

Research Article

Comparison of Tear Film Parameters Before and After Corneal Refractive Surgery: A Prospective Longitudinal Study

Asma Aftab¹, Adeel Chaudhry², Muhammad Arif³, M. Saeed Zafar Khan⁴, Saadullah Ahmad⁵, Yaseen Lodhi⁶

1. Assistant Professor, Ophthalmology, Wah Medical College, Wah Cantt, affiliated with National University of Medical Sciences (NUMS), Pakistan.
2. Senior Registrar, Lahore General Hospital, Lahore, Pakistan.
3. Associate Professor, Department of Ophthalmology, Abwa Medical College, Faisalabad, Pakistan.
4. Assistant Professor, FMH College of Medicine & Dentistry, Lahore, Pakistan.
5. Associate Professor, Orbit and Oculoplastics, Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan.
6. Associate Professor, Ophthalmology, Wah Medical College, Wah Cantt, Pakistan.

Asma Aftab: Corresponding author

Abstract

Corneal refractive surgery is widely performed for the correction of myopia, hyperopia, and astigmatism, offering excellent visual outcomes and patient satisfaction. However, postoperative alterations in tear film stability and ocular surface integrity remain among the most common complications, often resulting in dry eye symptoms and reduced visual quality. This prospective longitudinal study evaluated changes in tear film parameters before and after corneal refractive surgery and examined their association with postoperative ocular surface symptoms.

A total of 180 patients undergoing corneal refractive surgery were enrolled and followed

for six months. Tear film assessment included Schirmer I test, tear break-up time (TBUT), tear meniscus height (TMH), ocular surface disease index (OSDI), and corneal fluorescein staining. Measurements were obtained preoperatively and at 1 week, 1 month, 3 months, and 6 months postoperatively. Statistical analysis was performed using repeated-measures ANOVA and paired t-tests.

Preoperative mean TBUT was 11.8 ± 2.4 seconds, decreasing significantly to 6.7 ± 1.9 seconds at 1 month postoperatively ($p < 0.001$), before partially recovering to 9.8 ± 2.1 seconds at 6 months. Schirmer I test values declined from 18.6 ± 4.2 mm preoperatively to 12.1 ± 3.7 mm at 1 month

($p < 0.001$). OSDI scores increased significantly during the early postoperative period and remained elevated at 6 months compared with baseline ($p < 0.001$). Corneal staining scores were significantly higher after surgery.

Corneal refractive surgery induces significant but partially reversible alterations in tear film function and ocular surface health. Early identification and management of postoperative tear film dysfunction are essential to optimize patient comfort and visual outcomes.

Keywords: Corneal refractive surgery, tear film, dry eye disease, tear break-up time, Schirmer test

Introduction

Corneal refractive surgery has become one of the most commonly performed ophthalmic procedures worldwide for the correction of refractive errors, including myopia, hyperopia, and astigmatism. Advances in laser technology, surgical precision, and patient selection have significantly improved visual outcomes and safety profiles. Procedures such as laser-assisted in situ keratomileusis (LASIK), photorefractive keratectomy (PRK), and small-incision lenticule extraction (SMILE) have transformed refractive correction by reducing

dependence on spectacles and contact lenses [1–3].

Despite excellent refractive outcomes, postoperative dry eye symptoms remain among the most frequently reported complications following corneal refractive surgery. Dry eye disease may adversely affect visual quality, patient satisfaction, and postoperative recovery. The prevalence of postoperative dry eye has been reported to range from 20% to 70%, depending on the surgical technique, patient characteristics, and assessment methods employed [2–4].

The tear film is a complex trilaminar structure composed of lipid, aqueous, and mucin components that maintain ocular surface integrity, optical quality, and protection against environmental insults. Disruption of tear film homeostasis may result in ocular discomfort, fluctuating vision, inflammation, and epithelial damage. Corneal refractive surgery has the potential to alter multiple components of tear film physiology [3–5].

One of the primary mechanisms contributing to postoperative dry eye involves transection of corneal sensory nerves during flap creation or stromal ablation. Corneal denervation reduces reflex tear secretion and blink frequency, leading to tear film instability and increased evaporation. Additionally, surgical

trauma may induce inflammatory responses that further compromise ocular surface health [4–6].

Tear film assessment is commonly performed using objective and subjective measures. Schirmer testing evaluates aqueous tear production, tear break-up time assesses tear film stability, and tear meniscus height reflects tear volume. Corneal fluorescein staining provides information regarding epithelial integrity, while the Ocular Surface Disease Index (OSDI) quantifies patient-reported symptoms and functional impairment [5–7].

Several studies have reported significant reductions in tear production and tear stability following refractive procedures. However, the extent and duration of these changes vary considerably among studies due to differences in surgical techniques, follow-up periods, and patient populations. Some investigations suggest gradual recovery within months, whereas others report persistent tear film dysfunction beyond one year [6–8].

Understanding the temporal changes in tear film parameters following refractive surgery is clinically important for preoperative counseling, risk stratification, and postoperative management. Early recognition of ocular surface compromise

allows timely intervention with lubricants, anti-inflammatory therapies, and other supportive measures aimed at improving patient outcomes [7–9].

Given the increasing number of refractive procedures performed worldwide and the persistent concern regarding postoperative dry eye, further prospective evaluation of tear film dynamics remains warranted. The present study was therefore designed to compare tear film parameters before and after corneal refractive surgery and assess the progression of ocular surface changes during postoperative follow-up [8–10].

Methodology

This prospective longitudinal study was conducted at Wah Medical College, Wah Cantt, affiliated with National University of Medical Sciences (NUMS) over a period of 18 months. Patients scheduled for elective corneal refractive surgery for correction of myopia, hyperopia, or astigmatism were consecutively recruited.

Eligibility criteria included age between 18 and 40 years, stable refractive error for at least one year, best-corrected visual acuity of 20/25 or better, and suitability for refractive surgery based on comprehensive ophthalmic evaluation. Exclusion criteria included pre-existing dry eye disease, autoimmune disorders, ocular surface disease, previous

ocular surgery, contact lens use within two weeks before evaluation, pregnancy, and systemic medications known to affect tear production.

Sample size was calculated using Epi Info version 7. Assuming a mean reduction of 20% in tear break-up time after surgery, 95% confidence level, 80% power, and 10% potential loss to follow-up, a minimum sample size of 164 participants was required. To strengthen statistical power, 180 patients were enrolled.

All patients underwent standardized corneal refractive surgery performed by experienced refractive surgeons. Procedures included LASIK and SMILE according to clinical indications. Postoperative treatment consisted of topical antibiotics, corticosteroids, and preservative-free lubricants according to institutional protocols.

Comprehensive tear film assessment was performed preoperatively and at 1 week, 1 month, 3 months, and 6 months

postoperatively. Parameters included Schirmer I test without anesthesia, tear break-up time (TBUT), tear meniscus height measured by slit-lamp biomicroscopy, corneal fluorescein staining graded using the Oxford scale, and Ocular Surface Disease Index (OSDI) questionnaire scores.

All examinations were conducted by trained ophthalmologists masked to previous results. Measurements were obtained under standardized environmental conditions to minimize variability.

Data analysis was performed using SPSS version 27. Continuous variables were expressed as mean $\pm$ standard deviation. Repeated-measures ANOVA was used to compare tear film parameters across follow-up intervals. Bonferroni correction was applied for multiple comparisons. Statistical significance was defined as $p < 0.05$.

Ethical approval was obtained from the Institutional Review Board, and written informed consent was obtained from all participants before enrollment.

Results

Table 1. Baseline Demographic and Clinical Characteristics (n = 180)

Variable	Value
Age (years)	27.8 $\pm$ 5.6
Male, n (%)	94 (52.2)

Variable	Value
Female, n (%)	86 (47.8)
Mean spherical equivalent (D)	-4.85 ± 2.10
LASIK procedures, n (%)	112 (62.2)
SMILE procedures, n (%)	68 (37.8)
Preoperative BCVA (logMAR)	0.02 ± 0.04

The study population consisted predominantly of young adults undergoing myopic refractive correction, with no significant preoperative ocular surface abnormalities.

Table 2. Comparison of Tear Film Parameters Before and After Surgery

Parameter	Preoperative	1 Week	1 Month	3 Months	6 Months	p-value
TBUT (seconds)	11.8 ± 2.4	7.5 ± 2.1	6.7 ± 1.9	8.4 ± 2.0	9.8 ± 2.1	<0.001
Schirmer I (mm)	18.6 ± 4.2	13.4 ± 3.9	12.1 ± 3.7	14.8 ± 3.8	16.3 ± 3.9	<0.001
Tear Meniscus Height (mm)	0.31 ± 0.06	0.24 ± 0.05	0.22 ± 0.04	0.27 ± 0.05	0.29 ± 0.05	<0.001

Significant deterioration in all objective tear film parameters was observed during the early postoperative period, followed by gradual recovery.

Table 3. Ocular Surface Disease Index and Corneal Staining Scores

Parameter	Preoperative	1 Week	1 Month	3 Months	6 Months	p-value
OSDI Score	10.4 ± 4.8	28.5 ± 8.7	31.2 ± 9.1	21.8 ± 7.5	15.9 ± 6.2	<0.001
Corneal Staining Score	0.4 ± 0.3	1.8 ± 0.6	2.1 ± 0.7	1.3 ± 0.5	0.8 ± 0.4	<0.001

Subjective symptoms and epithelial staining increased significantly following surgery, with partial improvement by six months.

Table 4. Prevalence of Postoperative Dry Eye Symptoms

Time Point	Dry Eye Symptoms (%)
Preoperative	8.3
1 Week	61.1
1 Month	68.9
3 Months	42.8
6 Months	21.7

Postoperative dry eye symptoms peaked at one month and gradually decreased over time, although prevalence remained higher than baseline at six months.

Discussion

The present prospective study demonstrated significant alterations in tear film function and ocular surface health following corneal refractive surgery. Objective measurements including tear break-up time, Schirmer test values, and tear meniscus height showed substantial reductions during the early postoperative period, confirming that refractive procedures significantly affect tear film homeostasis [11–12].

The observed decline in tear break-up time represents impaired tear film stability, which is considered one of the earliest indicators of postoperative dry eye. Corneal nerve injury resulting from stromal ablation and flap creation likely contributes to reduced blink reflexes and altered lacrimal gland stimulation, thereby destabilizing the tear film [12–13].

Similarly, significant reductions in Schirmer test values indicate decreased aqueous tear production following surgery. Corneal sensory denervation disrupts the neural feedback loop responsible for reflex tearing, resulting in transient aqueous deficiency. The gradual recovery observed over six months likely reflects progressive corneal nerve regeneration and restoration of lacrimal gland function [13–14].

The marked increase in OSDI scores highlights the clinical significance of these physiological changes. Patients experienced substantial ocular discomfort, visual fluctuation, and functional impairment during the early postoperative period. Although symptom severity decreased over time, OSDI scores remained elevated at six months compared with baseline, suggesting incomplete recovery in some individuals [14–15].

Corneal fluorescein staining findings further support the presence of postoperative ocular surface compromise. Increased epithelial staining reflects disruption of epithelial barrier integrity and surface inflammation. Similar findings have been reported in recent studies evaluating corneal healing and ocular surface changes following refractive procedures [15–16].

The prevalence of dry eye symptoms exceeded 60% during the first postoperative month, consistent with previous reports identifying dry eye disease as the most common complication of refractive surgery. The gradual decline in symptom prevalence during follow-up suggests that most cases are transient; however, a subset of patients may develop persistent ocular surface dysfunction [16–17].

These findings underscore the importance of comprehensive preoperative evaluation and risk stratification. Identification of patients with borderline tear film function may facilitate individualized treatment planning and implementation of preventive measures aimed at reducing postoperative morbidity [17–18].

Several limitations should be acknowledged. The study combined different refractive techniques and did not perform subgroup analysis according to surgical modality.

Furthermore, advanced imaging of corneal nerve regeneration was not undertaken. Future studies incorporating in vivo confocal microscopy and longer follow-up periods may provide further insight into postoperative tear film recovery mechanisms [18–20].

Overall, the present findings confirm that corneal refractive surgery induces significant but largely reversible tear film dysfunction. Early diagnosis and proactive management remain essential to ensure optimal patient comfort and visual satisfaction.

Conclusion

Corneal refractive surgery results in significant deterioration of tear film stability, tear production, and ocular surface integrity during the early postoperative period. Although gradual recovery occurs over six months, tear film parameters often remain below baseline levels. Careful preoperative assessment and postoperative ocular surface management are essential for optimizing visual outcomes and patient satisfaction.

References

1. Solomon KD, Fernández de Castro LE, Sandoval HP. Refractive surgery outcomes and patient satisfaction. *Ophthalmology*. 2022;129(4):385–394.

2. Stapleton F, Alves M, Bunya VY, et al. Dry eye disease and ocular surface disorders. *Ocul Surf.* 2021;20:1–18.
3. Baudouin C, Irkeç M, Messmer EM. Tear film physiology and ocular surface health. *Prog Retin Eye Res.* 2022;87:100998.
4. Toda I. Dry eye after refractive surgery. *Curr Opin Ophthalmol.* 2021;32(4):303–309.
5. Craig JP, Nichols KK, Akpek EK, et al. TFOS DEWS II update on dry eye disease. *Ocul Surf.* 2023;28:1–22.
6. Moshirfar M, McCaughey MV, Santiago-Caban L. Post-LASIK dry eye syndrome. *Clin Ophthalmol.* 2022;16:221–231.
7. Pérez-Santonja JJ, Sakla HF, Cardona C. Tear film assessment after corneal refractive surgery. *Cornea.* 2023;42(5):620–628.
8. Denoyer A, Landman E, Trinh L. Ocular surface changes after refractive procedures. *J Refract Surg.* 2022;38(8):503–511.
9. Kim JH, Lim T, Kim EK. Longitudinal assessment of tear film recovery. *Am J Ophthalmol.* 2023;249:45–54.
10. Shtein RM. Postoperative dry eye management. *Ophthalmol Clin North Am.* 2024;37(1):65–78.
11. Xu Y, Yang Y, Zhao K. Tear film alterations after LASIK and SMILE. *Cornea.* 2022;41(11):1390–1398.
12. Li M, Zhou X. Corneal nerve injury and tear dysfunction. *Invest Ophthalmol Vis Sci.* 2023;64(8):21–29.
13. Zhang C, Wang Y. Schirmer test changes following refractive surgery. *Eye Contact Lens.* 2022;48(4):180–187.
14. Chao C, Richdale K. Ocular surface symptoms after laser vision correction. *Clin Exp Optom.* 2023;106(2):145–153.
15. Galor A, Levitt RC. Ocular surface inflammation and dry eye. *Prog Retin Eye Res.* 2022;88:101018.
16. Shen Y, Jian W, Sun L. Corneal epithelial healing after refractive surgery. *Eye.* 2023;37(6):1132–1140.
17. Trattler W, Majmudar PA. Dry eye risk assessment in refractive surgery candidates. *J Cataract Refract Surg.* 2022;48(9):1050–1058.
18. Kymionis GD, Tsiklis NS. Long-term tear film recovery after LASIK. *Clin Ophthalmol.* 2023;17:1105–1114.
19. Reinstein DZ, Archer TJ. Advances in corneal nerve regeneration research. *J Refract Surg.* 2024;40(2):89–97.
20. Nichols KK, Foulks GN. Contemporary management of postoperative dry eye disease. *Ocul Surf.* 2024;31:120–132.