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Comparative Study Of Corneal Sensitivity And Tear Production Alterations In Adults With Type 2 Diabetes

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Abstract

Diabetes mellitus is a long-term metabolic disease that impacts the eyes among other organs. Diabetes has important effects on the tear film and corneal integrity, which are less well known but can lead to symptoms of dry eye disease along with alterations in corneal function. Vital components of ocular surface health include the tear film, corneal sensitivity, and blink reflex their malfunction may severely impact visual comfort and quality of life. To evaluate how diabetes affects the eye and mainly how diabetes affects corneal sensitivity and tear production. This cross-sectional comparative study involved 42 subjects who were chosen through a non-probability sampling technique. Information was taken on a self-designed proforma after obtaining the consent. All participants who fulfilled the inclusion and exclusion criteria were included in the study. Tear film instability was measured with the Tear break up time method. Corneal sensitivity was measured using a cotton tip applicator and the Schirmers test was used to evaluate tear production. Statistical analysis was done by using the SPSS 21.0 statistical software using Fisher's Exact Test. The mean age of participants was 40.31 ± 3.848.Schirmer's test revealed that 81% of eyes in the control group were normal in both right and left eyes, with just a tiny minority exhibiting moderate (right: 19%, left: 14.3%) or severe dryness (left: 4.8%). Among diabetic patients with less than three years of illness, the right eye was 45.5% normal, 27.3% moderate, and 27.3% extremely dry, whereas the left eye was 54.5% normal, 9.1% moderate, and 36.4% extremely dry. For individuals with diabetes for 5-7 years, the right eye results were 50% normal, 10% moderate, and 40% extremely dry; the left eye was 40% normal, 50% moderate, and 10% extremely dry. TBUT grading in the control group revealed that 81% of the right and 71.4% of the left eyes were normal, with the rest having dry eyes.In diabetics with less than three years of illness, 72.7% (right) and 81.8% (left) had dry eyes, whereas 27.3% (right) and 18.2% (left) had normal eyes.Individuals with diabetes for 5–7 years, 60% had dry eyes and 40% had normal eyes. In all control eyes, corneal sensitivity was normal. 54.5% (right) and 63.6% (left) had impaired sensitivity, whereas 45.5% (right) and 36.4%

(left) had normal sensitivity among diabetics with less than three years of illness. Only 20% (right) and 10% (left) of patients with diabetes for 5–7 years had normal corneal sensitivity, whereas 90% (left) and 80% (right) had decreased corneal sensitivity. It was concluded from the study that the participants who have diabetes have greater chances of tear film instability and have a greater effect on corneal sensitivity and tear production than non-diabetic participants.

Introduction

The human eye is a complex organ comprised of numerous structures that operate collectively to accomplish vision. The chief refractive medium of the eye is the cornea. That is a transparent, convex-shaped structure, positioned anteriorly. It is comprised of these strata: Epithelium, Bowman's layer, Stroma, Descemet's membrane, Endothelium (1), and Dua's layer (2). It is a compactly innervated structure of the eye. Impulsive tearing and blinking are controlled by the sensory response from the corneal surface. It is also under the control of the epithelial firmness of the cornea. Reduced corneal sensitivity can set off changes in tear secretion (3).

Tear secretion is a crucial element for ocular well-being. It lubricates the front surface of the eye and guards it, moreover, it provides nutrition and supplies oxygen to it (4). The tear film (TF) is a fine layer that coats the anterior surface of the eye. It consists of 3 layers namely, lipid, aqueous, and mucin (5). The outermost layer is the lipid layer, which is produced by meibomian glands and is composed of lipids. This layer minimizes the evaporation of the underlying water layer and delivers an even visual surface for the eye. The lacrimal glands secrete an aqueous sublayer, the mid-layer, that contains most of the Tear Film (TF). It typically encompasses water combined with proteins, electrolytes, and antimicrobial compounds. It gives hydration to the corneal and conjunctival epithelia, nourishment, and eradicates debris as well as pathogens (6). The mucin layer which is the deepest layer incorporates the mucins, supplied by goblet cells in the conjunctiva. This layer upholds the aqueous sub-layer to stick to the cornea and conjunctival face, accelerating certainly distribution of the tear film and ensuring a stable optical surface (7). TF offers nutrients and sustains a smooth corneal surface therefore ensuring clear vision. Tear film instability leads to irritation, and dryness the condition known as dry eye disease (DED) (5).

Diabetes is a strong-growing global health subject (8). Diabetes mellitus (DM) is a term used for a diverse collection of conditions that have distinguishing elevated glucose levels in the blood. The most frequent type of DM is Type-2. Glucose levels can be raised due to insulin deficit or its diminished action. It triggers end-organ failure, typically impacting the eyes, heart, and blood vessels (9). These accompanied by retinopathy, and cataract, also bring in minor ocular surface complications such as DED that are often ignored (10).

The diabetic ocular surface disease disturbs the tear production and quality with squamous metaplasia and goblet cell damage that give the impression of progress in firm relation to metabolic control and peripheral neuropathy status (11). DM affects corneal and conjunctival epithelial cells, which results in weakened goblet cell and mucin production. Furthermore, the hydrophilic character of the ocular surface favors tear film instability (12). Depleted tear production detected in DM patients is due to a decline in the performance of the autonomic nervous system and is not normally associated with Sjögren's syndrome (13). The Lacrimal Function Unit (LFU) and ocular surface dysfunction play chief roles in DED, specifically hyperosmolarity and tear film instability. Patients with impairment of the main lacrimal gland have accompanying dry eye syndrome. In patients with reduced glycaemic control, they are frequently severe (14).

Declined corneal sensitivity classically manifests as the initial sign of diabetic keratopathy (15). Variations in corneal nerve features like density, and length occur in both type 1 and 2 DM. Besides, the loss of corneal nerves impedes sensory support,

hence triggering the impairment of corneal epithelial cells (16). DM causes depletion of corneal nerve trophic factors, extinct interaction of dendritic cells, and debilitated sensory nerve fibers that in turn leads to a reduction in corneal sensitivity. Numerous techniques, such as Cochet Bonnet Aesthesiometry, Non-Contact Corneal Aesthesiometry, and Confocal Microscopy can assess this condition. Corneal sensitivity is significantly related to neuropathy symptoms count (17). Corneal sensitivity can be evaluated qualitatively using a simple method. This is achieved in clinics by a cotton-tipped applicator because of its easy accessibility. A wisp of cotton is made and the cornea is slightly touched by the tip of the cotton applicator from the four sides to test all four quadrants. The corneal sensitivity is recorded in each location as absent, reduced, or normal (18).

The firmness of the TF can be evaluated with invasive and non-invasive methods. The Fluorescein Breakup Time procedure implies an invasive method and non-invasive tear breakup time practice includes a projected grid or similar pattern on the TF (19). The stability of tear film is significant for ocular health, Tear Film Break-Up Time (TBUT) performs a chief role in evaluating tear film stability. For invasive TBUT, it is performed such that a 1% fluorescein strip is placed in the eye. The patient blinks many times and then keeps the eye open. The eye is then inspected under a Slit lamp in a cobalt blue filter. Afterward, record the time between the previous complete blink and the appearance of the first black spot via a device such as a stopwatch (20). Schirmer's test is used to evaluate tear quantity. Its principle is capillary action in which tears move along a paper strip, the wetting of the strip provides a clue about the tear production rate. It can be executed with or without anesthesia. 5mm by 30mm test strips are positioned in the inferior conjunctival sac for 5 minutes and measure the wetted strip length. Dry eyes are indicated by a wet-area length on the Schirmer strip without anesthesia of less than 10 to 15 mm (21).

RATIONALE OF THE STUDY

This study was conducted to find the effects of diabetes on ocular health, especially cornea and tear film. It will facilitate the spread of awareness and guide people to take control of diabetes because it not only affects the retina but also causes a decrease in tear production and corneal sensitivity. Emphasizing this connection enabled earlier detection and treatment, promoting better health and preventing serious complications like corneal ulcers.

OBJECTIVES OF STUDY

- To access alternations in tear production and corneal sensitivity in diabetic subjects with type 2 diabetes.
- To compare tear production changes across varying durations of diabetes and with those in nondiabetic individuals.
- To analyze how corneal sensitivity differences relate to the duration of diabetes and compare the findings to non-diabetic individuals.

LITERATURE REVIEW

Dr. Kumar et al. published a cross-sectional study in 2018 to investigate the link between dry eye disease and corneal sensitivity in people with Type 2 Diabetes Mellitus (T2DM). The study wanted to determine how diabetes-related alterations in corneal innervation and TF affect ocular surface health. The primary purpose was to assess the frequency and severity of dry eye illness among T2DM patients, along with its relationship to altered corneal sensitivity. The study included subjects over 40 with T2DM and no other conditions that may affect dry eye or corneal sensitivity. This involves a Questionnaire-based study followed by tear film evaluation, TBUT, Fluoresceine, Lissamine green, and Aesthesiometer for the corneal sensitivity. Tear

production was significantly decreased in T2DM patients. TF stability was poorer in diabetics, with more frequent break-ups. T2DM patients showed dramatically lower corneal sensitivity, indicating neuropathic alterations. Diabetic individuals showed higher corneal staining scores, suggesting more ocular surface injury. It also emphasizes that people with diabetes had a greater risk of dry eye (48.9%) and decreased corneal sensitivity (28.9%) than nondiabetics (5.6%) and tells there was a substantial correlation among age and duration of diabetes, but not retinopathy. The study found there is an important association between T2DM and dry eye illness, which is largely caused by lower tear production, poor TF stability, and decreased corneal sensitivity owing to Diabetic Neuropathy. These data indicate that T2DM impairs both TF and corneal nerve health, resulting in an increased incidence of ocular surface diseases. This study emphasizes the need for frequent screening for dry eye and corneal sensitivity in diabetes patients in order to facilitate early diagnosis and therapy (22).

Meera F. Iyengar et al. conducted a study in a national public hospital in Lima, Peru in 2020 to investigate tear biomarkers and corneal sensitivity as indications of neuropathy in Type 2 diabetes and to evaluate the usefulness of Aesthesiometry for evaluating corneal damage in Diabetic Peripheral Neuropathy. They enlisted 90 volunteers and divided them into groups based on their diabetes and neuropathy status. Schirmer's strips were used to collect tear samples, Aesthesiometry was used to examine corneal sensitivity, whereas vibration perception threshold testing was used to assess Diabetic Peripheral Neuropathy. The analysis included 89 participants. The average age was 55.7± 1.46, with 58.4% being female. Individuals with Diabetic Peripheral Neuropathy had lower Aesthesiometry compared to those with diabetes alone ($p < 0.01$) and healthy controls ($p < 0.01$). The optimal cut-off point for Aesthesiometry was determined to be 5.8 cm, with 79% sensitivity and 75% specificity. This concluded tear biomarkers alone are ineffective for diagnosing Diabetic Peripheral Neuropathy. However, Aesthesiometry is simple accurate, and inexpensive for assessing corneal damage associated with moderate to severe Diabetic Peripheral Neuropathy. The study discovered a significant relationship between defects of the ocular surface and Diabetic Neuropathy. Neuropathy in T2DM was significantly indicated by decreased ocular sensitivity and elevated inflammatory markers in tears. These results indicate that corneal sensitivity tests and tear biomarkers may be non-invasive treatments for the early identification of Diabetic Neuropathy. The study demonstrates the value of corneal sensitivity testing and tear analysis may be useful tools in the clinical evaluation of diabetes complications (23).

Avetisov SE et al. published a study to examine the impact of the TF on the direct measurement of corneal sensitivity in 2020. The study emphasizes how important the TF is for preserving the homeostasis of the ocular surface and how it influences the precision of corneal sensitivity tests. This study involves 20 healthy individuals who had a steady TF, normal tear production, and no history of ocular or systemic illnesses. This study measured the sensory nerve response, researchers used Aesthesiometers, which are instruments that provide regulated mechanical or air shocks to the cornea. TBUT measured how long it took for dry areas to show up after a blink, which was used to evaluate the stability of the TF. The Schirmer Test measured tear production to assess the adequacy of the baseline TF. Osmolarity of Tears measured solute concentration as a sign of homeostasis and TF quality. A high association was found between the air pressure required to evoke a tactile sensation and the pressure at which the TF broke up (correlation coefficient $R = 0.91$ R=0.91, $p = 0.0094$ p=0.0094). This shows that the biomechanical stability of the TF has a considerable effect on the sensitivity thresholds determined during Aesthesiometry. The TF functions as a biomechanical barrier, which influences the accuracy of direct corneal sensitivity tests. A steady TF allows for more consistent and accurate corneal sensitivity measurements. Variations in TF resistance can cause inaccurate sensitivity. The study emphasizes the need to take into consideration TF properties when measuring corneal sensitivity,

particularly in clinical settings including dry eye syndrome, diabetes, or other ocular surface disorders. The authors recommended that practitioners examine the TF's state during corneal sensitivity assessments to ensure accurate diagnosis and enhanced treatment of ocular surface problems (24).

Manchikanti et al. published a cross-sectional comparative study on ocular surface changes in diabetes and their correlation with TF markers including many other factors in 2021. This study includes 42 subjects and requires 21 individuals in each group having 21 diabetics and 21 in the control group. Schirmer's test, TUBT, Ocular surface staining score (OSS), Ocular surface disease index (OSDI), and some other tests were performed. Compared with controls, Type 2 Diabetes Mellitus patients had significantly higher OSDI scores, decreased tear production, decreased TBUT, and higher OSS, results of all these indicate a more severe ocular surface dysfunction. Tests are performed like Schirmer's test for tear production, TBUT for stability, and OSS to evaluate surface damage and assess the integrity of superficial cell layers of the ocular surface. The results show lower Schirmer's and TBUT values in diabetics than in normal ones. Statistical studies employing t-tests, Mann-Whitney tests, and Chi-square tests showed significant differences between groups ($P < 0.05$). The study showed that T2DM has a considerable influence on ocular surface health, with inflammation and metabolic dysfunction being major contributors. The authors recommended that diabetic individuals be screened for OSD regularly, as well as more studies into possible

treatment strategies targeting TF indicators. This study helped to understand the mechanism of OSD in diabetes, its clinical effects, and the impact of diabetes on eye functions (25).

Dr. Nilesh Parekh et al. conducted a comparative study of TF tests in 2021 in diabetics and nondiabetics individuals. This study involves 75 individuals in each group. The major goal was to identify changes in TF properties and their relationship with diabetes and how the disease affects tear glands and ocular surface integrity. Different tests like Schirmer's, TBUT, Tear meniscus height, and Rose Bengal test are performed on all the individuals. The values of various TF tests are diminished in diabetics compared to the control group. Schirmers test yielded significantly different results for the right eye ($P< 0.0001$) and the left eye ($P=0.0001$). TBUT resulted in considerably different results for both groups, for the right eye ($P<0.001$), and ($P>0.0001$) for the left eye. This study concluded that dry eye is more common in diabetics than in the control group and the results of the TF test are also reduced. The research emphasized that diabetes has a negative impact on the stability, production, and health of the ocular surface, possibly as a result of vascular or neuropathic problems. These results highlighted the value of constantly inspecting the ocular surface in diabetes patients to evade additional consequences such as corneal infections or dry eye syndrome (26).

Dr. Kashyap Thakkar et al. conducted a cross-sectional study at the tertiary eye care hospital over the course of 1 year in 2022 to investigate the prevalence of dry eye-related ocular surface problems among Type 2 diabetic patients. It involved 200 patients above the age limit of 40.2 and different groups were made for diabetics and nondiabetics participants. This involves a questionnaire-based study and a full eye examination. The comparison shows nondiabetic individuals (52.58±9.27 years), and the mean age of patients with T2DM was marginally higher at (53.86 ±7.94 years). This also shows a higher number of patients with type 2 diabetes had low tear meniscus height and low TBUT and Schirmer's test score is also low. The study showed a clear correlation between T2DM and dry eye disease, emphasizing that ocular surface problems are made worse by poor glycemic management and an extended disease duration. In order to improve the quality of life and avoid consequences, our findings highlight the necessity of routinely and early evaluating dry eye symptoms in diabetic patients. This study highlights how crucial it is to incorporate regular tests of dry eyes into the clinical treatment of patients with Type 2 diabetes. So, it was concluded that

diabetes patients should get regular visual examinations to detect and manage the problem early to avoid severe complications (27).

Mangoli et al. conducted a cross-sectional study at a tertiary health care center in 2023 to compare the prevalence and severity of Dry eye disease, corneal nerve sensitivity, and diabetic retinopathy in diabetics and nondiabetic individuals. This study involves 400 participants including 200 Diabetics and 200 Non Diabetics. In particular, DED appeared in varied degrees in 70.5% of diabetics and in 34% of non-diabetics. The severity of DED was discovered to be correlated with the length of time that a person had T2DM. Compared to non-diabetics, diabetic patients had poorer Schirmer's test and TBUT scores, indicating poorer TF stability. The study emphasizes that DED in diabetics is probably caused by corneal nerve loss, Lacrimal unit dysregulation, and persistent hyperglycemia. This demonstrates how diabetes affects several organ systems, including the surface of the eye. As demonstrated by lower Aesthesiometry scores in diabetic patients, the severity of Diabetic Retinopathy commonly correlates with reduced corneal sensitivity (28).

MATERIALS AND METHODS

Case-control study design was used. Data was collected at Nawaz Sharif Social Security Hospital Lahore and Ghurki Trust Teaching Hospital Lahore. The study was completed 4 months after the approval of the synopsis. Non-probability Stratified sampling technique was used. The sample size was 42, as per the parent article. The target population was diabetic adults.

DATA COLLECTION PROCEDURE

Inclusion criteria:

- Age: 35-45.
- Both genders.
- Control Group: Non-diabetic.
- Diabetic individuals: Type 2, noninsulin-dependent.

1. Group A: Duration of diabetes less than 3 years.
2. Group B: Duration of diabetes between 5-7 years.

Exclusion criteria:

- Contact lens wearer.
- Topical medications.
- Ocular surgery within the last three months.
- Severe ocular disease fo example diabetic retinopathy.
- Other systemic diseases.

The study involved patients from OPD who met inclusion and exclusion criteria. Written and informed consent was taken from each participant before the research began. Based on their diabetes duration, the subjects were divided into 3 subgroups as mentioned.

Tear stability was accessed by the Tear Film Break-Up Test (TBUT). It was measured as an impregnated fluorescein strip moistened with non-preserved saline was instilled into the lower fornix. The patient was asked to blink several times. The tear film was examined at the slit lamp with a cobalt blue filter. The interval between the last complete blink and the appearance of the first black spot was noted. TBUT of less than 10 seconds is suspicious.



The quantity of tears was examined using Schirmer's test. Schirmer's test strips are labeled as "L" and "R" for the left and right eye respectively. The strip was bent. The patient was instructed to look up, strip was placed on the lower eyelid. Wetting of the strip was noted after 5 minutes. Wetting of less than 10mm of strip is considered suspicious, readings between 9 mm to 5mm are considered moderately dry eye while 4mm to 0 mm are considered extremely dry eye.

Corneal sensitivity was assessed using a cotton-tipped applicator by touching four quadrants of cornea from the side.

Data was recorded using proformas.


Data Collection Tools (Performa/Questionnaire)

- Schirmer's test
- Fluoresceine strips
- Slit lamp
- Cotton thread

DATA ANALYSIS

The data was analyzed by using the SPSS 21.0 statistical software.

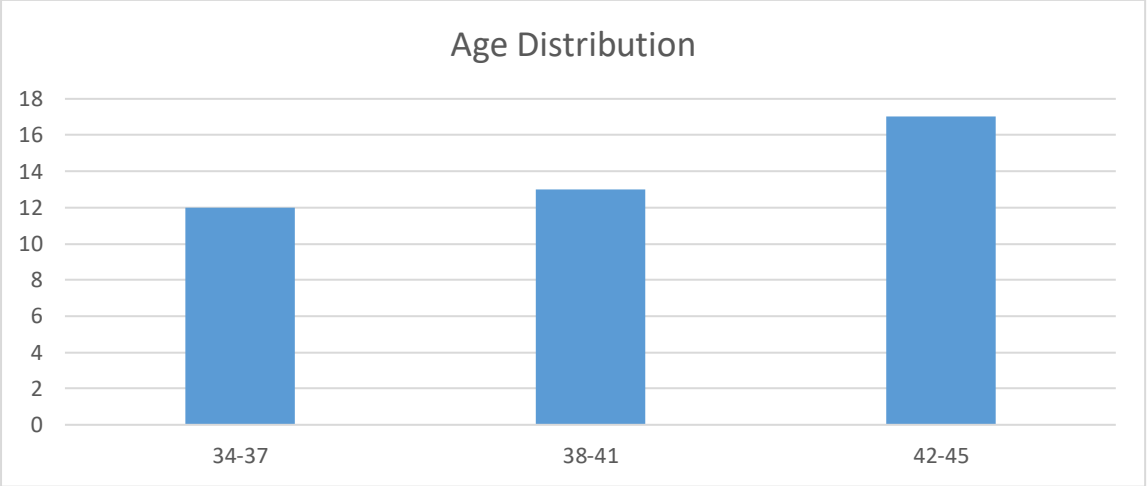
RESULTS

Mean Age of the participants.

Table 5.1 represents the age distribution of the study participants. The age group ranged from 35 to 45, and the mean age of participants was 40.31 ± 3.848.

Table 5.1: Mean age of the participants

	N	Minimum	Maximum	Mean	Std. Deviation
Age	42	35	45	40.31	3.848



Bar chart of age distribution.

Graph shows the age distribution of the study participants and their frequency.

Cross-tabulation/ percentage of dry eye with control and case groups (Right).

The table shows a comparison of the severity of dry eye. Schirmer's test was conducted to find the severity of dry eye across 42 participants, they were divided into two groups i.e. 21 were non-diabetic and 21 were diabetic. This table shows the results for the right eye only for the participants. For the non-diabetic group, 81% eyes were normal (17 eyes), while 19% of the eyes had a moderate dry eye (4 eyes). No severe dry eye was found in the non-diabetic group. However, for the diabetic group, there were further classification of participants was done based on the duration of diabetes being less than 3 years and between 5 - 7 years. For participants having less than 3 years, 45.5% eyes were normal (5 eyes), while 27.3% of the eyes had a moderate dry eye (3 eyes). 27.3% of the eyes had an extremely dry eye (3 eyes). For participants having diabetes for 5-7 years, 50% of eyes were normal (5 eyes), while 10% of the eyes had a moderate dry eye (1 eye). 40% of the eyes had an extremely dry eye (4 eyes).

The Fisher's Exact Test produced a p-value of 0.014, since the p-value is not as much as the characteristic threshold of 0.05, we would reject the null hypothesis. It indicates a statistically significant relationship between dry eye detected by Schirmer's test and the duration of diabetes.

Table Cross-tabulation/ percentage of dry eye with control and case groups (Right).

		Schirmer's test (Right)			Total	Fisher's Exact Test	p-value
		Extremely Dry (0-5mm)	Moderately Dry (5-10mm)	Normal >10mm			
Diabetic Category with percentage	Control	0 0%	4 19%	17 81.0%	21 100%	1 0.652	0.014
	Less than 3 years	3 27.3%	3 27.3%	5 45.5%	11 100%		
	5 to 7 years	4 40%	1 10%	5 50%	10		

					00%		
Total		7 1 6.7%	8 19 %	2 7 6 4.3%	4 2 1 00%		

Cross-tabulation/ percentage of dry eye with control and case groups (Left).

The table shows a comparison of the severity of dry eye. Schirmer's test was conducted to find the severity of dry eye across 42 participants, they were divided into two groups i.e. 21 were non-diabetic and 21 were diabetic. This table shows the results for the right eye only for the participants. For the non-diabetic group, 81% eyes were normal (17 eyes), while 14.3% of the eyes had a moderate dry eye (3 eyes), and 4.8% of the eyes had an extremely dry eye (1 eye). However, for the diabetic group, there were further classification of participants was done based on the duration of diabetes being less than 3 years and between 5-7 years. For participants having less than 3 years, 54.5% of eyes were normal (6 eyes), while 9.1% of the eyes had a moderately dry eye (1 eye). 36.4% of the eyes had an extremely dry eye (4 eyes). For participants having diabetes for 5-7 years, 40% of eyes were normal (4 eyes), while 50% of the eyes had a moderate dry eye (5 eyes). 10% of the eyes had an extremely dry eye (1 eye).

The Fisher's Exact Test has a p-value of 0.020**,** considering that the p-value is not greater than the threshold level of significance of 0.05, we would reject the null hypothesis. This statistically significant association suggests a link between dry eye detected by Schirmer's test and the duration of diabetes.

Table Cross-tabulation/ percentage of dry eye with control and case groups (left).

		Schirmer's test (Left)			Total	Fisher's Exact Test	p-value
		Extremely Dry (0-5mm)	Moderately Dry (5-10mm)	Normal >10mm			
Diabetic Category with percentage	Control	1 4.8%	3 14.3%	1 7 8 1%	2 1 1 00%	1 0.222	0 .020
	Less than 3 years	4 3 6.4%	1 9.1%	6 5 4.5%	1 1 1 00%		
	5 to 7 years	1 1 0%	5 50%	4 4 0%	1 0 1 00%		
Total		6 1 4.3%	9 21.4%	2 7 6 4.3%	4 2 1 00%		

Cross-tabulation/ percentage of TBUT with control and case groups (Right).

The table shows a comparison of the severity of dry eye. TBUT was conducted

to find the severity of dry eye across 42 participants, they were divided into two groups i.e. 21 were non-diabetic and 21 were diabetic. This table shows the results for the right eye only for the participants. For the non-diabetic group, 81% of eyes were normal (17 eyes), while 19% of the eyes had dry eyes (4 eyes). However, for the diabetic group, there were further classification of participants was done based on the duration of diabetes being less than 3 years and between 5-7 years. For participants having less than 3 years, 27.3% of eyes were normal (3 eyes), while 72.7% of the eyes had dry eyes (8 eyes). For participants having diabetes for 5-7 years, 40% of eyes were normal (4 eyes), while 60% of the eyes had dry eye (6 eyes).

The Fisher's Exact Test yielded a p-value of 0.006. Considering that the p-value is less than the threshold of significance 0.05, we would reject the null hypothesis. This shows that the association is statistically significant suggesting a link between dry eye detected by TBUT and duration of diabetes.

Table Cross-tabulation/ percentage of TBUT with control and case groups (Right).

		TBUT (Right)				
		Dry < 10 sec	Normal >10 sec	Total	Fisher's Exact Test	P-value
Diabetic Category with percentage	Control	4 19% 1	17 81% 1	21 100% 1	10.014	0.006
	Less than 3 years	8 72.7% 7	3 27.3 7	11 100% 1		
	5 to 7 years	6 60% 6	4 40% 4	10 100% 1		
Total		18 42.9% 4	24 57.1% 7	42 100% 1		

Cross-tabulation/ percentage of TBUT with control and case groups (Left).

The table shows a comparison of the severity of dry eye. TBUT was conducted to find the severity of dry eye across 42 participants, they were divided into two groups i.e. 21 were non-diabetic and 21 were diabetic. This table shows the results for the right eye only for the participants. For the non-diabetic group, 71.4% of eyes were normal (15 eyes), while 28.6% of the eyes had dry eyes (6 eyes). However, for the diabetic group, further classification of participants was done based on the duration of diabetes being less than 3 years and between 5-7 years. For participants under 3 years, 18.2% of eyes were normal (2 eyes), while 81.8% had dry eyes (9 eyes). For participants having diabetes for 5-7 years, 40% of eyes were normal (4 eyes), while 60% of the eyes had dry eyes (6 eyes).

The Fisher's Exact Test produced a p-value of 0.02, which is below the predetermined level of significance. Therefore, the null hypothesis is rejected, confirming a significant relationship between the duration of diabetes and dry eye as evaluated by TBUT.

Table Cross-tabulation/ percentage of TBUT with control and case groups

(Left).

		TBUT (Left)		Total	Fisher's Exact Test	P-value
		Dry < 10 sec	Normal >10 sec			
Diabetic Category with percentage	Control	6 2 8.6%	15 71 .4%	21 100%	8.601	0 .013
	Less than 3 years	9 8 1.8%	2 18 .2%	11 100%		
	5 to 7 years	6 6 0%	4 40 %	10 100%		
Total		21 5 0%	21 50 %	42 100%		

Cross-tabulation/ percentage of corneal sensitivity with control and case groups (Right).

The table shows a comparison of the corneal sensitivity among 42 participants, they were divided into two groups i.e. 21 were non-diabetic and 21 were diabetic. This table shows the results for the right eye only for the participants. For the non-diabetic group, 100% of eyes had normal corneal sensitivity (21 eyes), while none of them had reduced corneal sensitivity. However, for the diabetic group, further classification of participants was done based on the duration of diabetes being less than 3 years and between 5-7 years. For participants under 3 years, 45.5% of eyes had normal corneal sensitivity (5 eyes), while 54.5% had reduced corneal sensitivity (6 eyes). For participants having diabetes for 5-7 years, 20% of eyes had normal corneal sensitivity (2 eyes), while 80% had reduced corneal sensitivity (8 eyes).

Considering that the p-value is not greater than the threshold level of significance 0.05, we would reject the null hypothesis. This statistically significant association proposes a link between the decrease in corneal sensitivity and the duration of diabetes.

Table Cross-tabulation/ percentage of corneal sensitivity with control and case groups (Right).

		Corneal Sensitivity (Right)		Total	Fisher's Exact Test	P-value
		Normal	Reduced			
Diabetic Category with percentag	Control	21 10 0%	0 0%	21 100%	24 .822	0 .000
	Less than 3	5 45	6 54.	11		

e	years	.5%	5%	1 00%		
	5 to 7 years	2 20 %	8 80 %	1 0 1 00%		
Total		28 66 .7%	14 33. 3%	4 2 1 00%		

Cross-tabulation/ percentage of corneal sensitivity with control and case groups (Left).

The table shows a comparison of the corneal sensitivity among 42 participants, they were divided into two groups i.e. 21 were non-diabetic and 21 were diabetic. This table shows the results for the right eye only for the participants. For the non-diabetic group, 100% of eyes had normal corneal sensitivity (21 eyes), while none of them had reduced corneal sensitivity. However, for the diabetic group, further classification of participants was done based on the duration of diabetes being less than 3 years and between 5-7 years. For participants under 3 years, 36.4% of eyes had normal corneal sensitivity (4 eyes), while 63.6% had reduced corneal sensitivity (7 eyes). For participants having diabetes for 5-7 years, 10% of eyes had normal corneal sensitivity (1 eye), while 90% had reduced corneal sensitivity (9 eyes).

In this study, the Fisher's Exact Test yielded a p-value of 0.000, which is below the established significance threshold. Consequently, the null hypothesis was rejected, indicating a significant association between the corneal sensitivity and duration of diabetes.

Table Cross-tabulation/ percentage of corneal sensitivity with control and case groups (Left).

		Corneal Sensitivity (left)		Total	Fisher's Exact Test	P-value
		Normal	Reduced			
Diabetic Category with percentage	Control	21 10 0%	0 0%	2 1 1 00%	30 .680	0 .000
	Less than 3 years	4 36 .4%	7 63. 6%	1 1 1 00%		
	5 to 7 years	1 10 %	9 90 %	1 0 1 00%		
Total		26 61 .9%	16 38. 1%	4 2 1 00%		

DISCUSSION

The purpose of this study was to measure tear production and corneal sensitivity across diabetic adults in comparison with non-diabetic. A total of forty-two people were included in this study consisting of both males and females. The age bracket was set from thirty-five to forty-five years. Two groups were made having an equal number of people i.e. twenty-one people in the non-diabetic control group and twenty-one in the diabetic case group. The diabetic case group was further divided into two subgroups based on the duration of diabetes. Eleven diabetic participants had diabetes for less than three years and the rest ten people had diabetes in the range of five to seven years. Schirmer's test was conducted for Tear production and TBUT was used for assessing tear stability. Whereas corneal sensitivity was adjudged in person using a cotton-tipped applicator.

In the current study, participants were included from the OPDs of two different hospitals in Lahore, which is the capital of Punjab province having the largest population. This study was directed to validate whether the results come in comparison to the above-mentioned study or not. Moreover, a standardized scoring for Tear breakup Time (TBUT) and Schirmer's test were used in this study for standard outcomes. Results confirmed that many of the participants displayed a decrease in tear production and stability with the increasing diabetes duration. In addition to that, the current study also measures the consequence of diabetes on corneal sensitivity. Corneal sensitivity was also found to be decreased in diabetic participants.

In present study assessed specifically tear production, tear stability, and corneal sensitivity contrasting above cited study that evaluated diabetic neuropathy. In this study, Schirmer's test is used for evaluating tear production while TBUT is used to measure tera stability in both eyes of participants with no additional parameters like diabetic peripheral neuropathy.

In the light of results obtained from the current study and all the previous studies mentioned, it can be seen clearly that patients with type-2 diabetes are having adverse effects on the tear film markers such as tear film stability and tear production. In addition to effects on tear film markers, type-2 diabetes patients also displayed effects on corneal sensitivity. All these characteristics are reduced for diabetic patients when comparing them to healthy non-diabetic controls. Adding to it, the study also validates that the duration of diabetes has a significant impact on the results of these characteristics. As the duration increases with time, the variables get reduced as compared to patients with less duration of diabetes.

CONCLUSION:

- All of the findings concluded that the low Schirmer's test scores and shorter TBUT indicate decreased tear production in diabetes individuals than in normal ones.
- The results also concluded that there is reduced corneal sensitivity in diabetics. Hence rejecting the null hypothesis.
- The outcomes show diabetes affects tear production by decreasing the amount and stability of the tear film, which might increase the risk of developing dry eye syndrome.

RECOMMENDATIONS & FUTURE RESEARCH DIRECTION

- For further studies more accurate diagnostic instruments like Non-invasive Tear Break-up Time (NITBUT) methods and Aesthesiometers (such as the Cochet-Bonnet Aesthesiometer) can be used for evaluating corneal sensitivity. These techniques can improve data analysis by increasing accuracy and providing measurable outcomes.
- Additional researchers should assess the link between ocular characteristics and HbA1c levels, a measure of glycemic management. This might determine if

diabetes patients' decreased tear production and ocular sensitivity are lessened by improved blood sugar control.

- Optometrists should do proper counseling, use therapeutic measures like omega-3 supplements or artificial tears, and keep an eye on how they affect tear production and corneal sensitivity. Additionally, a longitudinal research design might help in assessing how these changes develop over time and how effective therapies are.
- Besides, teaching diabetic patients about the signs of dry eye disease and how diabetes affects ocular health like corneal sensitivity and tear production and the value of routine checkups can help with early identification and prompt treatment.
- In addition, a bigger sample size would enhance the statistical power of the study and enable a more accurate generalization of the results.
- Upcoming studies should conduct subgroup analysis according to age as these variables might affect corneal sensitivity and tear production. This would make it easier to spot particular demographic patterns among people with diabetes.
- Future investigations should analyze how the degree of tear production and changes in corneal sensitivity relate to diabetic microvascular problems (such as retinopathy or neuropathy). This could make it clear if complications worsen ocular changes.
- Advanced research should examine external factors that may affect tear production, such as screen time, contact lens use, and exposure to air-conditioned surroundings. Knowing these might make it easier to distinguish the effects of diabetes from other factors.
- Next researches should evaluate the ongoing changes in tear production and corneal sensitivity over time. It would help to determine whether the observed abnormalities worsen with time or stabilize with appropriate diabetes care.

LIMITATIONS:

- In our study, the sample size was very small, which may affect the results. By increasing the sample size it is expected that more accurate and reliable results would be found.
- In our study a cotton-tipped applicator, a simple and subjective technique, was used to test corneal sensitivity. More precise methods, such as Aesthesiometry, would yield accurate and measurable data, improving the findings' precision.
- In our study, data was collected at a single point. So, we were unable to track changes in corneal sensitivity and tear production as diabetes progresses.

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