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ORIGINAL ARTICLE

Influence of Tear Film Instability on IOL Power Calculation Accuracy

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ABSTRACT

Background: Accurate intraocular lens (IOL) power calculation is essential for achieving optimal refractive outcomes after cataract surgery. Tear film instability may affect corneal surface regularity and influence the accuracy of biometric measurements used in IOL calculation.

Objective: To evaluate the influence of tear film instability on the accuracy of IOL power calculation among patients undergoing cataract surgery.

Methods: This was a hospital-based analytical cross-sectional study conducted at Swat Medical Complex Teaching Hospital from April 2022 to April 2023, including 190 patients scheduled for cataract surgery.

Results: The mean age of participants was 61.8 ± 9.4 years. Tear film instability was observed in 54.7% of patients. The mean keratometry value was 43.84 ± 1.62 D and the mean calculated IOL power was 21.74 ± 2.56 D. Patients with tear film instability demonstrated greater refractive prediction error (0.58 ± 0.34 D) compared with those with stable tear film (0.32 ± 0.21 D). Good postoperative vision (≥6/12) was achieved in 74.7% of patients.

Conclusion: Tear film instability may reduce the accuracy of IOL power calculation by affecting corneal measurements. Preoperative identification and treatment of ocular surface abnormalities may improve the reliability of biometric measurements and enhance refractive outcomes following cataract surgery.

Keywords: Intraocular lens power calculation; Tear film instability; Cataract surgery; Keratometry; Ocular surface disease.

INTRODUCTION

Proper calculation of intraocular lens (IOL) power is a critical procedure in the present day cataract surgery since it concludes the refractive results of the postoperative outcomes and patient satisfaction in general[1]. Developments in optical biometry, as well as the development in the formula of calculating the IOL, have done much to improve the predictability of refractive outcomes after cataract surgery[2,3]. In spite of these technological advancements, some unexpected refractive errors may still take place and also, several variables, affecting preoperative measurements may be contributing factors to inaccurate estimations of IOL power[4]. A stability of the tear film over the corneal surface is one of the factors that can determine the accuracy of the biometric measurements[5]. The tear film is the initial refractive surface of the eye and is extremely crucial in sustaining optical quality through the supply of a smooth and uniform surface across the cornea[6]. Any imbalance in the stability of the tear film may cause anomalies in the corneal surface which may influence the results of the corneal keratometry that is important in the calculation of IOL power[7]. Tear instability is regarded as a common disease in the ocular surface and is closely related to the dry eye disease, which can be frequently seen in patients under cataract evaluation[8]. Age also contributes to the prevalence of the disease under consideration, and it is therefore especially applicable to cataract patients who are in older age categories[9]. Visual problems on the surface of the eye can lead to varying keratometric values, hence weakening the accuracy of the biometric data used in IOL computation equations[2,10].

It is evidenced by a number of researches that unstable tear film can result in erratic measurements of cornea curvatures, which eventually may cause refractive prediction error following cataract surgery[11,12]. The difference in the values of keratometry can modify the performance of the widely used IOL calculation formulae including modern theoretical and regression-based formulae[13]. Consequently, untreated patients with ocular surface disease can be found to have increased variability in the postoperative refractive outcome[14]. Proper preoperative evaluation of the ocular surface health has consequently attained significance of cataract surgery planning[15]. Tear break-up time (TBUT), Schirmer test, and ocular surface staining are examples of diagnostic tests that are quite common in assessing tear film stability and underlying presence of dry eye diseases[16,17]. Tear film instability can be detected prior to measuring the biometrics, which could assist in making measurements less erratic and enhance IOL power calculations[18,19].

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Objective: To evaluate the influence of tear film instability on the accuracy of IOL power calculation among patients undergoing cataract surgery.

METHODOLOGY

This was a hospital-based analytical cross-sectional study conducted at Swat Medical Complex Teaching Hospital from April 2022 to April 2023, including 190 patients scheduled for cataract surgery.

Inclusion Criteria

- Patients aged ≥40 years diagnosed with age-related cataract and scheduled for phacoemulsification with intraocular lens implantation.
- Patients with measurable keratometry and axial length readings obtained using optical biometry.
- Patients willing to participate and able to attend postoperative follow-up examinations.

Exclusion Criteria

- Patients with previous ocular surgery or corneal pathology affecting keratometry measurements.
- Patients with advanced glaucoma, retinal disease, or other ocular conditions influencing visual outcomes.
- Patients with systemic or ocular conditions that could interfere with tear film evaluation.

Data Collection: After obtaining informed consent, demographic and clinical data were collected using a structured proforma. A comprehensive ophthalmic examination was performed including visual acuity assessment, slit-lamp examination, and fundus evaluation. Tear film stability was assessed using tear break-up time (TBUT) and Schirmer test[16,17]. Based on TBUT findings, patients were categorized into two groups: stable tear film and tear film instability. Preoperative biometric measurements including axial length, keratometry values, and calculated IOL power were obtained using optical biometry[2,3]. Standard phacoemulsification with intraocular lens implantation was performed for all patients. Postoperative refractive outcomes were evaluated during follow-up visits, and refractive prediction error was calculated by comparing predicted and actual postoperative refractive results[11,12].

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Differences between groups with stable and unstable tear films were analyzed using independent t-test or chi-square test where appropriate. Correlation between tear film stability and refractive prediction error was also assessed. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 190 patients undergoing cataract surgery were included with a mean age of 61.8 ± 9.4 years. The largest proportion of patients belonged to the 56–65 year age group (72, 37.9%), followed by those older than 65 years (70, 36.8%) and 40–55 years (48, 25.3%). Male patients accounted for 104 cases (54.7%) while females represented 86 cases (45.3%)[9]. Surgery was almost equally distributed between right eyes (96, 50.5%) and left eyes (94, 49.5%). The mean preoperative visual acuity was 0.82 ± 0.31 LogMAR, indicating moderate visual impairment before surgery[1].

Tear film evaluation showed a mean tear break-up time of 8.6 ± 3.1 seconds. Stable tear film (≥10 seconds) was observed in 86 patients (45.3%), whereas tear film instability (<10 seconds) was present in 104 patients (54.7%)[16,17]. The mean Schirmer test value was 11.4 ± 4.2 mm. Normal tear secretion (≥10 mm) was found in 118 patients (62.1%), while reduced tear production (<10 mm) was seen in 72 patients (37.9%)[16]. These findings indicate that more than half of the patients demonstrated some degree of tear film instability.

Preoperative biometric measurements showed a mean axial length of 23.62 ± 0.94 mm. The mean average keratometry value was 43.84 ± 1.62 diopters, and the mean anterior chamber depth was 3.08 ± 0.39 mm. Based on these measurements, the mean calculated intraocular lens power was 21.74 ± 2.56 diopters[2,3].

Comparison between tear film groups revealed significant differences in several measurements. The mean keratometry value was slightly lower in the stable tear film group (43.62 ± 1.41 D) compared with the unstable tear film group (44.03 ± 1.77 D) (p = 0.041). The calculated IOL power was also lower in the stable group (21.38 ± 2.32 D) compared with the unstable group (22.01 ± 2.69 D) (p = 0.048). Postoperative refraction showed greater residual error in the tear film instability group (-0.51 ± 0.48 D) compared with the stable group (-0.28 ± 0.39 D) (p = 0.002). Similarly, the refractive prediction error was higher in patients with tear film instability (0.58 ± 0.34 D) than in those with stable tear film (0.32 ± 0.21 D) (p < 0.001)[11,12,18].

Postoperative visual outcomes showed significant improvement after surgery. The mean postoperative visual acuity improved to 0.21 ± 0.14 LogMAR. Good visual outcome (≥6/12) was achieved in 142 patients (74.7%), while moderate vision (6/18–6/60) was observed in 36 patients (18.9%) and poor vision (<6/60) in 12 patients (6.3%). Spectacle independence was achieved in 128 patients (67.4%), whereas 62 patients (32.6%) still required spectacles following surgery[1].

Table 1. Demographic and Baseline Characteristics of Patients Undergoing Cataract Surgery (N = 190)

Variable	Category	n (%) / Mean ± SD
Age (years)	Mean age	61.8 ± 9.4
Age Group	40–55 years	48 (25.3%)
	56–65 years	72 (37.9%)
	>65 years	70 (36.8%)
Gender	Male	104 (54.7%)
	Female	86 (45.3%)
Laterality of Eye	Right eye	96 (50.5%)
	Left eye	94 (49.5%)
Preoperative Visual Acuity (LogMAR)	Mean value	0.82 ± 0.31

Table 2. Tear Film Assessment Among Study Participants

Variable	Category	n (%) / Mean ± SD
Tear Break-Up Time (seconds)	Mean TBUT	8.6 ± 3.1
TBUT Category	≥10 seconds (Stable tear film)	86 (45.3%)
	<10 seconds (Tear film instability)	104 (54.7%)
Schirmer Test (mm/5 min)	Mean value	11.4 ± 4.2
Schirmer Category	≥10 mm (Normal tear production)	118 (62.1%)
	<10 mm (Reduced tear secretion)	72 (37.9%)

Table 3. Preoperative Biometric Measurements Used for IOL Power Calculation

Variable	Category	Mean ± SD
Axial Length (mm)	Mean value	23.62 ± 0.94
Average Keratometry (D)	Mean K value	43.84 ± 1.62
Anterior Chamber Depth (mm)	Mean value	3.08 ± 0.39
Calculated IOL Power (D)	Mean value	21.74 ± 2.56

Table 4. Comparison of IOL Power Calculation Accuracy Between Stable and Unstable Tear Film Groups

Variable	Stable Tear Film (n=86) Mean ± SD	Tear Film Instability (n=104) Mean ± SD	p-value
Average Keratometry (D)	43.62 ± 1.41	44.03 ± 1.77	0.041
Calculated IOL Power (D)	21.38 ± 2.32	22.01 ± 2.69	0.048
Postoperative Refraction (D)	-0.28 ± 0.39	-0.51 ± 0.48	0.002
Refractive Prediction Error (D)	0.32 ± 0.21	0.58 ± 0.34	<0.001

Table 5. Postoperative Visual Outcomes After Cataract Surgery

Variable	Category	n (%) / Mean ± SD
Postoperative Visual Acuity (LogMAR)	Mean value	0.21 ± 0.14
Visual Outcome	Good vision (≥6/12)	142 (74.7%)
	Moderate vision (6/18–6/60)	36 (18.9%)
	Poor vision (<6/60)	12 (6.3%)
Spectacle Independence	Achieved	128 (67.4%)
	Not achieved	62 (32.6%)

DISCUSSION

The aim of the study was to determine how the tear film instability affects the accuracy of intraocular lens (IOL) power calculation in patients who have cataract surgery. The age of the participants was 61.8 ± 9.4 with the largest proportion of patients being within the 56–65 age range (37.9%), and over half of them being males (54.7%)[9]. Tear film evaluation showed that the average tear break-up time was 8.6 ± 3.1 seconds, and 54.7% of the patients exhibited tear film instability[16,17]. Moreover, the decreased secretion of tears on the basis of Schirmer testing was noted in 37.9% of cases [16]. These results indicate that ocular surface abnormalities are prevalent among patients who were under cataract examination[17,19].

Axial length averaged 23.62 mm with a standard deviation value of 0.94 mm and the mean keratometry was 43.84 mm/SD 1.62 diopters with a resulting mean IOL power of 21.74 mm/SD 2.56 diopters[2,3]. These readings are in the normal physiologic range of cataract surgery patients. Similar biometric values have been recorded in other studies[2,3].

The comparison of the patients with stable and unstable tear films proved the possibility of the tear film instability to affect the accuracy of biometric measurements and refractive results. The average value of the keratometry was somewhat more in the tear film instability group (44.03 ± 1.77 D) than in the stable tear film group (43.62 ± 1.41 D). Furthermore, the refractive prediction error was greater in the patients who had a tear film instability (0.58 ± 0.34 D) than in the patients whose tear film was stable (0.32 ± 0.21 D)[11,12,18]. The implications of these findings are that tear film abnormalities can lead to some variation in the corneal curvature measurements, and therefore, variation in the IOL power calculations[19].

The visual outcomes of the current study were not bad in general, and good vision (at least 6/12) was obtained in 74.7% of patients and the average postoperative visual acuity was equal 0.21 ± 0.14 LogMAR. Independent spectacle was obtained in 67.4%[1]. These results demonstrate that cataract surgery is still very effective in vision restoration but a tear film instability can still be the cause of refractive quality in certain patients[18,19].

All in all, this research study indicates that the health of the ocular surface is significant prior to biometric measurement to be performed on cataract surgery. Early diagnosis and treatment of

tear film instability before surgery can give better consistency of keratometric values as well as accuracy in calculating IOL power, resulting in a better refractive value and patient satisfaction[16-19].

CONCLUSION

It is concluded that tear film instability can significantly influence the accuracy of intraocular lens power calculation in patients undergoing cataract surgery. A considerable proportion of patients demonstrated reduced tear film stability and tear secretion, which was associated with greater variability in keratometry measurements and higher refractive prediction error. Although postoperative visual outcomes were generally favorable, patients with unstable tear film showed less accurate refractive results[16-19].

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