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# Evaluation of the corneal morphologic and topographic alterations in patients with Bell's palsy

## *Bell paralizili hastalarda korneal morfolojik ve topografik değişikliklerin değerlendirilmesi*

Erman Bozali, Duygu Yalınbaş Yeter, Merve Çiftçi, Adem Bora

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**Abstract**

**Purpose:** To evaluate the effects of ocular surface changes that may develop due to Bell's palsy (BP) on dry eye parameters, corneal densitometry values, and aberrations in patients with unilateral BP and compare them with sound eyes.

**Materials and methods:** A total of 33 eyes of 33 patients diagnosed with unilateral BP and 33 sound fellow eyes of the patients were enrolled in this study. A complete ophthalmologic examination including best-corrected visual acuity (BCVA), intraocular pressure measurement, slit-lamp biomicroscopy to observe superficial punctate keratopathy (SPK), tear break-up time (TBUT) test, and detailed fundoscopic examination was performed for all patients. The corneal topographic, densitometric, and aberrometric measurements were performed using the Pentacam Scheimpflug imaging system.

**Results:** The mean age of 33 patients was 54.9±14.7 years of whom 19 (57.6%) were female; 14 (42.4%) were male. According to the House-Brackmann scale, the majority of the patients had grade II facial nerve palsy. The BCVA in the affected eye was lower and 0.74±0.23 compared to 0.87±0.21 in sound eyes ($p$=0.029). The mean TBUT was lower and 6.0±4.7 in eyes affected by BP compared to 8.7±4.0 in sound eyes ($p$=0.014). The SPK was present in 23 (69.7%) patients. The comparison of the corneal densitometry values revealed that the densitometry measurements in anterior concentric zones were slightly higher in affected eyes. Corneal aberrometric values were also slightly higher in affected eyes. No significant difference was observed between affected and sound eyes in terms of corneal keratometric, densitometric, and aberrometric values ($p$>0.05, for all).

**Conclusions:** Corneal exposure leading to visual complications, and lowering of the tear production may lead to dry eye in BP patients. The examination of the ocular surface to observe the ocular findings of BP is essential. The main priority of the ophthalmologist is to ensure adequate corneal protection to prevent undesired ocular outcomes.

**Key words:** Bell palsy, dry eye, lagophthalmos, densitometry, aberration.

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**Öz**

**Amaç:** Tek taraflı Bell paralizili (BP) hastalarda BP'ye bağlı gelişebilecek oküler yüzey değişikliklerinin kuru göz parametreleri, korneal dansitometri değerleri ve aberasyonlar üzerindeki etkilerini değerlendirmek ve sağlıklı gözleriyle karşılaştırmak.

**Gereç ve yöntem:** Bu çalışmaya tek taraflı BP tanısı konan 33 hastanın 33 gözü ve 33 sağlıklı diğer gözü dahil edildi. Tüm hastalara en iyi düzeltilmiş görme keskinliği (EİDGK), göz içi basıncı ölçümü, yüzeyel punktat keratopatiyi (YPK) gözlemlemek için biyomikroskopi, gözyaşı kırılma zamanı (GKZ) testi ve detaylı fundoskopik muayeneyi içeren tam bir oftalmolojik muayene yapıldı. Korneal topografik, dansitometrik ve aberrometrik ölçümler Pentacam Scheimpflug görüntüleme sistemi kullanılarak ölçüldü.

**Bulgular:** Çalışmaya katılan hastaların 19'u (%57,6) kadın, 14'ü (%42,4) erkekti ve 33 hastanın yaş ortalaması 54,9±14,7 yıldı. House-Brackmann skalasına göre hastaların büyük çoğunluğunda II. derece fasiyal sinir paralizisi vardı. Etkilenen gözdeki EİDGK 0,74±0,23 olup sağlıklı gözlere (0,87±0,21) kıyasla daha düşüktü ($p$=0,029). Paralizi tarafındaki gözlerde ortalama GKZ 6,0±4,7 olup, sağlam gözlere (8,7±4,0) kıyasla daha düşüktü ($p$=0,014). Yüzeyel punktat keratopati 23 (%69,7) hastada mevcuttu. Korneal dansitometri değerleri karşılaştırıldığında, etkilenen gözlerde anterior konsantrik zonlardaki dansitometri ölçümlerinin göreceli daha yüksek olduğu izlendi. Korneal aberometrik değerler de etkilenen gözlerde göreceli daha yüksekti. Korneal keratometrik, dansitometrik ve aberrometrik değerler açısından etkilenen ve sağlam gözler arasında anlamlı bir fark gözlenmedi (tümü için $p$>0,05).

Erman Bozali, Ass. Prof. Sivas Cumhuriyet University School of Medicine Department of Ophthalmology, Sivas, Turkey, e-mail: ermanbozali@gmail.com (https://orcid.org/0000-0001-7918-8381) (Corresponding Author)

Duygu Yalınbaş Yeter, Ass. Prof. Sivas Cumhuriyet University School of Medicine Department of Ophthalmology, Sivas, Turkey, e-mail: duyguyalinbas@gmail.com (https://orcid.org/0000-0000-0001-9001-0277)

Merve Çiftçi, M.D. Sivas Cumhuriyet University School of Medicine Department of Otorhinolaryngology, Sivas, Turkey, e-mail: mervekoc_2012@hotmail.com (https://orcid.org/0000-0000-0001-7505-8723)

Adem Bora, Assoc. Prof. Sivas Cumhuriyet University School of Medicine Department of Otorhinolaryngology, Sivas, Turkey, e-mail: adembora@yahoo.com (https://orcid.org/0000-0000-0002-5036-0595)

**Sonuç:** Bell paralizili hastalarda korneal ekspojur görsel komplikasyonlara ve gözyaşı üretiminin azalmasına neden olabilir. Bell paralizisinin oküler bulgularını gözlemlemek için oküler yüzeyin incelenmesi esastır. Göz hekiminin temel önceliği, istenmeyen oküler sonuçları önlemek için yeterli kornea korumasını sağlamaktır.

**Anahtar kelimeler:** Bell paralizisi, kuru göz, lagoftalmi, dansitometri, aberasyon.

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## Introduction

Bell's palsy (BP) is an acute, idiopathic, unilateral peripheral paralysis of the facial nerve that leads to muscle weakness on one side of the face and accounts for more than 70% of the cases of unilateral peripheral facial palsy [1]. The etiology still remains unknown even though reactivation of a dormant viral infection has been accused [2, 3]. Swelling of the facial nerve due to subsequent inflammation leads to compression and entrapment of the facial nerve in the Fallopian canal resulting in facial paralysis [2]. Early diagnosis and the prompt initiation of treatment can improve the chances of complete recovery [4].

The facial nerve is a motor nerve that provides innervation to the upper and lower facial muscles. The typical sign and symptoms of BP are inability to wrinkle the forehead, eyebrow ptosis, lagophthalmos, drooping mouth, and loss of the nasolabial fold. Postganglionic parasympathetic fibers originated from pterygopalatine ganglion, which regulates the flow of tears, innervate the lacrimal gland. Widened palpebral fissure, inadequate blinking, loss of orbicularis function result in corneal exposure leading to visual complications, and lowering of the tear production may lead to dry eye [5, 6]. These impairments precipitate inadequate corneal protection leading to corneal dryness, ulceration, and eventually blindness [5]. Primary management of the exposure keratopathy with artificial tears and ointment and precise intervention for lagophthalmos is of utmost importance to prevent corneal breakdown, scarring, and vision loss [7].

The optical quality of the human eye is limited by various factors including optical aberrations, diffraction, and light scatter [8]. The light backscatter, which indicates the optical health of the cornea may be considered as a substantial and useful indicator in the analysis of numerous corneal diseases with repeatability and reproducibility endorsed before [9]. Previous studies reported alterations in corneal densitometry and aberrometry in dry eye patients [10-12].

The aim of this study is to evaluate the effects of ocular surface changes that may develop due to BP on dry eye parameters, corneal densitometry values, and aberrations in patients with unilateral BP and compare them with sound eyes.

## Materials and methods

A total of 33 eyes of 33 patients diagnosed with unilateral BP and 33 sound fellow eyes of the patients were enrolled in this prospective observational study between January 2021 and November 2021. The study was approved by the Clinical Studies Ethics Committee of Cumhuriyet University and adhered to the tenets outlined in the Declaration of Helsinki. Written informed consent was obtained from all patients. The diagnosis of BP was made based on clinical presentation and a detailed physical examination performed by an experienced otorhinolaringology specialist. All patients were newly diagnosed with BP and none of patients in the study group was using any topical medication at the time of referral. Clinical evaluation of BP was done according to the classification described by House-Brackmann facial nerve grading system [13]. Table 1 demonstrates the characteristics of each grade and how the grading is done. Patients with a history of known trauma, infections, inflammatory diseases, chronic diseases, cranial pathologies, which are other known causes of unilateral facial nerve palsy, were excluded. Also, patients with a history of any ocular surgery and lid abnormalities including entropion, ectropion, lid retraction were excluded from the study. All patients underwent a complete ophthalmologic examination including best-corrected visual acuity (BCVA), intraocular pressure measurement using a pneumotonometer, slit-lamp biomicroscopy to observe any corneal pathology including the existence of superficial punctate keratopathy (SPK), and detailed fundoscopic examination. The ocular

**Table 1.** House-Brackmann Facial Nerve Grading System

| Grade | Description | Characteristics |
|---|---|---|
| I | Normal | Normal function in all areas |
| II | Slight | Slight synkinesis, complete eyelid closure with minimum effort |
| III | Moderate | Obvious facial asymmetry, complete eyelid closure with effort |
| IV | Moderately severe | Disfiguring facial asymmetry, incomplete eyelid closure |
| V | Severe | Barely noticeable facial movement, incomplete eyelid closure |
| VI | Total | No facial function |

surface was assessed with tear break-up time (TBUT) test which is performed by the same experienced clinician. The TBUT was measured using a fluoresceine strip paper (Fluorescein Sodium Strips, ERC Sağlık, Ankara, Turkey) wetted with saline and then applied to the inferior bulbar conjunctiva. Patients were asked to blink 3-5 times to form a film over the corneal surface and then not to blink while the tear film is observed under a broad beam of cobalt blue illumination. The TBUT was recorded as the seconds that elapse between the last complete blink and the appearance of the first dry spot in the tear film. The average of three consecutive measurements was recorded for both tests [14]. The corneal fluorescein staining was performed to demonstrate the presence of SPK in all patients.

Corneal topographic, densitometric, and aberrometric measurements were performed using a Scheimpflug imaging system (Pentacam HR, Oculus GmbH, Wetzlar, Germany). The best aligned and fixated scans and scans with a quality specification (QS) value marked as OK were included for the analysis following three consecutive scans for each eye as stated in the device manual. Thinnest corneal thickness (CT), corneal aberrometric measurements including the root mean square (RMS) of total aberrations (RMS-total), RMS of higher-order aberrations (RMS-HOA), RMS of lower-order aberrations (RMS-LOA), and spherical aberrations were calculated from the central 6 mm optical zone with Pentacam's built-in software v1.25r15. Corneal densitometry was measured automatically with the built-in analysis software provided with Pentacam HR in four concentric zones over a 12 mm corneal diameter. The first zone consists of a circular area with a diameter of two mm in the center of the cornea, and the second, third, and fourth zones are annular areas surrounding the center of 2-6 mm, 6-10 mm, and 10-12 mm, respectively. This analysis also provides densitometric values of the cornea at three different depths: the anterior (superficial 120 μm), central (subtraction of the anterior and posterior layer thickness from total), and posterior (60 μm of the innermost cornea) corneal layers. Corneal densitometry values are expressed as the pixel luminance per unit volume in the Scheimpflug image and are expressed in grayscale units (GSU). The light backscatter of the cornea varies from zero GSU meaning no corneal haze to 100 GSU defined as completely opaque cornea [15]. All corneal measurements were performed on the same day under the same environmental properties at the same dim-lit room setting. The TBUT test was performed after Pentacam HR measurements.

**Statistical analysis**

Analyses were performed using Statistical Package for the Social Science (SPSS version 20.0, IBM, Armonk, NY, USA) software for Windows. Variables were tested for normality using the Shapiro-Wilk test. The homogeneity of variables was determined using one-way ANOVA homogeneity of variance test. Symmetrically distributed variables in the text and tables are shown as mean ± standard deviation. If the distribution was heterogeneous, variables were shown as medians (minimum-maximum). Categorical variables were expressed as percentages. The student's t-test or the Mann-Whitney U test was used to compare continuous variables according to the data distribution. A chi-square test was used to compare the categorical variables. A value of $p<0.05$ was considered statistically significant.

## Results

The mean age of 33 patients was 54.9±14.7 years of whom 19 (57.6%) were female; 14 (42.4%) were male. According to the House-Brackmann scale, the majority of the patients had grade II facial nerve palsy. The best-corrected VA in the affected eye was lower and 0.74±0.23 compared to 0.87±0.21 in sound eyes. The mean TBUT was lower and 6.0±4.7 in eyes affected by BP compared to 8.7±4.0 in sound eyes. The difference between affected and sound eyes in terms of BCVA and TBUT was statistically significant ($p$=0.029, $p$=0.014, respectively). Superficial punctate keratopathy was present in 23 (69.7%) patients. Demographics and patient characteristics are summarized in Table 2. The mean time interval between the onset of symptoms to hospital admission was 2.45±1.43 days. All patients were hospitalized and initiated 1mg/kg intravenous corticosteroid therapy. Following ophthalmologic examination, conservative management including the instillation of artificial tears, applying ointments, and proper taping of the eyelid were done in all patients to prevent ophthalmic complications of BP. The mean CT was 541.1±38.3 in affected eyes and 540.6±35.7 in sound eyes and the difference was not statistically significant ($p$=0.953). Also, there was no significant difference between affected and sound eyes in terms of corneal keratometric values ($p$>0.05, for all) The mean CT and keratometric measurements are presented in Table 3. The comparison of the corneal densitometry values revealed that the densitometry measurements in anterior concentric zones were slightly higher in affected eyes compared to sound eyes, but none of the differences reached statistical significance (Table 4). Corneal aberrometric values were slightly higher in affected eyes however the difference was not statistically significant (Table 5).

**Table 2.** Demographics and clinical features of the patients

| | |
|---|---|
| **Age (years)**, mean±SD | 54.9±14.7 |
| **Gender**, n (%) | |
| Female | 19 (57.6) |
| Male | 14 (42.4) |
| **Affected eye**, n (%) | |
| Right | 24 (72.7) |
| Left | 9 (27.3) |
| **TBUT test (sec)**, mean±SD | |
| Affected eyes | 6.0±4.7 |
| Sound eyes | 8.7±4.0 |
| **House-Brackmann grade**, n (%) | |
| Grade I | 1 (3) |
| Grade II | 17 (51.5) |
| Grade III | 7 (21.2) |
| Grade IV | 7 (21.2) |
| Grade V | 1 (3) |

TBUT: Tear break-up time

**Table 3.** Corneal topographic measurements of the patients

| | **Affected eyes n:33** | **Sound eyes n:33** | ***p**** |
|---|---|---|---|
| **CCT (µm)** | 540.6±35.7 | 541.1±38.3 | 0.9 |
| **K1 (mm)** | 7.84±0.31 | 7.85±0.32 | 0.9 |
| **K1 (D)** | 43.09±1.73 | 43.05±1.78 | 0.9 |
| **K2 (mm)** | 7.64±0.34 | 7.65±0.33 | 0.9 |
| **K2 (D)** | 44.22±1.98 | 44.16±1.92 | 0.8 |
| **Kmean (mm)** | 7.74±0.31 | 7.75±0.31 | 0.9 |
| **Kmean (D)** | 43.66±1.79 | 43.6±1.79 | 0.8 |

*Independent sample t test. CCT: central corneal thickness, K1: Flat keratometry
K2: steep keratometry, Kmean: mean keratometry, D: diopters

**Table 4.** Corneal densitometry measurements of the patients

| | Affected eyes n:33 | Sound eyes n:33 | *p** |
|---|---|---|---|
| **Anterior (120 µm) (GSU)** | | | |
| 0-2 mm | 25.14±1.93 | 24.8±1.75 | 0.5 |
| 2-6 mm | 23.13±2.56 | 23±2.58 | 0.8 |
| 6-10 mm | 32.28±10.3 | 32.2±12.3 | 0.9 |
| 10-12 mm | 40.2±14.2 | 38.92±13.3 | 0.6 |
| Total (0-12 mm) | 29.1±6.6 | 29.0±5.7 | 0.9 |
| **Center (GSU)** | | | |
| 0-2 mm | 16.25±1.25 | 16.29±1.31 | 0.9 |
| 2-6 mm | 15.07±1.83 | 15.21±2.07 | 0.7 |
| 6-10 mm | 22.43±7.93 | 22.75±9.28 | 0.8 |
| 10-12 mm | 24.82±7.68 | 25.37±7.99 | 0.7 |
| Total (0-12 mm) | 19.27±4.12 | 19.5±4.67 | 0.8 |
| **Posterior (60 µm) (GSU)** | | | |
| 0-2 mm | 12.08±1.68 | 12.13±1.41 | 0.9 |
| 2-6 mm | 11.83±2.0 | 11.96±1.94 | 0.8 |
| 6-10 mm | 18.0±5.0 | 18.23±5.55 | 0.8 |
| 10-12 mm | 21.8±5.71 | 22.12±6.0 | 0.8 |
| Total (0-12 mm) | 15.52±3.06 | 15.69±3.32 | 0.8 |
| **Total thickness (GSU)** | | | |
| 0-2 mm | 17.83±1.35 | 17.77±1.17 | 0.8 |
| 2-6 mm | 16.68±1.98 | 16.73±2.08 | 0.9 |
| 6-10 mm | 24.24±7.55 | 24.43±8.94 | 0.9 |
| 10-12 mm | 28.5±8.54 | 29.26±8.94 | 0.7 |
| Total (0-12 mm) | 21.43±4.73 | 21.26±4.13 | 0.8 |

*Independent sample t test. GSU: gray scale units

**Table 5.** Comparison of corneal aberrometric values of the patients

| | Affected eyes n:33 | Sound eyes n:33 | *p** |
|---|---|---|---|
| **RMS Total (front)** | 2.26±1.0 | 2.06±0.73 | 0.3 |
| **RMS LOAs (front)** | 2.17±0.99 | 1.99±0.72 | 0.3 |
| **RMS HOAs (front)** | 0.58±0.29 | 0.50±0.21 | 0.2 |
| **SA (front)** | 0.29±0.15 | 0.31±0.09 | 0.3 |
| **RMS Total (back)** | 0.76±0.17 | 0.78±0.23 | 0.6 |
| **RMS LOAs (back)** | 0.74±0.17 | 0.76±0.22 | 0.6 |
| **RMS HOAs (back)** | 0.18±0.03 | 0.19±0.07 | 0.3 |
| **SA (back)** | -0.12±0.03 | -0.13±0.03 | 0.3 |

*Independent sample t test. RMS: root mean square, LOAs: low order aberrations
HOAs: high order aberrations, SA: spherical aberration

## Discussion

In this current prospective study, we evaluated the effects of ocular surface changes that may develop due to BP on dry eye parameters, corneal densitometry, and aberrations in patients with unilateral BP. Our results demonstrated a decrease in VA and TBUT test values, and the comparison of the corneal densitometry values revealed slightly higher densitometry measurements in anterior concentric zones in affected eyes compared to unaffected fellow eyes, however, none of the differences reached statistical significance.

The etiology of BP still remains obscure however reactivation of latent herpes simplex viruses was proposed to play a part in the pathophysiology of the disease [2, 3]. On the other hand, studies investigating the systemic manifestations of BP revealed higher serum cytokine levels, neutrophil-to-lymphocyte ratio, and Systemic Immune-Inflammation Index (SII) [16-18]. There are two major subtypes of dry eye

disease (DED). The aqueous-deficient subtype is associated with reduced lacrimal gland function and the evaporative subtype is accompanied mostly by meibomian gland dysfunction. Recent consensus support that these subtypes are part of a spectrum rather than being distinct entities and coexist as a continuum [19]. Paralysis of the orbicularis muscle leads to corneal exposure thus increasing tear evaporation and decreased tear production secondary to BP results in tear insufficiency [20]. The unopposed gravity on the paralyzed tissues, loss of orbicularis oculi function, lagophthalmos, and upper lid retraction all contribute to increased corneal exposure and an increased risk of exposure keratitis [21]. Previous studies reported lower TBUT and a significant correlation between meibomian gland dysfunction and grade and duration of facial nerve palsy [20, 22]. In the present study, we also observed lower TBUT in the eyes affected by BP in accordance with these aforementioned studies. In addition, the fluorescein staining of the cornea revealed that SPK was present in almost 70% of the affected. The decreased TBUT in our study indicates that excessive evaporation is the predominant cause of DED leading to SPK, eventually to exposure keratitis in BP patients.

Discrepant Schirmer-1 test findings in facial nerve palsy were reported in the literature. Even though there are studies presenting lower Schirmer-1 test results, a previous study by Takahashi et al. [23] reported higher Schirmer-1 test results in patients with cranial nerve VII palsy and concluded that reflexive hyperlacrimation due to exposure keratitis and decreased lacrimal pump function may be the reason [20]. Besides, abnormal flow of tears is further increased by the absence of lower-lid nasal twist which helps to pump tears into the lacrimal drainage system [24]. In this study, we were unable to properly position the precalibrated Schirmer-1 test strip and the strip was immediately wetted due to hyperlacrimation. This may be because of the widened palpebral fissure, paralytic ectropion, and lower eyelid sagging due to BP. Therefore, we did not evaluate the Schirmer-1 test results in our study population.

Keratometric alterations in patients with dry eye remain controversial. The influence of artificial tears on keratometric measurements in dry eye patients comprised the majority of the studies and demonstrated either similar or increased K-values compared to healthy controls [25-27]. Röggla et al. [27] assessed the influence of artificial tears on K-readings and observed that the influence of higher viscosity eye drops is stronger and more persistent. On the other hand, Sanal Dogan et al. [25] observed excellent repeatability among all topography parameters including keratometric measurements in dry eye patients compared to healthy controls. Our results were in accordance with the latter demonstrating no significant changes in affected dry eyes of BP patients compared to the sound fellow eyes.

Analysis of corneal densitometry has gained popularity in recent years by means of noninvasive Scheimpflug scans of the cornea which is easy to perform, quick, and repeatable. Corneal densitometry provides quantitative measurements of corneal clarity and transparency. The main sources of corneal light scattering are the corneal epithelial layer and corneal endothelium. To the best of our knowledge, this is the first study evaluating the corneal densitometric and aberrometric alterations in patients with BP. Corneal densitometric changes in dry eye patients have been evaluated previously. Koh et al. [10] reported increased corneal backward light scattering in patients with dry eye. They concluded that SPK is partially responsible for the increased light scattering. Another study demonstrated higher corneal densitometry values in rheumatoid arthritis patients compared to healthy controls [11]. They hypothesized that corneal densitometric changes may be altered due to subclinical inflammation however the study also referred that dry eye may be a confounding factor for the densitometric alterations mostly in the anterior layer which may be attributed to the presence of dry eye. Similarly, in our study, the anterior layer corneal densitometry values in most of the concentric zones in the affected eyes were higher than those of sound eyes however the difference was statistically insignificant. These measurements were gathered in the early phase of the disease, therefore the densitometric and aberrometric changes due to BP may increase in the long-term follow-up.

Pentacam Scheimpflug imaging system also calculates the anterior and posterior

corneal Zernike coefficients based on corneal elevation data which are used to describe corneal wavefront aberrations. The corneal aberrations are minor optical irregularities that result in light being unable to focus onto the retina properly and imperfections in the visual image. The anterior surface is the most powerful refractive component of the eye that even subtle changes in corneal shape may cause significant alterations in its optical characteristics [28]. In a study by Yildirim et al. [12], the RMS of total, LOAs, HOAs, and spherical aberrations were significantly higher in dry eye patients and they concluded that artificial tears reduced the anterior corneal aberrations. Our results revealed slightly higher values regarding anterior RMS of total, LOAs, and HOAs however none of them reached statistical significance.

The present study has some limitations. Relatively small sample size, variable time interval to hospital admission, lack of longer follow-up data are among the limitations of the study. The data collection and classification of the parameters could not be blinded. Evaluation of the patients may be exposed to observer bias due to the inability to blind the physician and technician to the side affected by BP. We also did not evaluate the meibomian gland disease in the study group since the control group was the sound fellow eyes of the patients. As mentioned before, the tests used to determine the subtype of DED in previous studies revealed inconsistent results. It is well known that demonstrating the subtype of DED without further tests including videokeratoscopy, tear film interferometry, and evaporimetry is challenging. Also, we were unable to properly position the precalibrated Schirmer test strip and the strip was immediately wetted due to hyperlacrimation. Therefore, we did not evaluate the Schirmer-1 or 2 test results in our study population.

In conclusion, this study demonstrates the ocular manifestations of BP including corneal exposure. Bell's palsy causes widened palpebral fissure, inadequate blinking, loss of orbicularis function result in corneal exposure leading to visual complications, and lowering of the tear production may lead to dry eye. Corneal densitometric and aberrometric changes may be observed consequent to dry eye. However, long-term studies with larger sample sizes are needed to evaluate these alterations. The examination of the ocular surface to observe the ocular findings following BP is essential. The main priority of the ophthalmologist is to ensure adequate corneal protection whether by lubrication with artificial tears, effective taping of the eyelid especially at nighttime, or surgical intervention to the eyelids to prevent undesired ocular outcomes.

**Conflict of interest:** No conflict of interest was declared by the authors.

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### Authorship contributions

Study Design: D.Y.Y., E.B.; Data Collection: E.B., D.Y.Y., M.C.; Analysis: D.Y.Y.; Writing: E.B., D.Y.Y., M.C, A.B.; Approval: D.Y.Y., A.B.