Original Article

Assessment of Corneal Biomechanical Properties using Scheimpflug Camera-Based Imaging in Night Shift Medical Staff

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Abstract

Purpose: To evaluate the effect of night shifts on the biomechanical properties of the cornea using Scheimpflug camera-based imaging (Corvis and Pentacam).

Methods: Thirty-four participants from the medical staff who had at least six night shifts per month as a case group and fifty-two participants as a control group participated in the study. The biomechanical characteristics of the cornea using the Corvis device and the topographical characteristics of the cornea using the Pentacam device were investigated in the participants.

Results: The main indices of corneal biomechanics including Corvis Biomechanical Index (0.17 ± 0.18 vs. 0.15 ± 0.14; *P* = 0.66 [adjusted] and 0.66 [unadjusted]) and Tomographic and Biomechanical Index (0.16 ± 0.19 vs. 0.14 ± 0.19; *P* = 0.78 [adjusted] and 0.63 [unadjusted]) were not significantly different between case and control groups.

Conclusion: Our study showed that night shifts do not independently affect corneal biomechanical indices.

Keywords: Corneal biomechanic, Corvis, Night shift, Pentacam

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Introduction

Night shifts and sleep deprivation are essential parts of a series of jobs, including physicians and other medical staff, which has caused burnout in the medical staff worldwide.[1] It is estimated that at least half of the medical staff around the world are facing job burnout, one of the most important causes of which is the lack of enough sleep.[2,3]

Sleep deprivation will disrupt the circadian cycle and the body's internal clock. The setting of this cycle is proportional to the brightness of the environment. On the other hand, circadian rhythm disorder is associated with hormonal and neuronal changes.[4] Because tear secretion is associated with neuronal function and different hormones, tear secretion can be affected by the patient's sleep–wake cycle, and, secondary to the change in the tear film, corneal biomechanics may change.[5]

Sleep disorders are significantly related to keratoconus (KCN)[6] occurrence. Studies have shown that sleep deprivation and staying awake at night can cause hyperosmolarity of tears, decreased tear film breakup time, and exacerbation of dry eye symptoms. The combination of these factors can cause ocular surface problems.[5,7]

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Some studies showed that, in addition to the association between eye itching and KCN, it implied the possible relationship between sleeping position and night-time work and KCN.[8] The present study attempts to investigate the effects of night shifts on corneal biomechanical indices.

Methods

This case–control study examines the medical staff (including residents, nurses, and other night shift workers) of Farabi Eye Hospital, totaling 34 individuals. In addition, a control group of 52 employees working regular daytime shifts were included for comparison. All participants were granted permission, as indicated in the consent form, to have their information published without disclosing their identities. The study's inclusion criteria encompassed individuals aged between 25 and 40 years old who had completed a minimum of 6 night shifts within the month, applying specifically to the case group.

The study has been approved by the local Ethics Committee of the Tehran University of Medical Sciences according to the Declaration of Helsinki ethical principles.

We obtained permission from participants in the consent form to publish their information without mentioning their names.

Notably, the control group had no experience with the night shifts. Individuals with corneal pathologies, including scars, corneal thickness below 470 µm, thick cornea with a thinnest point above 565 µm, myopia exceeding -5 diopters (D), hyperopia surpassing +5 D; systemic diseases including collagen vascular diseases and diabetes; any history of ocular trauma or surgery; and inadequate ocular imaging quality were excluded from the study. Furthermore, participants with the Strip Meniscometry Tube (SM-Tube) results measuring below 5 mm were excluded, which accounted for 7 individuals in the case group and 10 in the control group. Following the exclusion of these participants, data analysis was conducted, and participants who declined to continue their involvement in the study were also excluded.

A comprehensive ophthalmological assessment was conducted on all study participants. This assessment included a slit-lamp examination to evaluate the cornea, anterior segment, lens, and fundoscopy with pupil dilation to exclude any ocular pathologies or diseases. In addition, participants completed a questionnaire to provide essential data, including their monthly shift frequency, nocturnal wakefulness hours during shifts, medical history, and demographic details.

Refraction assessments were carried out by experienced optometric staff, and in cases where the results deviated from autorefractometer readings, a second experienced optometrist repeated the refraction. To evaluate the dry eye condition, the SM-Tube test involved placing the tube in the inferior tear meniscus for 5 s.

Each participant underwent imaging utilizing Pentacam and Corvis devices, both manufactured by Oculus Optikgeraete GmbH in Wetzlar, Germany. All examinations and measurements were conducted between 8 and 11 am to minimize the influence of circadian rhythms on our assessments of corneal biomechanical indices and intraocular pressure (IOP).

Statistical analysis

Statistical measures for data presentation, including the mean, standard deviation, median, range, frequency, and percentage, were utilized. Various statistical tests were employed to compare variables between two groups: the Chi-square test, *t*-test (for subject-related variables), and generalized estimating equation (GEE, for variables within eyes, accounting for potential correlations between measurements in both eyes of a subject). An additional GEE analysis was conducted to control for potential confounding variables.

All statistical analyses were executed using IBM SPSS Statistics software, Version 26.0, developed by IBM Corp. in 2019 (Armonk, NY, USA). A significance level of <0.05 ($P < 0.05$) was considered statistically significant.

Results

The study comprised 34 participants in the case group, encompassing 20 females (58.8%) and 14 males (41.2%). Conversely, the control group consisted of 52 participants, with an even distribution of 26 males and 26 females. The mean age for the case and control groups was 28.4 years, with standard deviations of 2.5 and 4.9 years, respectively. Notably, no statistically significant differences were observed between the case and control groups concerning the number of hours spent working on screens during the day (4.3 ± 0.5 vs. 4.4 ± 2.6; $P = 0.85$).

Regarding refraction, as measured by spherical equivalent, the case group exhibited −1.34 ± 1.38, while the control group showed −1.53 ± 2.08. Overall, no significant distinctions were observed between the case and control groups concerning gender, age, SM-Tube quantitative results, and refraction [Table 1].

Table 1: Demographic characteristics of study participants

Parameter	Levels/statistics	Group		*P*
		Case, *n* (%)	Control, *n* (%)	
Gender	Female	20 (58.8)	26 (50.0)	0.571*
	Male	14 (41.2)	26 (50.0)	
Age	Mean±SD	28.4±2.5	28.4±4.9	0.980**
	Median (range)	28 (25–39)	29.5 (25–37)	
Screen time (h)	Mean±SD	4.3±0.5	4.4±2.6	0.851**
	Median (range)	4.5 (3.5–5.5)	4.5 (1–6)	
SM-tube	Mean±SD	5.9±0.8	5.2±2.4	0.333***
	Median (range)	6 (5–7)	5 (5–8)	
Refraction (SE)	Mean±SD	−1.34±1.38	−1.53±2.08	0.758***
	Median (range)	−1 (−5.5–+2.5)	−2 (−4.5–+3.5)	

*Based on Chi-square test ,**Based on *t*-test ,***Based on GEE analysis. SD: Standard deviation, SM-Tube: Strip Meniscometry Tube, SE: Spherical equivalent, GEE: Generalized estimating equation

Table 2 presents the characteristics of the night shifts undertaken by participants in the case group, including the duration of their night shifts, the frequency of night shifts per month, and the duration of sleep each day following a night shift. The case group average engaged in night shifts for 3 years (equivalent to 36.4 months). The study participants experienced between 6 and 11 night shifts per month, with an average of 8.1, and subsequently slept 5 h each day following a night shift.

Table 3 provides information on the biomechanical properties of the cornea, as assessed using Pentacam and Corvis, within both the case and control groups. It is evident from Table 3 that the majority of corneal biomechanical parameters did not exhibit significant differences between the two groups. Differences between the groups were analyzed through adjusted models (accounting for all relevant study variables, including age, gender, screen time, SM-Tube result, and refraction) and unadjusted models. Notably, significant differences were only observed in three variables: integrated radius, deformation amplitude ratio (DA ratio), and biomechanically corrected IOP (BIOP).

Table 2: Characteristics of the night shifts of case group

Variable	Mean±SD	Median	Minimum	Maximum
Shift period (months)	36.4±14.5	36.0	6.0	72.0
Shift number (months)	8.1±2.5	6.0	6.0	11.0
Sleep time (h)	4.9±0.5	5.0	3.0	5.0

SD: Standard deviation

The integrated radius in the case group was lower than the control group (6.2 ± 1 vs. 8.7 ± 1.4; P < 0.001 [adjusted] and <0.001 [unadjusted]). The amount of DA ratio (3.8 ± 0.5 vs. 2.9 ± 0.3; P < 0.001 [adjusted] and <0.001 [unadjusted]) and BIOP (19.2 ± 2.1 vs. 17.7 ± 2.7; P = 0.03 [adjusted] and 0.01 [unadjusted]) in the case group was higher than the control group. The average IOP in the case group was higher than the control group (19.6 ± 3.2 vs. 17.9 ± 3.5), although this difference was not statistically significant (P = 0.055 [adjusted] and 0.10 [unadjusted]). The leading indices of corneal biomechanics, including Corvis Biomechanical Index (CBI) (0.17 ± 0.18 vs. 0.15 ± 0.14; P = 0.66 [adjusted] and 0.66 [unadjusted]) and Tomographic and Biomechanical Index (TBI) (0.16 ± 0.19 vs. 0.14 ± 0.19; P = 0.78 [adjusted] and 0.63 [unadjusted]) were not significantly different between case and control groups.

Considering the significant difference between the DA ratio and integrated radius variables in the case and control groups, we evaluated the correlation of night shift parameters with

Table 3: Biomechanical characteristics of the cornea in case and control groups using Pentacam and Corvis imaging results

Parameter	Group		Difference	95% CI		*P**	Adjusted *P***
	Case	Control		Lower	Upper		
Stiffness parameter	128.3±21.5	128.6±23	−0.28	13.46	12.9	0.976	0.777
Integrated radius	6.2±1	8.7±1.4	−2.52	−3.23	−1.82	<0.001	<0.001
ARTH	530.7±100.5	528.1±86.0	2.66	−38.38	43.69	0.898	0.183
DA ratio	3.8±0.5	2.9±0.3	0.87	0.62	1.11	<0.001	<0.001
IOP	19.6±3.2	17.9±3.5	1.66	−0.32	3.65	0.100	0.055
BIOP	19.2±2.1	17.7±2.7	1.53	0.12	2.94	0.033	0.010
K_{max}	43.9±1.6	44.6±1.4	−0.69	−1.62	0.22	0.139	0.143
IS value	0.09±0.6	0.05±0.72	0.03	−0.35	0.42	0.861	0.886
CBI	0.17±0.18	0.15±0.14	0.02	−0.07	0.12	0.660	0.668
BAD-D	0.98±0.64	1.16±0.69	−0.18	−0.58	0.21	0.358	0.368
TBI	0.16±0.19	0.14±0.19	0.01	−0.09	0.13	0.784	0.632
Thinnest point of cornea	532±31	533±32	10	−0.11	0.17	0.458	0.358

*Based on GEE analysis, **Adjusted for all possible variables. CI: Confidence interval, ARTH: Ambrósio relational thickness over the horizontal meridian, DA ratio: Deformation amplitude ratio, IOP: Intraocular pressure, BIOP: Biomechanically corrected intraocular pressure, K_{max}: Maximum keratometry, IS value: Inferior-superior value, CBI: Corvis Biomechanical Index, BAD-D: Belin/Ambrósio deviation, TBI: Tomographic and Biomechanical Index, GEE: Generalized estimating equation

Table 4: Correlation of shift period (months), shift number (months), and sleep time (h) with integrated radius and deformation amplitude ratio

Parameter	Integrated radius		DA ratio	
	Standardized coefficients	*P*	Standardized coefficients	*P*
Shift period (months)	−0.20	0.160	2.24	0.034
Shift number (months)	−0.30	0.046	−0.03	0.973
Sleep time (h)	−0.64	<0.001	−2.29	0.029

DA ratio: Deformation amplitude ratio

the DA ratio and integrated radius [Table 4]. The Integrated Radius Index has a significant relationship with the number of monthly shifts (standardized coefficients: −0.30, $P = 0.046$) and daily sleep time per hour (standardized coefficients: −0.64, $P < 0.001$). On the other hand, the DA ratio had a statistically significant relationship with the shift period (standardized coefficients: 2.24, $P = 0.034$) and the sleep time (standardized coefficients: −2.29, $P = 0.029$).

Discussion

Sleep disorders are one of the common problems in the treatment staff and people who have night shifts.[9] Occurrence of sleep disorders will cause many morbidities in patients.[10] Sleep disorders cause many changes in the endocrine and autonomic system, which increases blood pressure, increases stress hormones such as cortisol and norepinephrine,[11] and ocular disorders, which the most common disorder is tear secretion deficiency.[12] To the best of our knowledge, no study has been conducted to investigate the effect of night shifts on corneal biomechanics without considering the development of dry eye, and our study is an attempt to investigate this consequence. The study results show that night shifts have no significant relationship with biomechanical changes in the cornea.

Analyzing corneal biomechanical behaviors and indices is a beneficial method for diagnosing corneal ectasias and even predicting the probability of corneal ectasias because it can identify subclinical cases in contrast to topographic imaging findings.[13] On the other hand, combining topographical and biomechanical findings of the cornea is a better way to investigate ectatic corneal diseases,[14,15] which was the reason for our simultaneous use of Pentacam and Corvis in examining the participants in the study.

As mentioned in the literature review, no other study only examines the effect of night shifts on corneal biomechanical parameters. However, some studies have examined the effects of night shifts and sleep deprivation on KCN and dry eye. For example, Makateb and Torabifard[7] showed that night shifts would significantly increase patients' complaints of dry eyes and the clinical symptoms and findings of dry eyes. Moran *et al*.[8] also showed that night work and even sleeping positions have a significant relationship with the occurrence of KCN, which naturally indicates the influence of the mentioned factors on corneal biomechanical parameters. However, our study did not show the relationship between night shifts and changes in corneal biomechanical parameters independently.

In justifying the differences observed between our study's results and those of other studies, several points should be mentioned. First, our study measured only corneal biomechanical parameters. By excluding participants with dry eyes and adjusting the analysis for all available variables, no significant relationship was ultimately observed. Therefore, it is likely that the change in the biomechanical parameters of the cornea and the increase in the chance of KCN due to night shifts, as well as sleep deprivation and other sleep disorders[8,16] are related to the occurrence of dry eyes, decreased tear secretion, and other unknown mechanisms.

Second, most of the participants in our study were young and in their third decade of life (mean age 28.4 years) and experienced night shifts for an average period of 3 years. On the other hand, according to previous studies, the increase in ocular surface problems is associated with increasing age.[17,18] The longer follow-up of the participants in the study, which is associated with the increase in age and duration of night shifts, may show the relationship between changes in corneal biomechanical parameters and night shifts.

The results of our study indicate that the BIOP in the case group is significantly higher than the control group. However, this difference is found in the IOP; the higher IOP in the case group than the control group is not statistically significant. Of course, Kara and Yilmaz in a study mentioned the significant fluctuation of IOP and ocular perfusion pressure (OPP) in people with night shifts. However, their study did not have a control group to compare IOP and OPP between people with and without night shifts.[19]

As shown in Table 4, there is a significant relationship between some parameters of night shifts with DA ratio and integrated radius, but from a clinical point of view, the important criteria that evaluate the total effect of other criteria and demographic characteristics of patients on corneal biomechanics are the CBI and TBI indices, in which no significant difference was found between case and control groups.

The small sample size of participants limits our study. Another limitation of the study, as observed in Table 1, is the higher standard deviation of numerical variables in the control group compared to the case group. This discrepancy suggests that the two groups may exhibit significant differences, with a higher variance in the control group. On the other hand, an additional limitation stems from the cross-sectional survey of participants in the night shift group. Furthermore, the short follow-up period constitutes another constraint on the study. More compelling results can be obtained by designing another study with a larger sample size and an extended follow-up period to compare differences in the corneal biomechanical behavior of individuals after a night shift.

Considering the impact of sleep deprivation on the health of medical personnel, our study was conducted to investigate changes in corneal biomechanical indices resulting from night shifts. The findings indicate that night shifts do not independently affect corneal biomechanical indices and behaviors.

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Conflicts of interest

There are no conflicts of interest.

References

1. Grace MK, VanHeuvelen JS. Occupational variation in burnout among medical staff: Evidence for the stress of higher status. Soc Sci Med 2019;232:199-208.
2. Kancherla BS, Upender R, Collen JF, Rishi MA, Sullivan SS, Ahmed O, *et al.* Sleep, fatigue and burnout among physicians: An American Academy of Sleep Medicine position statement. J Clin Sleep Med 2020;16:803-5.
3. Etesam F, Arab Bafrani M, Akbarpour S, Tarighatnia H, Rajabi G, Dolatshahi M, *et al.* Depression, anxiety and coping responses among Iranian healthcare professionals during the coronavirus disease (COVID-19) outbreak. Iran J Psychiatry 2022;17:446-54.
4. Dibner C, Schibler U, Albrecht U. The mammalian circadian timing system: Organization and coordination of central and peripheral clocks. Annu Rev Physiol 2010;72:517-49.
5. Lee YB, Koh JW, Hyon JY, Wee WR, Kim JJ, Shin YJ. Sleep deprivation reduces tear secretion and impairs the tear film. Invest Ophthalmol Vis Sci 2014;55:3525-31.
6. Gupta PK, Stinnett SS, Carlson AN. Prevalence of sleep apnea in patients with keratoconus. Cornea 2012;31:595-9.
7. Makateb A, Torabifard H. Dry eye signs and symptoms in night-time workers. J Curr Ophthalmol 2017;29:270-3.
8. Moran S, Gomez L, Zuber K, Gatinel D. A case-control study of keratoconus risk factors. Cornea 2020;39:697-701.
9. Belingheri M, Pellegrini A, Facchetti R, De Vito G, Cesana G, Riva MA. Self-reported prevalence of sleep disorders among medical and nursing students. Occup Med (Lond) 2020;70:127-30.
10. Liew SC, Aung T. Sleep deprivation and its association with diseases – A review. Sleep Med 2021;77:192-204.
11. Green ME, Bernet V, Cheung J. Thyroid dysfunction and sleep disorders. Front Endocrinol (Lausanne) 2021;12:725829.
12. Li A, Zhang X, Guo Y, Wang J, Hao Y, Gu Y, *et al.* The association between dry eye and sleep disorders: The evidence and possible mechanisms. Nat Sci Sleep 2022;14:2203-12.
13. Bao F, Geraghty B, Wang Q, Elsheikh A. Consideration of corneal biomechanics in the diagnosis and management of keratoconus: Is it important? Eye Vis (Lond) 2016;3:18.
14. Ambrósio R Jr., Lopes BT, Faria-Correia F, Salomão MQ, Bühren J, Roberts CJ, *et al.* Integration of Scheimpflug-based corneal tomography and biomechanical assessments for enhancing ectasia detection. J Refract Surg 2017;33:434-43.
15. Ferreira-Mendes J, Lopes BT, Faria-Correia F, Salomão MQ, Rodrigues-Barros S, Ambrósio R Jr. Enhanced ectasia detection using corneal tomography and biomechanics. Am J Ophthalmol 2019;197:7-16.
16. Ahmad TR, Kong AW, Turner ML, Barnett J, Kaur G, O'Brien KS, *et al.* Socioeconomic correlates of keratoconus severity and progression. Cornea 2023;42:60-5.
17. Ahn JH, Choi YH, Paik HJ, Kim MK, Wee WR, Kim DH. Sex differences in the effect of aging on dry eye disease. Clin Interv Aging 2017;12:1331-8.
18. de Paiva CS. Effects of aging in dry eye. Int Ophthalmol Clin 2017;57:47-64.
19. Kara N, Yilmaz T. Twenty-four hour pattern of intraocular pressure and ocular perfusion pressure in night shift workers. Semin Ophthalmol 2015;30:188-92.