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Research Article

Impact of Artificial Tears of Different Viscosities on Keratometric Measurements in Cataract Patients with Dry Eye Disease

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Abstract

Background: To evaluate the variation in K-readings after application of artificial tears of different viscosities in mild to moderate dry eyes.

Design: Cross-sectional comparative study.

Methods: Setting: A tertiary care centre in Mumbai.

Patient or Study Population: Patients presenting with cataract in our OPD were screened for dry eye disease and 50 eyes of 30 patients with mild to moderate dry eyes were recruited for the study.

Observation Procedure (s): Baseline keratometric measurements were taken followed by Instillation of low viscosity artificial tears and repeating keratometry at 1 minute and 5 minutes after instillation. Then high viscosity artificial tears were instilled after 24 hours and keratometric measurements were taken at 1 and 5 minutes after instillation. Main Outcome Measure (s): variation of K-readings at 1- and 5-min interval after application of artificial tears compared to baseline.

Results: Instillation of both low and high viscosity artificial tears resulted in statistically significant changes in K1 measurements in both mild and moderate dry eyes at 1- and 5-minute intervals compared to baseline ($p>0.05$). However, K2 and axis did not show significant changes in both mild and moderate dry eyes.

Conclusions: The variations in K1 after the instillation of artificial tears can potentially confound IOL calculations and affect surgical outcomes. Clinicians should be mindful of these effects when interpreting keratometry data

Keywords: Cataract Surgery; Dry Eye Syndrome; Artificial Tears; Keratometry; IOL Power Calculation

Key Messages

Cataract surgery patients with dry eye syndrome often use artificial tears, which may influence keratometry readings. Our study found artificial tears significantly affected K1 values, especially in the steep corneal meridian, but K2 and axis remained stable. Accurate IOL calculations are critical for these patients. Further research is needed.

Introduction

According to the World Health Organization, cataract is the major cause of preventable blindness. The global prevalence rate of visual impairment due to cataract is 1253.9 per 100,00 population [1].

In India, cataract has been reported to account for 50%–80% of the bilaterally blind. Cataract surgery is the most cost-effective healthcare interventions currently available [1,2].

With advances in modern optical instrument technologies, cataract surgery has become a sophisticated surgery and not merely a lens replacement procedure. Presently, patients have higher expectations for accurate refractive outcomes and excellent quality of vision after intraocular lens (IOL) implantation [3].

The three main sources of IOL power prediction errors are incorrect measurements of axial length (AL), corneal power (K-values) and estimation of postoperative anterior chamber depth (ACD) accounting for 36%, 22% and 42% of the errors, respectively [4]. A 1.0 dioptre (D) error in the measured corneal power results in approximately a 1.0 D error in the postoperative refraction [5].

Studies done in larger cohorts in India have reported an increased incidence of Dry eye disease (DED) with age, which is also the pattern seen with cataract. It is hence common to encounter situations where we need to either simultaneously or sequentially manage both dry eye and cataract [6].

In dry eyes, the biometry sometimes has to be repeated several times because of an unstable tear film. Both short- and long-term repeatability of keratometry of dry eyes are known for their high variability [7].

Hence, pre-operative diagnosis and management of pre-existing DED are important prior to cataract surgery due to the potential for inaccurate biometric and corneal topographic assessments due to tear film irregularities [8].

"Artificial tears" which, as their name suggests, attempt to replace and/or supplement the natural tear film are traditionally considered a mainstay of DED therapy. Viscosity-enhancing agents are used in artificial tears can enhance lubrication and increase retention time on the ocular surface [9]. Artificial tears are also often used to ameliorate the ocular surface for obtaining a precise measurement of the eye (axial length (AL), corneal power (K-values)) [7].

While there is currently no recommendation regarding the use of artificial tears to establish a regular tear film before keratometry, or guidance on the optimal interval for eye drop instillation, this study aims to address these gaps. Specifically, it investigates how the viscosity of two commonly used artificial tears affects keratometry measurements, utilizing the TOPCON KR-1 Autorefractometer for precise K-readings.

Subjects and Methods

Study was done from march 2023 to February 2024 in a tertiary care hospital in Mumbai central. After approval by institutional research and ethical committee of the hospital, patients presenting with cataract and fulfilling inclusion and exclusion criteria were allocated in this study after taking written informed consent explaining in their own language. The study was performed in accordance with the ethical principles specified in the Declaration of Helsinki and as per the guidelines of Good Clinical Practice.

Sample size – The prevalence of dry eye disease in urban population is ~65% [10].

Sample size was calculated using the formula $n = \frac{(Z)^2 Pq}{L^2}$, Z = 2 at 95% confidence limit, P = prevalence of the disease, q = 100 – P, L = permissible error or allowable error, 20% of P.

$n = \frac{65X\ 35\ X\ 4}{(13)^2} = 53.84$ approximately 50, *n* is taken as approximately 50 for easy calculation and understanding.

Statistical analysis

After data collection, data entry was done in Excel. Data analysis was done with the help of statistical software SPSS V25.0 (Statistical Package for Social Sciences, Version 25.0) package. For quantitative continuous data, Mean, Standard Deviation and Coefficient of Variation were calculated. For categorical data, Number and Percentage was calculated. Tests of significance were used to calculate the *P* value.

Inclusion criteria

- Age 50 years or more
- Patients belonging to either sex
- Normal ocular adnexa
- Patients with cataract posted for phacoemulsification/SICS surgery
- Patients with mild to moderate dry eye
- Cataract of any grade

Exclusion criteria

- Patient refusal
- Who wore contact lenses within 7 days prior to study entry
- Active ocular infection, ocular inflammation, or allergic conjunctivitis.
- Any corneal pathology

- The use of any eye drops 24 hours before the examination
- Active ocular or nasal allergies
- Abnormalities of the nasolacrimal drainage apparatus
- Lid abnormalities
- Severe dry eyes
- Eyelid deformities and
- Preceding ocular surgery or trauma

Methodology

- When patient enrolls for study in their 1st visit, A complete ophthalmologic examination, examination of cataract and investigations for cataract surgery according to institutional protocol were done along with evaluation of dry eye. We used Ocular Surface Disease Index (OSDI) [11] to assess symptoms. For assessment of tear film stability, we used Fluorescein breakup time (FBUT)/tear film breakup time (TBUT) [11]. For assessment of tear volume, we used Schirmer test.[11] To avoid the influence of conjunctiva-corneal staining on the Schirmer test, it was carried out at an interval of 10 min after the TBUT test. Classification and grading of dry eye was done based on OSDI (Mild 13-22, Moderate 23-32, Severe ≥ 33).
- In 2nd visit (24 hrs. after 1st visit), baseline keratometric measurements were taken followed by Instillation of low viscosity artificial tears (refresh tears) and repeating keratometry after 1 minute and 5 minutes after instillation.
- In 3rd visit (24 hrs. after 2nd visit), high viscosity artificial tears (Systane hydration) were instilled and keratometric measurements were taken 1 min and 5 minutes after instillation.

Results

A total of 50 eyes of 30 patients with mild to moderate dry eyes participated in our study. The mean age of patients was 62.06 years. The majority of patients 16 (32%) came from the 55 to 60 years of age group, followed by 14 (28%) patients who belonged to the 65 to 70 years of age group, remaining 7 (14%) were from 50 to 54 and 61 to 64 years of age group and 6 (12%) were ≥ 71 years of age group respectively. Most of the patients came with involvement of the right eye 26 (52%) compared to the left eye 24 (48%). According to OSDI grading, the majority of patients had moderate dry eye 37 (74%) followed by 13 (26%) had mild dry eye, respectively.

According to TBUT scoring for dry eye, most of the patients 35 (70%) had a score of <10 compared to 15 (30%) had a >10 score. According to Schirmer's test scoring for dry eye, most of the patients 31 (62%) had a <10 score compared to 19 (38%) had a >10 score. TBUT and Schirmers test also had almost perfect agreement with ODSI in determining the severity of dry eyes (table 1).

Keratometry measurement at baseline, the mean K1 was 43.34 ± 5.11 D, K2 was 44.25 ± 1.87 D, and the axis was 94.75 ± 39.3 mm respectively.

Table 1: Demographics.

Age in years	Number of patients	Percentage
50-54 years	7	14
55-60 years	16	32
61-64 years	7	14
65-70 years	14	28
≥ 71 years	6	12
Total	50	100
Mean ± SD	62.06 ± 6.98	
Gender	Number of patients	Percentage
Male	24	48
Female	26	52
Total	50	100
Involvement of eye	Number of patients	Percentage
Right	26	52

Left	24	48
Total	50	100
OSDI Grade	Number of patients	Percentage
Normal	0	0
Mild	13	26
Moderate	37	74
Total	50	100
TBUT Scoring	Number of patients	Percentage
>10	15	30
<10	35	70
Total	50	100
Schirmers test	Number of patients	Percentage
>10	19	38
<10	31	62
Total	50	100

Effects of artificial tears on keratometry

Low Viscosity Artificial Tears: In the mild dry eye group (table 2), K1 and axis showed a statistically significant increase compared to baseline after 1 minute of instillation ($p < 0.001$ and $p = 0.03$ respectively). However, K2 measurements did not show significant changes ($p = 0.52$). At 5-minute intervals, K1 remained elevated compared to baseline ($p < 0.001$). K2 and axis measurements continued to show stability ($p = 0.85$ and $p = 0.35$ respectively), although the significance level may vary.

Table 2: Comparison of Keratometry measurement in mild dry eyes at baseline and after instillation of low viscosity artificial tear at 1 min and 5 min time interval.

Keratometry	Baseline	At 1 min	P value	At 5 min	P value
K1	43.34 ± 5.11	43.96 ± 1.74	<0.001	43.92 ± 1.72	<0.001
K2	44.25 ± 1.87	43.88 ± 2.05	0.52	43.55 ± 1.82	0.85
Axis	94.75 ± 39.3	94.38 ± 52.9	0.03	80.38 ± 45.1	0.35

In the moderate dry eye group (table 3), only K1 exhibited a statistically significant increase compared to baseline at both 1-minute and 5-minute intervals ($p < 0.001$). but K2 and axis measurements did not show significant changes at both 1-minute ($p = 0.97$ and $p = 0.56$ respectively) and 5-minute ($p = 0.94$ and $p = 0.91$ respectively) intervals.

High Viscosity Artificial Tears: In the mild dry eye group (table 4), it reveals that there is a statistically significant difference for mean K1 reading at both 1-minute and 5-minute intervals ($p < 0.001$) compared to baseline. Whereas K2 and axis measurements remained relatively stable at both 1-minute ($p = 0.94$ and $p = 0.96$ respectively) and 5-minute ($p = 0.94$ and $p = 0.67$ respectively) intervals.

Similarly, in the moderate dry eye group (table 5), K1 exhibited a statistically significant increase compared to baseline at both 1-minute ($p < 0.001$) and 5-minute ($p = 0.03$) intervals. but K2 and axis measurements did not show significant changes at both 1-minute ($p = 0.99$ and $p = 0.37$ respectively) and 5-minute ($p = 0.94$ and $p = 0.31$ respectively) intervals.

Table 3: Comparison of Keratometry measurement in moderate dry eyes at baseline and after instillation of low viscosity artificial tear at 1 min and 5 min time interval.

Keratometry	Baseline	At 1 min	P value	At 5 min	P value
K1	43.34 ± 5.11	45.05 ± 1.98	<0.001	45.03 ± 2.0	<0.001
K2	44.25 ± 1.87	44.51 ± 1.88	0.97	44.43 ± 1.85	0.94
Axis	94.75 ± 39.3	97.62 ± 43.13	0.56	95.86 ± 39.89	0.91

Table 4: Comparison of Keratometry measurement in mild dry eyes at baseline and after instillation of high viscosity artificial tear at 1 min and 5 min time interval.

Keratometry	Baseline	At 1 min	P value	At 5 min	P value
K1	43.34 ± 5.11	44.36 ± 1.93	<0.001	43.92 ± 1.68	<0.001
K2	44.25 ± 1.87	43.73 ± 1.89	0.94	43.11 ± 1.84	0.94
Axis	94.75 ± 39.3	102.38 ± 39.58	0.96	80.53 ± 41.78	0.67

Table 5: Comparison of Keratometry measurement in moderate dry eyes at baseline and after instillation of high viscosity artificial tear at 1 min and 5 min time interval.

Keratometry	Baseline	At 1 min	P value	At 5 min	P value
K1	43.34 ± 5.11	45 ± 2.06	<0.001	43.93 ± 6.90	0.03
K2	44.25 ± 1.87	44.56 ± 1.87	0.99	44.45 ± 1.85	0.94
Axis	94.75 ± 39.3	101.59 ± 44.6	0.37	102.62 ± 45.4	0.31

Discussion

Cataract surgery is a common procedure aimed at restoring vision in patients affected by cataracts. Dry eye syndrome, characterized by insufficient tear production or poor-quality tears, is a frequent comorbidity in cataract patients. It poses challenges both preoperatively and postoperatively. Artificial tears are often prescribed to alleviate dry eye symptoms, but their influence on keratometry readings in cataract patients remains a topic of interest and concern.

The choice of artificial tears may also influence their impact on keratometry readings. Different formulations may have varying effects on corneal hydration and surface properties. For example, preservative-free artificial tears may be preferable in cataract patients to minimize potential ocular surface toxicity and inflammation. Additionally, the frequency and timing of artificial tear instillation relative to keratometry measurements may also play a role in determining their influence, which we explored in our study.

In our study, In both mild and moderate dry eye groups, instillation of both low and high viscosity artificial tears resulted in a significant increase in K1 compared to baseline even at 5 minutes after instillation, indicating a greater effect on steeper corneal curvature, However, K2 and axis measurements remained relatively stable (except for axis measurements of low viscosity artificial tears at 1 min in mild dry eye group), suggesting minimal changes in the flattest meridian and orientation of corneal astigmatism.

A similar study was done in 2021 by VERONIKA RO¨ GGLA., *et al*. [7] they investigated the reproducibility of keratometry obtained by IOL master 500 in normal and dry eyes and the impact of adding lubricants of different viscosities. They took 3 measurements followed by instillation of either high- or low-viscosity eye drops, 30 seconds, 2 minutes, and 5 minutes after instillation. They observed significant changes in keratometry values after instillation of both low- and high-viscosity eye drops. Immediately after instillation of eye drops (30 seconds, 2 minutes), both the k-value and astigmatism showed significantly increased variability in both normal and dry eyes, these results are in agreement with our study. But Five minutes after applying the lubricants used in their study, the variabilities were no longer statistically significant, in contrast to our study where we found statistically significant differences in K1 even after 5 minutes of instillation of artificial tears in both low and high viscosity groups. Furthermore, they did not separate mild and moderate dry eyes in their study, which we did in our present study and we found similar results in mild and moderate dry eyes.

Takahiro Hiraoka., *et al*. [3] investigated the effect of DED on the repeatability of corneal curvature radius and axial length measurements in cataract patients using IOL master 500. They found the absolute difference in the two assessments on the same day (measurement repeatability) for the steep meridian of the corneal curvature radius was significantly larger in the DED group than in the no-DED group. In contrast, there was no significant difference in measurement repeatability of the flat meridian of the corneal curvature. Combined with the results of the steep meridian, it is deemed that the steep meridian was more susceptible to DED than the flat meridian. Similarly in our study we found greater variations in steeper meridian after application of artificial tears in dry eyes and minimal changes in the flattest meridian and orientation of corneal astigmatism.

Shizuka Koh., *et al*. [12] evaluated ocular Higher order aberrations and forward light scatter before and 1, 5 and 10 minutes after instillation of three eyedrops. Significant increase was seen in the Higher order aberrations 1 minute after instillation of the three eye drops for dry eye; In contrast to K1-readings in our study, Higher order aberrations returned to the pre-instillation level 5 minutes after instillation in their study.

Mia N. Jensen and associates [4] investigated the variance in keratometry (K) values after administration of different eye drops (saline, Systane Ultra, or Systane Complete), and the effects on intraocular lens (IOL) power calculations in relation to standard cataract surgery. In contrast to our results, the variability in K-values was not significantly changed by administration of any of the different eye drops tested in their study, Moreover, the SEQ predictabilities were similar to the final subjective manifest refractions 6 weeks postoperatively (SR) in their study, which we did not consider in our study.

Implications for cataract surgery planning

The variations in K1, particularly after the instillation of artificial tears, underscore the importance of accurate IOL power calculation in dry eye patients undergoing cataract surgery. Hence, in planning for cataract surgery, While K2 and axis stability may simplify surgical planning, adjustments may still be necessary to accommodate changes in K1 in IOL power calculations to ensure accurate refractive outcomes. Hence a customized treatment approach is essential for determining the most suitable IOL and surgical technique.

Furthermore, we excluded patients with severe dry eye disease or ocular surface irregularities who might exhibit greater variability in keratometry measurements, which is another drawback of our study.

Conclusion

The influence of artificial tears on keratometry readings in cataract patients with dry eye is a complex issue that warrants careful consideration. While artificial tears may provide symptomatic relief and improve ocular surface conditions, their use can potentially confound keratometry measurements and affect surgical outcomes. Clinicians should be mindful of these potential effects when interpreting keratometry data and planning cataract surgery in patients with dry eye syndrome. Close monitoring of corneal parameters, including K values, throughout the preoperative, intraoperative, and postoperative phases is critical for ensuring optimal surgical outcomes in dry eye patients. Further research is needed to better understand the mechanisms underlying the interaction between artificial tears and keratometry readings, as well as to optimize strategies for managing dry eye in this patient population while minimizing its impact on surgical outcomes.

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