ORIGINAL ARTICLE

Evaluation of dry eye pre and post phacoemulsification in diabetic patients

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ABSTRACT

Introduction: Dry eye is a common condition influenced by various factors, including cataract surgery and systemic diseases like diabetes. Phacoemulsification, a widely used cataract procedure, often leads to increased postoperative dry eye symptoms due to inflammation and changes in tear film stability. Diabetic patients, already prone to dry eye, may experience further worsening after surgery. This study evaluates dry eye status in diabetic patients before and after phacoemulsification.

Materials and Methods: This study included 126 patients, divided into diabetic and non-diabetic groups from Hospital Melaka and Hospital Pakar Universiti Sains Malaysia between September 2022 and July 2024. Patient demographics and dry eye parameters, including the Ocular Surface Disease Index (OSDI), Tear Break-Up Time (TBUT), and Schirmer's test, were evaluated at baseline, one week, and three months after surgery. Only patients who underwent uncomplicated phacoemulsification were included, while those undergoing extracapsular cataract extraction, intracapsular cataract extraction, or lens aspiration were excluded. The mean values of OSDI, TBUT, and Schirmer's test across the three time points were compared among groups with diabetic retinopathy, without diabetic retinopathy and non-diabetic patients using repeated measures ANOVA.

Results: 126 patients were studied: 44 non-diabetic, 40 diabetic without retinopathy (no DR), and 42 diabetics with retinopathy (DR). The mean ± SD (standard deviation) age was 64.06 ± 5.30 years, with males comprising 54.0% of the cohort. Hypertension was the highest proportion of comorbidity (75.4%), particularly in the DR group (90.5%). Dry eye parameters showed significant temporary changes post-cataract surgery. OSDI scores improved significantly from baseline to three months in all groups, with diabetic groups showing higher scores at three months than non-diabetics ($p < 0.05$). TBUT declined significantly at one week in the diabetic groups (DR, $p = 0.028$; no DR, $p = 0.019$) but showed substantial recovery by three months, with significant improvements across all groups. In all groups, Schirmer's test values improved significantly between one week and three months ($p < 0.05$), although baseline and one-week differences were not statistically significant.

Conclusion: Three months after cataract surgery, significant improvements in OSDI scores, TBUT, and Schirmer's test values were observed, indicating a recovery in dry eye status. Diabetic patients experienced more pronounced early postoperative changes but demonstrated comparable recovery trends to non-diabetics by three months. These findings highlight the importance of monitoring dry eye parameters in diabetics, particularly during the early postoperative period, to optimise outcomes and patient satisfaction.

KEYWORDS:
Dry eye, phacoemulsification, diabetic, non-diabetic, retinopathy

INTRODUCTION

Dry eye disease is a multifactorial condition that can significantly affect ocular comfort and vision. Various factors, including systemic diseases like diabetes and surgical interventions such as cataract surgery, can exacerbate dry eye symptoms.[1,2] Phacoemulsification, a common and minimally invasive procedure for cataract extraction, is associated with an increased incidence of postoperative dry eye symptoms due to factors such as reduced tear production, changes in corneal innervation, and inflammation.[2,3]

Diabetic patients predisposed to dry eye due to neuropathy, inflammation, and metabolic dysregulation may experience a heightened risk of developing or worsening dry eye following cataract surgery.[3,4] Given the prevalence of diabetes and the growing number of cataract surgeries performed globally, understanding the impact of phacoemulsification on dry eye symptoms in diabetic patients is critical for optimising postoperative care.

This study aims to evaluate the changes in dry eye status in diabetic patients undergoing phacoemulsification by assessing pre- and postoperative dry eye parameters, including the Ocular Surface Disease Index (OSDI) questionnaire, tear break-up time (TBUT) and Schirmer's test.

MATERIALS AND METHODS

Study design and study population

This prospective cohort study was conducted between September 2022 and July 2024 at the Ophthalmology Clinics

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of Hospital Melaka and Hospital Pakar Universiti Sains Malaysia. Ethical approval was obtained from the Medical Research and Ethics Committee of the Ministry of Health Malaysia (NMRR ID-22-01285-XDE (IIR)) and the Human Research Ethics Committee of Universiti Sains Malaysia (USM/JEPeM/22060353). The study included 82 diabetic patients, aged 40 to 75 years, who underwent cataract surgery via phacoemulsification, along with 44 non-diabetic patients as controls.

Participants were screened based on specific inclusion and exclusion criteria. Those with underlying ocular conditions known to contribute to dry eye, such as blepharitis, ectropion, entropion, pre-existing dry eye diagnosis, glaucoma, or a history of ocular trauma, were excluded. Similarly, patients undergoing non-phacoemulsification cataract surgeries, including extracapsular cataract extraction, intracapsular cataract extraction, or lens aspiration, were not eligible.

Participants with complicated cataract surgeries or those lost to follow-up at the one-week or three-month postoperative assessments were also excluded from the analysis. All enrolled participants underwent standardised dry eye assessments as part of the study protocol.

Demographic data, systemic and ocular history

Demographic data for participants, including age, gender, race, education level, duration of diabetes, and any underlying diseases, were collected. Detailed histories were also obtained through participant interviews, noting the use of any topical eye drops or medications such as antihistamines, antidepressants, or decongestants.

Ocular examination

Participants who provided informed consent underwent thorough examinations at the ophthalmology clinic. Comprehensive ocular assessments, including visual acuity measurement, anterior segment evaluation, and dilated fundus examination, were conducted using a slit lamp biomicroscope (Topcon Corp, Japan) and condensing lenses. Patients with ocular pathologies meeting the exclusion criteria were excluded.

Dry eye parameters were evaluated subjectively and objectively using the Ocular Surface Disease Index (OSDI), Tear Break-Up Time (TBUT), and Schirmer I test without anaesthesia. The OSDI identified patients with dry eye symptoms based on their responses to a 12-item questionnaire.

TBUT was assessed to evaluate tear film stability. A fluorescein-impregnated strip moistened with non-preserved saline was applied, and the fluorescein dye was distributed by blinking. Patients were instructed to look straight ahead without blinking, and the time between the last blink and the appearance of the first dry spot or break in the tear film was measured under cobalt blue light using a slit lamp. A TBUT of more or equal to 10 seconds was considered normal, while less than 10 seconds indicated dry eye. The test was repeated three times, and the mean value was recorded.

The Schirmer I test assessed both basic and reflex tearing. After drying the inferior fornix, a sterile paper strip was placed at the lateral third of the lower eyelid. The length of the moistened portion of the strip was measured after five minutes. A wetting length less than or equal to 10 millimetres (mm) indicates a dry eye. The Schirmer I test was performed once for each participant.

A 10-minute interval was maintained between the Schirmer I test and the TBUT assessment. All tests were performed at baseline (preoperatively), as well as at one week and three months postoperatively.

Statistical Analysis

The data were cleaned and analysed using SPSS version 29.0. The distribution of continuous variables was checked through histograms. Continuous variables found to be normally distributed are presented as mean (standard deviation, SD), while categorical variables are shown as frequency and percentage.

The mean OSDI, TBUT, and Schirmer's test values at baseline, one week, and three months post-cataract surgery were compared among the diabetic retinopathy, no diabetic retinopathy, and non-diabetic groups using repeated measures ANOVA (RM ANOVA). Mauchly's test of sphericity was conducted to assess the assumption of sphericity. When the assumption was violated, Greenhouse-Geisser correction was applied for Mauchly's $W < 0.75$, while Huynh-Feldt correction was used for Mauchly's $W > 0.75$. Estimated marginal means were calculated to evaluate the main effects of group and time, with Bonferroni correction applied for multiple comparisons. Additionally, repeated measures Analysis of Covariance (ANCOVA) was performed, adjusting for HbA1c levels and the duration of diabetes. All statistical tests were two-sided, with p-values < 0.05 considered significant.

RESULTS

Demographic characteristics

A total of 126 patients were included in the study, comprising 44 non-diabetic, 40 diabetics without retinopathy (no DR), and 42 diabetics with retinopathy (DR). The overall mean ± SD (standard deviation) age of the cohort was 64.06 ± 5.30 years. The DR group had the youngest mean age at 63.29 ± 4.90 years, while the no DR group had the oldest mean age at 65.68 ± 4.10 years. Males comprised 54.0% of the entire cohort, and females were the majority in the no DR group (52.5%). Nearly all female participants were postmenopausal (94.8%). The majority of patients were Malay (72.2%), with the highest proportion observed in the DR group (78.6%) (Table I).

Most had completed secondary education (66.7%), while only a small percentage had tertiary education, ranging from 7.10% in the DR group to 11.4% in the non-diabetic group. Hypertension was the most prevalent comorbidity (75.4%), highest in the DR group (90.5%), followed by hyperlipidaemia (35.7%). Only 7.1% reported no comorbid conditions. Right-eye involvement was more common overall (53.2%), particularly in the DR group (61.9%), while left-eye involvement predominated in the non-diabetic group (59.1%) (Table I).

Table I: Demographic characteristics of the patients

Characteristics	Overall (n= 126)	Non-diabetic (n= 44)	No DR (n= 40)	DR (n= 42)
Age in years, mean ± SD	64.06 ± 5.30	63.34 ± 6.33	65.68 ± 4.10	63.29 ± 4.90
Gender, n (%)				
Female	58 (46.0)	18 (40.9)	21 (52.5)	19 (45.2)
Male	68 (54.0)	26 (59.1)	19 (47.5)	23 (54.8)
If female, menopause, n (%)				
No	3 (5.2)	2 (11.1)	0 (0.0)	1 (5.3)
Yes	55 (94.8)	16 (88.9)	21 (100.0)	18 (94.7)
Race, n (%)				
Malay	91 (72.2)	29 (65.9)	29 (72.5)	33 (78.6)
Chinese	24 (19.0)	14 (31.8)	6 (15.0)	4 (9.5)
Indian	11 (8.7)	1 (2.3)	5 (12.5)	5 (11.9)
Educational level, n (%)				
Primary	31 (24.6)	11 (25.0)	11 (27.5)	9 (21.4)
Secondary	84 (66.7)	28 (63.6)	26 (65.0)	30 (71.4)
Tertiary	11 (8.7)	5 (11.4)	3 (7.5)	3 (7.1)
Comorbidities, n (%)				
No illness	9 (7.1)	9 (20.5)	0 (0.0)	0 (0.0)
Hypertension	95 (75.4)	26 (59.1)	31 (77.5)	38 (90.5)
Hyperlipidaemia	45 (35.7)	12 (27.3)	17 (42.5)	16 (38.1)
CKD/ESRF	10 (7.9)	1 (2.3)	1 (2.5)	8 (19.0)
IHD/AF	19 (15.1)	5 (11.4)	6 (15.0)	8 (19.0)
Stroke	3 (2.4)	2 (4.5)	0 (0.0)	1 (2.4)
Thyroid disorder	2 (1.6)	0 (0.0)	1 (2.5)	1 (2.4)
Bronchial asthma	7 (5.6)	5 (11.4)	2 (5.0)	0 (0.0)
Others	8 (6.3)	7 (15.9)	0 (0.0)	1 (2.4)
Laterality, n (%)				
Right eye	67 (53.2)	18 (40.9)	23 (57.5)	26 (61.9)
Left eye	59 (46.8)	26 (59.1)	17 (42.5)	16 (38.1)

Abbreviations: DR: diabetic retinopathy, SD: Standard deviation, CKD: chronic kidney disease, ESRF: end-stage renal failure, IHD: ischaemic heart disease, AF: atrial fibrillation

Table II: Characteristics of the diabetic patients

Characteristics	Overall (Mean ± SD)	No DR (Mean ± SD)	DR (Mean ± SD)	p-value
Duration of DM in years	10.76 ± 7.47	7.38 ± 5.39	13.98 ± 7.81	<0.001*
HbA1c	6.50 ± 0.48	6.20 ± 0.33	6.79 ± 0.41	<0.001*

*Independent sample t-test
Abbreviations: DR: diabetic retinopathy, SD: Standard deviation, DM: diabetes mellitus, HbA1c: Haemoglobin A1c

Characteristics of the diabetic patients
Table II outlines the characteristics of the diabetic patients, all of whom were classified with Type 2 diabetes mellitus (DM). The mean duration of diabetes was significantly longer in the DR group (13.98 ± 7.81 years) compared to the no DR group (7.38 ± 5.39 years, $p < 0.001$). Similarly, the mean HbA1c level was significantly higher in the DR group (6.79 ± 0.41) than in the no DR group (6.20 ± 0.33, $p < 0.001$).

Dry eye parameters
Table III summarizes the changes in dry eye parameters (OSDI, TBUT, and Schirmer's test) before and after cataract surgery among the diabetic retinopathy (DR), no diabetic retinopathy (no DR), and non-diabetic groups, analysed using repeated measures ANOVA (RM ANOVA).

Lower OSDI scores indicate an improvement in dry eye symptoms. Among all groups, the DR group consistently had the highest OSDI scores; however, these scores reflected only mild dry eye symptoms compared to the other groups. From baseline to one-week post-surgery, OSDI scores showed slight reductions across all groups, but these changes were not statistically significant. By three months post-surgery, however, all groups exhibited significant improvements in OSDI scores compared to baseline, as indicated by reduced scores: DR group (mean decrease of 6.41, $p = 0.015$), no DR group (mean decrease of 6.74, $p < 0.001$), and non-diabetic group (mean decrease of 6.68, $p = 0.001$). Between one week and three months post-surgery, OSDI scores continued to decline significantly across all groups ($p < 0.001$). These findings suggest a gradual but significant improvement in dry eye symptoms following cataract surgery.

From baseline to one-week post-surgery, TBUT significantly decreased in the DR group ($p = 0.028$) and no DR group ($p = 0.019$), while no significant change was observed in the non-diabetic group ($p > 0.950$). By three months post-surgery, TBUT values significantly improved compared to baseline in

Table III: Dry eye parameters before and after cataract surgery in the operated eyes of diabetic and non-diabetic patients (within factors)

Comparison	DR			No DR			Non-diabetic		
	Mean ± SD	MD (95% CI)	p value	Mean ± SD	MD (95% CI)	p value	Mean ± SD	MD (95% CI)	p-value
OSDI									
Baseline vs	13.15 ± 16.57	0.26 (-3.25, 3.76)	>0.950	12.16 ± 11.63	0.73 (-2.10, 3.57)	>0.950	9.89 ± 11.59	2.23 (-1.11, 5.56)	0.309
1 week	12.90 ± 12.13			11.43 ± 9.95			7.67 ± 8.19		
Baseline vs	13.15 ± 16.57	6.41 (1.02, 11.80)	0.015	12.16 ± 11.63	6.74 (2.73, 10.76)	<0.001	9.89 ± 11.59	6.68 (2.60, 10.75)	<0.001
3 months	6.75 ± 4.50			5.42 ± 3.91			3.22 ± 3.98		
1 week vs	12.90 ± 12.13	6.15 (2.80, 9.50)	<0.001	11.43 ± 9.95	6.01 (2.90, 9.13)	<0.001	7.67 ± 8.19	4.45 (1.73, 7.16)	<0.001
3 months	6.75 ± 4.50			5.42 ± 3.91			3.22 ± 3.98		
TBUT									
Baseline vs	7.31 ± 2.40	0.84 (0.07, 1.60)	0.028	7.72 ± 2.95	1.17 (0.16, 2.19)	0.019	7.05 ± 2.47	-0.02 (-0.87, 0.83)	>0.950
1 week	6.48 ± 2.22			6.55 ± 2.34			7.07 ± 2.11		
Baseline vs	7.31 ± 2.40	-2.03 (-3.03, -1.03)	<0.001	7.72 ± 2.95	-1.23 (-2.27, -0.19)	0.016	7.05 ± 2.47	-1.75 (-2.84, -0.66)	<0.001
3 months	9.35 ± 2.50			8.96 ± 2.22			8.80 ± 2.11		
1 week vs	6.48 ± 2.22	-2.87 (-3.69, -2.05)	<0.001	6.55 ± 2.34	-2.41 (-3.18, -1.63)	<0.001	7.07 ± 2.11	-1.73 (-2.34, -1.12)	<0.001
3 months	9.35 ± 2.50			8.96 ± 2.22			8.80 ± 2.11		
Schirmer's test									
Baseline vs	9.21 ± 5.31	0.14 (-1.58, 1.86)	>0.095	10.33 ± 5.76	0.93 (-0.99, 2.84)	0.705	8.18 ± 4.67	-0.71 (-2.57, 1.17)	>0.095
1 week	9.07 ± 3.99			9.40 ± 4.70			8.89 ± 4.49		
Baseline vs	9.21 ± 5.31	-1.41 (-3.13, 0.32)	0.146	10.33 ± 5.76	-0.48 (-2.33, 1.38)	>0.095	8.18 ± 4.67	-2.43 (-4.25, -0.62)	0.005
3 months	10.62 ± 3.46			10.80 ± 3.15			10.61 ± 3.53		
1 week vs	9.07 ± 3.99	-1.55 (-2.49, -0.60)	<0.001	9.40 ± 4.70	-1.40 (-2.46, -0.34)	0.006	8.89 ± 4.49	-1.73 (-2.63, -0.82)	<0.001
3 months	10.62 ± 3.46			10.80 ± 3.15			10.61 ± 3.53		

Abbreviations: OSDI: Ocular Surface Disease Index, DR: diabetic retinopathy, SD: Standard deviation, MD: Mean difference, CI: Confidence interval, vs: versus, TBUT: Tear break-up time

Table IV: Dry eye parameters in the operated eyes of diabetic and non-diabetic patients (between factors)

Comparison	Estimated Mean (95% CI)	MD (95% CI)	p-value
OSDI			
DR vs	10.93 (8.37, 13.50)	1.26 (-3.24, 5.76)	>0.950
No DR	9.67 (7.04, 12.30)		
DR vs	10.93 (8.37, 13.50)	4.01 (-0.39, 8.40)	0.086
Non-diabetic	6.93 (4.42, 9.43)		
No DR vs	9.67 (7.04, 12.30)	2.74 (-1.71, 7.19)	0.412
Non-diabetic	6.93 (4.42, 9.43)		
TBUT			
DR vs	7.71 (7.11, 8.31)	-0.03 (-1.08, 1.02)	>0.950
No DR	7.74 (7.13, 8.36)		
DR vs	7.71 (7.11, 8.31)	0.08 (-0.95, 1.10)	>0.950
Non-diabetic	7.64 (7.05, 8.22)		
No DR vs	7.74 (7.13, 8.36)	0.11 (-0.93, 1.15)	>0.950
Non-diabetic	7.64 (7.05, 8.22)		
Schirmer's test			
DR vs	9.64 (8.50, 10.77)	-0.54 (-2.53, 1.45)	>0.950
No DR	10.18 (9.01, 11.34)		
DR vs	9.64 (8.50, 10.77)	0.41 (-1.54, 2.35)	>0.950
Non-diabetic	9.23 (8.12, 10.34)		
No DR vs	10.18 (9.01, 11.34)	0.95 (-1.02, 2.92)	0.736
Non-diabetic	9.23 (8.12, 10.34)		

Abbreviations: CI: confidence interval, MD: Mean difference, OSDI: Ocular Surface Disease Index, DR: diabetic retinopathy, TBUT: Tear break-up time

all groups. The DR group showed the greatest increase (2.03 seconds, $p < 0.001$), followed by the non-diabetic group (1.75 seconds, $p = 0.001$) and the no DR group (1.23 seconds, $p = 0.016$). Between one week and three months post-surgery, TBUT values continued to recover significantly in all groups. The DR group demonstrated the largest improvement (2.87 seconds, $p < 0.001$), followed by the no DR group (2.41 seconds, $p < 0.001$) and the non-diabetic group (1.73 seconds, $p < 0.001$). These results indicate an initial post-surgical decline in TBUT among diabetic patients, followed by substantial recovery by three months.

Schirmer's test values showed minimal changes from baseline to one week post-surgery, with no statistically significant differences across all groups. By three months post-surgery, the DR and no DR groups demonstrated slight increases in Schirmer's test values, but these changes were not statistically significant ($p = 0.146$ and $p > 0.950$, respectively). In contrast, the non-diabetic group showed a significant improvement in Schirmer's test values during this period ($p = 0.005$).

Between one week to three months post-operation, Schirmer's test values increased significantly across all groups. The DR group showed an improvement of 1.55 ($p = 0.001$), the no DR group improved by 1.40 ($p = 0.006$), and the non-diabetic group exhibited the largest increase of 1.73 ($p < 0.001$). Overall, the non-diabetic group demonstrated the most notable increase in tear production by three months post-surgery.

Table IV presents the results of dry eye parameters analysed using repeated measures ANOVA (RM ANOVA) across the groups. No significant differences were found in any dry eye parameters between the groups ($p > 0.050$).

Table V presents the comparison of dry eye parameters (OSDI, TBUT, and Schirmer's test) among the DR, no DR, and non-diabetic groups at baseline, one week, and three months post-surgery.

At baseline, OSDI scores were comparable across all groups, with no statistically significant differences ($p > 0.050$). At one week post-surgery, although the DR group had slightly higher OSDI scores than the no DR and non-diabetic groups, the differences were not statistically significant ($p > 0.950$ for DR versus no DR, $p = 0.057$ for DR versus non-diabetic). By three months post-surgery, significant differences were observed between the DR and non-diabetic groups ($p < 0.001$) and between the no DR and non-diabetic groups ($p = 0.050$). However, no significant difference was found between the DR and no DR groups ($p = 0.446$). At three months, diabetic groups (DR and no DR) exhibited significantly higher OSDI scores compared to the non-diabetic group.

At baseline, TBUT values were comparable across all groups, with no significant differences detected ($p > 0.050$). One week after surgery, TBUT values decreased in both the DR and no DR groups; however, the differences between the groups remained statistically insignificant. By three months after surgery, TBUT values improved in all groups, but no significant intergroup differences were observed at any time point ($p > 0.050$). Overall, TBUT values were similar across the DR, no DR, and non-diabetic groups at all time points ($p > 0.050$, Table V).

At baseline, Schirmer's test values were similar across all groups, with no statistically significant differences observed ($p > 0.050$). One week post-surgery, minimal changes in Schirmer's test values were observed, with no statistically significant differences between the groups ($p > 0.950$). By three months post-surgery, Schirmer's test results were

Table V: Dry eye parameters before and after cataract surgery in the operated eyes of diabetic and non-diabetic patients (within-between factors)

Comparison	OSDI			TBUT			Schirmer's test		
	Mean ± SD	MD (95% CI)	p value	Mean ± SD	MD (95% CI)	p value	Mean ± SD	MD (95% CI)	p-value
Baseline									
DR vs	13.15 ± 16.57	0.99 (-6.23, 8.22)	>0.950	7.31 ± 2.40	-0.41 (-1.81, 0.99)	>0.950	9.21 ± 5.31	-1.11 (-3.93, 1.70)	>0.950
No DR	12.16 ± 11.63			7.72 ± 2.95			10.33 ± 5.76		
DR vs	13.15 ± 16.57	3.26 (-3.79, 10.31)	0.792	7.31 ± 2.40	0.27 (-1.10, 1.64)	>0.950	9.21 ± 5.31	1.03 (-1.72, 3.78)	>0.950
Non-diabetic	9.89 ± 11.59			7.05 ± 2.47			8.18 ± 4.67		
No DR vs	12.16 ± 11.63	2.27 (-4.88, 9.41)	>0.950	7.72 ± 2.95	0.68 (-0.71, 2.06)	0.714	10.33 ± 5.76	2.14 (-0.64, 4.93)	0.192
Non-diabetic	9.89 ± 11.59			7.05 ± 2.47			8.18 ± 4.67		
1 week									
DR vs	12.90 ± 12.13	1.47 (-4.00, 6.93)	>0.950	6.48 ± 2.22	-0.07 (-1.27, 1.12)	>0.950	9.07 ± 3.99	-0.33 (-2.69, 2.03)	>0.950
No DR	11.43 ± 9.95			6.55 ± 2.34			9.40 ± 4.70		
DR vs	12.90 ± 12.13	5.23 (-0.11, 10.57)	0.057	6.48 ± 2.22	-0.59 (-1.76, 0.57)	0.657	9.07 ± 3.99	0.19 (-2.12, 2.49)	>0.950
Non-diabetic	7.67 ± 8.19			7.07 ± 2.11			8.89 ± 4.49		
No DR vs	11.43 ± 9.95	3.76 (-1.64, 9.17)	0.281	6.55 ± 2.34	-0.52 (-1.70, 0.66)	0.863	9.40 ± 4.70	0.51 (-1.82, 2.85)	>0.950
Non-diabetic	7.67 ± 8.19			7.07 ± 2.11			8.89 ± 4.49		
3 months									
DR vs	6.75 ± 4.50	1.33 (-0.89, 3.55)	0.446	9.35 ± 2.50	0.39 (-0.83, 1.61)	>0.950	10.62 ± 3.46	-0.18 (-2.00, 1.64)	>0.950
No DR	5.42 ± 3.91			8.96 ± 2.22			10.80 ± 3.15		
DR vs	6.75 ± 4.50	3.53 (1.36, 5.69)	<0.001	9.35 ± 2.50	0.55 (-0.65, 1.74)	0.799	10.62 ± 3.46	0.01 (-1.77, 1.78)	>0.950
Non-diabetic	3.22 ± 3.98			8.80 ± 2.11			10.61 ± 3.53		
No DR vs	5.42 ± 3.91	2.20 (0.01, 4.39)	0.050	8.96 ± 2.22	0.16 (-1.05, 1.37)	>0.950	10.80 ± 3.15	0.19 (-1.61, 1.98)	>0.950
Non-diabetic	3.22 ± 3.98			8.80 ± 2.11			10.61 ± 3.53		

Abbreviations: OSDI: Ocular Surface Disease Index, SD: Standard deviation, MD: Mean difference, CI: Confidence interval, DR: diabetic retinopathy, vs: versus, TBUT: Tear break-up time comparable across all groups, with no significant differences detected ($p > 0.950$). Overall, Schirmer's test values remained consistent across the DR, no DR, and non-diabetic groups at baseline, one week, and three months post-surgery.

DISCUSSION

This study evaluated changes in dry eye parameters using OSDI scores, TBUT, and Schirmer's test among non-diabetic, diabetic without retinopathy (no DR), and diabetic retinopathy (DR) patients following phacoemulsification. Findings revealed important insights into the variations in dry eye symptoms and signs across these groups, with a gradual improvement in ocular surface health observed in the long-term post-surgery.

The cohort predominantly consisted of Malay participants, with hypertension being the most common comorbidity, especially in the DR group, aligning with previous studies linking systemic hypertension to the progression of DR.[5] Gender distribution showed a male predominance except in the non-diabetic group, where females outnumbered males. Notably, many of the females in the cohort were postmenopausal, a factor that may contribute to an increased risk of dry eye symptoms.[6,7] Sriprasert et al. highlighted that postmenopausal women are at a higher risk for ocular surface issues due to hormonal changes, which could influence both subjective symptoms and objective dry eye measures.[6] The study also found a slight age difference across groups, with the DR group being slightly younger, suggesting earlier onset or more rapid progression of retinopathy in some individuals, potentially contributing to the observed ocular surface changes post-surgery. Patients who are older and female are at an increased risk of developing dry eye symptoms following cataract surgery.[8]

Despite early postoperative dry eye symptoms, no significant differences in OSDI, TBUT, or Schirmer's test were found among groups at any time point. However, a significant improvement from baseline to three months suggests transient postoperative ocular surface stress with subsequent stabilisation. Jiang et al. reported a dry eye incidence of 17.1% in diabetic and 8.1% in non-diabetic patients one week post-cataract surgery, which resolved in both groups by three months.[3] Kasetsuwan et al. similarly found a 9.8% incidence of postoperative dry eye, peaking at one week before improving.[9] Their findings align with ours, showing no significant differences in TBUT, Schirmer's test, or OSDI early postoperatively. These results suggest that dry eyes following cataract surgery are predominantly transient, driven by postoperative inflammation and ocular surface stress.

For the OSDI parameter, no significant changes were observed between baseline and one week post-surgery in any group. However, a significant decrease was evident from baseline to three months and from one week to three months across all groups, suggesting that while early postoperative dry eye symptoms persist, substantial relief occurs within three months. Li et al. attributed postoperative dry eye to poor adherence to prescribed eye drops, aligning with the understanding that surgical inflammation initially worsens symptoms before recovery stabilises them.[10,11] At three months, DR and no DR patients reported greater discomfort than non-diabetic patients. Jiang et al. showed that diabetic patients had significantly increased OSDI scores post-surgery, with non-diabetics returning to baseline within a month.[3] This may reflect diabetic pathology affecting nerve function and inflammatory responses, prolonging subjective dry eye symptoms even as TBUT and Schirmer's test improve.[8,12] Zamora et al. reported significant post-surgical improvement, consistent with our findings.[12] In our cohort, DR patients had milder preoperative dry eye symptoms than no DR and non-diabetic groups, as indicated by the OSDI scores.[13,14] Notably, patients with altered preoperative values indicative of dry eye were more likely to experience prolonged ocular surface disease postoperatively.[9]

TBUT analysis revealed significant differences among groups. Both the DR and no DR groups experienced a marked reduction in TBUT from baseline to one week postoperatively, likely due to postoperative inflammation and tear film instability,[10] whereas non-diabetic patients showed no significant change. However, all groups exhibited substantial TBUT improvement from baseline to three months, reflecting progressive tear film recovery. Kohli et al. found a transient decline in dry eye parameters immediately post-surgery, with recovery evident by six weeks, while Garg et al. reported a significant TBUT reduction at one week, returning to baseline by one month.[2,15] These studies, however, did not distinguish between diabetic and non-diabetic patients. Identified risk factors contributing to dry eye included age, exposure to operating microscope light, and the duration of surgery.

Liu et al. highlighted slower TBUT recovery in diabetic patients compared to non-diabetic patients, which aligns with our findings.[16] Similarly, Shaaban and Aziz observed a significant TBUT decline in the first week, followed by improvement at one month, though values had not fully returned to baseline by three months, particularly in diabetics.[8] Our findings reinforce the immediate impact of cataract surgery on TBUT and variations in recovery timelines. While early declines are common, gradual improvement over subsequent months underscores the need for close monitoring and tailored dry eye management, particularly for diabetic patients with slower recovery.

Schirmer's test showed no significant changes from baseline to one week post-surgery in any group, suggesting a minimal immediate impact on tear production. However, by three months, non-diabetic patients showed significant improvement, highlighting recovery of baseline tear production levels as healing advances. A similar trend from one week to three months was observed across all groups, suggesting prolonged recovery facilitates better lacrimal gland function and tear secretion.[17,18] Zhang et al. found that diabetic patients had significantly lower preoperative TBUT and Schirmer's test scores than non-diabetics, with minimal post-surgical changes. Glycaemic control did not significantly influence these outcomes.[19] Additionally, the lack of significant differences in TBUT and Schirmer's test between the three groups at all time points suggests that while diabetic status influences subjective symptoms (OSDI), objective signs may not show the same degree of variance between groups. This finding emphasizes the complex nature of dry eye disease in diabetic populations, where symptomatic relief may not correlate linearly with clinical tests.[20] Cung et al. reported similar findings, showing that approximately one-third of patients developed mild keratoconjunctivitis sicca following cataract surgery. Schirmer's test scores significantly decreased during the first week but returned to baseline by three months.[17]

These findings emphasize that while early postoperative dry eye symptoms are common, significant improvement occurs within three months across all groups. The slower recovery in TBUT for DR patients suggests microvascular and neuropathic changes associated with diabetic eye conditions, which could delay or modify the response to ocular surgery.[21] Post-surgical dry eye is influenced by multiple factors. During phacoemulsification, exposure of the corneal surface and conjunctiva to the operating microscope's light and air can lead to tear film instability.[21,22] Surgical incisions can damage corneal nerves, causing denervation and resulting in changes to the ocular surface. Additionally, mydriatic agents and topical anaesthesia can decrease tear production and promote tear film instability.[17,22] Inflammation following surgery can elevate cytokine levels on the ocular surface, which undermines tear film stability and intensifies dry eye symptoms.[9] Oxidative stress during surgery may damage corneal epithelium and conjunctival cells, worsening dry eye, especially in diabetic patients. The prolonged use of corticosteroids and antibiotics post-surgery may impact gland function, contributing to tear film disruption. Corneal nerve damage may also lead to neurotrophic keratopathy, which reduces corneal sensitivity and interferes with the blink reflex, limiting effective tear distribution and prolonging dry eye symptoms.[19] Environmental and mechanical factors, including frequent blinking during recovery and exposure to air conditioning, add stress to the tear film. For diabetic patients, delayed wound healing and persistent inflammation can exacerbate these challenges to the ocular surface.[18]

Differences in the diabetes duration and HbA1c levels were noted between the DR and no DR groups. To account for these variables, repeated measures ANCOVA were performed for all dry eye parameters, but no significant differences were found. However, the DR group consistently exhibited slightly poorer scores, suggesting a trend toward greater ocular surface dysfunction. Similarly, Yu et al. found more pronounced tear film dysfunction in patients with proliferative diabetic retinopathy than in those with non-proliferative diabetic retinopathy highlighting the increased risk of dry eye in advanced diabetic complications.[18] Unlike our findings, their study reported significant differences between the DR and no DR groups.

Unlike previous studies that primarily focused on early postoperative dry eye symptoms, our findings demonstrate a significant improvement in dry eye parameters as early as three months post-phacoemulsification. Most studies assessed recovery within a shorter follow-up period of less than three months.[2,12,19] Elminshawy et al. reported that TBUT levels exceeded baseline values in both diabetic and non-diabetic groups, further supporting the potential for ocular surface recovery.[4] This suggests that postoperative dry eye symptoms may be transient and reversible with appropriate management and care.

This study's three-month follow-up may not fully capture long-term changes in dry eye parameters or the sustained effects of diabetes and cataract surgery on ocular surface health. The reliance on OSDI, TBUT, and Schirmer's test limits evaluation by excluding patient-reported symptom burdens or advanced diagnostics like meibography and tear osmolarity. Furthermore, TBUT and Schirmer's test may not adequately address the inflammatory aspects of dry eye, which are particularly relevant in diabetic patients. Future studies should prioritise targeted postoperative interventions to enhance tear film stability, particularly in diabetic and retinopathy patients. Longer follow-up is needed to assess sustained ocular surface changes. Incorporating patient-reported outcomes and stratifying diabetic patients based on glycaemic control or disease severity could provide deeper insights. Advanced diagnostics, such as tear osmolarity and meibography, may further clarify dry eye pathophysiology and guide more effective management strategies.

CONCLUSIONS

Three months after phacoemulsification, significant improvements in OSDI scores, TBUT, and Schirmer's test values were observed, indicating a recovery in dry eye status. Diabetic patients experienced more pronounced early postoperative changes but demonstrated comparable recovery trends to non-diabetics by three months. Unlike previous studies, which primarily reported transient postoperative dry eye symptoms, our findings uniquely highlight significant long-term improvements. These findings highlight the importance of monitoring dry eye parameters in diabetics, particularly during the early postoperative period, to optimise outcomes and patient satisfaction.

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