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ORIGINAL ARTICLE

# Nurses can play an active role in the early diagnosis of exposure keratopathy in intensive care patients

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## Abstract

**Aim:** This study was conducted in order to determine nurses' ability to diagnose exposure keratopathy reliably in the early stage in intensive care patients.

**Methods:** This methodological and descriptive study was carried out between 2011 and 2012 in the Neurology and Anesthesiology and Reanimation Intensive Care Units of a teaching hospital in western Turkey. The sample consisted of 4354 ocular assessments in 156 corneas of 78 patients. A patient identification form and a fluorescein test patient tracking chart were used in the data collection. The corneas of the patients were checked by a fluorescein dye test by the same nurse and ophthalmologist.

**Results:** The mean age of the patients was 59 ± 15.5 years and 47.4% of them were female. The consistency between the nurse and the ophthalmologist was almost perfect in terms of determining the presence of exposure keratopathy, characteristics, and the grade of corneal staining. Exposure keratopathy was detected at a rate of 2% by the ophthalmologist. A significant relationship was found between the presence of lagophthalmos and the development of exposure keratopathy. A positive correlation was found between the grade of corneal staining and the degree of the eyelid position of the patients and the duration of mechanical ventilation therapy.

**Conclusion:** After eye care and assessment training, intensive care nurses can play an effective role in detecting early-stage exposure keratopathy in intensive care patients.

**Key words:** corneal assessment, early diagnosis, exposure keratopathy, intensive care unit, nursing practice.

## INTRODUCTION

Defense mechanisms of the eye are destroyed when treatments, such as mechanical ventilation, sedation, and neuromuscular blockage, are added to factors such as metabolic disorders, multiple organ failure, and unconsciousness in intensive care unit (ICU) patients. Ocular problems that start with lagophthalmos (the inability to fully close the eyelids) can lead to corneal abrasion, chemosis (conjunctival edema), exposure keratopathy, dry eye syndrome, and irreversible microbial keratitis (Grixti, Sadri, Edgar, & Datta, 2012; Güler, Eşer, & Fashafsheh, 2016; Kousha, Kousha, & Paddle, 2015; Kuruvilla *et al.*, 2015; Saritaş *et al.*, 2013).

Exposure keratopathy refers to dryness of the cornea with subsequent epithelial breakdown. Incomplete or inadequate eyelid closure, resulting in evaporative tear loss and tear film insufficiency, leads to exposure keratopathy. Mild cases are managed easily, but if they are severe, undetected, and/or undertreated, serious consequences can occur. Corneal dryness is more likely to go undiagnosed or uncured in ICU patients when other medical problems are being focused on (Kuruvilla *et al.*, 2015; Oliveira *et al.*, 2016; Werli-Alvarenga, Ercole, Botoni, Oliveira, & Chianca, 2011).

Exposure keratopathy has been seen to be at a rate of almost 40% in a study that was conducted by McHugh,

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Alexander, Kalhoro, and Iodines (2008). In a study by Jammal *et al.* (2012), exposure keratopathy was detected in 57% of the patients who were under sedation or under mechanical ventilation in the ICU. In addition, McHugh *et al.* reported that 70% of the patients with lagophthalmos had exposure keratopathy. As a result of recent research, it has been determined that exposure keratopathy developed in 13.2% of the patients ($n$ = 301) in the ICU at an average of 4.6 ± 2.6 days after they were hospitalized and the prevalence of this disorder was ascertained as 27.3% (Kuruvilla *et al.*, 2015). These percentages suggest that eye problems in ICU patients have to be taken into consideration.

Unfortunately, no special practice is undertaken by ICU staff with respect to the eyes in general unless the symptoms and clinical findings that are related to ocular complications become clearly visible. This situation increases the risk of eye disorders and causes visual impairment during the recovery period of the critical disease (Alansari *et al.* 2015; de França *et al.*, 2016; Güler *et al.*, 2016; Kousha *et al.*, 2015; Kuruvilla *et al.*, 2015; Leadingham, 2014; Oliveira *et al.*, 2016). Consequently, patients' quality of life is decreased and the treatment cost and work load of the health staff members who are responsible for their care and treatment increase.

Eye care is a simple, but very effective, method for the prevention of eye complications (Kousha *et al.*, 2015; Kuruvilla *et al.*, 2015). An early diagnosis is the first and the most important step in nursing care. The evaluation of ocular problems, as well as the documentation of the findings that are obtained, lead the way in care and treatment.

An assessment of the vision and ocular function is an ophthalmologist's responsibility. However, it is difficult for ophthalmologists to screen the ocular surface of all ICU patients routinely (McHugh *et al.*, 2008). In addition, it is suggested that the cornea could be evaluated for epithelial damage during eye care practices by an ICU nurse or physician through a fluorescein staining test (Demirel, Cumurcu, Fırat, Aydoğan, & Doğanay, 2014; McHugh *et al.*). Actually, it is thought that ICU nurses, who are in continuous and direct contact with these patients, could take more of a role in establishing an early diagnosis during the provision of care, as physicians generally focus on the vital problems of ICU patients. This evaluation, which would be routinely carried out, could prevent unnoticed ophthalmic problems, as well as the further complications that are likely to occur later on. Thus, as the treatment period decreases, the treatment costs and work load will be minimized, as a result of which the patient's quality of life will increase.

Throughout the world, as well as in Turkey, no research has been carried out on the ability of an ICU nurse to establish a diagnosis of exposure keratopathy, which is one of the major ocular complications that is likely to lead to serious problems in ICU patients when not prevented. This study, which was conducted in line with this objective, bears the quality of being the first in this field. The results of this research will pioneer an extension of the scope of the role of ICU nurses in establishing an early diagnosis.

The main objective of this research was to determine the status of a nurse in being able to diagnose early on exposure keratopathy in ICU patients through a fluorescein staining test. To determine the incidence and related factors of exposure keratopathy was the secondary objective of the research.

## METHODS

### Design and sample

This descriptive research was carried out between November 15, 2011 and December 30, 2012. The research was conducted in the Neurology and Anesthesiology and Reanimation ICUs of a teaching hospital in western Turkey. The hospital has a 2000-bed capacity, of which 187 beds are devoted to intensive care, and it serves a population of ~250,000 inpatients per year. The inpatient bed capacity in the Anesthesia ICU is 30 and the capacity in the Neurology ICU is 12.

The sample of the research consisted of the 156 eyes of 78 ICU patients in the Anesthesia and Neurology ICUs. The patients were aged >18 years old, had accepted to participate in the research, and they and their families had completed written informed consent forms.

### Study instruments

The data were collected by using a patient identification form and a fluorescein test patient tracking chart, which were developed by the authors in line with an extensive literature review, standard recommendations and protocols, and existing questionnaires and schedules (Imanaka *et al.*, 1997; Kam *et al.*, 2013; McHugh *et al.*, 2008; Oh *et al.*, 2008; Werli-Alvarenga *et al.*, 2011).

 

## Patient identification form

There were 15 items in the instrument, which covered the demographic characteristics of the patients, such as their age, sex, medical diagnosis, length of ICU stay, duration of mechanical ventilation support, level of consciousness, ventilation mode, positive end-expiratory pressure, and the status of the administration of sedatives and muscle relaxants, as well as ocular evaluations such as the degree of eyelid closure and the presence of a spontaneous eye-blink reflex.

## Fluorescein test patient tracking chart

The fluorescein test is conducted by dropping 2% (~2 μL) of a tiny fluorescein drop into each conjunctival sac. By using a cobalt-blue slit lamp in this test, erosion in the cornea and in the conjunctiva due to the lack of tears can be seen more clearly (Câmara *et al.*, 2016; Phadatare, Momin, Nighojkar, Askarkar, & Singh, 2015). Any finding that involved the presence of corneal staining in the patients' eyes and, if any, the characteristics and degree of staining were recorded in the fluorescein test patient tracking chart. The characteristics and the degree of staining in the cornea were classified as in Figure 1. This chart was distributed individually and the raters (nurse and ophthalmologist) were urged to carry out their task rapidly and without discussing their evaluations. The nurse had acquired knowledge and practical experience by receiving 1 week of training in conducting the fluorescein test and determining the characteristics and degree of corneal staining. The nurse had received training from an ophthalmologist who was working in the Ophthalmology Unit and had no relationship with the study or the authors.

## Validity and reliability of the tools

The tools were sent to eight experts (one anesthesiologist, one ophthalmologist, two experienced ICU nurses, and four nurse academics) for assessment of the content validity. The content of the tools was approved based on their feedback. Minor wording modifications were made in the instruments.

A pilot study for the reliability of the instruments also was conducted. A test–retest evaluation was carried out with a 2 week time interval by using seven ICU nurses from different ICUs, who were initially given 1 week's training in the fluorescein dye test. They were not included in the study. The coefficients of the test–retest reliability of the patient identification form and the fluorescein test patient tracking chart were 0.91 and 0.80, respectively.

## Data procedure

The two raters (the nurse and the ophthalmologist) were blinded to each other's results and independently assessed the corneal epithelium of the same patients. All the evaluations were made on the same occasions. Fluorescein was dropped into the eyes of the patients and then two raters determined the corneal staining, as well as the characteristics and degree of staining within 3 min of each other. Later on, the nurse and the ophthalmologist recorded the results on the charts that had been prepared for them, after which the charts were submitted to the nurse manager in the ICU. This precaution was taken for the purpose of ensuring the objectivity of the research and to avoid any interaction between the raters in regard to the fluorescein test results. The evaluations were carried out daily.

## Data analysis

The analysis of the data that were obtained from the research was conducted by using IBM SPSS Statistics for Windows, v. 17.0 (IBM Corporation, Armonk, NY, USA). The distribution of the descriptive data that contained the demographic and some clinical characteristics of the patients was given in numbers and percentages. Inter-rater agreement (the nurse and the ophthalmologist) for the fluorescein test results was analyzed by means of Kappa statistics and the Kappa coefficient, which had a value that ranged between 0 and 1, also was calculated. When there was complete agreement, $\kappa = 1.0$. If the observed agreement was greater than or equal to the agreement due to chance alone, $\kappa \geq 0$. If the observed agreement was less than the amount of

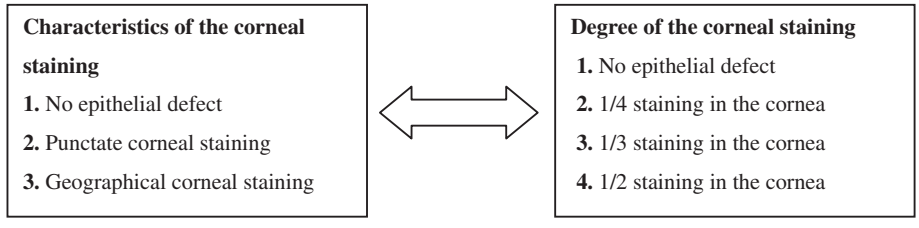


**Figure 1** Classification of the corneal staining that was obtained from the fluorescein test.

 

agreement that is expected from chance alone, then $\kappa < 0$ (Fleiss, Levin, & Paik, 2003). Landis and Koch (1977) have categorized the strength of agreement of $\kappa$ as <0 = "poor," 0–0.20 = "slight," 0.21–0.40 = "fair," 0.41–0.60 = "moderate," 0.61–0.80 = "substantial," and 0.81–1.0 = "almost perfect." Spearman's correlation was used to determine the relationship between the grade of corneal staining and the degree of the eyelid position and the length of mechanical ventilation and the correlation coefficient was calculated.

### Ethics

Approval was received from the ethics committee of the teaching hospital (reference date and number: 06.04.2011; 11-3.1/43), from the ethics committee of the General Directorate for Pharmaceuticals and Pharmacy of the Ministry of Health (reference date and number: 26.09.2011; 1398/11-3.1/43), and from the authorities of the ICUs where the research was conducted. Permission to conduct the research was obtained with an informed consent form from the patients themselves if they were conscious or from close relatives of the unconscious patients.

## RESULTS

### Demographic characteristics

$\overline{x} = 23 \pm 16.2$ daysTwo raters monitored the 156 eyes of 78 consecutive patients. The ages of the patients varied between 21 and 85 years ($\overline{x} = 59 \pm 15.5$) and 47.4% of them were female. The range of ICU stay days varied between 2 and 80 days ($\overline{x} = 23 \pm 16.2$ days). It also was determined that the duration of mechanical ventilation therapy was the same as the duration of the patients' stay in the ICU. It was found that the Glasgow Coma Scores of 85.9% of the patients were <7 and the pressure-controlled mechanical ventilation mode was used in all the patients. It was ascertained that 76.9% of the patients were being administered with sedatives and 35.8% of them were being administered with muscle relaxants (Table 1).

Also, 87.7% of the patients were found to have had no spontaneous blink reflex. The level of eyelid closure in 9.3% of the patients was found to be Degree 1 (eyelids are closed). In 32.4% of the patients, the level of eyelid closure was Degree 2 (conjunctiva is visible), in 48.8% it was Degree 3 (one-third or less of the cornea is visible), and in 9.5% of the patients, it was Degree 4 (half or more of the cornea is visible).

**Table 1** Demographic characteristics of the patients ($n$ = 78)

| Demographic variable | N | % |
|---|---|---|
| | Mean ± SD | |
| Length of ICU stay (days) | | |
| Minimum–maximum | 2–80 | |
| Mean ± SD | 23 ± 16.2 | |
| Length of MV therapy (days) | | |
| Minimum–maximum | 2–80 | |
| Mean ± SD | 23 ± 16.2 | |
| Age (years) | | |
| Minimum–maximum | 21–85 | |
| Mean ± SD | 59 ± 15.5 | |
| Sex | | |
| Male | 41 | 52.6 |
| Female | 37 | 47.4 |
| Medical diagnosis | | |
| Neurological disease | 32 | 41.0 |
| Pulmonary disease | 25 | 32.1 |
| Metabolic disease | 15 | 19.2 |
| Others | 6 | 7.6 |
| Glasgow Coma Score | | |
| <7 | 67 | 85.9 |
| ≥7 | 11 | 14.1 |
| MV mode | | |
| Spontaneous respiration | – | – |
| Pressure-controlled respiration | 78 | 100.0 |
| PEEP | | |
| >5 cm $H_2O$ | 69 | 88.5 |
| ≤5 cm $H_2O$ | 9 | 11.5 |
| Infection | | |
| Yes | 58 | 74.4 |
| No | 20 | 25.6 |
| Total | 78 | 100.0 |
| Medications[†] | | |
| Sedatives | 60 | 76.9 |
| Atropine | 36 | 46.1 |
| Muscle relaxants | 28 | 35.8 |

[†] Patients were given more than one medication. ICU, intensive care unit; MV, mechanical ventilation; PEEP, positive end-expiratory pressure; SD, standard deviation.

The humidity level of the environment was measured via a hygrometer and it was found to be in the range of 37% to 44% ($\overline{x} = \%35 \pm 1.7$) throughout the study.

### Inter-rater agreement regarding the fluorescein test results

A total of 4354 corneal evaluations were conducted in the study by the nurse and the ophthalmologist on the 156 eyes of 78 patients. While the nurse detected exposure keratopathy in 2.3% ($n$ = 49) of 2177 evaluations, the ophthalmologist detected exposure keratopathy in 2% ($n$ = 43). The consistency between the nurse and

**Figure 2** Punctate corneal staining.

the ophthalmologist was found to be almost perfect in terms of detecting exposure keratopathy ($\kappa = 0.93$, $P = 0.00$).

The characteristics of the corneal staining of the patients in which exposure keratopathy was detected were determined by the nurse as punctuate staining (Fig. 2) in 28.1% ($n = 76$) of the patients, while the staining of the same type was determined by the ophthalmologist as being at a level of 26.3% ($n = 71$). Geographic staining (Fig. 3) was determined to be 71.9% ($n = 194$) by the nurse and 73.7% ($n = 199$) by the ophthalmologist (Table 2). The inter-rater agreement between the nurse and the ophthalmologist was found to be almost perfect in terms of determining the characteristics of the staining in the cornea ($\kappa = 0.91$, $P = 0.00$).

**Figure 3** Geographic corneal staining.

As for the corneas of the patients in which exposure keratopathy was detected, both of the observers found that one-quarter of 21.5% ($n = 58$) of the corneas had been stained. While the research nurse stated that one-third of 61.9% ($n = 167$) of the corneas had been stained, the ophthalmologist found this rate to be 60.7% ($n = 164$). While the nurse determined that half of 14.9% of the corneas ($n = 40$) had been stained, the ophthalmologist determined that half of 16.3% of the corneas ($n = 44$) had been stained (Table 3). The consistency between the nurse and the ophthalmologist was found to be almost perfect in terms of determining the degree of staining in the cornea ($\kappa = 0.93$, $P = 0.00$).

### Association between the demographic characteristics of the patients and the development of exposure keratopathy

The relationship between the age, sex, medical diagnosis, Glasgow Coma Score, length of ICU stay, duration of mechanical ventilation support, mechanical ventilation mode, positive end-expiratory pressure, and environmental humidity and the development of exposure keratopathy was found to be insignificant ($P = 0.05$). A significant relationship was found between the presence of lagophthalmos and the development of exposure keratopathy ($P = 0.02$). Additionally, a positive correlation was found between the degree of eyelid closure and the degree of corneal staining ($r = 0.31$, $P = 0.001$). There was also a positive correlation between the length of mechanical ventilation therapy and the degree of corneal staining ($r = 0.43$, $P = 0.02$).

## DISCUSSION

This is an original study, in which the ability of a nurse to detect a significant ocular complication (exposure keratopathy) in ICU patients was tested for the first time in Turkey and even in the world. In the study by McHugh *et al.* (2008)s, which was the starting point of this research and was conducted for the same purpose, the ability to carry out a reliable corneal scan by using the fluorescein test was tested for ICU physicians. It was reported in a previous study that ICU nurses were supposed to carry out an eye assessment that focused only on evaluating the apparent symptoms without applying any diagnostic test on several complications, such as swelling of the eyelids, inflammation of the conjunctiva, haziness in the cornea, eye discharge, and crusting on the eyelid margins (Werli-Alvarenga *et al.*, 2011). The findings that are obtained through a single observation

 

**Table 2** Inter-rater agreement regarding the characteristics of the corneal staining ($n$ = 4354)

| | Ophthalmologist | | |
|---|---|---|---|
| | Punctuate staining (N) | Geographicstaining (N) | Total N (%) |
| Nurse | | | |
| Punctuate staining (N) | 69 | 7 | 76 (28.1) |
| Geographic staining (N) | 2 | 192 | 194 (71.9) |
| Total N (%) | 71 (26.3) | 199 (73.7) | 270 (100.0) |

$\kappa$ = 0.91, $P$ = 0.00. Cohen's kappa.

alone could lead the health team towards inaccurate and unnecessary approaches and might not always be sufficient to determine the actual problem.

In this study, the nurse detected exposure keratopathy in the cornea in 2.3% of 2177 evaluations, while the ophthalmologist detected damage in 2% of evaluations. These results suggest that the consistency between the observers was almost perfect in terms of determining exposure keratopathy in the cornea. According to this research, the consistency between the observers was found to be very good in relation to determining the characteristics of the corneal staining and almost perfect in terms of determining the degree of the staining.

In the study that was conducted by McHugh *et al.* (2008), which was carried out in order to determine whether or not two ICU physicians were able to scan the ocular surface in a reliable way for keratopathy, a total of 48 corneal evaluations was carried out on 18 ICU patients. According to the ocular assessments that were carried out in the study, the rate of determining exposure keratopathy was ascertained as 37.8% by the ophthalmologist and as 31.3% by the two ICU physicians. Additionally, in the study, the sensitivity of the ICU assistants was found to be 77.8%, while the specificity was found to be 96.7% in terms of determining corneal erosion, while no statistically significant difference was found between the ophthalmologist and the ICU physicians in terms of ocular assessments. In the results of the study by McHugh *et al.*, it was proposed that any ICU employee (physician, nurse) could detect epithelial damage to the cornea. This study's research was conducted in line with this suggestion and the findings were similar to McHugh *et al.* in terms of the consistency between the observers (nurse and ophthalmologist). As a result of a study that has been carried out very recently, one of the diagnostic tests (Schirmer's Test) that is used for determining a dry eye, which is a similar eye complication to exposure keratopathy, was recommended to be applied by an ICU nurse. Additionally, the authors stated that further evidence was required with respect to the methods of diagnosing a dry eye, which was to be carried out with the participation of ICU nurses (Câmara *et al.*, 2016). This recommendation suggests that the authors of the current study are on the right path in studying nurses' ability to detect exposure keratopathy early on in ICU patients.

In this study, it was ascertained that exposure keratopathy was seen by the ophthalmologist in ICU patients at a rate of 2%. It has been determined in a few current studies that the exposure keratopathy rates were 13.2% (Kuruvilla *et al.*, 2015), 13.8% (Alavi, Sharifitabar, Shaeri, & Hajbaghery, 2014), 15% (Saritaş *et al.*, 2013), and 26.6% (Horng *et al.*, 2014). As seen in all

**Table 3** Inter-rater agreement regarding the grade of the corneal staining ($n$ = 4354)

| | Degree of corneal staining Ophthalmologist | | | | |
|---|---|---|---|---|---|
| | 1/4 corneal staining (N) | 1/3 corneal staining (N) | 1/2 corneal staining (N) | 2/3 corneal staining (N) | Total N (%) |
| Nurse | | | | | |
| 1/4 corneal staining | 56 | 2 | 0 | 0 | 58 (21.5) |
| 1/3 corneal staining | 2 | 161 | 4 | 0 | 167 (61.9) |
| 1/2 corneal staining | 0 | 1 | 39 | 0 | 40 (14.8) |
| 2/3 corneal staining | 0 | 0 | 1 | 4 | 5 (1.8) |
| Total N (%) | 58 (21.5) | 164 (60.7) | 44 (16.3) | 4 (1.5) | 270 (100.0) |

$\kappa$ = 0.93, $P$ = 0.00.

 

the studies, exposure keratopathy continues to be seen at varying rates in ICUs, although in some they are seen to be at lower rates, which reinforces the view that ocular problems are major issues that must never be ignored. The fact that exposure keratopathy was seen at lower rates in this study, when compared to other studies, could be associated with the fact that polyethylene covers and ocular lubricants were used routinely for the eyes of patients in the ICUs where the research was conducted.

When the studies were reviewed, continuous sedation, neuromuscular blockage, the lack of a spontaneous eye-blink reflex, multiple organ failure, notably serious respiratory failure, hospitalization in the ICU for a period of >1 week, impaired consciousness, intubation, metabolic disorders, an extended period of ventilation, and sepsis were reported to be the risk factors for ocular complications (Kuruvilla *et al.*, 2015; Oh *et al.*, 2008; Oliveira *et al.*, 2016; Werli-Alvarenga *et al.*, 2011). As a result of the current study, the relationship between exposure keratopathy and many descriptive characteristics, such as the age and sex of the patients, hospitalization period in the ICU, and the Glasgow Coma Score, were found to be insignificant. Besides, a significant relationship was found between insufficient eyelid closure and exposure keratopathy. In addition to this finding, a positive correlation was found between the grade of corneal staining and the degree of the eyelid position of the patients and the duration of mechanical ventilation support. In accordance with the objective of this research, it also was found in the research that was conducted by McHugh *et al.* (2008) that exposure keratopathy was seen at higher rates in the presence of insufficient eyelid closure (28.9%, $P = 0.02$). Additionally, the association between the degree of keratopathy and other demographic characteristics of the patients (age, sex, length of ICU stay, level of consciousness etc.) was found to be insignificant in their study. These findings are similar to the current research. The significant correlation between lagophthalmos and exposure keratopathy also has been shown in some current studies (Anuradha, Iatha, Reddy, & Latha, 2015; Horng *et al.*, 2014; Kousha *et al.*, 2015; Kuruvilla *et al.*, 2015).

### Limitations of the study

First, this study was conducted among ICU nurses from one hospital only and the results might not represent the knowledge and practices of all ICU nurses in Turkey. Second, the ICUs where the research was conducted were limited to the Neurology and Anesthesiology and Reanimation ICUs due to the time limitation of the ophthalmologist. Third, the educational levels, experience, and areas of expertise of the raters were not the same. In addition, they should have had the same experience and knowledge regarding the evaluated parameter, but cocoordination of the raters in this study was very difficult due to the different professions and the main purpose of the study was to determine whether or not a nurse could conduct a fluorescein test reliably and interpret the results of the test. Fourth, the originality of the research and the fact that there is no identical study in this field have limited the discussion of this research, in which the ability of a nurse to detect exposure keratopathy in ICU patients in a reliable way was examined for the first time in this country and in the world literature. Nevertheless, the study has provided significant insight into extended nursing roles in relation to critically ill patients.

## CONCLUSION

This study presents an important insight into the extended nursing roles of ICU nurses. It has been shown that ICU nurses can play an active role in detecting exposure keratopathy after receiving training, especially in the early stages. It is recommended that eye care should be included in the educational programs for the care of ICU patients. Additionally, practices that allow an ocular surface assessment of the presence of any eye complication should be taught to ICU nurses as part of eye care. Finally, it is recommended that the role of ICU nurses, the boundaries of which are expanding in establishing an early diagnosis, should be supported by other studies on this subject.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## AUTHOR CONTRIBUTIONS

E. K. G. decided on the research design, acquired the data, and carried out the data coding, analysis, and manuscript composition; İ. E. and S. E. supervised the whole study process and critically reviewed the manuscript. All the authors read and approved the final manuscript.

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