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 (1). 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 microtrauma and of secondary infection (2).

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 (3).

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...
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...
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 pneumatic 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. Thirteen 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 in 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 opposition pollicis and 18 abductor digitii minimi muscles were clinically weak or paralyzed, with neuropathic EMG recording (Table 1). Moreover, in four opposition pollicis and six abductor digitii minimi muscles, the EMG recording was neuropathic, while their clinical muscle power was normal. In the 12 patients with lagophthalmos, only three opposition pollicis and one abductor digitii minimi muscle had normal muscle power and EMG recordings (Figs. 8, 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;
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 lagophthalamos, which may easily be overlooked if the physical examination is not carried out carefully.

The best method of examination for lagophthalamos 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
Results of examination of muscle power and EMG study in 15 patients without lagophthalmos.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Normal</th>
<th>Weak</th>
<th>Paralyzed</th>
<th>Normal</th>
<th>Neuropathic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper orbicularis oculi</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td>Lower orbicularis oculi</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>Frontalis</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td>Orbicularis oris</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td>Opponens pollicis</td>
<td>18</td>
<td>6</td>
<td>6</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Abductor digitii minimi</td>
<td>12</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>24</td>
</tr>
</tbody>
</table>

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

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.
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, frontal, orbicularis oris, opponens pollicis and abductor digitii 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.

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, frontal, orbicularis oris, opponens pollicis and abductor digitii 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.

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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 lagofthalmos bilateral, cuatro con lagofthalmos unilateral y 15 sin lagofthalmos. La condición de los músculos orbicularis oculi, superiores e inferiores, frontales, orbicularis oris, opponens pollicis y abductor digitii minimi se comparó en todos los pacientes.

Se demostró que el lagofthalmos 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 zygomatica del nervio facial. Parece que la debilidad del músculo orbicularis oculi inferior está asociada con un lagofthalmos de intensidad media, en tanto que lagofthalmos de grados moderados o severos son causados por el daño producido tanto a las partes superiores como inferiores de este músculo.

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

En general, el lagofthalmos 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.
De manière générale, la lagophthalmie précède l’apparition de lésions dans d’autres branches du nerf facial. Les nerfs cubital et médian sont habituellement endommagés avant le nerf facial.

REFERENCES