Original Article

An Investigation of the Psychosocial Outcomes of Dry Eye Disease Treatment in Children with Computer Vision Syndrome

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Abstract

Objectives: Computer vision syndrome (CVS) is a common disorder among children and is often associated with dry eye disease (DED). While researchers have shown a higher prevalence of psychopathology in older patients with DED, the impact of CVS-induced DED on the psychological state of children is not well known. This study aimed to evaluate psychological outcomes before and after DED treatment in pediatric patients with CVS-related DED.

Materials and Methods: In this study, a total of 38 children (32 girls, 6 boys) with CVS-related DED were evaluated with the Schirmer test, tear break-up time (TBUT), ocular surface disease index (OSDI), and Oxford grading scale at the time of diagnosis and after treatment with artificial tear drops. Additionally, quality of life (QoL) and anxiety and depression symptoms were assessed using self-report scales for children.

Results: The mean age and mean daily screen exposure of the patients were 13.95±2.42 years and 5.65±2.31 hours, respectively. After treatment, TBUT and Schirmer test values of the patients increased significantly, while OSDI values decreased ($p<0.001$ for all). The anxiety and depression scores of the patients decreased, while QoL functionality scores increased ($p<0.05$ for all) following treatment. There were significant correlations between Schirmer test values and anxiety scores ($r=-0.32$, $p=0.045$) and QoL total scores ($r=0.38$, $p=0.016$).

Conclusion: Enhanced QoL and decreased anxiety and depression scores were associated with improved Schirmer test results, indicating that appropriate DED treatment may mitigate the psychosocial effects of CVS-related DED in pediatric patients.

Keywords: Dry eye disease, computer vision syndrome, children, quality of life, anxiety, depression

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Introduction

Computer vision syndrome (CVS) is defined as a collection of eye-related issues and visual disturbances that occur due to prolonged use of digital screens.[1] CVS is commonly associated with prolonged computer usage exceeding 3 hours per day, and it is often characterized by visual, ocular and musculoskeletal symptoms.[2] The exponential proliferation of digital devices has made them an integral part of daily life, putting millions of individuals across all age groups at risk of developing CVS. Individuals spend more time on computers, laptops, smartphones, tablets, and e-readers, which contribute to CVS. Compared to the last few decades, children also spend extensive time using digital screens for schoolwork, playing video games, and engaging in communication activities such as sending and receiving text messages.[3] According to previous studies, the prevalence of CVS in children and adolescents is estimated to range from 50% to 70%.[4,5]

The primary clinical manifestation of CVS is dry eye disease (DED), which occurs at a prevalence of approximately 60%.[6] DED is characterized by persistent symptoms such as tearing, burning or stinging sensations, ocular discomfort, blurred vision, and photophobia. These symptoms have been documented to have negative effects on quality of life (QoL), impacting not only vision-related daily life but also broader aspects of general well-being.[7,8,9] Additionally, studies have revealed a higher prevalence of psychiatric disorders in patients with DED.[10,11,12] Among psychiatric diagnoses, anxiety and depressive disorders were the

most frequently investigated, and findings consistently indicated that individuals with DED exhibited elevated levels of anxiety and depressive symptoms compared to those without DED.[13,14,15]

Treatment options for DED often involve the use of artificial tear substitutes, which aim to replenish the natural tear film and lubricate the eyes to alleviate symptoms.[16] Previous studies have reported that artificial tear therapy has been associated with improvement in QoL.[17] Additionally, the potential of artificial tears to alleviate symptoms of anxiety and depression in DED patients has also been described.[18,19]

Drawing from the aforementioned research, it can be inferred that DED treatment might positively impact the psychological well-being of children diagnosed with CVS-related DED. The primary objective of the present study was to assess the impact of DED treatment on health-related QoL, as well as levels of depression and anxiety, among pediatric patients with CVS-related DED.

Materials and Methods

Study Design and Participants

This prospective study was conducted in the ophthalmology and psychiatry departments of a secondary care hospital. The study was approved by the Haseki Training and Research Hospital Ethics Committee (approval number: 55-2022, date: 23.03.2022) and conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all children and their parents.

The study included 38 children between 9 and 18 years old who were diagnosed with CVS-related DED and presented to the ophthalmology outpatient clinic. CVS was diagnosed based on the presence of eye complaints such as eye fatigue, burning, irritation, redness, and blurred vision due to long-term computer or digital screen use. All patients complained of worsening symptoms during exposure to digital screen light. To assess average daily screen exposure, a questionnaire was employed to determine the duration of computer, laptop, and phone usage during the last 6 months, measured in hours per day. Total daily screen exposure time was calculated for each child before and after DED treatment.

Exclusion criteria were the presence of neurological disorders (e.g., cerebral palsy, epilepsy), systemic chronic illnesses (e.g., type 1 diabetes), and history of any psychiatric diagnosis. Ophthalmological exclusion criteria were as follows: presence of any other eye diseases (e.g., retinal disease, uveitis, glaucoma, congenital cataract, pterygium, conjunctivitis, keratitis, blepharitis, nystagmus, orbital pathology, or history of ocular trauma or surgery); previous diagnosis of dry eye; use of any ophthalmic medication or contact lenses; and spherical equivalent outside the range of ±0.5 diopters, intraocular pressure measurements exceeding 21 mmHg, best corrected visual acuity below 20/25, or non-cooperation during the initial ophthalmological examination.

Initially, 85 children with CVS-related DED were recruited for the study. Of these, we also excluded participants with other factors that may contribute to DED symptoms, such as exposure to sun, wind, or air conditioning (n=15), those without complete ophthalmologic examinations during follow-up (n=20), and those who were non-cooperative with psychiatric assessments (n=12). Finally, a total of 38 children were included in the analysis.

Ophthalmologic Evaluation

All participants underwent comprehensive ophthalmological assessments that included best corrected visual acuity measurement using the Snellen chart, biomicroscopic examination of the anterior segment, intraocular pressure measurement via non-contact tonometry, and dilated fundus examination. A single automatic refractor-keratometer device (RF-K2, Canon Inc., Tokyo, Japan) was utilized to measure spherical equivalent.

Ocular surface damage and signs of tear dysfunction were assessed using the tear break-up time (TBUT) test, Schirmer test, ocular surface disease index (OSDI), and Oxford grading scale before and one month after treatment. The OSDI questionnaire was completed by the children with the assistance of their parents and specialists. The question regarding night driving was deemed irrelevant for children and was consequently excluded from the final score calculation.[20] The reliability of the OSDI among children has been previously assessed and confirmed.[21] To evaluate TBUT, fluorescein was instilled in the lower conjunctival sac, and the tear film was examined with a blue filter. The appearance of the first dry spots on the cornea since the last blink was observed, and the average of three consecutive measurements was obtained in seconds. Schirmer's test was evaluated with topical proparacaine hydrochloride (Alcaine, Alcon, Fort Worth, USA) to test basal tear secretion using a specialized Schirmer's strip prepared from Whatman grade 41 filter paper. Symptomatic DED was diagnosed using the OSDI questionnaire, TBUT, and Schirmer tests. The criteria for diagnosis included an OSDI score of ≥13, a TBUT of ≤10 seconds, and a Schirmer test result of ≤10 mm. The Oxford grading scale was used to rate the grade of corneal and conjunctival staining.

Dry Eye Treatment

Treatment for DED consisted of preservative-free artificial tear drops containing dextran and hydroxypropyl methylcellulose (Tears Naturale Free, Alcon, Fort Worth, USA) to reduce the ocular irritation secondary to preservatives. The administration of topical drops (4 times daily) was to be supervised by parents at home and by teachers during school hours. Additionally, the 20-20-20 rule and digital screen limitation were recommended for all patients. This rule can be defined as taking a 20-second break to look at something 20-feet away every 20 minutes.[22]

Psychiatric Measures

Following the ophthalmologic examination, all participants were asked to complete the psychiatric scales in one session that lasted approximately 30 minutes. After one month of follow-up, the same questionnaires were repeated.

In the current study, the Revised Child Anxiety and Depression Scale-Child Version (RCADS-CV) and Pediatric Quality of Life Inventory (PedsQL) were used to assess the children's psychiatric symptoms and QoL, respectively, based on children's own reports.

The PedsQL was developed by Varni et al.[23] to assess health-related QoL in children. The PedsQL 4.0 Generic Core Scales include 23 items in 4 subscales: (1) physical functioning, (2) emotional functioning, (3) social functioning, and (4) school functioning. A 5-point response scale with scores ranging from 0 to 4 was used to assess child self-reports. Items were reverse-scored and linearly transformed to a 0 to 100 scale (0 = 100%, 1 = 75%, 2 = 50%, 3 = 25%, 4 = 0%), so that higher scores indicated better QoL. The score range was based on the percentage of the total summary and subscale scores on the PedsQL.[24] The Turkish version of the PedsQL was found to be valid and reliable for the age group of 7 to 18 years.[25,26]

The RCADS-CV was developed to screen for anxiety, depression, and obsessive-compulsive symptoms in children and adolescents. This self-report questionnaire consists of 47 items in 6 subscales: generalized anxiety disorder, separation anxiety disorder, panic disorder, obsessive-compulsive disorder (OCD), social phobia, and major depressive disorder. Additionally, there are two comprehensive subscales referred to as "total internalizing" and "total anxiety." Each item is scored between 0 and 3 (0 = never, 1 = sometimes, 2 = often, 3 = always).[27] The validity and reliability of the Turkish version were conducted by Gormez et al.[28]

Statistical Analysis

A statistical power analysis was conducted to estimate the required sample size. To achieve an 80% power level (alpha = .05) for the detection of a medium effect size, the anticipated sample size required, as determined by G*Power 3.1, was approximately 34.[29,30,31] Statistical analyses were performed using SPSS 24.0. The Shapiro-Wilk test was utilized to determine whether the data were normally distributed. Comparisons of psychiatric scale measures and dry eye evaluation tests between pre- and post-treatment were reported using paired-samples t-test due to the normal distribution of the data. Pearson's correlation analyses were conducted to determine the associations between the improvements in ophthalmic measurements and psychiatric scales.

Results

The demographic and clinical characteristics of the patients are summarized in Table 1. Of the 38 children diagnosed with CVS-related DED, 32 (84.2%) were female, and 6 (15.8%) were male. The mean age was 13.95±2.42 years. The mean duration between two consecutive assessments was 35.36±8.62 days.

According to the analysis of the children's dry eye tests, which included TBUT, Schirmer, and OSDI values before and after topical treatment, statistically significant differences were identified (Table 2). Mean TBUT and Schirmer test results were 7.45±3.43 s and 11.84±6.50 mm at the time of diagnosis and 9.92±2.89 s and 15.66±6.40 mm at the time of the follow-up examination, respectively. The mean OSDI score decreased from 45.99±15.47 to 25.46±13.37 with DED treatment (p<0.001). There was also a significant reduction in daily screen exposure time between the pre- and post-treatment evaluations (5.65±2.31 h vs. 4.88±2.56 h, p=0.004). When examining the pre- and post-treatment Oxford grading scale results, we observed that in the pre-treatment assessment, 6 children (15.8%) were classified as having an Oxford grade 1, whereas 32 of them (84.2%) were categorized as grade 0. Following the post-treatment evaluations, all children exhibited an Oxford grade of 0.

Table 1. Sociodemographic and clinical characteristics of the patients (n=38)

Characteristic	
Age (years)	13.95±2.42
Sex (male/female), n (%)	6 (15.8)/32 (84.2)
BCVA (Snellen decimal)	0.97±0.05
Spherical equivalent, D	-0.09±0.55
IOP, mmHg	15.7±3.1
Daily screen exposure (hours)	5.65±2.31

Values are presented as mean ± standard deviation unless otherwise noted. BCVA: Best corrected visual acuity, D: Diopter, IOP: Intraocular pressure

Additionally, significant improvements in QoL and anxiety, depression, and OCD symptoms were found among children with CVS-related DED following treatment. Pre-treatment scores and post-treatment outcomes are displayed in Table 2 with corresponding p-values. According to the results, a substantial improvement in QoL and a decrease in RCADS-CV subscales were observed.

At the time of the initial examination, daily screen exposure time was not associated with TBUT but was significantly correlated with OSDI score (r=0.401, p=0.025) and Schirmer test results (r=-0.366, p=0.049). Additionally, no significant correlation was detected between screen usage time and psychiatric measures (p>0.05 for all). At the follow-up examination, Schirmer test values were positively correlated with QoL scores (total and emotional functioning domain) and negatively correlated with generalized anxiety, total anxiety, and total internalizing scores. QoL scores were also negatively correlated with anxiety and internalizing scores (Table 3).

Discussion

In this study, we observed a decrease in anxiety and increase in functionality in association with reduced dry eye severity after dry eye treatment. This suggests that CVS-related DED may have detrimental psychosocial effects in pediatric patients that could potentially improve with appropriate DED treatment.

Given the widespread use of digital screens, the age at first exposure to screens is decreasing. Studies have reported digital screen usage rates of up to 92.7% in the pediatric population.[32] The widespread use of digital screens such as computers, tablets, and smartphones has significantly contributed to the spread of CVS-induced DED in children and adolescents.[33,34] A recent

Table 2. Comparison of dry eye test results and psychiatric scale scores before and after treatment for dry eye			
Dry eye tests	**Pre-treatment Mean ± SD**	**Post-treatment Mean ± SD**	**p***
TBUT, s	7.45±3.43	9.92±2.89	**<0.001**
Schirmer test, mm	11.84±6.50	15.66±6.40	**<0.001**
OSDI	45.99±15.47	25.46±13.37	**<0.001**
Scales			
PedsQL			
Physical functioning	72.44±19.28	82.15±14.40	**<0.001**
Emotional functioning	64.86±21.03	73.94±18.16	**0.006**
Social functioning	84.86±21.73	90.13±13.87	**0.04**
School functioning	68.28±18.82	75.65±17.09	**0.003**
Total	72.76±16.94	80.47±12.61	**<0.001**
RCADS-CV			
GAD	49.08±10.97	43.07±11.24	**0.002**
SAD	53.29±11.37	49.36±10.35	**0.03**
PD	57.24±13.07	52.44±10.91	**0.01**
OCD	53.21±11.52	47.78±10.94	**0.004**
SP	48.16±13.10	40.39±10.88	**0.001**
MDD	49.55±14.09	44.47±12.25	**0.003**
Total anxiety	52.94±13.22	45.05±12.25	**0.001**
Total internalizing	52.36±13.58	44.73±12.40	**0.001**

*Paired-samples t-test. Bold values indicate statistical significance (p<0.05). SD: Standard deviation, TBUT: Tear break-up time, OSDI: Ocular surface disease index, PedsQL: Pediatric Quality of Life Inventory, RCADS-CV: Revised Child Anxiety and Depression Scale-Child Version, GAD: Generalized anxiety disorder, SAD: Social anxiety disorder, PD: Panic disorder, OCD: Obsessive-compulsive disorder, SP: Social phobia, MDD: Major depressive disorder

Table 3. Correlations between psychiatric scale scores and Schirmer test						
		Schirmer	**RCADS-anxiety**	**RCADS-internalizing**	**RCADS-GAD**	**PedsQL-total**
RCADS-anxiety	**r** **p**	**-0.32*** **0.045**				
RCADS-internalizing	**r** **p**	-0.30 0.067	**0.99***** **<0.001**			
RCADS-GAD	**r** **p**	**-0.32*** **0043**	**0.89***** **<0.001**	**0.88***** **<0.001**		
PedsQL-total	**r** **p**	**0.38** **0.016**	**-0.48**** **0.002**	**-0.47**** **0.002**	**-0.39*** **0.014**	
PedsQL-emotional functioning	**r** **p**	**0.32*** **0.043**	-0.29 0.075	-0.30 0.066	-0.27 0.092	**0.79***** **<0.001**

Bold values indicate statistical significance (*p<0.05, **p<0.01, ***p<0.001). RCADS: Revised Child Anxiety and Depression Scale-Child Version, PedsQL: Pediatric Quality of Life Inventory, GAD: Generalized anxiety disorder, r: Pearson's correlation coefficient

study exploring the correlations between computer exposure time and dry eye tests, including Schirmer, TBUT, and OSDI, indicated that longer exposure time results in worse dry eye test results.[35] In line with this study, we found significant correlations with digital screen exposure time for OSDI score and Schirmer test results. However, the relationship was not significant for TBUT.

It is well known that DED has a detrimental impact on the patient's daily life. The unpleasant symptoms of dry eye, such as burning, stinging, ocular grittiness, foreign body sensation, blurred vision, and photophobia, could contribute to impaired QoL.[36] In addition to alterations in visual performance and ocular functioning, chronic pain may also play a role in the poor QoL of patients with DED.[8,9,37] Moreover, topical eye drops for DED were found to be associated with improved QoL compared to baseline, as a significant number of patients reported relief from symptoms.[38,39] Consistent with this, our study revealed statistically significant improvements in QoL across all domains at the post-treatment assessment. Furthermore, positive correlations were observed between QoL scores, particularly

emotional functioning and total summary scores, and the results of the Schirmer test. These results suggest that DED symptoms resulting from prolonged digital screen exposure can have detrimental effects on adolescents' QoL, and accurate treatment of CVS-related DED may lead to an increase in QoL for pediatric patients.

Dry eye symptoms can exacerbate or trigger symptoms of anxiety and depression. For instance, ocular pain and discomfort may lead to psychosocial stress, depression, and anxiety.[40,41] Conversely, depression, stress, and anxiety can influence subjective ocular symptoms and pain perception, contributing to the establishment of a cyclic relationship.[42,43,44] Anxiety may also arise from patients' concerns regarding their symptoms and the potential occurrence of DED.[15] Additionally, it has been proposed that individuals with depression may be more susceptible to DED due to elevated levels of proinflammatory cytokines,[45] as well as alterations in neurotransmitters and neuropeptides.[46]

Regarding the depression and anxiety levels of participants in this study, we observed statistically significant reductions in depression, all subtypes of anxiety, and total internalized symptoms following DED treatment compared to baseline scores. This underscores the notable association between the severity of DED and the presence of depression and anxiety symptoms, suggesting that successful management of DED may have a beneficial effect on alleviating symptoms of depression and anxiety.[18] In accordance with this thought, a recent study demonstrated an association between eye drop frequency and depression and anxiety scores, suggesting that topical eye drops potentially play a significant role in the psychosocial status of patients with DED.[19] In the current study, significant associations between the increase in Schirmer test values and the decreases in generalized anxiety and total anxiety scores were also detected. This is also in line with previous research indicating that the severity of DED symptoms impacts depressive symptoms in both younger and older populations.[37,38,39,42] In summary, CVS-related DED may increase depressive symptoms and anxiety levels in pediatric patients, suggesting it has detrimental effects not only on the ocular system but also psychiatric well-being.

Study Limitations

This study has several notable strengths and limitations. Primarily, it fills a crucial void in the existing literature by being the first study to delve into the QoL, depression, and anxiety levels of pediatric patients afflicted with CVS-related DED specifically. The prospective study design also allowed an evaluation of changes over time, thereby bolstering the reliability and credibility of the findings.

Nevertheless, it is imperative to delineate certain limitations inherent in the study. Foremost, the relatively modest sample size may limit the generalizability of the findings and impede the discernment of subtle yet clinically significant differences. To mitigate this limitation, future research endeavors should utilize a longitudinal design and larger cohort to validate and strengthen the conclusions drawn. Additionally, the short follow-up period employed in this study might fail to capture enduring changes in QoL and psychological outcomes. Therefore, conducting investigations with prolonged follow-up is warranted to elucidate the trajectory of these outcomes over time. However, it is pertinent to recognize that CVS-related DED typically does not necessitate protracted treatments, as it commonly resolves rapidly following topical interventions and adherence to recommendations concerning digital screen usage. Furthermore, the abbreviated follow-up period in our study may offer a more accurate depiction of psychological outcomes, given their susceptibility to fluctuations influenced by various social and environmental factors. Another limitation of the present study pertains to the absence of impression cytology within our methodology. Moreover, reliance on self-report measures to assess QoL, anxiety, and depression levels may introduce potential biases such as recall bias or subjective interpretation. To enhance the robustness and validity of the findings, future studies could integrate objective measures or clinical assessments. Additionally, it is conceivable that a notable placebo effect might be at play, potentially confounding the observed results. Lastly, the absence of a control group receiving no treatment for DED due to ethical considerations poses a limitation, as it precludes the ability to discern the specific effects of the intervention. Subsequent research with a more targeted approach toward this aspect are warranted to gain a comprehensive understanding of the associations under investigation.

Conclusion

In conclusion, there is a noticeable dearth of research focusing on the impact of topical treatment on QoL and psychosocial well-being, including anxiety and depression symptoms, in children with CVS-related DED in the available literature. The present study revealed a significant reduction in anxiety levels and improvement in QoL functionality scores following treatment for DED. These findings underscore the notion that pediatric patients with CVS-related DED experience considerable psychosocial effects that might be alleviated through appropriate treatment interventions for DED. Moreover, the study highlights the importance of further research endeavors aimed at elucidating the intricate relationship between psychiatric disorders and dry eye symptoms among children and adolescents afflicted with CVS-related DED. By delving deeper into these associations, future studies can contribute to a more comprehensive understanding of the multifaceted impact of DED on the psychosocial well-being of children and adolescents. Such investigations are crucial for informing tailored interventions and support strategies aimed at ameliorating the psychosocial burden experienced by this vulnerable population.

Ethics

Ethics Committee Approval: The study was approved by the Haseki Training and Research Hospital Ethics Committee (approval number: 55-2022, date: 23.03.2022) and conducted in accordance with the ethical principles of the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from all children their parents.

Authorship Contributions

Surgical and Medical Practices: A.M.K., E.Ö., Concept: R.D.T., A.M.K., Design: R.D.T., A.M.K., E.Ö., Data Collection or Processing: R.D.T., A.M.K., E.Ö., Analysis or Interpretation: R.D.T., A.M.K., Literature Search: R.D.T., A.M.K., E.Ö., Writing: R.D.T.

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