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The electromyographic analysis of orbicularis oculi muscle in epiphora

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Purpose: Functional epiphora is a clinical condition that presents with the complaint of watery eyes, but without anatomical stenosis in the lacrimal drainage system. Although the mechanism is not clear, there are various possibilities involving the movement of the orbicularis oculi muscle, especially its deeper segment (Horner's muscle). We aimed to evaluate the function of the orbicularis oculi muscle in patients with patent, but dysfunctional lacrimal drainage system using a quantitative motor unit potential (MUP) analysis. **Methods:** Twenty-eight patients with functional epiphora (mean age = 59 years) and a control group of 28 volunteers were included in the study. Inclusion criteria were persistent and symptomatic epiphora or wiping >10 times per day and diagnosis confirmation by lacrimal irrigation test. Electromyography (EMG) was performed on the deeper segment of the orbicularis oculi muscle (medial and lateral parts). MUP parameters (duration time, amplitude, number of phases, number of turns, area, rise time, and thickness) were evaluated in both groups. Any increase in amplitude, prolongation time (>14 ms), number of turns, and satellite potential was taken as characteristic of the neurogenic type of epiphora, whereas shortened motor unit duration time, increased phase number, and low amplitude are the features of myopathic type. **Results:** Upon MUP analysis of the medial and lateral orbicularis oculi muscle, the increase in duration and thickness values in the medial part and the increase in duration, amplitude, area, and thickness values of the lateral part were found to be statistically significant in the patient group compared to the control group ($P < 0.001$). In the evaluation of the patients' medial and lateral orbicularis oculi muscle, the increase in phase values and decrease in amplitude, area, and rise time values were found to be statistically significant ($P = 0.024$, $P < 0.001$, $P < 0.001$, and $P = 0.010$, respectively). **Conclusion:** These data show that functional epiphora is due to neurogenic damage of the orbicularis oculi muscle and should be investigated in more detail.

Key words: Electromyography, functional epiphora, orbicularis oculi muscle

Epiphora remains a complex lacrimal problem.[1] This clinical condition is of uncertain cause and not due to any anatomical disorder, so the term "functional epiphora" is used to describe lacrimal drainage dysfunction in the presence of a patent, but non-functioning lacrimal system.[2-5] According to the patient's history and/or clinical findings, factors that may be responsible for lacrimal hypersecretion are either canalicular (pre-sac) or nasolacrimal (post-sac) obstruction or stenosis, or even a functional (non-anatomical) disorder that may result from "lacrimal pump" failure.[2,6]

Studies on the mechanism of functional epiphora agree that it involves movement of the orbicularis oculi muscle, particularly the deeper segment (Horner's muscle) attached to the lacrimal sac.[2] The "Horner's muscle" is a term used for the musculus orbicularis oculi pars lacrimalis or tensor tarsi, one of the three sections of orbicularis oculi muscle known as the palpebral, orbital, and lacrimal parts.[7] Although it was first described by William Edmonds Horner in 1822, this muscle was actually first discovered about a century before that by Jacques-François-Marie Duverney. The first published definition of what is now known as Horner's muscle appeared in a study by one of Duverney's students, Johann Caspar Schobinger, in 1730.[7] The relationship between the lacrimal canaliculi and Horner's muscle provides the main mechanism of action in the lacrimal drainage system, but the relationships between other parts of the orbicularis oculi muscle, the lacrimal sac, and the nasolacrimal duct are also thought to be important.[8]

Various theories have been proposed for the exact cause of epiphora. According to Jone's theory, the enlarged sac with contraction of the Horner's muscle creates negative pressure, which causes the resorption of tears.[2,9-11] Alternatively, the Rosengren–Doane theory postulates that tears are aspirated into the sac by elastic expansion of the lacrimal papilla, and then contraction of the orbicularis oculi creates a positive pressure, allowing the tears to drain into the nose along the nasolacrimal duct.[2,9-11]

The causes of muscle wasting and weakness may be myopathic or neurogenic mechanisms. To distinguish

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myopathy from neurogenic muscle motor neuron disease, electromyography (EMG) is used as an important tool to detect abnormalities, such as chronic denervation or fasciculation, that are not evident in clinically normal muscle.[2] Isolating the discharge of single motor units as achieved by triggering and delaying their display enables the measurement of motor unit potential (MUP) parameters.[2]

In this study, in order to evaluate the relationship between the entire orbicularis oculi muscle and lacrimal passage, a quantitative MUP analysis method – multi-MUP analysis, a type of decomposition analysis of the EMG signal – was used in the deeper segment of orbicularis oculi muscle (medial and lateral parts). We aimed to investigate which neurogenic motor neuron or myopathic mechanism might be responsible in patients with patent but dysfunctional drainage system (functional epiphora).

Methods

Twenty-eight patients with a mean age of 59.60 ± 8.35 years who had had complaints of persistent watery eyes and associated skin irritation for a long time were included in this study, together with a second group of 28 asymptomatic volunteers, who formed the control group, with a mean age of 53.89 ± 14.80 years.

The study protocol adhered to the tenets of Declaration of Helsinki and was approved by the ethics committee. Fully informed written consent was taken from patients.

Inclusion criteria were validated on the basis of the patent lacrimal irrigation test based on persistent and symptomatic epiphora, wiping >10 times daily or continuous tearing, and grade 4–5 epiphora. Patients with lacrimal hypersecretion due to ocular surface disease, trichiasis, facial nerve palsy, lower eyelid or punctal malposition or eyelid laxity of sufficient severity to contribute to epiphora (lower eyelid distraction test score of >10 mm or abnormal lower eyelid snap-back test results), punctal or canalicular obstruction, previous dacriocystorhinostomy operation, lacrimal canaliculi rupture, or congenital absence of lacrimal puncta and canaliculi were excluded from the study.

Patients' visual acuity and their clinical history, including details of onset, severity and frequency of watering, any lid margin diseases, punctum examination, lacrimal irrigation test, and dacryoscintigraphy, were recorded, and a full endoscopic examination of the nasal cavity for any nasal pathology was performed on all patients. Gradings for eyelid or punctal malposition or eyelid laxity according to distraction and snap-back tests [Table 1], of epiphora according to Munk scale [Table 2], and of fluorescein dye disappearance test (a semi-quantitative assessment of delayed tear outflow) together with a Schirmer test reading [Table 3] were performed for all patients complaining of epiphora to determine whether their complaints were due to dry eye or not [Table 4]. Also, a meibography device, OCULUS Keratograph 5M (OCULUS, Wetzlar, Germany), was used in grading meibomian gland dropout[12,13] [Table 5].

In order to understand the relationship between the entire orbicularis oculi muscle and the lacrimal passage, EMG was performed in the deeper segment (medial and lateral parts) of the orbicularis oculi muscle and the functions of the medial (Horner's muscle) and lateral parts of the orbicularis oculi muscle were examined. MUP parameters (duration time, amplitude, number of phases, number of turns, area, rise time, and thickness) were examined, and any asymmetry in both groups was noted. According to these parameters, any increases in amplitude, prolongation time (>14 ms), number of turns, and satellite potential are characteristic of the neurogenic type of epiphora, whereas shortened motor unit duration time, increased phase number, and low amplitude are the features of the myopathic type.

Study Protocol with EMG

EMG examinations were performed in a quiet room at normal room temperature with subjects lying in a supine position. For the MUP analysis, a computer-supported analysis method four-channel Nihon Kohden EMG device (Neuro pack RMEB-5504 K; Nihon Kohden, Tokyo, Japan) was used. EMG responses were recorded by a disposable concentric needle electrode (25 mm × 0.33 mm, 30G; Neuroline, Ambu), which was inserted in the medial (Horner's muscle) and lateral parts of the orbicularis oculi muscle of the eye on the side of complaint, with the same procedure performed in the control group [Fig. 1].

Filter settings were arranged at 10 kHz for high cut and 5 Hz for low cut. The sweep speed was 5 ms/div, and the gain was 100 μV/div. MUPs were studied in muscles with a slight, voluntary contraction. After data collection, the MUPs were evaluated through visual inspection and 20 MUPs with good quality were selected for each muscle for the final analysis.

Among the MUP parameters, amplitude, duration, area, rise time, thickness (area divided by amplitude), and the numbers of phases and turns were calculated. MUP amplitudes were calculated from peak-to-peak amplitude (in μV); duration was measured from onset of the first to offset of the last deviation from baseline (in ms); area was calculated as the sum of MUP values (in mVms) multiplied by sampling interval; rise time

Table 1: Grading eyelid laxity according to snap-back test and eyelid distraction test for medial and lateral cantal tendon laxity

Grade	Snap-back test	Medial canthal tendon laxity	Lateral canthal tendon laxity
0	Returns to normal position immediately	0-1 mm displacement	0-2 mm displacement
1	2-3 s to return to position	2 mm displacement	2-4 mm displacement
2	4-5 s to return to position	3 mm displacement	4-6 mm displacement
3	>5 s to return to position	>3 mm displacement	>6 mm displacement
4	Never returns to position, may continue to hang down	Does not return to baseline	Does not return to baseline, even with blink

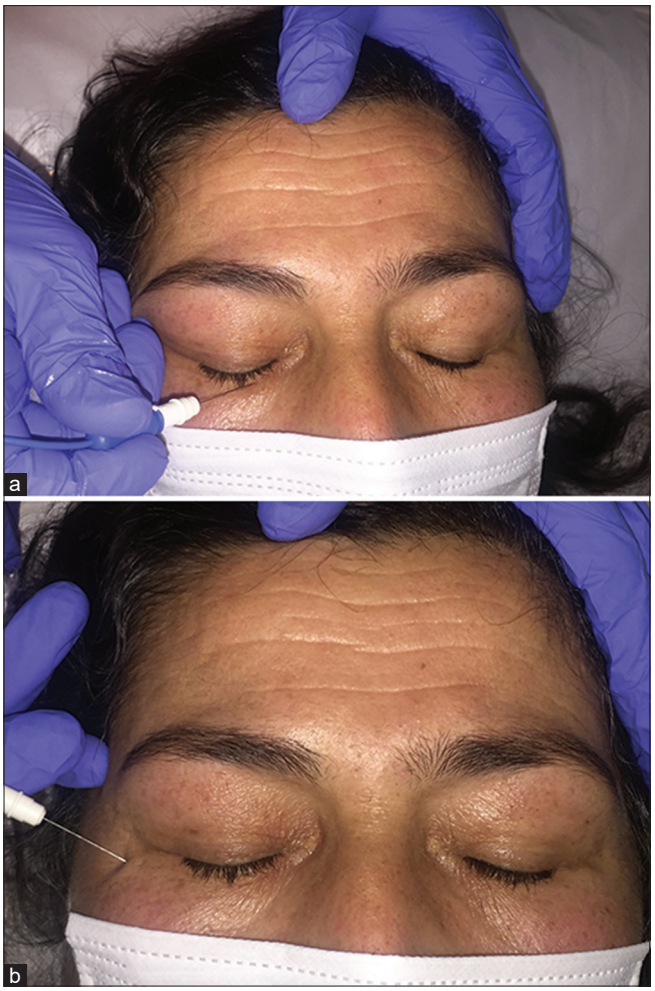

Figure 1: EMG of the orbicularis oculi muscle. (a) A disposable facial electromyography needle electrode was inserted into the medial part (Horner's muscle) of the orbicularis oculi muscle; (b) the electrode was inserted into the lateral part of orbicularis muscle. EMG=Electromyography

was the time between initial positive peak and subsequent negative peak (in μs); the number of MUP phases was counted as baseline crossings − 1; and a turn was the change in the direction of MUP amplitude for at least 25 mV.[14,15]

All MUP parameters were performed and interpreted by one investigator as described.

Statistical Analysis

PASW 18.0 for Windows program was used for statistical analysis. Descriptive statistics were presented as numbers and percentages for categorical variables, and mean, standard deviation, median, minimum, maximum, percentile 25, and percentile 75 for numerical variables. The conformity of the variables to the normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov–Smirnov/Shapiro–Wilk tests). A Chi-square test for categorical variables was applied when the condition was met for pair wise group comparisons; otherwise, Fisher's exact test was used. A *t*-test was used for pair wise group comparisons for numerical variables when the normal distribution condition was met, and the Mann–Whitney U test was used when it was not met. Statistical significance was accepted at $P < 0.05$.

Table 2: Munk scale for grading of epiphora

Grade	Munk scale
0	No epiphora
1	Epiphora requiring dabbing less than twice a day
2	Epiphora requiring dabbing 2-4 times a day
3	Epiphora requiring dabbing 5-10 times a day
4	Epiphora requiring dabbing more than 10 times a day
5	Constant epiphora

Table 3: Grading of fluorescein dye disappearance test

Grade	Observation of dye and color intensity
0	No residual dye
1+	Minimal residual dye
2+/3+	Determined by repeated experience of observation
4+	No decrease in color intensity

Table 4: Schirmer test values

Schirmer reading	mm
Normal	>15 mm
Low normal	10-15 mm
Borderline	6-10 mm
Abnormal	6 mm

Table 5: Grading of meibomian gland dropout

	Meiboscore
0	No loss of meibomian glands
1	Loss of less than one-third of the total meibomian gland area
2	Loss of one-third to two-thirds of the total area
3	Loss of more than two-thirds of the area

Results

Twenty-eight patients with bilateral watery eyes and 28 asymptomatic healthy individuals were included in the study. The mean ages of the patient and control groups were 59.60 ± 8.35 years (range: 48–80) and 53.89 ± 14.80 years (range: 43–62), respectively.

Patient demographics and clinical details are shown in Table 6.

All patients had persistent and symptomatic epiphora, with a Munk score of 4 or 5, which did not change whether they were outdoors or indoors, and grade 0 fluorescein dye disappearance test. Schirmer test values were within the normal range. Meibomian glands were arranged separately along the upper and lower tarsal plates in both groups, with no loss of meibomian glands (grade 0).

All patients had a patent lacrimal irrigation test and dacryoscintigraphy showing patent but delayed passage of dye into the distal part of the nasolacrimal duct and nasal cavity. To investigate whether this delay was due to physiological dysfunction of the lacrimal pump failure, we examined the function of the orbicularis oculi muscle with MUP-EMG.

The medial (Horner) and lateral orbicularis oculi muscle of both eyes was examined by MUP-EMG in both the patient and control groups. For each muscle, at least 20 epochs were analyzed. Insertional activity was normal in all muscles analyzed, and no spontaneous activity was observed.

The patient group MUP-EMG parameters and differences from the control group (*P*-value) were as follows. The median duration of MUP for Horner's muscle was 6.554 ms; for the lateral part of the orbicularis oculi muscle, it was 6.655 ms (P = 0.617). The median amplitude values for the medial (Horner) and lateral parts of the orbicularis oculi muscle were 0.614 and 1.091 mV, respectively ($P < 0.001$). The median numbers of phase values for the medial (Horner) and lateral parts of the orbicularis oculi muscle were 6.55 and 5.185, respectively ($P = 0.024$). The median numbers of turn values for the medial and lateral parts of the orbicularis oculi muscle were

Table 6: Patient demographics and clinical details

	Patient (*n*=28)	Control group (*n*=28)	*P*
Gender			
Female (%)	15 (53.6)	18 (64.3)	0.415[€]
Male (%)	13 (46.4)	10 (35.7)	
Age	60±9	54±5	0.004[¥]
Orbicularis oculi muscle Involvement			
Medial part (Horner)	24 (87.5)	26 (92.9)	0.669[£]
Lateral part	22 (78.6)	27 (96.4)	0.101[£]
Diagnostic tests			
Fluorescent dye disappearance test	3.60±0.89 s	3.03±0.86 s	
Schirmer test	14.03±1.26 mm	14.22±0.83 mm	
Meibomian gland dropout	No loss	No loss	
External examination			
Lacrimal irrigation test	Patent	Patent	
Lower eyelid distraction test			
MCT laxity test	1.29±0.45 mm	1.22±0.41 mm	
LCT laxity test	2.07±0.76 mm	2.07±0.79 mm	
Snap-back test	1 s	1 s	
Punctal/canalicular obstruction	None	None	
Corneal/conjunctival pathology	None	None	

MCT=Medial canthal tendon, LCT=Lateral canthal tendon, [€]Chi-square tes, [£]Fischer Exact Test, [¥]T-Test

Table 7: MUP-EMG analysis of medial (Horner) and lateral parts of orbicularis oculi muscle for the patient group

	Medial (Horner) orbicularis oculi (*n*=28)	Lateral orbicularis oculi (*n*=28)	*P*
Duration	6.554 (6.074-8.44)	6.655 (5.662-7.86)	0.617[a]
Amplitude	0.614 (0.412-0.8)	1.091 (0.77-1.543)	<0.001[a]
Number of phases	6.55 (5.575-8.365)	5.815 (5.17-6.66)	0.024[a]
Number of turns	6.81 (5.3-8.55)	6.21 (4.795-8.27)	0.342[a]
Area	0.56 (0.361-0.962)	1.439 (0.956-2.234)	<0.001[a]
Rise time	333.75 (295.31-449.175)	420 (377.57-681.944)	0.010[a]
Thickness	1.02 (0.804-1.339)	1.088 (0.929-1.631)	0.283[a]

EMG=Electromyography, MUP:Motor unit potential. [a]Mann–Whitney U test

Table 8: MUP-EMG analysis of medial (Horner) orbicularis oculi muscle for patient eyes

	Right Horner's muscle (*n*=28)	Left Horner's muscle (*n*=28)	*P*
Duration	6.554 (6.074-8.44)	6.514 (5.619-8.624)	0.712[b]
Amplitude	0.614 (0.412-0.8)	0.612 (0.477-0.81)	0.863[b]
Phase	6.55 (5.575-8.365)	7.325 (6.35-8.87)	0.108[b]
Number of turns	6.81 (5.3-8.55)	7.415 (6.145-8.75)	0.390[b]
Area	0.56 (0.361-0.962)	0.508 (0.409-0.692)	0.502[b]
Time	333.75 (295.31-449.175)	275 (206.25-348.75)	0.042[b]
Thickness	1.02 (0.804-1.339)	0.949 (0.717-1.11)	0.103[b]

EMG=Electromyography, MUP=Motor unit potential, [b]Mann–Whitney U test

6.81 and 6.21 s, respectively ($P = 0.342$). The median area values for the medial and lateral parts of the orbicularis oculi muscle were 0.56 and 1.439 μVms, respectively ($P < 0.001$). The median rise time values for the medial and lateral parts of the orbicularis oculi muscle were 333.75 and 420 ms, respectively ($P = 0.010$). The median thickness (area/amplitude) values for the medial and lateral parts of the orbicularis oculi muscle were 1.02 and 1.088 μVms/mV, respectively ($P = 0.283$) [Table 7].

Comparison of the MUP data analysis of the Horner's muscle of the patients' (left and right) eyes showed no statistically significant difference, except for the increase in the rise time values on the side with the complaint of watering ($P = 0.042$) [Table 8].

In the control group, the median duration of MUP for the medial (Horner) part of the orbicularis oculi muscle was 4.43 ms, and for the lateral part of the orbicularis oculi muscle, it was 5.133 ms ($P = 0.001$). The median amplitude values for the medial (Horner) and lateral parts of the orbicularis oculi muscle were 0.678 and 0.713 mV, respectively ($P = 0.544$). The median values for the median and lateral numbers of phases

Table 9: MUP-EMG analysis of medial (Horner) and lateral orbicularis oculi muscle for the control group

	Horner's muscle (*n*=28)	Lateral orbicularis oculi (*n*=28)	*P*
Duration	4.43 (4.255-4.827)	5.133 (4.595-5.48)	0.001[b]
Amplitude	0.678 (0.54-0.784)	0.713 (0.514-0.899)	0.544[b]
Number of phases	6.175 (5.35-6.75)	5.35 (4.97-6.23)	0.035[b]
Number of turns	6.22 (5.515-7.28)	5.744 (4.385-6.71)	0.131[b]
Area	0.443 (0.352-0.632)	0.64 (0.44-0.923)	0.029[b]
Rise time	302.33 (234.52-392.5)	371.25 (282.775-496.875)	0.078[b]
Thickness	0.663 (0.556-0.827)	0.823 (0.727-0.958)	0.017[b]

EMG=electromyography, MUP=motor unit potential. [b]Mann–Whitney U test

Table 10: MUP-EMG analysis of medial (Horner) orbicularis oculi muscle for control group eyes

	Right eye Horner's muscle (*n*=28)	Left eye Horner's muscle (*n*=28)	*P*
Duration	4.43 (4.255-4.827)	4.6 (4.357-5.3)	0.189[a]
Amplitude	0.678 (0.54-0.784)	0.698 (0.481-0.808)	0.987[a]
Phase	6.175 (5.35-6.75)	5.3 (5.09-5.95)	0.119[a]
Number of turns	6.22 (5.515-7.28)	5.71 (5.076-6.22)	0.129[a]
Area	0.443 (0.352-0.632)	0.53 (0.355-0.795)	0.302[a]
Time	302.33 (234.52-392.5)	316.6 (286.36-448.955)	0.171[a]
Thickness	0.663 (0.556-0.827)	0.825 (0.703-1.086)	0.010[a]

EMG=electromyography, MUP=motor unit potential. [a]Mann–Whitney U test

Table 11: MUP-EMG analysis of medial part (Horner) and lateral part of orbicularis oculi muscle for the patient and control groups

Orbicularis oculi muscle	Patient (*n*=28)	Normal control (*n*=28)	*P*
Medial			
Duration	6.554 (6.074-8.44)	4.43 (4.255-4.827)	<0.001[d]
Amplitude	0.614 (0.412-0.8)	0.678 (0.54-0.784)	0.436[d]
Number of phases	6.55 (5.575-8.365)	6.175 (5.35-6.75)	0.207[d]
Number of turns	6.81 (5.3-8.55)	6.22 (5.515-7.28)	0.207[d]
Area	0.56 (0.361-0.962)	0.443 (0.352-0.632)	0.154[d]
Rise time	333.75 (295.31-449.175)	302.33 (234.52-392.5)	0.201[d]
Thickness	1.02 (0.804-1.339)	0.663 (0.556-0.827)	<0.001[d]
Lateral			
Duration	6.655 (5.662-7.86)	5.133 (4.595-5.48)	<0.001[d]
Amplitude	1.091 (0.77-1.543)	0.713 (0.514-0.899)	0.001[d]
Number of phases	5.815 (5.17-6.66)	5.35 (4.97-6.23)	0.333[d]
Number of turns	6.21 (4.795-8.27)	5.744 (4.385-6.71)	0.125[d]
Area	1.439 (0.956-2.234)	0.64 (0.44-0.923)	<0.001[d]
Rise time	420 (377.57-681.944)	371.25 (282.775-496.875)	0.075[d]
Thickness	1.088 (0.929-1.631)	0.823 (0.727-0.958)	0.001[d]

EMG=electromyography, MUP=motor unit potential. [d]Mann–Whitney U test

for the medial (Horner) part of the orbicularis oculi muscle were 6.175 and 5.35, respectively (P = 0.035). The median values for the number of turns for the medial and lateral part of the orbicularis oculi muscle were 6.22 and 5.744 s, respectively (P = 0.131). The median area values for the medial and lateral parts of the orbicularis oculi muscle were 0.443 and 0.64 μVms, respectively (P = 0.028). The median rise time values for the medial and lateral parts of the orbicularis oculi muscle were 302.33 and 371.25 ms, respectively (P = 0.078). The median thickness (area/amplitude) values for the medial and lateral parts of the orbicularis oculi muscle were 0.663 and 0.823 μVms/mV, respectively (P = 0.0117) [Table 9].

In the MUP-EMG analysis of the medial (Horner) part of the orbicularis oculi muscles in the right and left eyes of the control group, only the thickness value was statistically significant (P = 0.010) [Table 10].

The MUP analysis data for the medial and lateral parts of the orbicularis oculi muscle in the patient and control groups are shown in Table 11. The MUP parameters of median duration and thickness of the right eye medial (Horner) orbicularis oculi muscle of the patient group were significantly different compared to the control group (P < 0.001). The right eye lateral orbicularis oculi muscle duration, amplitude, area, and thickness values were similarly different (P < 0.001), as were the MUP parameters of left eye Horner's muscle duration, number of phases, and number of turns values (P < 0.01).

Discussion

One of the most common symptoms of any ocular pathology, epiphora or watering, is mostly caused by an obstruction in the lacrimal drainage system, but can also occur due to other causes such as eyelid and adnexal pathologies.[16,17] While watering due to obstruction in the tear drainage system is defined as true epiphora, excessive watering due to dry eye, foreign body in the cornea, corneal abrasion, or reflex irritation of the cornea and conjunctiva is expressed as lacrimal hypersecretion.

It is important to distinguish whether the epiphora is an anatomical or functional lacrimal outflow pathway obstruction. In anatomical obstruction, a structural pathology, such as punctal and canalicular stenosis and block, or a nasolacrimal duct obstruction in the lacrimal outflow tract, prevents tear drainage system. In functional dysfunctions, the lacrimal outflow tract is anatomically open, but there is a defect in the lacrimal pump mechanism.[17]

In the presence of a clinically or radiologically confirmed patent lacrimal drainage system, epiphora causes much discomfort in the daily activities of patients, who complain about watery or mucus (sticky eye) discharge, and it is often more difficult to treat than mucopurulent discharge, as seen in punctal and canalicular stenosis.[1-3,9,10]

However, the precise underlying causes of epiphora remain unclear. Among the studies on this subject, there are no validated diagnostic criteria and management approaches for functional epiphora.[1] In this study, we aimed to examine the orbicularis oculi muscle functions using MUP analysis in patients with functional epiphora to assist in developing the best treatment approach.

The causes of muscle wasting and weakness can be divided into myopathic and neurogenic mechanisms and are distinguished by EMG, which, demonstrating the widespread denervation and fasciculation required for a comprehensive diagnosis, is the standard tool for distinguishing myopathic from neurogenic muscle motor neuron disease.[2]

MUPs represent the sum of the synchronously firing activity of a muscle or fibers of a motor unit. For this reason, any structural abnormality in a motor unit will result in alterations in the MUP parameters. Thus, the quantification of MUP parameters has been used to define neuromuscular disorders since EMG was first introduced.[18]

In myopathic conditions, the duration and amplitude of MUPs decrease, whereas increased duration and amplitude than normal appear in neuropathic conditions. Similarly, area measurements may also help to differentiate neuropathy from myopathy.[14,15]

Chronic reinnervation has been associated with normal phase number and long-term MUPs. In general, the amplitude of MUPs is less than 2 mV and the duration is 10–5 ms with three to four phases. In chronic partial denervation, intramuscular sprouting and reinnervation can occur at amplitudes of 10–20 mV and for durations of up to 20–30 ms. Only short-term light motor unit amplitude potentials have been observed in primary muscle disease; typical amplitude and duration values are 0.5 mV and 5–10 ms, respectively.[1,19]

In our study, we used EMG to evaluate the orbicularis oculi muscle medial and lateral parts and their relationships with functional epiphora, and we compared the results of symptomatic eyes (patients eyes) with healthy eyes (control group). Our results for the MUP data analysis of Horner's muscle showed that the duration time was notably longer and the area and thickness were significantly higher among epiphora patients than in the control group. The other MUP characteristics did not show a statistically significant difference between the two groups.

Our findings for Horner's muscle are consistent with those of Lu *et al*.,[2] who also reported that the duration of EMG waveforms was significantly longer in the functional epiphora group than in the control group. Moreover, they stated that the longer duration time in patients with functional epiphora might mean chronic partial denervation suggestive of neurogenic muscle motor neuron disease, and that it may help to treat functional epiphora in a different way.

When we compared the MUP data analysis of the medial (Horner's muscle) and lateral parts of orbicularis oculi muscle in patients, we found that the amplitude, area, and rise time values of MUPs were significantly higher in the lateral part of the orbicularis oculi muscle. As for the data of the lateral part of orbicularis oculi muscles of the patient and control groups, the mean values of all the MUP parameters were found to be significantly increased in epiphora patients. Based on these findings, we would suggest that in the pathophysiology of epiphora, the involvement of the entire orbicularis oculi muscle plays a role, not only the Horner's muscle.

Studies on MUP-EMG analysis of the orbicularis oculi muscle in patients with functional epiphora in the literature

are limited. Our results showed that the functional epiphora has a neurogenic origin, and that neuropathic changes in the orbicularis oculi muscle may be responsible for this condition.

Among the limitations of the study are the low number of patients and the lack of re-evaluation of MUP parameters after proper treatment of the epiphora patients.

Conclusion

Epiphora with a patent but non-functioning lacrimal system causes much discomfort in the daily activities of patients, who complain about watery or mucus (sticky eye) discharge. The epiphora may be either myopathic or neuropathic in origin. The findings reported here indicate that not only does the neuropathic involvement of the Horner's muscle contribute to this condition, but also that of the entire orbicularis oculi muscle may do so. Further studies are needed to identify the role of specific muscle groups.

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Conflicts of interest

There are no conflicts of interest.

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