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Original Research Article

A cross-sectional study to assess the effect of tear substitutes on keratometric measurements in cataract patients with and without dry eyes

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Abstract

Background: In an era of premium IOLs and increase in patients' visual demands after cataract surgery, it is important to ensure accurate IOL power calculation. The rising incidence of dry eyes poses a challenge to record accurate keratometric readings required for IOL power calculation. This study was conducted to assess the effect of tear substitutes on keratometry at different time intervals in cataract patients with and without dry eyes.

Materials and Methods: This cross-sectional study was conducted in 260 patients diagnosed to have cataract. They were classified into 2 groups based on TBUT test- 1) Dry eyes 2) Non-dry eyes. Baseline keratometry was performed using optical biometer. Keratometric readings were again obtained at 30 seconds and 5 minutes after instillation of 1 drop of 0.1% Hydroxypropyl methylcellulose. IOL power was calculated with SRK-T formula using keratometric readings at different time intervals. Data was analysed using SPSS software.

Results: At 30 seconds post instillation, in patients with dry eyes, a statistically significant change in keratometry and a subsequent change in IOL power was observed (P < .001), but in patients without dry eyes, this change was not statistically significant (P=0.454 and P=0.47 respectively). There was no statistically significant difference in keratometry and IOL power at 5 minutes in both the groups. Variability of keratometry was observed to be higher in the dry eyes group as compared to the non-dry eyes group.

Conclusion: Instillation of tear substitutes is likely to affect keratometry readings. In cases where they have to be invariably used to stabilize the tear film, keratometry should be done at least 5 minutes after instillation of tear substitutes.

Keywords: IOL power calculation, Keratometry, Tear substitutes, Dry eyes.

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1. Introduction

With the advancements in techniques of cataract surgeries and types of premium and multifocal IOLs, the expectations of patients to eliminate the need of spectacle use after surgery has increased drastically. Precise keratometric assessments are crucial in ascertaining correct intraocular lens (IOL) power calculation, consequently guaranteeing the best possible refractive results for patients.[1] Optical biometers are commonly used for measuring keratometry since they are gold standard for measurement of keratometry, axial length and IOL power.[2] Changes in keratometric reading (in dioptres) changes the IOL power in a ratio of approximately 1:1 i.e. if the keratometry increases by 0.50D, IOL power decreases by 0.50D.[3]

Estimates of the prevalence of dry eye disease vary greatly between populations; they range from 5% to 50% worldwide[4] and in India it is roughly 18.4-54.3%[5] making it a prevalent health issue. Dry eyes cause tear film instability and in turn makes it difficult to perform keratometry due to distortion of mires.[6,7] The use of tear substitutes is a common practice prior to performing keratometry to obtain regular

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mires and hence ease the procedure of performing keratometry. Some studies have found out that tear substitutes contribute to increased variability and low repeatabilty in keratometric measurements, especially in individuals with dry eyes.[8,9]

Hence, this study mainly aimed to assess whether instillation of tear substitutes can cause any change in the keratometry. It also aimed to evaluate the effect of tear substitutes on keratometric measurements at different time intervals in cataract patients with and without dry eyes, to ascertain the time interval after which keratometry should be performed after instillation of tear substitutes. This will help us to minimize the errors in keratometric value measurement and in turn calculate correct IOL power to give the best uncorrected vision post cataract surgery.

2. Aim and Objectives

2.1. Aim

To assess the influence of tear substitutes on keratometric measurements in cataract patients with and without dry eyes.

2.2. Objectives

1. To assess the change in average keratometric values and keratometric values in both meridia before, at 30 seconds and 5 minutes after instillation of tear substitutes in cataract patients with and without dry eyes.
2. To assess the change in IOL power before, at 30 seconds and 5 minutes after instillation of tear substitutes in cataract patients with and without dry eyes.
3. To compare the variability of the keratometric measurements between patients with dry eyes and patient without dry eyes.

3. Materials and Methods

This is a cross sectional, analytical study which was conducted in Department of Ophthalmology of a tertiary care hospital in Maharashtra from June 2022 to May 2024. It adhered to Declaration of Helsinki and was approved by Institutional Ethics Committee (Approval number BVDUMC/IEC/101). Written informed consent was taken from all the participants after providing a thorough explanation of study's nature and purpose. 260 patients were included in this study (130 patients with dry eyes and 130 patients without dry eyes). Data of only 1 eye per person was taken. The sample size was calculated based on previous studies comparing effect of tear substitutes on keratometry, ensuring sufficient statistical power to detect significant differences in keratometry at different time intervals with a confidence level of 95% and a power of 80%.

3.1. Inclusion criteria

Diagnosed case of cataract.

3.2. Exclusion criteria

Patients with ocular surface pathologies like corneal opacities, pterygium, etc., ocular allergies, conjunctival or corneal infections, preceding history of trauma or surgery and diagnosed case of dry eyes on treatment.

3.3. Procedure

All the patients underwent detailed ocular examination which included visual acuity assessment, slit lamp examination and dilated fundus examination. Tear film breakup time (TBUT) test (which is a standard, routinely used and widely accepted test for diagnosis of dry eyes[10]) was performed and the patients were classified into two groups:

1. Dry eyes group (TBUT<10 seconds).
2. Non dry eyes group (TBUT>10 seconds).

On the following day, baseline keratometric values were measured using Topcon Aladdin Optical biometer. An average of 3 readings were taken. 1 drop of 0.3% Hydroxypropyl methylcellulose was then instilled. Keratometry was repeated at 30 seconds and 5 minutes after instillation of tear substitutes. Intraocular lens power was calculated using SRK-T formula, using the keratometry values obtained at baseline, 30 seconds and 5 minutes after instillation of tear substitutes.

3.4. Statistical analysis

All data were recorded on a standardized proforma and entered into Microsoft Excel for analysis. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., New York, USA). Results from descriptive studies with continuous variables were shown. The results for the categorical variables were shown using percentages and frequencies.

The keratometric values as well as IOL power of cataract patients with and without dry eyes was compared using a paired T test to determine if there is a significant mean difference.

Results were considered significant at 5% level throughout the investigation. A 95% confidence interval was used to display all of the results. A significance level of $P < 0.05$ was considered significant.

4. Results

This study included a total of 260 patients, equally divided into two groups: those with non-dry eyes and those with dry eyes. The demographic distribution was similar between the 2 groups (**Table 1**). The age of the participants ranged from a minimum of 35 years to a maximum of 84 years. The mean TBUT for the dry eye group was 6.53 ± 1.64 seconds, as compared to the non-dry eye group, which had a mean TBUT of 13.83 ± 2.70 seconds.

Change in average keratometry, IOL power and keratometry in vertical (K1) and horizontal (K2) meridia was analysed in this study.

In the dry eyes group, the average keratometry was 44.39 ± 1.55D at baseline, 44.19 ± 1.71 at 30 seconds and 44.38 ± 1.55 at 5 minutes. In the non-dry eyes group, average keratometry was 43.82 ± 1.45 at baseline, 43.81 ± 1.48 at 30 seconds and 43.82 ± 1.44 at 5 minutes.

The average keratometry showed significant change at 30 seconds after instillation of tear substitutes in patients with dry eyes ($p<0.001$) but at 5 minutes, it was more or less comparable to baseline and was not statistically significant ($p=0.21$). In patients without dry eyes, the change was not statistically significant at 30 seconds ($p=0.454$) as well as at 5 minutes ($p=0.51$). (**Table 3** and **Table 4**)

The IOL power was 22.72 ± 2.47 at baseline, 22.93 ± 2.64 at 30 seconds and 22.72 ± 2.48 at 5 minutes in patients with dry eyes, where as it was 23.02 ± 2.82 at baseline, 23.04 ± 2.82 at 30 seconds and 23.04 ± 2.83 at 5 minutes in patients without dry eyes.

Significant change in IOL power was seen at 30 seconds after instillation of tear substitutes in patients with dry eyes ($p<0.001$), but it was more or less comparable to baseline at 5 minutes and was not statistically significant ($p=0.82$). In patients without dry eyes, the change in IOL power was not statistically significant at 30 seconds ($p=0.47$) as well as at 5 minutes ($p=0.25$). (**Table 3** and **Table 4**)

We further analysed the change in keratometry in vertical (K1) and horizontal (K2) meridian. The change in K1 was statistically significant 30 seconds after instillation of tear substitutes in dry eyes as well as non-dry eyes group ($p<0.001$ and $p=0.036$ respectively), but at 5 minutes, the change was not statistically significant ($p=0.07$ and $p=0.36$ respectively). The change in K2 was not statistically significant in dry eyes and non-dry eyes group at 30 seconds ($p=0.09$ and $p=0.248$ respectively) as well as at 5 minutes ($p=0.53$ and $p=0.81$ respectively) after instillation of tear substitutes (**Table 5** and **Table 6**).

Greater variability was seen at 30 seconds in patients with dry eyes as compared to patients without dry eyes (**Figure 1**). At 30 seconds, 79.23% of the patients with dry eyes had change in keratometry of more than 0.50D. Only 4.61% of patients in the non-dry eyes group had a change of more than 0.50D. At 5 minutes, both the groups did not have any change of more than or equal to 0.50D.

Table 1: Demographic characteristics of patients with non-dry and dry eyes

		Non-dry eyes	Dry eyes
Age (years (mean ± SD))		66.92 ± 7.20	62.29 ± 9.13
Sex (n (%))	Male	60 (46.15%)	63(48.46%)
	Females	70 (53.85%)	67 (51.54%)
Eye (n (%))	Left eye	62 (47.69%)	61 (46.92%)
TBUT (seconds (mean ± SD))		13.83 ± 2.70	6.53 ± 1.64

Table 2: Comparison between average keratometry measurements at baseline, at 30 seconds and at 5 minutes

	Keratometry in dry eyes group			Keratometry in non-dry eyes group		
	Minimum	**Maximum**	**Mean ± SD**	**Minimum**	**Maximum**	**Mean ± SD**
Baseline	41.33	48.02	44.39 ± 1.55	41.22	47.88	43.82 ± 1.45
30 seconds	40.80	48.42	44.19 ± 1.71	41.06	47.60	43.81 ± 1.48
5 minutes	41.27	47.94	44.38 ± 1.55	41.11	47.88	43.82 ± 1.44

Table 3: Comparison between keratometry measurements and IOL power at baseline and at 30 seconds

Parameters	**Groups**	**Baseline**	**30 seconds**	**Difference**	**p value**
		Mean ± SD	**Mean ± SD**		
Average keratometry (in Dioptres)	Dry	44.39 ± 1.55	44.19 ± 1.71	0.20	<0.001
	Non-dry	43.82 ± 1.45	43.81 ± 1.48	0.01	0.454
IOL Power (in Dioptres)	Dry	22.72 ± 2.47	22.93 ± 2.64	0.21	<0.001
	Non-dry	23.02 ± 2.82	23.04 ± 2.82	0.02	0.47

Table 4: Comparison between keratometry measurements and IOL power at baseline and at 5 minutes

Parameter	Group	Baseline	5 minutes	Difference	p value
		Mean ± SD	Mean ± SD		
Keratometry (in Dioptres)	Dry	44.39 ± 1.55	44.38 ± 1.55	0.01	0.21
	Non-dry	43.82 ± 1.45	43.82 ± 1.44	0.00	0.51
IOL power (in Dioptres)	Dry	22.72 ± 2.47	22.72 ± 2.48	0.00	0.82
	Non-dry	23.02 ± 2.82	23.04 ± 2.83	0.02	0.25

Table 5: Comparison between K1 and K2 at baseline and at 30 seconds

Keratometry (in Dioptres)	Group	Baseline	30 seconds	Difference	p value
		Mean ± SD	Mean ± SD		
K1	Dry	44.32 ± 1.68	44.01 ± 1.99	0.31	<0.001
	Non-dry	43.73 ± 1.55	43.67 ± 1.58	0.06	0.036
K2	Dry	44.45 ± 1.58	44.37 ± 1.67	0.08	0.09
	Non dry	43.90 ± 1.51	43.93 ± 1.57	0.03	0.248

Table 6: Comparison between K1 and K2 at baseline and at 5 minutes

Keratometry (in Dioptres)	Group	Baseline	5 minutes	Difference	p value
		Mean ± SD	Mean ± SD		
K1	Dry	44.32 ± 1.68	44.30 ± 1.66	0.02	0.07
	Non-dry	43.73 ± 1.55	43.72 ± 1.57	0.01	0.36
K2	Dry	44.45 ± 1.58	44.46 ± 1.57	0.01	0.53
	Non dry	43.90 ± 1.51	43.90 ± 1.48	0	0.81

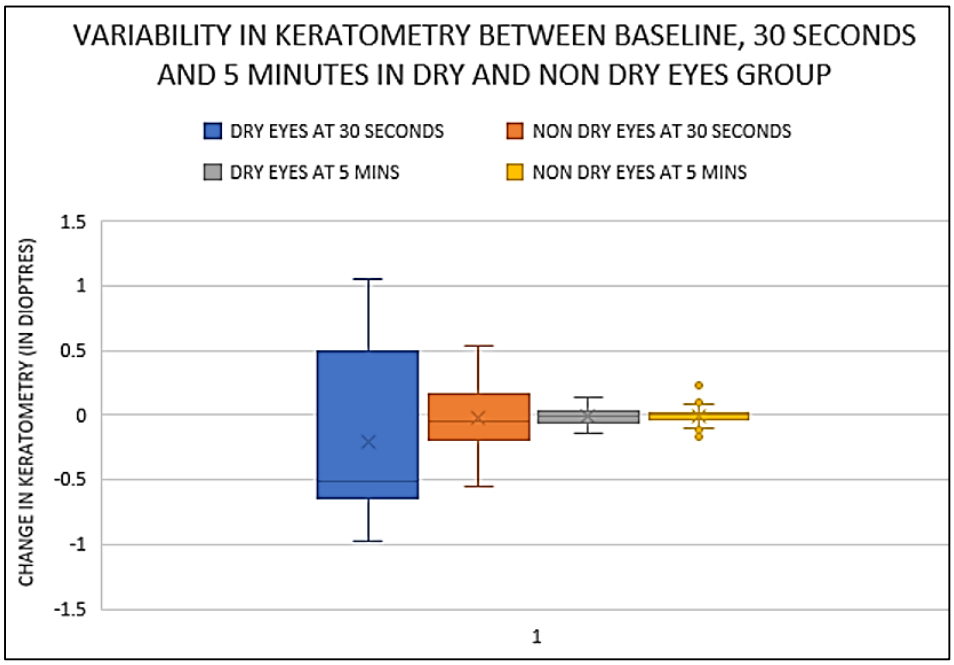

Figure 1: Box and Whisker plot showing variability in keratometry between baseline, 30 seconds and 5 minutes in dry and non-dry eyes group

5. Discussion

Our primary objective was to evaluate how tear substitutes affected keratometry in patients diagnosed with cataract, who had dry eyes and did not have dry eyes. In patients with dry eyes, a significant change in average keratometry was observed 30 seconds after the instillation of tear substitutes ($p < 0.001$). However, the difference was no longer statistically significant ($p=0.21$) 5 minutes after instillation, indicating that the keratometry returned to baseline levels at that point. It was found that in patients without dry eyes, there was no discernible change in keratometry at 30 seconds ($p=0.454$) or at 5 minutes ($p=0.51$) following the instillation of tear substitutes. This indicates that tear substitutes have a limited impact on keratometric measurements in non-dry eye patients due to their inherently stable tear films.

Study conducted by Roggla V and associates had similar findings in dry eyes group and dissimilar findings in the non-dry eyes group.[11] According to the study's findings, patients with and without dry eyes showed a statistically significant change in keratometry 30 seconds after applying high- and low-viscosity tear substitutes; however, the variability was greater in the group with dry eyes than in the group without dry eyes.[11] The keratometry returned to baseline levels approximately five minutes later. On the other hand, Teshigawara T and colleagues[12] found that the tear substitutes had a noticeable impact on stability of tear film in patients with dry eyes, resulting in significant changes in keratometric values. However, non-dry eye patients maintained stable measurements regardless of the type of tear substitute used. This was in accordance to our findings. A study by Montes- Mico and colleagues[13] found that tear substitute instillation significantly altered total, spherelike, and comma-like aberrations in dry-eye patients. However, this change was only statistically significant at 5- and 10-minutes post-instillation, which may be attributed to the fact that high viscosity drops were used in this study.

We further analysed the effect of tear substitutes on keratometry in horizontal and vertical meridian. We observed that there was a significant change in the keratometry measured in the vertical meridian at 30 seconds after instillation of tear substitutes in both the groups. But at 5 minutes, the change was insignificant. In contrast to this, the change in keratometry in horizontal meridian was insignificant in both the groups. This may be because of the tear meniscus causing flattening of cornea in the steeper meridian, i.e. vertical meridian. But as tear film becomes evenly distributed at 5 minutes, keratometry in vertical meridian comes back to normal. Hiraoka T. and colleagues[14] focused at how dry eye disease (DED) affected the reliability of ocular biometric assessments in people with cataracts. Those with dry eyes had much less repeatability in measuring the corneal curvature radius along the steep meridian (vertical meridian) than those with normal eyes. However, in our study, we found that both groups underwent a notable transformation.

Our secondary objective was to assess whether this change in keratometry caused by tear substitutes can affect the IOL power calculation. Patients with dry eyes showed a significant change in IOL power 30 seconds after tear substitute instillation ($p < 0.001$), while patients without dry eyes showed no significant change ($p=0.47$). Statistical analysis revealed no statistically significant change in calculated IOL power at baseline or 5 minutes after tear substitute instillation in either the dry eyes group ($p=0.82$) or the non-dry eyes group ($p=0.25$). Study conducted by Jensen MN and associates (15) conducted a pilot study on 38 participants to assess the variance in keratometric (K) values and intraocular lens (IOL) power calculations after administering tear substitutes in cataract surgery patients. It found out that neither keratometry nor IOL power prediction were found to be affected by tear substitutes. This is accordance to our study which concluded that tear substitutes do not affect keratometry and IOL power in patients without dry eyes.

At 30 seconds, patients with dry eyes exhibited more variability than patients without dry eyes. A keratometric change of more than or equal to 0.50 D was observed in 79.23% of dry-eye patients at 30 seconds. Only 4.61% of patients in the non-dry eyes group had a change of more than or equal to 0.50D. These findings were in accordance to study conducted by Roggla V. and associates[11] which found that there was more variability in keratometry in the group with dry eyes as compared to the group without dry eyes.

6. Limitations

Firstly, in our study, the severity of dry eyes was not considered. We have analysed the cumulative data of patients with mild, moderate and severe dry eyes. Secondly, we have used only one type of tear substitute. Effect of other types of tear substitutes with higher viscosity was not assessed.

7. Conclusion

In patients with dry eyes, after instillation of tear substitute, early keratometry documentation (at 30 seconds) as well as IOL power shows statistically significant change, but in patients without dry eyes, this change was not statistically significant. The change was also not significant when we compared baseline and measurement at 5 minutes in both the groups. Variability of keratometry appeared higher in dry eyes compared with non-dry eyes group.

Hence, instillation of tear substitutes prior to performing keratometry should be done with caution. In cases where it has to be invariably used to stabilize the tear film in order to obtain regular mires, keratometry should be done at least 5 minutes after instillation of tear substitutes.

8. Source of Funding

None.

9. Conflict of Interest

None.

10. Ethical Approval

Ethical No.: BVDUMC/IEC/101.

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