

Impact of Prolonged Digital Screens Exposure On Ocular Surface

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Purpose: To assess effect of prolonged digital screen exposure on ocular surface.

Methodology: In this prospective cohort study, patients were enrolled on the basis of history of prolonged digital exposure (>2hrs/day). Dry eye evaluation was done by Schirmer's with anesthesia, Fluorescein-Tear film Break-up Time (F-BUT) and corneal and conjunctival fluorescein staining. Patients were categorized as per our severity based grading based on objective tests.

Results: Twenty six patients (52 eyes) of mean age 27.76 +/- 5.16 years (range 17 to 41 years) were selected for the study. Headache and redness were the most common symptoms (22.22% each). F-BUT was found to be less than 5 seconds in 92.3% of patients. Ocular surface staining was present in 75% of the patients. Schirmer's came to be the most unreliable factor (>10 mm). Majority (71.15%) of the patients were having moderate grade of digital strain, as per our severity grading. Exposure duration was not found to be correlating with objective tests.

Conclusion: Routine dry eye objective tests are affected in patients with prolonged digital screens exposure. There is no defined minimum duration of exposure that will have adverse effects on ocular surface. New grading system may serve as common guideline for the treatment of digital strain in future.

Abstract

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Keywords: Computer vision syndrome, dry eye, tear film break up time

Introduction

India being one of the major economic centers of the world has a very high population of young professionals who works on the digital screens. Government itself has encouraged the use of computers and other multimedia devices for faster and better performance at work. It is known that screen usage as low as 1 hour can lead to various adverse effects which are termed as digital strain.^{1,2} Its features are dry eye syndrome (DES), low back pain, tension headaches, psychosocial stress etc. Many studies have reported the association between prolonged computer use and adverse effects. Most of them mainly focused on western adult subjects. However, very little work has been done on the effect of computer use on Indian population.⁹ To the best of my knowledge none of the study assessed effect of digital exposure on ocular surface of the patients and attempted to classify this set of patients on routine objective tests.

Thus the present study was conducted to assess the effects of digital exposure on ocular health in the Indian population.

Methodology

A prospective cohort study was conducted at a tertiary eye centre from December 2016 to August 2017 in Maheshwari clinics, New Delhi. Patients between the age group of 15 to 60 years with history of prolonged computer exposure were enrolled in the study. Persons using digital screens including computers, mobiles and televisions for more than 2 hours per day or 15 hours per week were included. Patients were excluded if they have uncorrected refractive errors, were contact lens users, on treatment with topical or systemic steroids, secondary dry eyes due to meibomian gland disease, any autoimmune conditions like Stevens-Johnson syndrome, systemic lupus erythematosus, pregnant and lactating women. Patient on systemic medications like anti-

hypertensives, anti-depressants, anti-allergics were also excluded. Patients who had undergone corneal surgery or any ocular surgery in the preceding one year were also excluded.

A self administered questionnaire was used to collect socio-demographic data, symptoms of DES, details of computer usage and potential risk factors. Questions on symptoms of DES were adapted from the Ocular Surface Disease Index (OSDI) questionnaire.¹⁰ It is composed of twelve questions that provide a rapid assessment of the symptoms of ocular irritation consistent with DES and their impact on vision-related functioning. DEWS 2 was adapted for the severity grading of OSDI.¹¹

Age, gender and province of residence were assessed as demographic data. The information collected on computer usage was daily digital usage that included cumulated hours spent on computer, television and mobile/tablet. Questions on potential risk factors were prepared after reviewing the articles on computer vision syndrome in the literature. Subjects underwent a detailed ophthalmic examination, including best-corrected visual acuity, intraocular pressure measurement with noncontact tonometer, anterior segment and fundus examination with a slit-lamp biomicroscope. The tests were administered at the end of the work day and measurement conditions remained the same for all subjects. Following the OSDI questionnaire and ophthalmic examination, subjects underwent the fluorescein tear break up time (F-BUT), corneal and conjunctival fluorescein staining¹² and the Schirmer's test. A gap of 5 min was kept between staining and Schirmer's.¹¹ Sequence of tests was kept as described by Bron.¹³

To measure F-BUT, a sterile strip of fluorescein was applied in the lower eyelid fornix and then removed. The subject was asked to blink three times and then look straight forward,

without blinking. The tear film was observed under the cobalt blue filtered light of the slit lamp microscope and the time that elapsed between the last blink and appearance of the first break in the tear film was recorded with a stopwatch. This procedure was repeated three times on both eyes. A F-BUT of less than 10 seconds was considered consistent with DES. It was further graded into mild (6-9 sec), moderate (1-5 sec) and severe (0 sec).

Corneal fluorescein staining was assessed and was recorded as central and peripheral staining. Conjunctival fluorescein staining was noted as present or absent.

Five minutes after the F-BUT, Schirmer's I test (with anesthesia) was performed to evaluate reflex tear secretion. In the Schirmer's I test, a filter paper strip (35 × 5 mm) was used to measure the amount of tears produced over 5 minutes. The strip was placed at the junction of the middle and the lateral thirds of the lower eyelid. The test was performed under ambient light. The patients were directed to look forward and to blink normally during the course of the test (5 minutes). Then wetting of the filter paper in 5 minutes was recorded. Wetting less than 10 mm was considered consistent with DES. It was further graded into mild (7-10 sec), moderate (4-6 sec) and severe (0-3 sec).

We have classified patients as per severity on the basis of F-BUT and ocular surface staining; mild: patients with F-BUT >5 sec with or without only conjunctival staining, moderate: patients with F-BUT less than 5 but not 0 and/or peripheral corneal staining, severe: patients with F-BUT 0 sec and/or with central corneal staining. This classification was correlated with OSDI grading.

Statistical analysis was done with SPSS software. Descriptive analysis was shown as percentages. T-test was used for to calculate significance between groups and chi-square and fisher exact test were used for proportions. For correlation, crosstab and Pearson correlation analysis was done. Post hoc analysis was done with Tukey's test. ROC curves were made for individual objective test. Significance was kept as 0.05.

Results

A total of 26 subjects were enrolled in the study; 7 (26.9%) were female and 19 (73.1%) were male. The mean age was 26.76 ± 5.16 years and 76.92% patients were less than 30 years of age with significant male preponderance (p=0.019). Mean duration of exposure was 9.84 ± 2.50 hours/day (range 4–15 hours). Males have higher mean usage (10 hours versus 9.42 hours) though it was not found to be significant (p=0.298) (Table 1).

To assess effect of exposure duration, we divided patients in two groups according to exposure duration: Group A with less than 8 hour exposure and Group B with more than 8 hour exposure. OSDI was significantly higher in Group B (41.5+/-11.50, p=0.04). None of the objective test was found to be significantly different in both groups (Table 2).

Most common presenting complaints were headache and redness of the eyes (22.22% each). Others reported complaints were heaviness, foreign body sensation, irritation, burning sensation, pain, glare and blurring in decreasing frequency. As per OSDI grading, 65% of the patients were in severe grade. Males have significantly higher tendency to have

Table 1: Age-wise gender distribution and duration of exposure

Age-Group (in years)	Gender Distribution		Mean Exposure Duration (in Hours)	
	Male	Female	Male	Female
<30	15	6	9.86+/-2.85	9.18+/-0.98
30-40	4	0	10.5+/-3.32	"-"
>40	0	1	"-"	11+/-0

Table 2: Relationship of Exposure Duration

Parameters	Exposure Duration		P value
	<8 hours	>8 hours	
Age (in years)	27.25+/-3.65	28+/-5.79	0.7399
Gender Ratio (Male:Female)	3:1	2.6:1	0.8762
Presenting Symptom	Redness (41.67%)	Headache and Heaviness (41.67%)	
OSDI score	31.77+/-8.75	41.58+/-11.50	0.0424
Schirmer's	11.81+/-6.53	16.25+/-8.32	0.1951
F-BUT	3.56+/-2.55	2.81+/-1.86	0.4056
Conjunctival Staining +	62.5%	77.78%	0.4259
Corneal Staining +	75%	75%	1.0000
Central Corneal Staining +	12.5%	16.67%	0.7897

Table 3: Mean values of various tests

Dry Eye Parameters	Mean	Min	Max
OSDI	38.56+/-11.52	20.8	68.75
Schirmer's	14.88+/-8.02	2	35
F-BUT	3.04+/-2.11	0	10

moderate to severe scores as compared to females (p=0.000). OSDI is also found to be significantly correlating with corneal (p=0.000) and conjunctival (p=0.006) staining. Patients with central corneal staining had moderate to severe OSDI score (mean OSDI 36.98).

Schirmer's was in normal range in 78.85% of the patients. F-BUT was less than 5 sec in 92.3% and 0 sec in 7.69% of the patients. (Table 3) It did not significantly correlate with age, gender, exposure duration, OSDI and Schirmer's test. Conjunctival staining was present in 38 eyes while corneal staining was present in 39 eyes. Central corneal staining was present in 8 eyes. ROC curves for individual test showed that corneal and conjunctival staining are more sensitive tests for dry eyes and schirmer's was found least sensitive (Figure 1), (Table 4).

As per our classification, 7.69% eyes were in mild group, 71.15% eyes were in moderate group and 19.23% eyes were in severe group. As per our grading, majority patients were in moderate group while as per OSDI grading, majority patients were in severe grade (Table 5), (Figure 2).

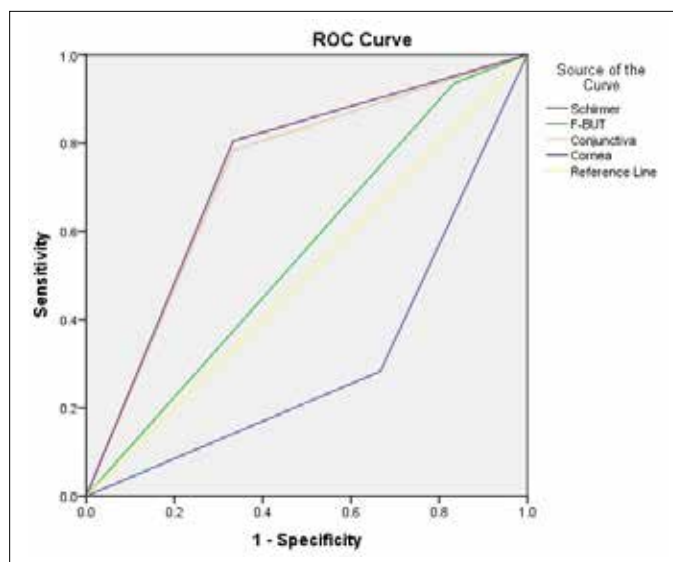


Figure 1: ROC curve of all objective tests: Ocular surface staining showed largest AUC thus was more sensitive as compared to F-BUT and Schirmer's. Schirmer's test with least AUC was least sensitive method of all.

Table 4: AUC of objective tests for dry eyes

Test Result Variables	Area Under the Curve			Asymptotic 95% Confidence Interval	
	Area	Std. Error	Asymp-totic Sig.	Lower Bound	Upper Bound
Schirmer test	.308	.119	.129	.075	.541
F-BUT	.551	.133	.688	.290	.812
Conjunctiva Staining	.725	.118	.076	.492	.957
Cornea Staining	.736	.118	.063	.503	.968

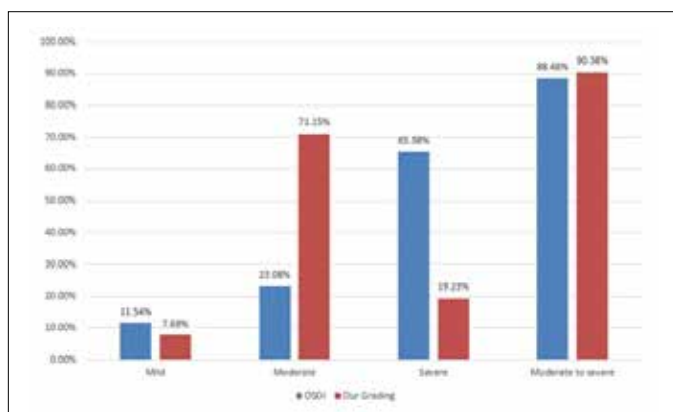


Figure 2: Comparison of new grading system with OSDI score grading (subjective): As per OSDI, majority patients were of severe dry eye while as per objective tests, ocular surface changes were of moderate grade.

Table 5: Our Severity Grading and its comparison with OSDI scores

Grading	OSDI	Our Grading	P value
Mild	11.54%	7.69%	0.64
Moderate	23.08%	71.15%	0.0006
Severe	65.38%	19.23%	0.0009
Moderate to severe	88.46%	90.38%	0.82

Discussion

This study was done to evaluate DES in digital screen users with routine objective tests which include Schirmer's, F-BUT and ocular surface staining. We found 76.92% of the patients were in the age group less than 30. Various other studies also reported similar prevalence in less than 30 years age group (6). Our study found higher prevalence in males which also corroborates with previous studies.⁹

Mean exposure duration was highest in 30-40 years age group but this was not significant ($p=0.458$). This can be explained by the lesser number of patients in the >30 years group. All except one patient has exposure duration >6 hours. Ranashinge et al studied 2212 patients and found mean daily computer usage in patients with digital strain was 7.8 ± 3.3 h.¹⁴

Asthenopic symptoms like headache, heaviness and glare were the most common presenting complaint in 44.67% of the patients. Symptoms related to digital screens were classified by Porcar et al in 2016 and they also reported that asthenopia is the most common presentation.⁷

OSDI significantly correlated with gender ($p=0.00$), ocular surface staining ($p=0.00$) and Schirmer's test ($p=0.015$). Patients with ocular surface staining were having mean OSDI score of 40.05. This can be interpreted as patients with ocular surface damage were more symptomatic. OSDI was not found to be significantly correlating with exposure duration ($p=0.201$) and F-BUT ($p=0.422$). Unlu et al did not found significant correlation between exposure duration (range 1-12 hours) and OSDI. They also reported 42% incidence of dry eyes with FBUT and 35% incidence with OSDI >35 . They found significant correlation of FBUT with OSDI in diagnosis of DES.¹⁵ This discrepancy in results can be explained partly by their higher cut-off value of OSDI (score 35) as compared to cut-off value used in our study (OSDI score 12). They also have not mentioned cut-off values of FBUT. Their mean value of TBUT was also higher (11.37 sec) as compared to our values (3.03 sec).

Ong et al calculated discordance score (DS) for symptoms and signs in 326 patients of DES with mean age of 62 years. DS was the difference between the patient's ranked score on their transformed OSDI (range 0-1) and their ranked composite signs severity score (range 0-1). As such DS ranged from -1 (minimal symptoms and maximal signs) to 1 (maximal symptoms and minimal signs). A positive DS indicates more symptoms than signs. They reported that age was negatively correlated with DS ($r=-0.30$, $p<0.0005$). (16) In our study patients were younger so non-significant correlation of OSDI and F-BUT can be explained by higher DS in younger patients.

F-BUT was not found to correlating with any variable. It may be explained by two factors. One is high exposure duration in all the groups. Previous studies reported continuous exposure as long as 1 hour can cause symptoms of DES and the minimum exposure duration in our study was 4 hours. It may also be because of small sample size and unequal distribution of patients in different sub-groups. There is no other study that has reported this analysis before and there is no minimum safe exposure duration defined. We have found that even exposure duration of 4 hours can cause

decrease in F-BUT. But future large case-control studies are required to compare the effect of low and high exposure duration. Area under curve was 0.551 for F-BUT thus it was not found as very sensitive tool for dry eye. This need to be re-evaluated with large sample size.

Ocular surface staining was present in 74% patients. Central corneal staining was present in 15.38% of the patients. Patients with central corneal staining were found to have T-BUT <3 sec. Ocular surface staining was sensitive for diagnosing dry eyes though it was not significant. It can be due to small sample size.

Schirmer's 1 test was more than 10mm in 35 out of 52 eyes. Sensitivity of Schirmer's test was found to be 32.69%. Lucca et al¹⁷ and Farris et al¹⁸ also reported low sensitivity of Schirmer's tests in their studies. DEWS 2 also reported high variability in sensitivity, specificity and repeatability of Schirmer's. And they not mentioned Schirmer's in their proposed diagnostic test battery. This report also mentioned about the ways to decrease the chances of error.¹¹ Despite having low sensitivity, significant correlation with OSDI and Schirmer's test can be explained by the reflex epiphora. This may be because of ineffective anesthesia. It is a flaw in our study; we should have repeated Schirmer's after re-anesthetizing eyes. But we have not used Schirmer's values for our severity grading thus it has no impact on our grading system.

Classification as per exposure duration analysis showed that there is ocular surface damage in both groups but it was not statistical different. But patients with higher exposure duration were more symptomatic as their OSDI score was higher. Even our severity based grading showed that majority patients were in moderate grade (57.69%) while as per OSDI majority patients were in severe grade (65.38%). This discordance in symptoms and signs is well documented in literature.¹⁵ This concordance with the literature strengthens validity of our severity grading system.

There is no consensus on the treatment guidelines for the management of DES.¹⁹ As per our grading, 90.38% patients and as per OSDI grading 88.46% patients were in moderate to severe group (p=0.82). It can be interpreted as majority of the patients who are symptomatic also have F-BUT <5 sec and positive corneal staining. Goto et al also found cut-off value of F-BUT < 5 sec to be 98% sensitive.²⁰ A prospective study will be planned in future to assess the validity of classification. If validated, it can serve as simplified treatment protocols and also there will not be any disparity in management.

But our study results should be interpreted with caution because of small sample size thus sub-group analysis could have been skewed. Furthermore, we have included only digital screen users and excluded all other causes and confounding factors thus cannot comment on effect on other causes. Also we have not included Schirmer's for treatment protocols; it might have affected our results. But it is not advised in DEWS II battery tests for the diagnosis of DES. Patients presented to us could have exposed to different environmental conditions. This could have resulted in over or underestimation of severity.

There are few strong points also in our study. We have

compared OSDI with our classification based on routine diagnostic tests and found them correlating. Despite this, further studies with large sample size will be required to reinforce results found in this study and validate our classification. This will help in defining treatment protocol for this set of patients.

Conclusions

With this study, it can be concluded that digital screens are causing ocular surface damage. There is no defined minimum duration of exposure that will have adverse effects on ocular surface. Proposed classification for the severity of digital strain can serve as base of severity based treatment protocol.

List of Abbreviations:

- DES: Dry Eye Syndrome
- OSDI: Ocular Surface Disease Index
- F-BUT: Fluorescein Tear Break up Time
- DS: Discordance Score

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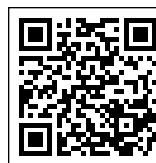
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