1916 mm, and -0.0762 mm to 0.0954 mm for ‘standard’ vs ‘dry’, ‘standard’ vs ‘wet’, and ‘dry vs ‘wet’ comparisons, respectively.

IOL calculations

The median spherical equivalent differences (SEQ difference) between the SR and the predicted SEQs from the IOL calculations for right and left eyes separately, showed no significant differences between ‘standard’, ‘dry’ and ‘wet’ groups (One-way ANOVA on ranks; right eyes, p = 0.995; left
eyes, \( p = 0.686 \)). After comparing only ‘wet’ SEQ differences, we found no statistically significant differences either (right eyes, \( p = 0.901 \); left eyes, \( p = 0.332 \)). However, the smallest difference between the predicted SEQ and the post-operative SR was obtained using saline eye drops before biometric measurements. Table 3 shows SEQ median differences between the SR and the predicted SEQs from the IOL calculations for pooled values of right and left eyes.

Figure 2 shows scatter plots comparing predicted SEQ-values with SR-values. Most values are located beneath the equality line suggesting that most patients became more hyperopic than expected from the IOL calculations. The correlation coefficients between SRs and predicted SEQs from IOL calculations for ‘standard’, ‘dry’ and ‘wet’ groups were \( R=0.52 \) (\(<0.001\)), \( R=0.48 \) (\( p=0.002 \)), and \( R=0.32 \) (\( p=0.04 \)), respectively.

[Table 3 over here]
Discussion

We tested saline, Systane Ultra®, and Systane Complete® eye drops to assess if any of them would influence the precision of the IOL calculations by causing variances in the K-values. To our knowledge, this is the first study of its kind. We found no statistically significant differences after comparing ‘standard’, ‘dry’ and ‘wet’ K-measurements. Moreover, the spherical equivalent (SEQ) predictabilities calculated from ‘standard’, ‘dry’ and ‘wet’ measurements were similar to the final subjective manifest refractions 6 weeks post-operatively (SR). The most precise IOL calculation was achieved after administration of a saline eye drop (Table 3); however, the difference in precision was not statistically significant.

The mean paired differences in K-measurements between groups were surprisingly small ranging between −0.0107 mm and 0.0096 mm. This difference accounts for less than 0.12 D in the spectacle plane according to Olsen, T. (2007). The 95% confidence intervals for paired differences were the broadest for ‘standard’ versus ‘wet’ groups (−0.1938 mm to 0.1916 mm), and in the spectacle plane these would be approximately -1.11 D to 1.09 D. These values are clinically significant and stress the importance of valid K-measurements.

The mean paired differences in K-measurements between groups showed a number (n = 8) of outliers, exceeding the 95% confidence interval. This variation may be due to the quality of the tear film in these patients. However, we do not have data to support this hypothesis, and this is a major limitation of our study.

We observed the smallest difference between the predicted SEQ and post-operative subjective manifest SEQ when using saline eye drops before biometric measurements. This difference was not significantly different from those in other groups, but the sample size was small in the saline group (n_total = 23). Thus, further studies with larger sample sizes need to assess possible differences between groups. Future studies should ideally also include objective pre-operative measurements of the tear film quality such as tear break up time, tear film osmolarity and a dry eye questionnaire. Epitropoulos et al (2015) investigated hyperosmolarity, which is seen in dry eye disease, and concluded that hyperosmolarity increases K-value variability and enhances the likelihood of unexpected refractive errors resulting from inaccurate K-readings. Thus, an association with eye drop administration may still be found. Moreover, administration of artificial eye drops a week before the biometric measurement may limit the number of K-measurement outliers.

In conclusion, we did not observe a statistically significant variability difference in K-values between standard keratometry and keratometry after eye drop administration (saline, Ultra®, and...
Complete®). Larger studies are needed to reveal the influence of the quality of the tear film on the K-measurements and its implications on the post-operative refraction.
Acknowledgements

- None
References


Table 1.

Patient demographics

<table>
<thead>
<tr>
<th>Gender</th>
<th>Female</th>
<th>Male</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
<td>16</td>
<td>38</td>
</tr>
</tbody>
</table>

Age (years ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Oldest</th>
<th>Youngest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>73.5 ± 6.86</td>
<td>88</td>
<td>58</td>
</tr>
</tbody>
</table>

Eyes

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21</td>
<td>22</td>
<td>43</td>
</tr>
</tbody>
</table>

Visit* (weeks ± SD) = 6.33 ± 0.53

*weeks from operation date to post-examination. SD = standard deviation.

Table 2. Keratometric measurements.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>n</th>
<th>Median (mm)</th>
<th>25%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>72</td>
<td>7.670</td>
<td>7.520</td>
<td>7.805</td>
</tr>
<tr>
<td>Dry</td>
<td>72</td>
<td>7.700</td>
<td>7.520</td>
<td>7.900</td>
</tr>
<tr>
<td>Wet</td>
<td>72</td>
<td>7.700</td>
<td>7.545</td>
<td>7.810</td>
</tr>
<tr>
<td>Saline</td>
<td>23</td>
<td>7.675</td>
<td>7.475</td>
<td>7.810</td>
</tr>
</tbody>
</table>

This article is protected by copyright. All rights reserved
Keratometric measurement (K-value), estimated as the average keratometry value between the meridians (K1 and K2) for right and left eye pooled values.

n = sample count; mm = millimeters; IQR = interquartile range.

Table 3.

Spherical equivalent differences between predicted (from IOL calculations) and post-operative subjective manifest refraction values.
n = sample count; D = dioptrre; IQR = interquartile range.
Figure 1

(A) Standard - dry measurements

(B) Standard - wet measurements

(C) Dry - wet measurements
**Fig. 1.** Bland-Altman plot between K-values (mm) of “standard” and “dry” measures (A), “standard” and “wet” measurements (B) and “dry” and “wet” (C) for all eyes. The middle dashed-blue line indicates the bias, which is the mean of the difference between the paired data. The dashed-blue lines above and below show the 95% limits of agreement (LoA) [Mean ± 1.96 SD].

**Fig. 2.** Scatterplot of predicted spherical equivalent values (SEQ) vs post-operative subjective manifest refraction (SR; final refraction) for “standard” (A), “dry” (B) and “wet” (C) measurements. Correlation coefficients between SR and predicted SEQ from IOL calculation for “standard”, “dry” and “wet” were: R=0.52 (p<0.001), R=0.48 (p=0.002) and R=0.32 (p=0.04), respectively (broken lines). The solid black line indicates refractive equality [SEQ = SR].