# An Electromyographic Study of Lagophthalmos in Leprosy<sup>1,2</sup>

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Peripheral nerve lesions are an integral part of leprosy. With the exception of some of the long peripheral nerves, the facial nerve is the most commonly damaged. This occurs in approximately 10 per cent of cases (<sup>4</sup>). An important manifestation of lesions of the facial nerve is lagophthalmos, which, in addition to the cosmetic effect produced, may lead to eye damage as a result of corneal exposure to microtraumata and of secondary infection (<sup>6</sup>).

The direct cause of lagophthalmos is weakness or paralysis of the orbicularis oculi muscle. The upper and lower parts of the orbicularis oculi are innervated by separate subdivisions of the first branch of the facial nerve, viz., the occipito-temporal and zygomatic nerve respectively (<sup>3</sup>).

Antia, Dastur and Divekar (1,2) have demonstrated that in leprosy there may be histopathologic changes and parallel electromyographic (EMG) signs of localized damage of the zygomatic nerve. If this possibility, and that of the occurrence of a scattered type of nerve lesion, are accepted, the question arises as to whether the two parts of the orbicularis oculi are damaged independently or are both affected simultaneously as one muscle. If a distinct lesion of one part of the orbicularis oculi is present, it is important to determine its significance in the causation of lagophthalmos. Also of interest is a possible relation between the grade of lagophthalmos

and the severity of weakness of any one part of the orbicularis oculi muscle. This problem becomes even more significant if we consider the fact that lagophthalmos may occur independently or be accompanied by either scattered or widespread damage to other facial muscles innervated by any of the three main branches of the facial nerve. In addition, comparative data are required on the chronologic order of damage to the facial nerve as compared with other peripheral nerves commonly involved.

The present study is an attempt to answer some of these questions and assess their clinical applications.

#### MATERIALS AND METHODS

Twenty-seven patients (23 with lepromatous and 4 with tuberculoid leprosy) were examined. Eight of them had bilateral and four unilateral lagophthalmos. Since the degree of involvement of the facial nerve on each side can vary, each eye was assessed separately. The study was carried out, therefore, on 20 eyes with and 34 eyes without lagophthalmos. The lagophthalmos had been present for from three to 15 years prior to our examination. The 15 patients without lagophthalmos were examined for comparative purposes.

Each patient underwent a careful physical examination, with special reference to the presence and grade of lagophthalmos and the degree of muscle power of the orbicularis oculi (upper and lower parts), frontalis, orbicularis oris, opponens pollicis and abductor digiti minimi muscles. The muscle power was graded as:

Normal. Contraction was possible against resistance applied by the examiner. The two parts of the orbicularis oculi muscles were considered normal if the patient was able to close, and hold shut, the eyelids

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against the counter resistance of the thumb and index finger of the examiner.

Weak. The muscle was able to contract, but not against resistance. The orbicularis oculi was considered weak if closure of the eye was possible, but the slightest resistance on the part of the examiner was sufficient to overcome even maximal volitional contraction of either part of the muscle.

*Paralyzed.* Extremely weak or no volitional contraction was possible.

The lagophthalmos was divided into three main groups:

Mild. Closure defect of less than one



FIG. 1. Unilateral lagophthalmos, Grade 1.

Fig. 2. Bilateral lagophthalmos, Grade 2.

FIG. 3. Bilateral lagophthalmos, Grade 3. mm., obvious only on slow closure of the eyelids at the inner canthus (5 eyes) (Fig. 1).

*Moderate.* Closure defect of 1-4 mm. accompanied by exposure of the bulbar conjunctiva and of the lower part of the cornea (5 eyes) (Fig. 2).

Severe. Closure defects of 5 mm. or more, with extensive exposure of the cornea (10 eyes) (Fig. 3).

The EMG studies were carried out on a Medelec two-channel apparatus, provided with a mnemoscopic unit, filming camera and loud speaker. The EMG machine was connected to a digital and analog-to-digital TMC computer of average transients for duration and amplitude analysis. The coaxial needle electrodes were inserted into various parts of each muscle examined, and the results were compared. An EMG recording was considered normal if no spontaneous activity was present with the muscle relaxed, while if, in volitional contraction, the duration was 3-6 msec. and the amplitude above 450 micro V., and if, in maximal volitional contraction, a full interference pattern was obvious (Fig. 4). The diagnosis of a neuropathic pattern was based mainly on prolonged duration of the motor unit potentials, loss of motor units during volitional contraction, and possible spontaneous activity during rest (Fig. 5).

#### RESULTS

Table 1 and Figures 6 and 7 show the condition of muscle power and the results of EMG studies of the muscles tested. Thirty upper and 30 lower orbicularis oculi muscles in the patients without lagophthalmos had normal muscle power and normal EMG records, except that in one instance, a neurogenic EMG record was found in the lower orbicularis oculi while the muscle power was normal.

In the mild lagophthalmos group the upper orbicularis oculi was normal in four cases and weak in one, while the lower orbicularis oculi was weak in one instance and completely paralyzed in four cases. It should be stressed that, in this group, the upper orbicularis oculi was never found to be paralyzed. The same findings were reflected by EMG studies: all the lower orbicularis oculi muscles exhibited a neuropathic pattern, while the upper orbicularis oculi showed a normal pattern in four instances. In the moderate and severe groups of lagophthalmos, the muscle power and EMG records were similar in both the upper and lower orbicularis oculi muscles.

In the moderate lagophthalmos group, the upper orbicularis oculi was weak in four and normal in one instance. The lower orbicularis oculi was weak in four and completely paralyzed on one case; normal muscle power was never found in this group.

In the severe lagophthalmos group, all the lower orbicularis oculi muscles were paralyzed, while two of the upper orbicularis oculi muscles were weak, the rest also being paralyzed (Fig. 6). The EMG findings paralleled the clinical condition (Fig. 7).

In the severe lagophthalmos group, almost all the frontalis muscles were found to be completely paralyzed, while the orbicularis oris muscles were only weak. This is to be expected, as both the frontalis and the upper orbicularis oculi are innervated by the same branch of the facial nerve. An interesting finding is that in the control group (without lagophthalmos), 12 opponens pollicis and 18 abductor digiti minimi muscles were clinically weak or paralyzed, with neuropathic EMG recording (Table 1). Moreover, in four opponens pollicis and six abductor digiti minimi muscles, the EMG recording was neuropathic, while their clinical muscle power was normal. In the 12 patients with lagophthalmos, only three opponens pollicis and one abductor digiti minimi muscle had normal muscle power and EMG recordings (Figs. 6, 7).

## DISCUSSION

The main facts emerging from this investigation are that lagophthalmos, especially of mild grade, may be caused by weakness of only one part of the orbicularis oculi muscle and that there may be a marked discrepancy in the degree of damage between the two parts of the orbicularis oculi. We tend to agree with Dastur and coworkers  $(^2)$  that the lower part of the muscle is generally the first to be damaged;





FIG. 4. EMG of lower orbicularis oculi. Calibration 300 micro V. time base 1.0 msec., normal pattern.

FIG. 5. EMG of lower orbicularis oculi. Calibration 300 micro V., time base 1.0 msec., neuropathic pattern as manifested by prolonged duration and severe loss of motor units during forced volitional contraction of the muscle.

moreover, our results clearly show that, except in severe general facial damage, the lower part is usually more severely damaged. The present study also provides evidence that damage to the lower part of the orbicularis oculi only may suffice to cause mild lagophthalmos, which may easily be overlooked if the physical examination is not carried out carefully. The best method of examination for lagophthalmos is to ask the patient to close the eyelids slowly. In mild cases a gap of about 1 mm. will be observed between the upper and lower lids near the inner or outer canthus (Fig. 1). This will not be noticed if the patient is asked to close the eyelids firmly and forcefully, because the upper orbicularis oculi will compensate for the

Muscle	Muscle power			EMG	
	Normal	Weak	Paralyzed	Normal	Neuropath <sup>;</sup> c
Upper orbicularis oculi	30			30	-
Lower orbicularis oculi	30			29	1
Frontalis	30			30	
Orbicularis oris	30			30	
Opponens pollicis	18	6	6	14	16
Abductor digiti minimi	12	9	9	6	24

TABLE 1. Results of examination of muscle power and EMG study in 15 patients without lagophthalmos.

gap in eye closure (Figs. 8, 9). Mild lagophthalmos is most obvious while the patient is asleep, and this fact, together with the diminished sensitivity of a damaged cornea, explains the appearance of exposure keratitis in the lower part of the cornea even though there is no gross lagophthalmos clinically. Hence, it is evident that early diagnosis, through a careful clinical and EMG examination in doubtful cases of lower orbicularis oculi damage, may be important in prevention of injury to the eye.

This situation becomes even more significant if we consider that the present study shows that lagophthalmos may be the first sign of facial nerve damage, without weakness of other facial muscles.

The more common lesion of the frontalis muscle in moderate and severe lagophthalmos is explained by the fact that the upper orbicularis oculi muscle, which in these grades of lagophthalmos is almost always damaged, is innervated by the same branch of the facial nerve. It is also our impression that in leprosy the azygomatic branch may be damaged selectively, with subsequent weakness of the lower orbicularis oculi and mild lagophthalmos. This type of lesion is never observed in facial palsies of other origins, with the exception of direct traumatic injuries to any of the nerve branches. A possible explanation may be the "mechanical predisposition" suggested by Antia *et al.* (1, 2).



FIG. 6. Relationship between grade of lagophthalmos and muscle power in the 12 patients with lagophthalmos.



FIG. 7. Relationship between grade of lagophthalmos and EMG results in the 12 patients with lagophthalmos.

In relation to the chronology of damage to the facial, ulnar, and median nerves, it is clear from our material that in most cases the ulnar, and, to a lesser degree, the median nerves are damaged first. Only rarely do we find a facial lesion or lagophthalmos without prior paralysis of at least some of the muscles of the hand, although the possibility should always be considered.

No EMG evidence of subclinical damage of either part of the orbicularis oculi, or of the frontalis or upper orbicularis oris, was found. This is in contrast to our previous



FIG. 8. Grade 1 unilateral lagophthalmos, apparent on soft closure of the eyelids.

FIG. 9. Same patient as in Figure 8. Firm closure of the eyelids. No lagophthalmos is observed. findings in the hand muscles (<sup>5</sup>). It may be explained by the fact that all the facial muscles are kinesiologically synergistic, and therefore the mildest weakness in any one of them becomes evident immediately through the asymmetric pull of the parallel or contralateral muscle.

Last, it has been proved again that electromyography is a very reliable tool for the early diagnosis of nerve damage. This makes the EMG examination the method of choice for qualitative assessment of the facial nerve palsy in leprosy and virtually excludes the need for diagnostic biopsy.

## SUMMARY

Clinical and EMG studies were carried out in 27 leprosy patients, eight of them with bilateral, four with unilateral and 15 without lagophthalmos. The condition of the upper and lower orbicularis oculi, frontalis, orbicularis oris, oppenens pollicis and abductor digiti minimi muscles was compared in all the patients.

It was shown that lagophthalmos could be caused by weakness of only one part of the orbicularis oculi muscle. This may be the result of selective damage to the zygomatic branch of the facial nerve. It would seem that weakness of the lower orbicularis oculi muscle is associated with mild lagophthalmos, while moderate or severe grades of lagophthalmos are caused by damage to both upper and lower parts of this muscle.

No direct correlation was found between weakness of the orbicularis oculi and the muscle power of the frontalis and upper orbicularis oris, except in the presence of severe lagophthalmos, when there is most probably damage to at least one major branch of the facial nerve.

In general, lagophthalmos precedes manifestations of lesions in other branches of the facial nerve. The ulnar and median nerves are usually damaged before the facial nerve.

### RESUMEN

Estudios clínicos y EMG fueron realizados en 27 pacientes de lepra, ocho de ellos con lagoftalmo bilateral, cuatro con lagoftalmo unilateral y 15 sin lagoftalmo. La condición de los músculos orbicularis oculi, superiores e inferiores, frontalis, orbicularis oris, opponens pollicis y abductor digiti minimi se comparó en todos los pacientes.

Se demostró que el lagoftalmos puede ser causado por la debilidad de solo una parte del músculo orbicularis oculi. Esto puede ser el resultado del daño selectivo de la rama zygomática del nervio facial. Parecería que la debilidad del músculo orbicularis óculi inferior está asociado con un lagoftalmos de intensidad media, en tanto que lagoftalmos de grados moderados o severos son causados por el daño producido tanto a las partes superior como inferior de este músculo.

No se encontró relación directa entre la debilidad del músculo orbicularis oculi y la fuerza muscular del frontalis y orbicularis oris superior, excepto en la presencia de un severo lagoftalmos cuando existe una mayor probabilidad de daño por lo menos en una rama mayor del nervio facial.

En general, el lagoftalmos precede a las manifestaciones de lesiones en otras ramas del nervio facial. Los nervios ulnar y mediano generalmente se afectan antes que el nervio facial.

#### RÉSUMÉ

Chez 27 malades atteints de lèpre, on a procédé à des études cliniques et électromyographiques. Huit de ces malades souffraient de lagophtalmie bilatérale, quatre de lagophtalmie unilatérale, et 15 ne présentaient pas de lagophtalmie. Chez tous les malades, on a comparé l'état des muscles suivants: l'orbiculaire supérieur et l'orbiculaire inférieur de l'oeil, le frontal, l'orbiculaire buccale, l'opposant du pouce, et l'abducteur du cinquième doigt.

On a constaté que la lagophtalmie pouvait étre produite par la faiblesse d'une partie seulement du muscle orbiculaire de l'oeil. Ceci peut être le résultat d'un dommage sélectif atteignant la branche zygomatique du nerf facial. Il semblerait que la faiblesse du muscle orbiculaire inférieur de l'oeil est associée à une lagophtalmie légère, tandis que, par alleurs, des degrés modérés ou grave de lagophtalmie sont produits par un endommagement des parties supérieure et inférieure de ce muscle à la fois.

Aucune corrélation directe n'a été observée entre la faiblesse de l'orbiculaire de l'oeil et la puissance musculaire du frontal et de l'orbiculaire buccale supérieur, sauf s'il existe une lagophtalmie grave, qui révéle plus que probablement l'existence d'une lésion au niveau d'une des branches principales au moins du nerf facial. De manière générale, la lagophtalmie précéde l'apparition de lésions dans d'autres branches du nerf facial. Les nerf cubital et médian sont habituellement endommagés avant le nerf facial.

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